World Congress of Agroforestry 2009
Nairobi Kenya 23-28 August

Book of Abstracts

Agroforestry - The Future of Global Land Use

http://www.worldagroforestry.org/wca2009/
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2nd World Congress of Agroforestry

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23-28 August 2009
Nairobi, Kenya

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FOREWORD

We are pleased to present this compilation containing the extended abstracts of all of the invited symposium presentations and abstracts of voluntarily submitted papers selected for oral presentation at the Technical Sessions of the 2nd World Congress of Agroforestry, August 2009, convened in Nairobi, Kenya. We believe that this compilation represents a comprehensive snapshot of the current state of knowledge about agroforestry worldwide, as well as an overview of the rising expectations and aspirations for this rapidly growing field in addressing many of mankind’s most pressing concerns.

The response to “Call for Papers” for the Congress was overwhelming: more than 1,000 submissions were received from over 100 countries around the world for oral or poster presentations in one of the 35+ technical sessions. In spite of detailed instructions and guidelines to prospective participants, the abstracts came in different styles and formats. While the vast majority were related to agroforestry, a few were deemed unrelated to agroforestry. Following a preliminary screening that eliminated such outliers, the abstracts were sent to the respective Congress session organizers for scrutiny and decision on acceptability for oral or poster presentations. The session organizers were as accommodating as possible in making their decisions, yet some abstracts had to be rejected. The authors who passed this initial scrutiny were given the opportunity to modify their abstracts online to address the session organizer’s comments and/or update the contents. The abstracts of papers that were selected for oral presentation were edited for length (maximum 300 words), format, and language and included in this compilation. Because of the volume of work and tight time schedule, all edited versions may not have been sent back to the authors for their final approval; we request the authors’ understanding and forbearance for this. For papers accepted as poster presentations, the titles, authors’ names and institutional affiliations are included in this volume; the full abstracts will be retained on the Congress website (www.worldagroforestry.org/wca2009). At the time of sending this to press, some authors’ participation in the Congress and presentation of their work are still uncertain because of financial and administrative reasons; nevertheless, we thank the authors for their permission to include their abstracts in this volume.

A number of these presentations will be developed as full-length journal articles for the special issues of thematic journals that will feature Congress themes. For those abstracts that may not be published in such other professional and academic publications, this Book of Abstracts will remain the only source of reference. Thus, we believe that this book will be a valuable knowledge resource. The book will be made available to Congress participants electronically, and the abstracts will be posted on the Congress website and will be retained indefinitely after the Congress.

It is indeed an enormous task to handle so many technical abstracts within a short span of time, respond to the myriad of questions by the vast number of authors, and coordinate with the session organizers. Moreover, the layout, formatting, and printing of the book required considerable effort and time. Michael Hailu, Wahida Patwa Shah, Rebecca Selvarajah-Jaffery, Delicia Pino and Reagan Sirengo of the Congress Secretariat did a superb job of accomplishing all of these tasks so admirably. We sincerely thank these individuals for their dedication and hard work. Finally, we thank all the authors and session organizers. This publication would not have been possible without their splendid cooperation and timely inputs.

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2. Domestication of agroforestry tree crops - **Roger Leakey**, James Cook University, Australia

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5. Segregate or integrate for multifunctionality and sustainagility - **Meine van Noordwijk**, World Agroforestry Centre, Indonesia

6. Land rehabilitation and landcare - **Keith Shepherd & Tor-Gunnar Vagen**, World Agroforestry Centre, Nairobi

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8. High Carbon Stocks Development Pathways - **Peter Minang**, ASB Partnership for the Tropical Forest Margins, Kenya

9. Satoyama - Socio-ecological production landscape approach - **Maiko Nishi** (United Nations University, Institute of Advanced Studies (UNU-IAS), Japan), and **Anantha Duraiappah**, United Nations Environment Programme, Nairobi
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Symposia Abstracts
Biofuel Value Chains in the US: Drawing Lessons for Newcomers

Abstract

With the recent emergence of biofuels as an alternative source of transportation fuel, there is wide interest in many countries to establish and expand their biofuels sector. The US, Brazil, and EU have taken the lead in this context and there are lessons to be learned from their experiences for other countries. In this paper we give an overview of the development and the current structure of the US biofuels industry, with particular attention to the ethanol sector – so as to highlight the lessons that emerging biofuel economies should be aware of. By taking the US ethanol value chain as an example, we are able to identify the general features of a biofuels chain that would make a given conversion process viable and successful in a local and global market environment. The paper points out the advantages that dried distillers grains (DDG) create through their use as a replacement for corn in the livestock feed rations, which create close linkages between the biofuel value chain and the livestock sector within the US. We also point out the tight competition that exists between feed, fuel and the considerable export demand for corn, which creates strong price pressures that impinge upon the profitability of both livestock producers and ethanol plants. Thus, if a new biofuel economy chooses an edible biomass for biofuel production, similar to the case of US, this may introduce some rigidity into the market and impact the investors’ decisions since the demand for food products is relatively inelastic. We point out the importance of securing a stable and consistent biomass supply for newcomers into the biofuels sector, so as to ensure favourable feedstock costs and profit margins. Through national policy measures that encourage biomass production or securing supply through long-term contracts with farmers, the long-term sustainability of the sector can be enhanced and investment flows can also be encouraged to enter the sector. We also illustrate the impact of transportation costs on the value chain, which is driven by the location of biofuel plants relative to the refiners and blenders, as well as to the livestock producers who use the DDG by-products. The role that policy plays in supporting the early expansion of the industry can also be important to the functioning of the sector. In the paper, we show these to be the result of either demand-side policies that generate a ‘floor’ for biofuel demand – thereby reducing the volatility of biofuel demand and on-farm profit margins – or through supply-side policies that encourage biomass production and provide a consistent feedstock supply for the biofuel plants. Examples of such policies, in the US, are the Energy Bill of 2005 and the Energy Independence and Security Act (EISA) of 2007 which have introduced mandates for consumption of ethanol. Other US policies were tax credits for refiners blending ethanol with gasoline and a cellulosic ethanol tax credit. Similar policy tools can be employed in other countries to make the process viable at the initial stages, and to ensure that the cost economies are favourable, thereby helping to reduce the risk for investors seeking opportunities in the biofuels industry. Finally, we show that if a non-edible product, like jatropha, is used for biofuels production, rather than an edible product that generates a wider range of co-products, such as corn or rapeseed, the resulting value chain for this type of sector will be different. In this context, choosing the appropriate biomass/technology for biofuel production based on the production capability (particularly land availability) of the country and the alternative market for the biomass used in biofuel production is critical in defining the characteristics of the biofuel value chain within an economy.
A comparison of the medicinal plant trade chains in Ethiopia and South Africa

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Abstract

Traditional plant-based medicines play an important role in African society, supplying accessible medicines, sustaining cultures and providing income earning and enterprise development opportunities. However due to the informal nature of these medicinal plant markets, little formal information is available on the volume and value of the trade, which limits informed decision making by policy makers and consequently leads to a unsustainable economic sector. The growing scarcity of medicinal plant stocks illustrates this problem. The aim of this paper is to show the role of the medicinal plant trade in African livelihoods, and the precarious nature of that role in the face of diminishing plant stocks by comparing the medicinal plant trade chains in Ethiopia and South Africa. The analysis of the Ethiopian and South African trade chains were based on a similar methodology, wherein local market surveys were undertaken to map market chains and to project supply and demand trends, which are then extrapolated to the national level using broader population estimates. For both of the two trade chains plant sources, harvesting methods, transport, wholesale, processing, retail and consumption patterns are described and compared between the two countries. Findings show that in both countries medicinal plants are mostly collected from the wild, which supplies more than 75% of the market volume. The South African market is smaller in volume than the Ethiopian market but is more formalised with cultivated plant stocks being formally processed through pharmaceutical manufacturers. Ethiopia does not have pharmaceutical companies processing medicinal plant products for the formal market and all medicinal plants are marketed through traditional channels. In both countries these informal markets encompass trade of raw and processed material in informal markets as well as processed plants and medicine prescribed and distributed through traditional healers. We estimate an annual consumption of 36,000 tonnes by 48 million consumers in Ethiopia and the annual consumption of 20,000 tonnes by 27 million consumers in South Africa. In both countries, the sector provides significant income earning and enterprise development opportunities with about 160,000 jobs created in trade in Ethiopia and at least 130,000 jobs in trade in South Africa. However, with much of the plant stocks being unsustainably harvested from unmanaged wild stocks the social and economic benefits of the trade are at risk. We conclude that a major opportunity exists for mainstreaming agroforestry initiatives and describe their potential structure. Large scale medicinal plant production and/or wild or domestic stocks management offer opportunities for African governments to sustain the benefits of the plant trade to society, such as rural health, job creation, trade and maintaining biodiversity.
Symposium 2: Domestication of agroforestry tree crops

Impact of participatory tree domestication on farmer livelihoods in West and Central Africa

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Abstract  
Research on participatory domestication of indigenous trees in West and Central Africa started in 1998 with the objective of increasing incomes of rural communities and the resilience of their livelihoods by cultivating indigenous trees and developing strategies for marketing the produce. Over the years, a low-cost technology, well-adapted to local communities was developed and the capacities of technicians from NGOs, extension services and community-based organizations to cope with tree domestication and marketing were strengthened. Ten years later, surveys were conducted in the Centre and North-West Provinces of Cameroon to assess impact of participatory tree domestication on farmer livelihoods. Farmers practicing tree domestication were asked to describe its benefits to tree cultivation on their farms, household income, health and human capacity development, and the constraints they face in its practice. Reasons why some farmers discontinued their tree domestication and others preferred not to adopt were also investigated. The majority of adopters realize that tree domestication can bring quick results, either through sales of nursery plants or through early fruiting plants. Overall, household revenue derived from tree domestication varies with areas. In some income was quite low while in others the study showed several cases where tree domestication has permitted farmers to send their children to secondary school and upgrade their habitat, investments they could not afford without the innovation. Health benefits from tree domestication include increased fruit consumption and use of medicinal plants, both through more awareness and increased availability on farm. Probably the most direct felt impact of tree domestication is capacity development. Knowledge not only related to trees, but also on group dynamics, conflict resolution and financial management, has turned adopters into veritable resource persons in their communities and beyond. The study also revealed that successful models are the main driver for the diffusion of tree domestication. Farmers who discontinued the innovation and non-adopters admit doing so because they lack tangible signs of impact. On the contrary, in sites where tree domestication results are unmistakably visible, more farmers are encouraged to take up the innovation, resulting in turn into greater impact.

Smallholder Production of Agroforestry Germplasm: Experiences and lessons from Brazil, Costa Rica, Mexico and Peru

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Introduction

Over the last 20 years or so, interest has grown in promoting smallholder germplasm production as a mechanism for simultaneously securing a series of benefits. We describe a number of initiatives of this sort in Latin America. We then evaluate their performance in terms of four potential benefits of smallholder germplasm production (although we recognize that not all the initiatives had these explicitly aims). We then discuss these in order to identify lessons of relevance to future activities of this sort.

The four initiatives:

Brazil: Seed production by the Parakanã indigenous community

Type of activity: component of a private sector development programme.
Implementing agencies and location of activities: Tucuruí Municipality, Pará State, Brazil.
Principal purpose of activity: generation of income; value-adding to discourage felling.
Nature of community seed production activities: Collection, sale of seed of six tree species.
Impacts (germplasm sale) and current status: In 2005, income from seed sales was approximately R$7000 (c.$2800 at 2005 exchange rates, i.e. $4.45 / community member).

Central America and the Caribbean: the Forest Tree Seed Project (PROSEFOR)

Type of activity: externally funded development project (1992-2001) (Denmark)
Implementing agencies and location of activities: CATIE, National Seed Banks or forest authorities (Costa Rica, the Dominican Republic, Guatemala, Honduras, Nicaragua, Panama, and El Salvador), Danish Forest Tree Seed Centre.
Principal purpose of activity: increase supply of and demand for quality forest tree seed.
Nature of smallholder seed production component: The project established 308 approved seed sources of 78 species, many located on private land. Seed was to be marketed through the national seed banks, and regionally/internationally through CATIE seed bank, with proceeds (less costs) returned to the seed stand owners.
Impacts (germplasm sale) and current status: By 1999, annual demand for seed from the seed banks had reached 31,317 kg. Total receipts were $832,000. However, of this total, 32% were of Honduran pine seed, sourced primarily from state forests. Of the remainder, $216,000 was from sales of teak and gmelina from Costa Rica, the great majority derived from smallholder plantings. The seed banks continue to market a wide range of species.

Mexico (Yucatán): Conservation and use of big-leaf mahogany (Swietenia macrophylla) and Spanish cedar (Cedrela odorata)

Type of activity: externally funded (USA Foreign Agricultural Service) research and development project (1999-2002).
Implementing agencies and location of activities: ICRAF, CATIE, INIFAP; Quintana Roo, Mexico (seed collections also in other states, Central American countries).
Principal purpose of activity: genetic conservation, elucidation of patterns of genetic variation, ensure access of smallholders to genetic resources, facilitation of seed production through conversion of trials to seed orchards
Nature of community seed production component: Four provenance-progeny trials on communal (ejido) land. Further work was done to identify, map and register a seed stand (112 trees of both cedar and mahogany).
Impacts (germplasm sale) and current status: There are two surviving trials. These are expected to produce seed within the next five years. The seed stand has not been used for collection of seed and in 2007 was damaged by a Category 5 Hurricane (Dean).

Peru (Ucayali): Participatory Domestication of Agroforestry Trees

Type of activity: multidonor (World Bank, European Union, Tinker Foundation, USAID, and others) research and development program (1995-present).
Implementing agencies and location of activities: ICRAF, INIA-Peru, PROSEMA; Ucayali Region, Peruvian Amazon.
Principal purpose of activity: genetic conservation, elucidation of patterns of genetic variation, ensure access of smallholders to genetic resources, facilitation of seed production, income generation through germplasm sales.
Nature of community seed production component: seed orchards, three species, established on multiple smallholdings. Participating farmers formed PROSEMA (The Aguaytia Valley High Quality Seed and Timber
Producers’ Association) and a limited company (ECOCUSA) to commercialize their products (seed, plants, other agricultural products).

**Impacts (germplasm sale) and current status:** In 2008, 4.33 kg of bolaina seed were sold for a total of S/.8660 (about $3210). In the same year, 0.9 kg of capirona was sold for S/.1550 (about $575). In addition, S/.5500 (about $2000) was received as advance payment for production of planting stock.

**Evaluation with regard to benefits of smallholder germplasm production**

**Genetic conservation:** Germplasm production units can only fulfill a useful genetic conservation function if the genetic resources they comprise would otherwise have been lost. In at least some degree, this was achieved in all four initiatives. However, germplasm production units clearly varied widely in their genetic conservation value.

**Smallholder control of genetic resources:** The initiatives were successful in this regard. However, under current legislative arrangements, full control of these resources may be lost as soon as they can be multiplied elsewhere (i.e., in the plantations established from the seed sold).

**Income generation:** Two of the projects have generated income for the landholders involved. There is scope for increasing income, either through increased volume of sales or higher prices. We show that the common practice of pricing seed in terms of weight seems to result in unreasonably low prices for small-seeded species. This practice is uninformative for the buyer and likely to be unremunerative for the seller. Another approach would be for germplasm producers to (also) sell planting stock.

**Sustained germplasm production, facilitating smallholder tree planting:** There would appear to be three principal conditions that must be fulfilled before this outcome can be achieved. First, as tree germplasm is typically bought and sold as plants rather than seed, germplasm producers would have to be producing seedlings, rather than seed. Second, the species they are producing must be those demanded by their potential smallholder clients. Third, prices must be acceptable both to buyers and sellers. As yet, it is doubtful whether all of these conditions obtain in any of the cases analyzed here.

**Conclusions**

The idealized concept of smallholder germplasm production is of a “win-win” intervention, whereby germplasm producers profit whilst facilitating livelihood-enhancing smallholder tree planting. The initiatives analyzed here go some way towards achieving this ideal, even though their explicit objectives were not always framed in these terms. In order to approach the “win-win” ideal more closely, a number of conditions must be met. For germplasm producers to win, they need to produce material that can be sold in sufficient quantities at high enough prices. This implies: rational pricing based on reproductive potential rather than an arbitrary attribute such as weight; possibly a bias towards large-seeded species (if seed, rather than plants, are to be produced); selection of high demand but low supply species (e.g., pau rosa), and production of plants rather than (or as well as) seeds. For smallholder tree planters to win, the right material needs to be available to them, in the form they require. This represents a challenge for smallholder germplasm producers, who may find it easier to supply industrial buyers than local smallholders.

**Protecting the rights of farmers and communities while securing long term market access for producers of non-timber forest products: Experience in southern Africa**

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**Abstract** PhytoTrade Africa is engaged in addressing the sustainable use and commercialization of natural products produced by indigenous plants, especially the trees of the Miombo woodlands. The approach which has been developed is to work with indigenous communities and local companies and to help them to secure long-term access to these markets through the protection of their intellectual property rights. To date specific case studies have included the following indigenous fruit trees of southern Africa:

- The African sausage tree (*Kigelia africana*)
- Baobab (*Adansonia digitata*)
- Marula (*Sclerocarya birrea*) subsp. caffra
- Sour plum (*Ximenia caffra* and *X. americana*)
- Mongongo (*Schinziophyton rautanenii*)
Mafura (*Trichilia emetic*)

These are species that are tolerant of the dry conditions in southern Africa, where agriculture is constrained by low and unpredictable rainfall, poor soil quality, and poor infrastructure to support agricultural production. Experience to date indicates that by enabling market opportunities for these local resources can facilitate significant livelihood options for otherwise marginalised farmers and producers. The overall objective is to promote both the sustainable use of indigenous resources and to reduce poverty by generating critically important supplementary income and other livelihood benefits for the poorest rural producers. In this endeavour PhytoTrade Africa is engaged in a partnership approach with industry based on four areas of intervention aimed at the pro-poor commercialization of the traditionally important products derived from indigenous trees. These areas of intervention are:

- **Product development**
- **Market development**
- **Supply chain development**
- **Institutional development**

Partnerships between producers and the local-to-global cosmetic, food, beverage, herbal medicine and pharmaceutical industries are developed by carefully constructing commercial agreements with leaders in the relevant sector. Critically this involves the establishment of a strong and viable trade association that is forward thinking and market oriented. Through these partnerships it is possible to ensure long term relationships and supply agreements. Such agreements ensure that the target producers remain in the value chain.

PhytoTrade Africa's strategy is to initially focus on wild-harvested naturally occurring resources. This takes advantage of the easy access that poor producers have to wild resources and additionally the better access to markets enjoyed by entrepreneurs in industry, so raising the barrier to market entry by those in competition with the target producers. Critically this strategy uses market forces and tools in support of poor producers. PhytoTrade has been engaged in some innovative approaches to protecting the Intellectual Property Rights of poor communities and the business they work with, including Patents, Trade Marks, and Geographical Indicators, with the intention of securing long term strategic market access and to be able to influence commercial strategy. Once markets have been secured the strategy will, where necessary, evolve to establishing supply chains from domesticated or farmed sources in a way that keeps the initial producers in the value chain as far as possible.

Commentators have suggested that the rights of farmers or communities in the supply chain will be jeopardised in the commercialisation process. Entering into any market will expose suppliers to competition. It is therefore important that the supply chains, and the manufacture of the products, are efficient and competitive to shut out casual and opportunistic competitors. PhytoTrade Africa therefore believes that this risk can be managed and the primary producers are able to secure long term access to the markets developed for their products.

Several important factors need to be considered in the selection of the species and the products that can be derived from them. It is critical that the abundance of the resource, and the ownership over the resource by the target producers, is sufficient to ensure sustainable and reliable supply. This approach can, under certain circumstances, also create a barrier to entry for plantation developers who can be seen to be competitors to small-scale producers and farmers.

To date, as mentioned, the focus has been on naturally occurring wild resources, but the recent emergence of highly compatible pro-poor participatory domestication technologies for indigenous fruit and nut trees in developing countries offers considerable opportunity for the better integration of domestication and commercialization for the alleviation of poverty, malnutrition and hunger in marginalized agricultural communities.

Some new products will require regulatory approval in markets such as in the EU and the USA. It is possible to tie the approval of these products to the target producers. This has to an extent been achieved by PhytoTrade Africa’s successful application to have Baobab fruit approved as a novel food ingredient in the EU under Regulation (EC) 258/97.

PhytoTrade Africa is the Southern African Natural Products Trade Association. It was formed in 2001 and has some 60 members drawn from Botswana, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe.
Adaptation of forests and people to climate change

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Abstract  Forests provide essential services to support human well-being. The impacts of future climate change on forest ecosystems and the goods and services they provide are therefore of major global concern. Consequently, an international Expert Panel was established in 2007 to make an assessment on the impacts of climate change on forests and forest-dependent people as well as on management and policy options for effective adaptation to climate change. This paper summarizes the main findings of the assessment.

The available scientific information confirms that climate change is already affecting forest ecosystems and the services they provide, and will have increasing effects on them in the future. The ongoing climate change could put at risk essential ecosystem services, including carbon regulation and the maintenance of biodiversity.

While deforestation is responsible for about 18 percent of greenhouse gases, forests currently still absorb more carbon than they emit. The trees and soils of the world’s forests are storing about half of the carbon stored in land ecosystems. This carbon-regulating sink service of forests is at risk of being lost entirely under a global warming of 2.5°C or more relative to pre-industrial levels, when land ecosystems would begin to turn into net sources of carbon.

The negative social and economic consequences of a loss of forest ecosystem services due to climate change are potentially dramatic. The forest-dependent poor in particular will, in many regions, face increasing difficulty in meeting basic needs for energy, food and clean water, which would lead to deepening poverty, deteriorating public health and increasing social conflicts.

Climate change could have positive effects as well. The increases in economic productivity that will occur in forests in some regions due to increased tree growth will present new opportunities for forest industry and forest-dependent communities. However, over the long-term, if climate change continues at the current pace these benefits will be offset by an increase in insect invasions, fires, and storms.

Climate change is only one factor affecting forests and the people depending on them for their livelihoods. Others include human population growth, changes in the extent of croplands and pasturanelands, epidemic diseases, invasive species, forest fire and industrial pollution. The effects of such factors, and their interactions with climate change, complicate analyses of the impacts of climate change on forest goods and services.

The assessment has revealed the limitations in current knowledge on the impacts of climate change on forests and people. Forest adaptation studies are relatively recent, and only a few have documented evidence of success in the implementation of adaptation strategies. Given the diversity of forests, more precise regional and local climate-change projections are required. Much more research is especially needed on the forest-related social and economic impacts of climate change. It is necessary, therefore, to continue to support research that will reduce uncertainty about the climate-change impacts on forests and improve knowledge about management and policy measures that will promote successful adaptation.

Despite the limitations of current knowledge, climate change is progressing too quickly to postpone action pending the outcomes of future studies. The assessment confirms that the practices associated with sustainable forest management are likely to help reduce environmental, social and economic vulnerabilities under a wide range of potential future climatic conditions. Many management actions taken in the context of adaptation, such as the prevention of large-scale forest fires, could also assist in the mitigation of climate change.
By and large, forest managers will need sufficient flexibility to choose locally appropriate adaptation measures.

New modes of governance are required that enable meaningful stakeholder participation and provide secure land tenure and forest user rights, and sufficient financial incentives. Flexible approaches to policy design are needed that are sensitive to context and do not rely on a single, one-size-fits-all mechanism.

Climate change adaptation and mitigation are closely linked and complementary. Indeed, given the importance of forests to climate, successful mitigation requires that forests are able to adapt to climate change. However, even if adaptation measures are fully implemented unmitigated climate change would exceed the adaptive capacity of many forests in the course of the current century. On their own, therefore, adaptation measures will be insufficient for forests to adapt to climate change. Large reductions in emissions from fossil fuels and deforestation are needed to preserve the adaptive capacity of forests and to enable them to continue making their essential contribution to the mitigation of climate change.

Climate Change Mitigation through Agroforestry: Science in Support of the Concept

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Abstract The United Nations Framework Convention on Climate Change (UNFCCC) allows the use of carbon (C) sequestration through afforestation and reforestation as greenhouse (GHG) offset activities. Consequently, the role of tree-based land-use systems such as agroforestry as a strategy for C sequestration and climate-change mitigation has raised considerable expectations. Research on the extent of C sequestration under agroforestry systems, especially in soils, is, however, scanty. Little wonder then that most reports on the subject present the rhetoric of wishful thinking and global/regional projections based on unsubstantiated assumptions. During the past six years, we studied soil C sequestration under agroforestry systems in several agroforestry practices in five countries:

- Silvopasture in Ultisols and Spodosols in Florida, USA
- Traditional “dehesa” (silvopasture) and a simulated silvopasture in Spain
- Multispecies homegardens in Kerala, India
- Traditional intercropping as well as live fence and fodderbank, in Segou, Mali
- Shaded cacao system under natural (cabruca) or planted shade in Bahia, Brazil
- Silvopasture under Eucalyptus sp. in Minas Gerais, Brazil.

The studies involved uniform procedures such as fractionation of soil into different particle-size classes (2000 – 250 µm, 250 – 53 µm, and < 53 µm) and use of stable isotope ratio wherever applicable to determine the relative contribution of trees and grasses to soil C in depth classes up to 1 m depth.

The results indicate that:

1. Tree-based agricultural systems, compared to treeless systems, store significantly more C in deeper layers of soils under comparable conditions;

2. Higher SOC content is associated with higher species richness and tree density, especially in the upper 50 cm soil and in the <53 µm soil fraction;
3. Soil near the tree, compared to away from the tree, store more C;
4. C3 plants (trees) contribute to more C in the silt- + clay-sized (<53 µm) fractions than C4 plants in deeper soil profile;
5. Traditional agroforestry systems had larger C stock than the improved systems, but have only limited potential for sequestering additional C.

Chronosequence studies are needed to quantify the extent of soil C sequestration. But they are difficult and time consuming, and are therefore often supplanted by procedures such as the one used in this study, yielding scientifically credible results. Our results present a comprehensive set of data on soil C sequestration under various AF systems and underscore the importance of agroforestry in climate change mitigation through soil carbon sequestration.

**Some Recent Publications:**


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Agroforestry options for climate change mitigation and adaptation: implications for carbon markets

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Abstract

Agriculture is the human enterprise that is most vulnerable to climate change. While there have been gains in recent years, more than 800 million people in the world are still chronically malnourished, and 1100 million live in absolute poverty. Tropical agriculture, especially subsistence agriculture is particularly vulnerable, as smallholder farmers do not have adequate resources to adapt to climate change. Agroforestry has the potential to play a significant role in mitigating the atmospheric accumulation of greenhouse gases (GHG) through sequestering carbon from the atmosphere. Additionally, there are opportunities for synergy as agroforestry also has a role to play in helping smallholder farmers adapt to climate change.

Agroforestry options may provide a means for diversifying production systems and increasing the sustainability of smallholder farming systems. The most worrisome component of climate change from the point of view of smallholder farmers is increased inter-annual variability in rainfall and temperature. Tree-based systems have some obvious advantages for maintaining production during wetter and drier years. First, their deep root systems are able to explore a larger soil volume for water and nutrients, which will help during droughts. Second, increased soil porosity, reduced runoff and increased soil cover lead to increased water infiltration and retention in the soil profile which can reduce moisture stress during low rainfall years. Third, tree-based systems have higher evapotranspiration rates than row crops or pastures and can thus maintain aerated soil conditions by pumping excess water out of the soil profile more rapidly than other production systems. Finally, tree-based production systems often produce crops of higher value than row crops. Thus, diversifying the production system to include a significant tree component may buffer against income risks associated with climatic variability.

One constraint to wider adoption of agroforestry is the lack of financial support to promote greater uptake. Farmers face financial barriers to uptake of improved management practices and extension services across the developing world are poorly funded. Whereas sequestration through agroforestry offers significant and cost effective means of reducing atmospheric concentrations of GHGs, there is potential to tap the strength of carbon markets to promote agroforestry systems that simultaneously provide mitigation and adaptation benefits. In the examples worked out in this report on agroforestry, total costs for sequestration are on the order of $10 per tCO2e and the estimates of global feasibility are between 0.7 and 2.1 GtCO2e per year. Many of these practices are economically beneficial, but do not occur due to a number of barriers. Investment targeted at overcoming these barriers is much less than the total cost, and therefore, there are opportunities to share costs with other beneficiaries. The analysis suggests that the cost associated with overcoming these barriers at the farm level is less than $4.50 per tCO2e. This is well below the current market value of carbon credits. Thus, it is easily conceivable that funds form carbon credits could provide resources to improve extension agencies and overcome financial barriers to adoption of improved agroforestry practices, thereby contributing simultaneously to climate change mitigation and adaptation.
Gender and Agroforestry Adoption: Are rural women benefitting?

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Abstract

Gender in this paper is viewed against an agroforestry system where crops, trees, and animals interact with both men and women. Particular emphasis is given to women, their role and comparative advantage as managers. Agroforestry has significant potential advantages for women as it often involves few costs and provides a range of products and services. But women’s adoption ability is threatened by inadequate control over production resources, inadequate access to extension education, cultural norms/taboos and lack of control over benefits arising from their hard work.

In the last three decades, agroforestry as a practice has made major technological advances. However, despite some successes, there is still not much understanding of the role it plays in rural women’s livelihoods. Women form the backbone of agriculture in developing countries, as they are responsible for the double role of reproduction and production, yet they face many challenges, which limit them from benefitting from AF interventions. The challenges they face are mostly due to the fact that women carry out their roles in the context of a gendered social environment that favours men. Despite these limitations, there are some success stories where women are reaping the benefits of agroforestry. This paper is therefore a synthesis of the adoption of agroforestry by women and the challenges and successes they experience. Particular agroforestry practices examined include woodlots, fruit production and processing, fodder production, soil fertility improvement using organic fertilizers and other practices. The paper presents lessons learned and gives recommendations on how to promote greater participation of women in agroforestry through technological, institutional and policy interventions.

Harnessing the Potentials of Fertilizer Trees for Sustainable Food Security in Southern Africa

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Abstract

The rising human population and inorganic fertilizer prices, coupled with unsustainable production practices have resulted in decreasing trend of food production per capita in sub-Saharan Africa. The food security challenge is estimated to be further worsened by climate change and land degradation, especially soil fertility decline. Substantial amount of investment has been made to develop a new range of soil fertility management options. One of these options that was developed through an extensive multi-disciplinary research for development (R4D) effort in the last two decades in southern Africa is the “fertilizer tree system,” that helps resource-poor farmers replenish their soils within a short period of time. This paper synthesizes first and second generation studies on the evidence for crop yield response to fertilizer trees, from several on-station and on-farm sites. Studies on the economics, adoption and impact of fertilizer trees are also discussed.

The synthesis shows that fertilizer trees add substantial amounts of N. Nutrient contributions from fertilizer tree biomass can reduce the requirement for mineral N fertilizer by 75%, translating to substantial savings on mineral fertilizer imports. Nutrient balance studies in Malawi and Zambia have recorded positive balances even after 8-12 years of continuous cultivation. A recent meta-analysis has provided conclusive evidence that with good management, fertilizer trees can double or even triple maize yields compared with local
farmer practices of maize cultivation without addition of external fertilization. There was also evidence of synergy between mineral fertilizers and fertilizer trees thus providing opportunities for budgetary savings on mineral fertilizer. Financial analysis showed that fertilizer tree systems are not only profitable but, also have higher net returns on investment than continuous maize cropping without fertilizer. Returns to labour in fertilizer trees are twice that of unfertilized fields, and fertilizer trees require less labour than fertilized maize fields for the same unit of land. Economic impact assessment showed that the increase in yield due to fertilizer trees is equivalent to 54–114 additional person days of maize consumption, capable of reducing hunger period by 2–3 months per household. Fertilizer trees also provide non-food benefits to households and enhanced environmental services to the wider community. Hundreds of thousands of smallholder farmers have been testing, adapting and adopting fertilizer trees in the last decade. It is concluded that widespread adoption and scaling-up of fertilizer trees can reduce the amount of mineral fertilizer needs, maintain the soil ecosystem, and positively impact on the livelihoods of farm households in southern Africa.

The impact of fodder shrubs on livelihoods in East Africa

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Abstract Most milk in East Africa is produced by smallholder farmers, and this production is growing steadily. A major constraint to milk production is the availability and costs of high quality feeds. Fodder shrubs are a good source of enriched feeds. Since the late 1980s a significant amount of research on integrated use of fodder trees in sub-humid farming systems has been carried out by ICRAF in collaboration with the Kenya Agricultural Research Institute (KARI) and the Kenya Forestry Research Institute (KEFRI). A gap existed on the wider impact of fodder shrubs on livelihoods and gender dynamics. To fill these gaps a qualitative study was carried out in Embu and Maragua Districts of central Kenya. This paper synthesises research findings from the past two decades and the recent livelihood impact study. In early trials, *Calliandra calothyrsus* emerged as one of several appropriate species for scaling-out because it had good agronomic and animal production characteristics and was preferred by dairy farmers. By 2006, 224 organizations across Kenya, Uganda, Rwanda, and northern Tanzania were promoting fodder shrubs and over 200,000 farmers had planted them. A network of more than 25 fodder shrub seed dealers was established in central Kenya.

Farmers’ prime purpose for planting fodder trees is to feed animals, and to derive benefits from the animals. A linear relationship between the amounts of leucaena leaf meal fed and milk yield has been established by farmers in Tanzania, while increasing amounts of leucaena leaf meal fed to steers of Tanzanian farmers resulted in increasing growth rates. On-farm research in Kenya showed that by planting 500 calliandra shrubs, a farmer’s net income increases by about $US 101 to $US 122 a year. Thirty-eight to 72 % of farmers in sampled areas in Kenya and Uganda also mentioned firewood, increased soil fertility, and improved animal health as benefits of fodder shrubs. In central Kenya, dairy cattle farming was the most valued source of livelihood. Farmers relied on dairy farming for short and long term household needs. For most of the households studied, there was no direct income generated from the sale of the fodder shrubs, but the benefits were experienced in terms of savings of monies otherwise spent on purchase of fodder and dairy meal. Saved income allowed farmers to meet household obligations such as payment of school fees, building of permanent household dwellings, hiring of labour and other domestic needs. Saved time was also used for other income generating activities. For most women there was a discrepancy between work done and income derived from farming generally. Most men owned bank accounts. Female participation in community groups and affairs has increased over time, leading to liberation and owning of resources.

Synthesis of reports suggests that there has been considerable financial impact by adopting fodder trees. Majority of adopters could still increase their financial and other benefits by increasing the number of shrubs on-farm. To achieve this, community based extension systems and gender awareness training amongst others are recommended.
Symposium 5: Segregate or integrate for multifunctionality and sustainagility

Introduction: Segregate or integrate for multifunctionality and sustainagility

Agroforestry as the interface of the agricultural and forestry spheres has strong roots in an ‘integrate’ approach to multifunctionality. It achieves short, medium and long term goals in the provision of valued goods and services. The ‘segregate’ approach achieves multiple goals by intensive agriculture (or tree production) in one part of the landscape and areas dedicated to conservation elsewhere. It minimizes the interface of agriculture and natural forests. By contrast, the integrate approach combines functions. The segregate-or-integrate choice plays out at multiple spatial scales, from farm to landscape, but also across time. The ‘segregate’ pathway has been associated with the ‘intensification’ hypothesis, expecting that more productive forms of agriculture will leave more space for conservation. In reality, however, this forms a necessary but not sufficient condition for achieving conservation goals. The shape of tradeoff curves between the multiple functions provides a guide to rational choices in the segregate-or-integrate dilemma. Locking up land for single functions may seem efficient for now, but reduces future options. The sustainagility questions focuses on the maintenance of resources for future change and includes the reversibility of choices and opportunities for cross-scale access to biological resources for future goods and services. The symposium will start with current concepts and criteria, and then provide perspectives from three continents and bridging the science-policy continuum.

Panelists:

Meine van Noordwijk: Concepts and quantitative criteria
Hesti Lestari Tata: A case study of change in the integrated rubber agroforest landscape of Jambi (Sumatra)
Jianchu Xu: Maintaining ecological connectivity in the greater Mekong subregion through agroforestry
Celia Harvey: Dynamic landscape mosaics in C America at the interface of conservation and farm profitability

Segregate or integrate for multifunctionality and sustainagility: Concepts and quantitative criteria

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Abstract

The ‘segregate’ or ‘integrate’ choice relates to functions (based on goods and/or services) as well as components that provide for the functions (e.g. trees versus annual crops as the original definition of agroforestry implied). The equivalent area of land needed to produce the same amount of products or functions has been a yardstick of success in combining or separating functions. For functions that don’t scale with area, the criterion cannot be used. Scaling rules in both time and space need to be understood before ‘benchmark’ level findings can be used in broader debates and policy development.

The relevance of segregated or integrated systems for achieving multifunctionality depends on the shape (convex, linear or concave) of the tradeoff curve (or ‘production possibility frontier’) between the functions. For functions, such as biodiversity value or buffering of waterflows, that do not scale proportional to area the shape of the tradeoff curve with functions that do scale with area (such as yield, rainfall transmission or C stocks) is itself dependent on scale. While a local observer may find ‘integration’ of biodiversity and marketable yields feasible, for a more distant observer, interested in other aspects of biodiversity, it may be less so.

The sustainagility lens aims focus on the resources that will allow future change – either through access to external resources, or by maintenance of within-landscape resources. Current climate change adaptation discourse provides a new rationale for risk-reduction-by-diversity. To be effective, however, a lifecycle perspective on survival of biota in a landscape mosaic that contains a range of management intensities is needed.

For spatial mixtures the perimeter/area relationship allows quantification of the pattern, and can be derived from ‘edge erosion’ of digitized images. The sphere of influence belowground may be larger than that aboveground. In lifecycle assessments of land cover types the seed
dispersal distances of trees linked to the mobility of the natural or human-assisted dispersal agent determines the relevant scale of evaluation. The case studies of the following three speakers will provide further context to the management of landscape mosaics (with and for trees) as dynamic approaches to maintenance of multi-functionality in a rapidly changing world.

A case study of change in the integrated rubber agroforest landscape of Jambi (Sumatra)

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**Abstract**
The introduction of Hevea brasiliensis (‘para rubber’) in Sumatra hundred years ago caused a revolutionary change in the land use pattern, when the new cash crop was found to be compatible with local forest conditions. Forest domestication preceded tree domestication. Complex rubber agroforest (RAF) are characterized by a substantial share of rubber trees in the total tree biomass, but also by a large diversity in species of native forest trees and understory plants. Rubber agroforests can range in intensity from secondary forests with some rubber (e.g. 5 – 10 % of tree basal area) to vegetation dominated by rubber with a complement of native forest trees.

Sumatra is the world’s fifth largest island and part of the biogeographical ‘Sundaland’ domain that is widely recognized for its high biodiversity. It contains a wide variety of natural and derived vegetation types, from forestland shrub land, wet lands, agriculture and grassland. During the nineteen-nineties forest cover in Sumatra declined dramatically, due to forest conversion by pulp mills, oil palm plantations and illegal logging.

Complex agroforests have gained recognition for their value in biodiversity conservation. Tree seedling and sapling diversity is still high in RAF, at par with the secondary forests used for comparison, but pole and tree diversity is substantially reduced by selective thinning. Farmers retain native trees with valuable fruits or other products, but not timber as its future harvest is still considered illegal. The tree flora of RAF includes Red List and threatened species. Fauna diversity (including birds, primates, bats) is high, and partially associated with tree diversity as pollination or seed dispersal agent. RAF management has so far kept its place among the repertoire of local land uses, as the returns to labour are comparable to those of more intensively managed rubber, despite lower per ha yields. The current shift to rubber monocultures, oil palm plantations and intensive tree and crop production systems, leads to a rapid loss of landscape-level biodiversity and regeneration potential. Opportunities for ecological corridors and connectivity are rapidly being lost, as conservation efforts are focussed on ‘islands’ rather than the landscape as a whole. We’ll discuss options for maintaining ‘integration’ of functions at field, farm and landscape scale.

Developing carbon and biodiversity assets for multifunctional landscapes in the Upper Mekong

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**Abstract**
Change in the Upper Mekong Region influences the ecology and livelihood options in the lower Mekong countries. Agricultural intensification and markets for regional trade change land use. Secondary forests which used to cover 88% of the landscape in a portion of northern Thailand, 92% in southern Yunnan, and 91% in northern Laos, could be replaced by rubber, tea, and other diversified farming systems over the next four decades. Until recently only limited attention has been given to understanding the environmental consequences of the conversion of vast landscapes to rubber and other monoculture plantations. The threat to biodiversity is intuitive for situations where primary forest is preplaced by monoculture plantations. Being part of the Indo-Burma hotspot, the upper Mekong is renowned for its great biodiversity. Even conversion of secondary forests can equate to substantial losses in biodiversity. Forest conversion to rubber plantations may cause substantial reductions in total carbon biomass as well as negative hydrological consequences.

Upland farmers, including many indigenous ethnic communities still play an important
role in protecting forests, landscapes, and watersheds, and maintaining biodiversity through traditional land-use practices, such as agroforestry, in the culturally and ecologically diverse Upper Mekong region. There are seminal signs of government support for sustainable upland development in the Mekong, and traditional products, such as non-timber forest products, as well as eco-tourism development and establishment and expansion of protected areas are being encouraged. Both upland farmers and local government officials seek alternatives to the development dilemma in the region. We suggest that the long-term viability of the environment requires the interactive, innovative and integrated approaches involving stakeholders at all levels in conservation and development of multifunctional landscape.

The project ‘Making Mekong Connected’ (MMC) aims to support development of agroforestry landscapes with high carbon and biodiversity assets in the Upper Mekong region: the multifunctional landscape-corridors that protect secondary forests with a high conservation value and stepping stones with agroforestry systems and framework species in the quadrangle areas of China’s Yunnan Province, Laos, Myanmar, and Thailand along the Mekong River. The goal of the project is to support enhanced and connected multifunctional landscape corridors with both positive livelihood and environmental benefits, managed by smallholder farmers through agroforestry system. The major outputs of this project include: a) the multifunctional landscape corridors with stepping stones and framework species identified; b) potential agroforestry system assessed and evaluated; c) biodiversity and carbon assets assessed; d) opportunities for carbon financing and biodiversity offset determined; e) capacity of national partners and key stakeholders enhanced.

Dynamic landscape mosaics in C America at the interface of conservation and farm profitability

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Abstract
The challenge of reconciling agricultural production with biodiversity conservation is particularly acute in Central America, an area of high biodiversity conservation value that is rapidly being transformed by deforestation, fragmentation and conversion to agricultural production. In the agricultural mosaics that now dominate the region, a key question is whether it is possible to integrate biodiversity conservation and agricultural production successfully- or whether conservation will only be successful in designated protected areas that are separated from production regions. In this presentation, I present a synthesis of research in several agricultural landscapes in Central America which suggests that an integrated, landscape approach, in which both agricultural land uses and conserved forest areas are closely integrated in a mosaic landscape, can provide an important means of conserving biodiversity within agricultural landscapes, while also maintaining farm productivity. Agricultural mosaics which retain abundant tree cover (whether as forest fragments, riparian areas, live fences or dispersed trees) can conserve high plant and animal species richness, by providing complementary habitats, resources and landscape connectivity for a significant portion of the original biota. Landscape configurations that connect forest patches and retain high structural and floristic complexity will generally conserve more species than those lacking connectivity or habitat complexity. However, while the overall species richness may be similar to that of intact forests, the agricultural mosaics often contain a modified suite of plant and animal species and often lack those forest-dependent species of greatest conservation concern, so that their overall contribution to biodiversity conservation is less than that of a designated protected area. The integration of tree and forest cover into agricultural landscape also provides key agricultural benefits, such as shade, provision of timber, fruits and other products, but these benefits depend on tree species composition and density, and there are likely thresholds above which these benefits quickly diminish. Overall, our research suggests that while there are clear opportunities for achieving biodiversity conservation and agricultural production within agricultural mosaics through careful management of the tree and forest cover, there will be some tradeoffs related to which densities, tree species and spacing are used and it will likely not be possible to optimize both conservation and production simultaneously. However, the opportunity for enhancing biodiversity conservation within existing agricultural landscapes, at little or no cost to production, has tremendous potential and offers hope to stemming the rapid loss of biodiversity in the region.
**Symposium 6: Land Rehabilitation and Landcare**

**Land Health Surveillance: An Evidence-Based Approach to Land Management**

**Introduction**

Land degradation is a global threat to habitat, economy and society, and is the overarching environmental issue of concern in Africa, threatening food security, ecosystems and livelihoods. Soil degradation and fertility decline is a major concern for food security in developing countries. However, current measurement and information systems on land degradation in developing countries are grossly inadequate for the task of planning and evaluating land health and agroforestry policy and practice. There is need for systematic approaches to assessing land health risks and efficient targeting of land management and agroforestry interventions and to answer questions such as:

- What are the socioeconomic and biophysical determinants of land degradation (land health risks) how are they geographically distributed?
- How much future land degradation can be avoided or reversed through targeted action to reduce risks?
- What is the impact of preventative and rehabilitation agroforestry intervention programmes under different conditions?

This symposium will introduce land health surveillance concepts and provide examples of science-based approaches to land rehabilitation and land care. Land health surveillance is based on principles adapted from public health surveillance, where accurate measuring and monitoring of changes and improvements in the health of populations is closely integrated with statistical methods to form a scientific basis for policy development, priority setting and management. A key question the symposium addresses is: How can land health surveillance systems strengthen evidence-based decision-making on land and agroforestry management at multiple scales and help (i) better understand hazardous and protective factors affecting land health risk, (ii) target agroforestry options, (iii) allocate resources and set priorities, and (iv) learn through quantitative monitoring and impact assessment?


Sara Scherr. Reducing and Reversing Risks to Land and Ecosystem Health through Ecoagriculture Landscape Strategies.


**Managing Ecosystem Services in Agricultural Systems: The African Challenges**

**Abstract**

Africa is facing globally unique socio-ecological challenges in the 21st century. Due to the well known demographic developments on the continent these include a rapidly growing demand for the provision of ecosystem services from which people derive benefits in the context of climate and land cover change. There has also been a strong tendency to trade off increases in the demand for provisioning services (e.g., for food, forage, fibre, fuel and other commodities) for regulating (e.g., nutrient, greenhouse gas and hydrological cycling) and supporting services (e.g., biodiversity). In many places in Africa, the resulting positive feedback dynamics have led to a rapid loss in the capacity of ecosystems to deliver essential resources. In some instances this has initiated catastrophic ecological regime shifts, with prominent examples including the Lake Victoria Basin of East Africa, the Sahelian drylands and the humid forests of Madagascar. These highly undesirable changes are not easily reversible and are major, though largely hidden, costs of development, which challenge the prospects of a better future for Africans, trapping them into poverty, and potentially leading to increased conflicts over land.
As Africa’s population doubles over the next 25-30 years, it will not only demand more services from ecosystems as a whole, but its per capita demand for such services must also increase if human development and poverty indices are to improve. While all economic sectors are likely to be affected, we focus a two groups of agricultural systems, small holder agriculture and pastoralism, which are providing livelihoods to the majority of the economically active population on the continent. We analyse the different ecosystem service requirements as well as the biophysical constraints specific to each system placing some emphasis on water in pastoral systems and soil health in small holder farming. Aside from biophysical challenges, it is also evident that individual and societal attitudes towards risk in both agricultural systems, i.e. a general tendency to short-term risk avoidance, are a major force hindering the application of long-term strategies securing future social and economic benefits and sustainable natural resource utilisation.

**Land Health Monitoring in Kenya’s “Forgotten” Range Lands**

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**Abstract**  
Approximately 34% of Kenya is classified as rangelands. These lands comprise the fertile Maasai steppes of the Mara through to the arid and semi deserts of Northern Kenya. They harbour some of Kenya’s greatest bio-diversity, some of the “poorest” and most vulnerable communities and are probably the most at risk to due to the effects of global warming. For millennia nomadic tribes, who have moved their stock with the seasons and lived in harmony with the environment, have populated these lands. The combination of increasing populations, improved animal health and agricultural encroachment into traditional dry season grazing lands have all severely impacted on the ability of the environment to sustain this lifestyle. New approaches need to be identified and researched if these ecosystems are to survive. A holistic understanding of the health of Kenya’s rangelands, incorporating scientific research and the traditional knowledge of the pastoralist communities within these lands, is a starting point.

This paper describes the implementation of a Land Degradation Surveillance Protocol within a 30,000 hectare sector of North Laikipia. The results will provide invaluable information on the current status of the health of the rangeland including soil condition and carbon stocks. Working with and gaining an understanding of the needs of the communities will add further value to the overall evaluation of the ecosystems within the project site. There are no rapid solutions for improving the health of Kenya’s rangelands. Human beings by their very nature adapt best where there is an incentive. By understanding the “holistic” health of the rangelands, there is a chance that the practical implication of scientific principles combined with a full understanding of the socio-economic benefits of implementing these principles, will provide the market incentives required to ensure the long term health of Kenya’s rangelands.

**Reducing and Reversing Risks to Land and Ecosystem Health through Ecoagriculture Landscape Strategies**

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**Abstract**  
Agricultural landscapes, because of their extent and location, play an increasingly important role in providing ecosystem services, including wildlife habitat, water flows and water quality, soil fertility, greenhouse gas sequestration, microclimate regulation, and pollination, as well as food and fibre. Determining how to manage the mosaic of cultivated and uncultivated production lands and natural habitats is critical to ensure adequate ecosystem services for the people within these landscapes and other stakeholders beyond. Conventional patterns of crop and grazing land management sometimes pose serious risks to those functions. For example, fragmentation leads to loss of connectivity of wildlife habitat; intensive soil cultivation releases greenhouse gases; clearing of vegetative cover impedes infiltration of rainfall into aquifers. Ecoagriculture landscape strategies can reduce or reverse these risks, by adapting production systems to produce more ecosystem services without sacrificing food supplies or income; by siting and managing natural areas to benefit farming communities as well as nature; and by establishing institutional mechanisms to coordinate farming,
conservation and rural development efforts. New strategies for ensuring the health of the land can generate benefits for both agricultural production and ecosystems.


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Abstract:

Development interventions targeting the reduction and reversal of serious threats to land health depend on influencing the management decisions of smallholder producers en masse if they are to generate appreciable impact. One of the perennial challenges confronting the promotion of rapid transitions to agroforestry land use systems is that small-holder producers are required to incur significant initial costs, while deferring receipt of any tangible benefits until some later point. Cash, labour and land are required to produce or purchase seedlings, establish plantings, provide dry season watering and protection from grazing animals, as well as attend to other species-specific management needs. In addition, farmers also must forego income in the form of lost revenue from the existing cropping system on lands where trees are planted, while they wait for any direct benefits from the trees themselves, in the form of marketable products or enhanced environmental services, until the trees mature.

Over time, large areas in the high and middle Atlas Mountains of Morocco have been deforested and placed under continuous annual crop production. Land health in areas under cultivation is threatened by high rates of soil erosion, leading to declining yields and the gradual impoverishment of the agricultural population. This paper provides a financial analysis of the impact on household finances of smallholder farmers transitioning from hillside annual crop production to the establishment of terraced plantings of olives, figs and almonds, with conservation tillage in the inter-terrace areas. The financial analysis considers five agroecological zones, and two household classes, in areas located in central and northern Morocco targeted for investments through Morocco's Millennium Challenge Account. Ultimately, the new land use system significantly increases farmers’ household incomes, while greatly decreasing soil loss. The analysis also reveals a significant income "gap" created by the transition from annual crop production to a terraced agroforestry system in the early years. The paper considers the potential of carbon offset payments, based upon the modelled sequestration of carbon by the planted trees, as a means of bridging the financial gap, thereby enabling greater adoption of resource-conserving agricultural practices and the long-term improvement of land health.
Carbon sequestration and biodiversity in Agroforestry Systems established in the Atlantic biogeographic region of Europe

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Abstract

Agroforestry systems can deliver important ecosystem services dealing with carbon sequestration and biodiversity in industrialized countries. In Europe, the last regulation on support for rural development by the European Agricultural Fund for Rural Development (15th September 2005), establishes that “measures targeting the sustainable use of forestry land through the first establishment of agroforestry systems on agricultural land” should be taken. Based on it, different national and regional directives have been established to promote agroforestry systems use, which possible benefits, from an environmental point of view should be evaluated. This presentation describes the effect of different types of agroforestry management practices (tree density, tree species, soil fertilization) on productivity, carbon sequestration balance and biodiversity based on long term experiments in recently afforested areas. The results are based on the establishment of silvopastoral systems with conifers and broadleaves in soils with very different initial soil pH. Initial tree growth and pasture production was higher in those soils with high pH, where this soil variable was quickly reduced in time if conifers were used. Broadleaved tree species enhance biodiversity compared with conifers due to the branches structure and leaf distribution. Soil carbon sequestration as well as nutrient recycling is promoted by broadleaved species compared with conifers due to the higher soil organic matter below broadleaves. The increment of tree density reduces biodiversity and enhances soil carbon levels below both broadleaved and conifer canopies. Fertilization type effect on biodiversity depended on initial soil conditions, and the modifications on pH that fertilization causes. When agroforestry systems are established in a soil with an initial high soil pH (close to 7), through the implementation of agri-environment measures dealing with afforestation, fast growing species like Pinus radiata D. Don modifies soil chemical characteristics (pH, CEC, Soil Organic Matter) and light quality and quantity reaching the soil. This causes a drastic reduction of biodiversity, due to the litterfall soil accumulation which limits the development of herbaceous and shrub species. However, if the same management is established in soils with an initial low pH (around 4.5) in the same area, biodiversity is maintained due to the presence of already existing low-fertility adapted species. When beta biodiversity indicators are taken into account comparing the results of both areas, it has been found that the type and the number of the herbaceous species are very different between them, even though experiments are not far away. Therefore, land change use through afforestation should take into account previous land use, and the modifications caused by tree development, in order to develop strategies to promote herbaceous understory species development, with a clear ecological (biodiversity, soil organic carbon) and forage function to adequately implement silvopastoral systems.

Assessment of ecosystem services provided by agroforestry systems in Europe

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Abstract

Recently, the increasing human population, the increasingly affluent lifestyles, the increasing needs for energy and other resources, and the requirement to store increasing levels of atmospheric carbon dioxide is generating more and more pressure on land. Furthermore, fossil fuels must be replaced by sustainable, renewable resources in the very near future. In Europe and its already intensively managed land, inappropriate biofuel production will cause additional pressure on soil and water resources, on social and on ecological functions of forest and agricultural ecosystems.
Innovative solutions are required that combine high productivity with equivalent or enhanced levels of other ecosystem services that also allow adaptation to changing climatic conditions. In this context the term “ecosystem services” can be defined as follows:

**Ecosystem services refers to a wide range of conditions and processes through which natural ecosystems, and the species that are part of them, help sustain and fulfil human life. These services maintain biodiversity and the production of ecosystem goods, such as forage, timber, biomass fuels, natural fibres, and many pharmaceuticals, industrial products, and their precursors. The harvest and trade of these goods represent important and familiar parts of the human economy.**

Combining forestry and agricultural systems in agroforestry systems seems to be a promising solution. Agroforestry systems are traditional land management systems that are used throughout Europe even today. These systems are defined as sustainable ways of land use which integrate both agricultural and forestry practices on the same land and at the same time. They are of particular significance to marginal regions and degraded lands where the land use system represents an alternative to land abandonment and afforestation, leads to diversification of land use and offers new socio-economic benefits including tourism and recreation.

Agroforestry systems improve the efficiency of utilisation of resources (light, water, soil, nutrients), improve microclimatic conditions within the system (reduction of wind speed, balancing temperature and soil moisture), can help mitigate severe soil erosion problems and nitrate leaching, enhance landscape biodiversity (increased structural heterogeneity in the landscape), lead to an overall high biomass production for material or energetical conversion (fuelwood), and thus matching the increasing demand for a self-supply with bioenergy in rural decentralized areas. Furthermore, with the integration of hedgerows, as it is done within alley cropping systems, a perennial tree component is introduced into conventional cropland. If the trees are managed as short rotation plantations the plants remain for several decades at the sites and accumulate carbon in their biomass above and below ground. Through litter fall this biomass is injected into the processes of decomposition, which supports the formation of vital soil biology and a growing soil humus pool with positive influences on soil quality and thus agricultural production. For this reason, in the temperate zone, agroforestry systems attract more and more public attention as they offer a promising and comprising way for adapting agricultural production to Climate Change and providing comprehensive ecosystem services.

While in-depth knowledge was established for tropical and subtropical agroforestry systems, agroforestry in temperate regions (with exception of the United States to some extend) is relatively new and scientifically not well investigated. Recently, some international projects (e.g., EU project ‘Silvoarable-agroforestry for Europe’, Acronym SAFE; www.montpellier.inra.fr/safe/) related to land use adaptation to Climate agroforestry have been initiated within the European Union. Although long-term agroforestry expertise is available, many of them lack scientific rigour. Several interrelated and site-specific factors ranging from agroecological conditions to system management practices influence the rate and extent of carbon sequestration, so that generalizations are difficult. Furthermore, widely and easily adaptable methodologies are not available for estimating the carbon sequestration potential and other benefits. In spite of these, there is an increasing demand for developing “best-bet estimates” based on the current level of knowledge and experience for multifunctional land use and the simultaneous food, fodder, fibre and fuel production. A comprehensive assessment of the ecosystem services in agroforestry systems in temperate regions should consider:

1. **A biophysical assessment:**

   Evaluation of the potential to produce biomass and food modelling of system interactions identification of performance, limits and constraints on different areas (e.g. degraded areas, brownfields and post-industrial regions).

2. **An evaluation of the carbon and nutrient budgets:**

   Investigation of the impact of C sequestration for soil organic matter and biomass pools as well as of microclimate modification by trees on soil organic matter stabilization processes evaluation of the nitrogen and phosphate dynamics

3. **An assessment of landscape biodiversity:**
Assessment of the potential impact of agroforestry on biodiversity at landscape scale evaluation of the impact of the selected tree species in homogeneous arable lands investigation of the relationship between biodiversity and the proportion of the area occupied by non-arable (including agroforestry) and arable habitats.

4. A valuing of the benefits and sustainability:

Exploration of the sustainability functions and socio-economic cross-cutting issues of agroforestry systems, valuation of economic benefits of commercial and experimental agroforestry practices, assessment of the current state-of-the-art thinking on the ecosystem and economic benefits of integrating trees on farms (identification of best practice).

These key issues are relevant to policy by providing current and reliable information on the interactions between land management, ecosystem services and society. Further studies are needed to document to which extent a more widespread introduction and targeted design and implementation of agroforestry systems can further optimise the level of provisioning ecosystems services from a limited area of land. Agroforestry management systems can have interesting opportunities on an economic and landscape ecology level under certain conditions. The objective must be to research if and when agroforestry systems are a valid option to traditional methods.

Temperate Agroforestry: A Canadian perspective

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Abstract

Canada continues to increase its emphasis on agricultural sustainability with program development at federal and provincial levels aimed at increasing the adoption of Beneficial Management Practices (BMP’s), which explicitly include the adoption of agroforestry systems. But Canada is a large country with major climatic and regional differences. Agroforestry is practiced in all agricultural regions of the country, but the species, uses and designs vary. Several uses of agroforestry are highlighted in this presentation, including the protection of aquatic habitat and silvopasture initiatives in the western province of British Columbia, windbreaks on the prairies, forest remnants as habitat in Ontario and shelterbelts for protecting blueberry pollinators in Quebec and the Atlantic Provinces. In British Columbia, wild salmon that live in the ocean depend on freshwater streams where they spawn in the spring. It is critically important for the commercial salmon fishery as well as for the protection of threatened or endangered aquatic species, that freshwater streams be protected in this coastal region. Trees or shrubs along these water courses provide shade and cover for the fish as well as habitat for other fauna and, in this region, valuable trees or tree products can be produced at the same time. In the interior of British Columbia, between mountain ranges, a semi-arid eco-region exists in which coniferous forests give way to productive pasture land. At the interface of the two vegetation types, both commercial forestry and commercial livestock production often occur on the same land base with a forestry company holding the forestry rights and a livestock producer holding the grazing rights. There is a policy challenge in this area to refine policies so that the two users are encouraged to develop land management plans that are profitable for both and that result in sustainable silvopasture practices. Prairie shelterbelts depend on drought-hardy, long-lived tree species to protect people, buildings, crops and livestock. Although the species used in this region are generally not suitable for commercial forestry because of their slow growth and much-branched habit, they provide aesthetic and other benefits that contribute
to the quality of life of rural residents. Southern Ontario and southern Quebec have some of Canada’s most valuable and intensively managed agricultural land which was once natural forest. Forest remnants separate fields and continue to represent critically important habitat for the native flora and fauna of that region. In eastern Quebec and Canada’s Atlantic Provinces, the native blueberry is a valuable crop that thrives on shallow, acidic forest soils. But fruit production depends on effective insect pollination and it has been found that smaller fields bordered by planted or natural shelterbelts are more productive and profitable than very large, open blueberry meadows. These various agroforestry BMP’s are all appropriate, as long as they are understood in their regional and climatic context.

Meanwhile, socio-economic and biophysical research in Canada seeks to understand the balance of private and public benefits from agroforestry practices. This is important so that public support for BMP’s can be structured to increase landowner adoption of appropriate agroforestry practices. Researchers in Agriculture and Agri-Food Canada, which is the Government of Canada’s agriculture department, and researchers at universities and other organizations across Canada have conducted a range of biophysical agroforestry research that has touched on many topics. We, in Canada, have studied windbreak effects on wind, soil erosion, snow distribution and dust particles in the air. We have studied biodiversity effects of agroforestry on plants, insects, birds and mammals. We have studied tree-crop interactions and different ways of designing or managing tree plantings. We have conducted many genetic selection and tree-breeding projects to make sure that farmers get well-adapted seedlings for their agroforestry plantings. We have conducted social and economic research projects and surveys. And yet there is much to learn. We try to summarize the things that we know, from our own Canadian research, from that of our colleagues south of the border in the United States and from researchers around the world, and communicate that knowledge to our own policy makers and to those who are managing the land so that the adoption of agroforestry is increased and that its effectiveness is greater.

In Canada most agricultural land is privately owned. The landowners are the people who are primarily responsible for managing their land and they have to manage their farms profitably. BMP’s, programs or policies cannot be properly implemented without the understanding and agreement of Canada’s farmers. Farmers recognize that they have a stewardship responsibility – that is, to manage their land for the good of all society and for future generations. Farmers know that poor environmental management can affect their neighbours and communities and they do try to minimize negative environmental impacts of their farming, impacts such as soil erosion or the escape of agriculture chemicals or fertilizers.

When good environmental stewardship is for the benefit of society as well as for the benefit of the landowner, it becomes society’s responsibility to support the landowner through effective government programming at local, provincial and federal levels. As a result of our agroforestry research in Canada, we understand something of the private/public balance of different agroforestry practices. We know, for example, that woody riparian buffers have many important environmental benefits to society, while the benefits to landowners may be relatively small. Therefore, targeted and substantial public support would likely increase landowner adoption of riparian buffers. Such considerations are taken into account as we develop our agroforestry policies.

In general, the Government of Canada, through the recently created national Agri-Environment Services Branch of Agriculture and Agri-Food Canada, seeks to support improved environmental performance in the agriculture sector at the same time as it increases its profitability. This support is provided through strong partnerships with Canada’s provincial governments. Agroforestry is an important component of the new Branch’s overall approach. Agroforestry practices continue to be supported in western Canada through the long-standing Prairie Shelterbelt Program headquartered at the Shelterbelt Centre at Indian Head, Saskatchewan. This program annually supplies 3 to 5 million seedlings along with technical assistance to more than 10,000 rural landowners. This program is possible only through a co-operative partnership with provinces, non-government organizations and rural landowners. In addition, rural landowners across Canada have an opportunity to receive financial support from Agriculture and Agri-Food Canada to offset some of the establishment and maintenance costs associated with tree-related BMP’s. Individual landowners or groups of landowners develop Environmental Farm Plans that identify their environmental risks and potential solutions. Once those plans are completed, landowners can recover 50% of their tree establishment and maintenance costs through the National Farm Stewardship Program.
Some provinces and non-government agencies supplement these initiatives with their own programs.

Norman Ross, the Prairie Shelterbelt Program’s superintendent in 1923, called the government/landowner partnership in shelterbelt planting the “co-operative system”. Since both partners recognize the need for the trees and since both partners get benefits from them, this co-operative system is both appropriate and necessary. Although we have had many successes over more than 100 years of agroforestry programming in Canada, we continue to be challenged to develop or fine-tune programs and policies so that the distribution of costs between the partners is fair. As Canadian landowners and governments continue this co-operative system, this partnership, we in Canada recognize that our actions are a part of the larger, global picture. When we seek to protect our air and water through agroforestry BMP’s and other agricultural BMP’s, we understand that climate change, the availability of clean, fresh water and the maintenance of biodiversity are global concerns. This year, as part of our awareness campaign, we have made the landowners who are the clients of the Prairie Shelterbelt Program aware, that their tree planting efforts put them shoulder to shoulder with tree planters in Kenya and all over the world and we have encouraged them to register their tree plantings on the United Nations Environment Programme website for the Billion Tree Campaign (www.unep.org/billiontreecampaign). Finally, the result of these programs, policies, partnerships and education efforts should be the adoption of appropriate and effective agroforestry measures that help protect Canada’s and the world’s environment, while Canadian landowners manage their farms profitably and sustainably.

Ecosystem Services from Agroforestry Practices in the USA


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Abstract

For many developing nations, farmers with limited land resources use those limited resources to provide for all of their basic needs including food, fuel, shelter, and fibre. As a result, agroforestry is an integral part of the agricultural landscape. However, in highly developed nations where agriculture has become heavily industrialized, agroforestry fills a different primary role. Here, agroforestry provides a broad range of long-term ecological benefits at the least cost. In the United States, the opportunity cost of transferring land from commercial agricultural production to some use that reduces soil loss or minimizes nutrient runoff can be highly significant. For example, taking cropland out of corn production and converting it to riparian forested buffers can have an opportunity cost from the loss of corn revenue of as much as $6074 per acre converted. Therefore, it is essential that the amount of land that is converted from cropland to riparian buffer be minimized.

In developed countries, such as the United States, the agricultural producer has been socially conditioned to focus exclusively on market-based valuation. In other words, costs and benefits are reflected in market prices for inputs and market prices for outputs. Unfortunately, many of the benefits of agroforestry are not commodities traded in an open market, neither are they easily quantifiable. Thus, when a landowner is faced with an environmental issue related to his production operation, the natural response is to choose a solution with the least cost based on market parameters. An excellent example is when a landowner is dealing with a soil erosion or run-off problem. It may be cheaper in the short-run to establish grass filter strips to address the issue; however, in the long-run a forested buffer may provide a more permanent fix to the problem and increase biodiversity, improve aesthetics, and sequester more carbon than the low cost alternative. Unfortunately, the landowner, who makes decisions based on the market, isn’t able to properly weigh information in his decision that is not framed in a market price.

One goal for agroforestry in industrialized nations is to develop practices that minimize the amount of land converted from agricultural production and maximize the amount of ecosystem benefit. Numerous studies have been conducted that reflect the ecosystem benefits of agroforestry. These long-term ecosystem benefits include removing agricultural nutrients and chemicals from the soil, air, and water, reducing soil erosion, improving soil
physical properties, providing long-term carbon sequestration, increasing biodiversity; and, a long list of socio-economic benefits, such as increasing aesthetics and income diversity. More specifically, riparian forest buffers are being widely adopted as a management practice used to protect and restore streams that have been damaged through crop or livestock management practices. In addition to providing bio-filter services along fields and streams, agroforestry can be applied to a wide variety of agricultural applications.

Another goal for agroforestry in developed nations is to apply some form of “green accounting” that can accurately reflect the benefits of these practices. One common method of “green accounting” is establishing a cost to cure whatever environmental problem is being created by the agricultural production system. Another common method is to aggregate the potential market-based benefits that are an indirect result of the adopted practice.

This paper takes three established agroforestry practices applied in an industrial agricultural framework and identifies the potential opportunity cost of using agroforestry versus other methods of providing ecosystem services. In addition, identification of the direct and indirect market based benefits to the landowner of each of these practices is quantified and compared to direct and indirect benefits of other options. The first practice that is analyzed is a silvopasture practice that was established in an existing Missouri Ozarks oak forest in 2003. The economic benefits of this practice have not only been seen in the increased growth of the trees, but also the reduction in heat stress on the livestock herd during the summer, which is reflected in weight gains and feed efficiencies.

The second agroforestry practice that is analyzed is a windbreak, established in 2008, around a confined animal feeding operation (CAFO) located in north central Missouri. The main environmental issue that the windbreak was designed to address was the reduction in odours from the operation; however, indirectly the windbreak has improved the heating and cooling efficiency of the confinement building.

The final agroforestry practice that is analyzed is a field buffer practice that was established in a row crop operation in the north east corner of Missouri. This practice was established in 1993 and has been shown to reduce sediment and nutrient runoff, as well as, increase soil porosity and soil carbon, and improve water filtration and soil density. The economic benefits of this practice are reflected in the estimated cost to cure the loss of soil and nutrients from the row crop operation, along with the potential indirect market value as a result of the increased biodiversity and improved soil quality.

For many landowners, the ecosystem benefits of agroforestry are either unknown or not easily understood. In a culture where management decisions are based on cashflow, net present value, and net income, non-market benefits often get overlooked or under emphasized in the decision process. This paper puts non-market benefits into an economic framework that is more readily understood and actionable by the landowner.
Symposium 8: High Carbon Stocks Development Pathways

Organized by Peter Minang, Acting ASB Global Coordinator, World Agroforestry Centre.

Introduction:
Large areas of the humid tropics are like mosaics, combining features of forests and agriculture and housing hundreds of millions of people. Land uses that store high quantities of carbon, such as agroforestry and other tree-based systems, make up a large part of those mosaic areas. Yet current discussions on reducing emissions from deforestation and degradation (REDD) within the UNFCCC do not adequately address these land uses as part of a potential mitigation strategy. Thy symposium will highlight evidence showing the potential of such land uses for storing carbon, stabilizing forest resources and generating income. Policies and strategies that harness this potential can contribute to high carbon rural development in the humid tropics.

Speakers:
Cocoa agroforestry in West-Central Africa - Dr. Jim Gockowski. International Institute of Tropical Agriculture (IITA)

Swiddens in Indonesia - Dr. Niken Sakuntaladewi. (ICRAF-Indonesia).

Environmental Services Provision in the Transamazon through Cocoa -based Agroforestry and Certified Community-Company Forest Management – Roberto Porro1 & Giovanny Guzzo2. 1World Agroforestry Centre (ICRAF), Amazon Initiative Consortium, 2Agriculture Secretary, Municipality of Anapu, Pará-Brazil

UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN REDD) - Mario Boccucci1 and Niklas Hagelberg2. 1UN Environment Programme (UNEP), Division of Environmental Policy Implementation (DEPI) Nairobi, Kenya, 2UN Environment Programme (UNEP), Freshwater & Terrestrial Ecosystems Branch (DEPI), Nairobi, Kenya.

Cocoa Agroforests in West and Central Africa

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Abstract
In humid forest systems of West and Central Africa in general, agriculture has continued to play dominant role in the provision of food, raw material for the industries, employment and foreign earning, which are used in financing development activities. In the course of the last 40 years industrial tree crops, notably cocoa, coffee, oil palm and rubber have largely dominated the export agriculture.

Cocoa has been the leading agricultural export, according to FAOSTAT from 1984 to 2006 cocoa production in Côte d’Ivoire, Ghana, and Nigeria increased by 1.7 million tons. In most of West and Central African countries, cocoa production was achieved by increasing the area cultivated rather than by improving yield. That means that cocoa production has been associated with a continuous deforestation of virgin tropical forests. The largest expansion in the area harvested has been of 2.3 million ha the most rapid growth has occurred in the Western Region of Ghana and the Bas Sassandra region of Côte d’Ivoire where the last remnants of the West African Guinea Forests are under siege. These cocoa forests conserve a considerable portion of the original forest biodiversity and interact in ecosystem functioning (Sonwa, 2004, Zapfack, et al., 2002).

Today, cocoa systems in West Africa range from no-shade mono-specific systems to complex cocoa-fruit timber-medicinal agroforestry systems. No-shade systems are found mostly in the lower guinea forest systems in Liberia, Côte d’Ivoire and Nigeria, while the more complex systems are found mainly in Cameroon and the Congo Basin countries. Complex systems have biodiversity values nearly equivalent to secondary forests (Sonwa, 2004, Gockowski et al., 2006, Sonwa, et al., 2007) with non-cocoa revenue accounting for 23% of total revenue. In the Eastern region of Ghana, avian, mammalian, plant and butterfly biodiversity were evaluated in shaded and full sun cocoa using identical protocols. The
recorded mammalian and avian species richness of shaded systems was more than 3 times that of full sun systems, while plant species and butterfly richness were 4 and 30 times that of full sun systems (Ofori-Frimpong and Asase, 2005).

Intensifying low-shade cocoa systems would improve shade to about 30% and optimize yield. However when tree cover is increased beyond 30% as in multi-storey cocoa systems that promote biodiversity, yield decreases, and so other benefits are needed to offset the cost of increased shade. For these systems to be economically viable to farmers, they must generate income comparable to low shade systems. By sequestering carbon as well as optimizing production, a 30% shade system generates new and additional carbon credits that would not be generated under a low shade system. Financial incentives might be created to account for the carbon and biodiversity benefits of higher shade systems. But input, organizational and marketing challenges are still plentiful.

References:


Challenges for swidden cultivation in relation to REDD schemes: Lessons from Indonesia

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Abstract Swidden cultivation, along with pastoralism, have been the basis of land use for thousands of years and are still practiced by the communities living in and around the remaining tropical forest, who normally have low incomes. With increasing population density and the associated reduction in fallow length, swidden systems change. In stead of being part of sustainable forest management, swidden systems become viewed as threats to the forest. In many Asian countries, national development programs include targets to transform swiddens into permanent cultivation systems. Similarly, the Government of Indonesia (GoI) perceives swidden cultivation as no longer suitable for current conditions and as destructive of environmental integrity; it is seen as a driver of deforestation and as backward agricultural practice and culture, without support for economic growth. The heavy smoke from land clearing fires, especially on peatlands, affects people’s health, hinders socio-economic activities and affects relationship with neighboring countries. Distinctions between ‘swidden’ and ‘slash and burn’ land clearing for plantation establishment are not made.

In contrast to this policy perspective, studies in South East Asian countries indicate that swidden cultivation is a dynamic system, has an economic rational in the returns to labour it provides and can be environmentally sound, culturally accepted, with continued technological innovation and further adaption (Fox. 2000, Mertz. 2000, Noordwijk et al. 2008, Nugraha. 2005, Palm et al. 2005, Tomich et al. 1999). Swidden systems evolve, not merely by shorter fallsows and more intensive annual crop production, but also through
modification and enrichment of the fallow towards tree based (rubber and fruit trees) livelihood systems in the form of agroforests. The resulting agroforests, such as ‘jungle rubber’, can retain considerable species diversity (Rahayu. 2009, Tomich et al. 1999, Tata et al. this meeting) as found in Sumatra and Kalimantan. Cycle lengths can increase to 30-50 years, and C storage can increase over systems that focus on annual crops.

Such findings provide a basis for including swidden agriculture and its dynamics in schemes to Reduce Emission from Deforestation and Degradation (REDD). Major challenges exist, however. They include:

1. Forest definitions and scope of REDD; the internationally accepted forest definition allows ‘temporarily unstocked’ areas to be part of ‘forest’, and thus ensures that swiddening is not a driver of deforestation; yet, forest institutions don’t interpret it this way;

2. Intensifying agriculture and short-cycle tree plantations in one part of the landscape and extensifying forest management (increasing management cycle lengths) elsewhere can contribute to overall emission reduction; it requires a landscape-scale assessment rather than focus on ‘forest’;

3. The voice and perceptions of local stakeholders involved in swiddens and its alternatives needs to be heard; the strong perceptions and values of dominant ‘public/policy ecological knowledge’ prevent a fact-based approach;

4. Current implementation procedures for REDD in Indonesia focus on forest management and planning procedures that are difficult to achieve for local stakeholders; a stronger focus on outcome-base (‘bottomline’) approaches and less reliance on input-planning is needed to bring local stakeholders on board and achieve fairness + efficiency in REDD value chains.

References:

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Environmental Services Provision in the Transamazon through Cocoa-based Agroforestry and Certified Community-Company Forest Management

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Abstract Smallholder colonists from land-reform settlement programs in the Brazilian Transamazon highway are increasingly forced to replace their traditional slash-and-burn systems by sustainable land uses. Cocoa agroforestry plots were initiated, but their dissemination needs financing. In one of these schemes, the Anapú Sustainable Development Project, a community-company partnership established a 30,000 ha Forest Management Project since 2007, but certification is needed to reach better markets. Payments for environmental services (PES) from reduced emission from deforestation and forest degradation (REDD) are sought to co-fund agroforestry plots and certification. This project will demonstrate the feasibility of PES based on smallholder REDD according to carbon market’s acceptable standards.

Deforestation position this region as one of the areas under great threat of forest loss and low-carbon land uses, due to both smallholder agriculture and large-scale cattle ranching. Land use change in the region features initial clearings for smallholder agriculture followed by the conversion of shifting cultivation plots to pasture, and by a process of land concentration that consolidates the expansion and connectivity of large tracts of land for extensive ranching. Pastures often degrade after a decade of inadequate management, stimulating a
new cycle of land clearing inward on forested areas. The region extends over 227,000 km² and is home to approximately 40,000 family farms and 15 indigenous reservations. While official colonization programs no longer exist, frontier dynamics continue to the present day through the expansion to areas further from roads, and an intense mobility within the Amazon. It is thus critical, for the sake of forest conservation, and for the livelihoods of indigenous and traditional communities, that colonist communities remain in their assigned areas, managing their ecosystems properly, and obtaining sustainable benefits from their activities.

Their traditional slash-and-burn cultivation needs to be replaced by high-carbon stock land uses. Supported by Sister Dorothy Stang (who was murdered in 2005), social movements in Anapu have claimed novel forms of tenure security combined with environmental conservation since the mid-1990s. They founded the grassroots organization ASSEEFA (Economic and Ecological Solidarity Association for Amazonian Fruit Producers) to support migrant smallholders in pursuing this goal. In 2002 the federal government established Anapu’s SDP through which smallholders are allowed to use 20 ha for agriculture. However, without the implementation of incentive-based management options farmers are likely to reproduce in this area the regional pattern of land conversion resulting in the deforestation and pasture conversion of an average of 50 ha/household after 15 years.

This action will prevent climate and biodiversity deterioration, and enhance smallholders’ livelihood opportunities through the integration of REDD schemes, cocoa-based high-carbon stock agroforestry and certified forest management. The integration of adequate investment and returns from agroforestry and sustainably managed forests make this a proper for the REALU approach, with specific objectives of (a) Avoid deforestation of 16,800 ha over 15 years through a community-managed demonstrative REDD scheme that rewards measurable ecosystem services for carbon markets; (b) consolidate a community-company partnership to run a 30,000 ha community-based forest management project and obtain certification from the Forest Stewardship Council; and (c) integrate PES and forest management income to finance the restocking of 2,100 hectares of high-carbon stock cocoa-based agroforestry plots, reducing slash-and-burn and emissions.

**UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN REDD)**

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**Abstract**

Tropical forests are continuing to disappear at an alarming rate: between 1990 and 2005, the rate of deforestation averaged about 13 million hectares a year, occurring mostly in tropical countries. In many of these countries, deforestation, forest degradation, forest fires and slash and burn practices make up the majority of carbon dioxide emissions. There are many causes of deforestation and forest degradation and they vary from place to place. They include, among other things, agricultural expansion, conversion to pastureland, infrastructure, development, destructive logging, fires etc. Deforestation and forest degradation also have severe adverse impacts on forest biodiversity, the availability of wood and non-wood forest products, soil and water resources and local livelihoods often remove an important safety net for the rural poor. Reducing Emissions from Deforestation and Forest Degradation in Developing Countries would create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development.

Support for efforts to reduce emissions from deforestation and forest degradation has been expressed at the highest political levels (G8, UN General Assembly) and has been included in the Bali Action Plan of the United Nations Framework Convention on Climate Change (UNFCCC). Concerted efforts have been made by developing countries with support of the international community for the past couple of decades or longer to reduce unplanned
deforestation, stem forest degradation and implement sustainable forest management. Despite some success stories, the challenges have proven to be considerable. Delivering emission reductions adds a significant layer of complexity and risks. Many developing countries may need assistance to set up systems to assess carbon emissions and removals on forest land, using methodologies recognized by IPCC (IPCC Good Practice Guidance) so that future results could be demonstrable, transparent, verifiable, and estimated consistently over time.

The scale of the REDD challenge is fully acknowledged. The rationale for the UN Collaborative Programme on REDD is to assist forested developing countries (pilot countries: Democratic Republic of Congo, Tanzania, Zambia, Indonesia, Papua New Guinea, Viet Nam, Bolivia, Panama and Paraguay) and the international community to gain experience with various risk management formulae and payment structures. The aim is to generate the requisite transfer flow of resources to significantly reduce global emissions from deforestation and forest degradation. The immediate goal is to assess whether carefully structured payment structures and capacity support can create the incentives to ensure actual, lasting, achievable, reliable and measurable emission reductions while maintaining and improving the other ecosystem services forests provide.

The collaborative programme has two components: (i) assisting developing countries prepare and implement national REDD strategies and mechanisms; (ii) supporting the development of normative solutions and standardized approaches based on sound science for a REDD instrument linked with the UNFCCC. The programme will help empower countries to manage their REDD processes and will facilitate access to financial and technical assistance tailored to the specific needs of the countries. At the global level, the UN-REDD Programme supports country efforts to build consensus and knowledge, and ensuring consistency in approaches and economies of scale in the delivery of REDD. The Programme actively explores and documents examples of “best practices”. These activities seek to promote confidence-building in REDD and raise awareness about the options for including a REDD mechanism in a post 2012 regime.
Symposium 9: Satoyama - A socio-ecological production landscape approach to sustainable use of ecosystem services and human development

Introduction

Satoyama is a Japanese term for rural landscapes that comprises several types of ecosystems including secondary forests, agricultural lands, irrigation ponds, and grasslands, along with human settlements. These landscapes have been formed and developed through prolonged interaction between humans and ecosystems. It is considered that satoyama comprises more than 40 per cent of Japan’s total landmass. Importantly, satoyama connotes a way of life illustrating the symbiotic interaction between humans and the environment, as central to the management of the ecosystems in satoyama for the sustainable supply of ecosystem services essential for human well-being. This concept of the interaction in satoyama also extends to satoumi, which includes marine and coastal ecosystems, and is similar to satoyama in terms of its functions, use and prolonged interactive mechanisms.

Although satoyama is a Japanese term, this type of multi-ecosystem landscape is not unique to Japan alone. Such landscapes are commonly found throughout many regions of the world, though the issues might vary from one area to the other. Given the features of satoyama, which typically embodies a symbiotic relationship between a mosaic of ecosystem types and human societies to produce a bundle of ecosystem services of value for human well-being, it is an issue not only of significance to the local region, but also of international importance. All processes including sustainable development (e.g. the Rio Agenda and the WSSD), multilateral environmental agreements (e.g. the Convention on Biological Diversity, the Ramsar Convention, and the Convention on Migratory Species) and initiatives on preservation of culture (e.g. the UNESCO World Heritage Convention) relate to satoyama and its features.

This symposium intends to bring some key experts in the field of ecology, economics and development to explore how the satoyama concept can be used as a mechanism to operationalize the three objectives of the Convention of Biological Diversity (CBD) while at the same time contribute to rural development and poverty reduction.

Symposium Format

The symposium will be presented as a panel discussion with three key speakers and a moderator. Each speaker will address one of the three objectives of the CBD convention through the lens of agro-forestry, rural development and poverty reduction.

Speakers

Prof. B. Mohan Kumar, Associate Dean, College of Forestry, Kerala Agricultural University / Editor, Journal of Tropical Agriculture

Prof. Takakazu Yumoto, Professor, Research Institute for Humanity and Nature, National Institute for Humanities

Prof. Masataka Watanabe, Professor, Faculty of Environment and Information Studies, Keio University / Special Guest Researcher, National Institute for Environmental Studies (NIES)/Visiting Professor, United Nations University Institute of Advanced Studies (UNU-IAS)

Dr. Alphonse Kambu, Senior Programme Officer, Biodiversity and Land Law and Governance Unit, Division of Environment Law and Conventions (DELC), UNEP

Moderator

Dr. Anantha Kumar Duraiappah, Chief, Ecosystem Services and Economics, UNEP

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Cultural Service Provided by Satoyama Landscape and Its Role in the Conservation of Biodiversity

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Satoyama as a Mosaic

The word satoyama in Japanese implies literally the mountains nearby human settlements. In fact, satoyama is a heavily human-impacted ecosystem which people have been repeatedly used, for harvesting firewood, making charcoals, collecting litter and leaved-branches for manure, obtaining wild plants and fungi for foods, etc. In the other words, we can define satoyama as an ecosystem which has been modified by human being for the purpose of obtaining “blessing of nature”, or provisioning service, in sustainable ways. Also, satoyama connotes not only the landscape itself, but also traditional wisdom or knowledge for obtaining sustainable ecosystem services as well as culture which has been developed under rich flora and fauna in the Japanese Archipelago.

The landscape of satoyama is characterized by a mosaic of different land uses to obtain different types of ecosystem services. In the Archipelago, paddy field cultivation began in the small basin, alluvial fan and fluvial terrace, not in large delta. Owing to tiny and fragmented topographic areas, monoculture has not developed in Japanese agriculture until recently. So agriculture in satoyama in hilly area is a typically multi-crop culture, including not only annual crops such as rice, wheat, barley, beans and vegetables, but also perennial plants such as fruiting trees, bamboo, firewood.

Cultural Services Provided by Satoyama

Broad-leaved tree plantations for firewood and charcoal began in the sixteenth century, using coppiced stands of kunugi trees (Quercus actissima) for charcoal production. People harvested the sprouting stems at an interval of 8 to 10 years as wood for charcoal production. Also, mulberry trees (Morus bombysis) were planted for feeding silkworms, and were coppiced. People planted seedlings of Q. actissima and M. bombysis even in the terraced fields, because they regarded it as a crop. As people have been obtained various materials from satoyama, the sustainable managements and utilization based on traditional ecological knowledge (TEK) have been done. In the rural culture, techniques to produce tools, textiles and medicines from various kinds of woods, bamboo, herbs, grasses and sedges are most developed. Although those techniques are regarded as out-of-date because of world-widely commodity distribution, learning such a rural TEK is still very popular for younger generations in green tourism.

Large area of satoyama has been managed and utilized as the commons in the local community, with strict rules as limited memberships, obligation and punishment. A certain day was declared as the beginning of harvesting grasses, acorns, fungi, firewood etc. respectively. Overuse of satoyama resources has been avoided under the strong governance of the local community. Each of most local communities was an identical worship group under a shrine. Usually a sacred forest was accompanied with each shrine as a guard. Sometimes the source of water supply for paddy field was protected as a sacred forest. Taboos to maintain sacred forests as semi-primeval forests are also abided by the governance of local communities. A mosaic of satoyama landscape including agricultural lands as well as sacred forests may have nourished Japanese sensibility to nature: to love the landscape as a miniature garden, to love a moderate mixture of nature and artefact, or to love delicate differences and changes in nature. Such a Japanese sensibility is represented as an art of gardening e.g. Katsura Rikyu Imperial Villa, which shows a harmonic combination of nature and artefact.

Roles of Satoyama in Biodiversity Conservation

As satoyama provides various materials, people have intentionally kept high diversity of useful plants and animals. Also, as satoyama is a mosaic of various land use and provides various habitats including ecotone, unintentionally high biodiversity has been kept too. Evergreen broad-leaved forests in western Japan have been changed into deciduous woodlands by coppicing so that many plant species of undergrowth have survived. Grassland maintained to harvest manure has been provided habitats for grassland specialists of plants and animals. Paddy field and irrigation system provides habitats for lentic fish and insects. Even the species specific to the primeval forests have been survived in sacred forests. The increasing number
of evidences for proving these roles is being obtained, because abandonment of satoyama managements in Japan is leading to the extinction of plants and animals which depend on satoyama landscape.

A mosaic land use for obtaining various ecosystem services can be found not only in Japan, but also in other regions in the world. It is called as satoyama in Japan, maeul in Korea, munoa in Sarawak (Iban), Malaysia and so on. Especially regions with subsistence agriculture based on paddy field have their own TEK to maintain and utilize various plant materials in sustainable ways, which lead to, more or less, the conservation of biodiversity intentionally and unintentionally. A message from satoyama studies is not a nostalgic one “going back to the past”, but a highly contemporary one: TEK in each region and area for obtaining ecosystem services in sustainable way gives us a hint for building new lifestyles of health and sustainability, and for establishing a compatible way of biodiversity conservation and utilization.

Ecosystem Services Management on Satoyama for Sustainable Society

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Abstract: Humans fundamentally depend on ecosystems and biodiversity, while protected against environmental changes by culture, science and technology. In the past several decades, however, the ecosystems in many developing countries have been depleted and exhausted more rapidly than at any time in human history. Those in Japan, in particular those called satoyama, have been extensively abandoned due to various factors including global trade, increased rural-urban migration, and aging in rural society. Satoyama used to be a typical traditional rural landscape or system in Japan, often similarly found in other countries under the Monsoon Asia where the rice cultivation is a longstanding culture. Recently satoyama has been degraded and decreased, while endangered by global changes such as climate change, food crisis, and financial meltdown. It is therefore critical to identify means of utilizing natural resources without declining ecosystems and biodiversity in order to address the challenges associated with foreseeable uncertainties on the issue of satoyama and contribute to building sustainable society.

The study focuses on the management of the ecosystem services (including provisioning, regulating, cultural, supporting services) provided by satoyama in Japan with the specific emphasis on land use, ecological conservation, biomass, and resources recycling. It will apply the conceptual framework developed by the Millennium Ecosystem Assessment (MA) to assess the drivers of changes in the ecosystem services from satoyama, and their impacts on human well-being, and to demonstrate how much degree of human interventions should be required to optimize the ecosystem services without loss of biodiversity in satoyama. It will also develop scenarios to explore plausible futures for Japan by using qualitative typology of local societies and at the same time using key qualitative data and information related to land use, population, and industry. Finally, it will seek to define a role of satoyama as a new commons which is a system or institution for natural resource utilization beyond the boundary conditions of the existing property rights and use rights, so as to propose policy options for building sustainable society in Japan.

The study is intended to feed into the implementation of the Strategy for an Environmental Nation in the 21st Century where the Japanese government proposes the three types of societies (i.e. low-carbon society, recycling society, and nature-harmonious society) to be integrated for sustainable society. By examining the interlinkages and relations between different types of societies in detail, it is also expected to contribute to the sustainability discourse that has been held in the international community.
Agroforestry in the Western Ghats of peninsular India and the Satoyama landscapes of Japan: a comparison of two sustainable land use systems

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Abstract: Agroforestry in the Western Ghats (WG) of peninsular India and satoyama in rural Japan are traditional land use systems with similar evolutionary trajectories. Some of their relevance, however, was lost by the middle of the twentieth century, when modern agricultural technologies and urbanization engineered shifts in emphasis towards maximizing crop production. There has been a resurgence of interest recently in the traditional land use systems, in view of their ability to provide ecosystem services. Both agroforestry and satoyama are thought to be harbingers of biological diversity and have the potential to serve as “carbon forests.” Carbon (C) stock estimates of the sampled homegardens in WG ranged from 16 to 36 Mg ha–1. Satoyama woodlands owing to higher tree stocking had higher C stocks (49 to 279 Mg ha–1) than homegardens. They also differ in nature, complexity, and objectives. While agroforestry involves key productive and protective functions, and adopts ‘intensive management’, the satoyama woodlands are extensively managed; understory production is seldom a consideration. Differences in canopy architecture (multi-tiered structure of agroforestry vs. the more or less undifferentiated canopy of satoyama) and land ownership pattern (privately owned/managed agroforestry holdings vs. community or local government owned satoyamas) pose other challenges in the transfer and application of knowledge gained in one system to the other. Nonetheless, lessons learnt from satoyama conservation may be suitable for common pool resource management elsewhere in Asia and aspects relating to understory production in agroforestry may be relevant for satoyama under certain scenarios.
Oral Presentations
Session 01
Multistrata agroforestry systems with perennial crops
Change legislation to rebuild agroforests. Rebuild agroforests to change legislation

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Session 01 Multistrata agroforestry systems with perennial crops
Abstract In recent years, research has emphasized the benefits of agroforestry in enhancing positive externalities and environmental services of biodiversity in cocoa cultivation. However, in practice, in the two major producing countries, complex agroforestry cocoa production systems are shrinking both in terms of surface area and number of species. The timber legislation in Africa and what farmers perceive of this legislation, having been excluded from the legal timber market for decades, is one of the main factors behind this trend. One of the reasons farmers cut or burn their trees is to avoid disturbance by logging companies that come to extract trees from their cocoa farms, without any reasonable compensation. The main objective of this paper is to show that this trend will not be reversed by legislation change coming from the top, with the hope that fewer trees will be spoiled, but rather by a move from below, from farmers themselves. The question is now less one of preserving existing or surviving ‘chocolate agroforests’, but rather one of having smallholders favouring tree regeneration from the stumps and planting trees, mostly indigenous trees, and organising themselves for that purpose. The only method is to review a few initiatives taken by a few institutions and by farmers themselves with the aim of re-inserting timber trees in their farming systems, mostly by planting. Among these initiatives, one undertaken in Ghana in the early 2000s by an Italian NGO seems to have been successful since some farmers continued to maintain their trees and even kept planting after the project closed. Some farmers also started to informally organize themselves to get coverage in papers in the capital of the country and defend their property rights. The paper evaluates the main factors and lessons that can be drawn from of this experience.

Diversity of coffee shade trees and traditional management practices in coffee-based agroforestry systems of South Ethiopia

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Abstract The coffee-based agroforestry systems of Dale district which evolved from wild coffee forests, possess diversity of tree species maintained as shade for coffee, boundary and front yards plantings. This research was undertaken to understand the traditional coffee-based agroforestry and tree-shade management practices and species diversity in the system. The major data collection techniques used in this study were a semi-structured questionnaire-based survey, point transect-based sampling of shade tree diversity and percent canopy cover, a group interview, observation and review of secondary data. The collected data were analysed descriptively and logically. The result shows that 5 tree species are most frequently used as shade and a similar number of other tree species was entirely excluded from the farm because of inferior qualities with respect to several parameters. The main criteria for selecting and using a tree in farm practices are soil-improving quality, moisture discharging capacity, availability of seed, wood quality, shade level, moisture retention, cash generation, cultural value and non-negative effects on livestock and people. On the basis of a transect-based tree inventory, 71 perennial species were registered. Trees that were severely threatened and scarce in the natural forest also grew more abundantly in a domesticated landscape. Farmers manage shade trees to maximize benefits and reduce their adverse impact on component crops. Major tending practices used are: pruning of branches; pollarding of the entire crown; removing the stump of dead and felled trees; and removing less vigorous trees. The shade trees are either planted, deliberately retained or
wildlings. In order to avoid competition and enhance complementarity of species, farmers manipulate their trees and crops by segregating them in time and space. It can be concluded that traditional coffee shade management is contributing to the preservation of species diversity in the region.

**Keywords:** shade trees diversity, agroforestry, south Ethiopia, coffee-shade management

### Ecological and economic analysis of coffee agroforestry systems: A case study from central Western Ghats, India

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**Session**

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**Abstract**

In the present scenario of an alarming deforestation rates in the tropics, the concept of protected areas may not serve the purpose of conservation of all the earths’ biodiversity and it is challenging to find alternative conservation approaches that can reduce the pressure on forested ecosystems. In this context, the present study is an attempt to throw light on the conservation significance of coffee agroforestry systems (CAFS) as an alternative conservation tool. The present study was conducted in the CAFS of Kodagu district, South India, by using a stratified random sampling technique. The economic value of tree species was calculated by using the volume of timber and the value of timber per unit volume. The preliminary results indicated that, species richness was higher (96) in CAFS of moist deciduous vegetation compared to CAFS under a semi-evergreen vegetation type. Shannon diversity values were higher for the CAFS of semi-evergreen vegetation compared to CAFS of moist deciduous vegetation. Standing volume of timber of trees with girth at breast height < 30 cm was higher in CAFS under semi-evergreen vegetation (84.7 ± 7.4 m$^3$) compared to CAFS under moist deciduous vegetation (59.8 ± 7.2 m$^3$). The proportion of threatened and endemic tree species was also higher in CAFS of semi-evergreen vegetation types (7.94% and 11.11%, respectively) compared to CAFS under moist deciduous vegetation (4.26%, both threatened and endemic trees). On the other hand, the economic value of trees in CAFS under moist deciduous vegetation was higher (14 000 ± 1300 USD) compared to CAFS under semi-evergreen vegetation type (9860 ± 1120 USD). In addition to providing support to various flora, fauna and economic returns the CAFS also reduced the pressure on the primary forest by providing timber, fuelwood and wide ecosystem services.

### Effect of voluntary private standards on coffee commodity chain in Costa Rica

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**Abstract**

During the last 20 years, private voluntary standards for coffee have been developed around the world. In Costa Rica, they were strongly developed after the coffee crisis in the early 2000s. Nowadays, half of Costa Rican production is certified. This paper proposes an analysis of the effect of the increase of voluntary private standards (organic, fair trade, UTZ certified, Rain Forest alliance, Starbucks, Nespresso) in the coffee sector on the commodity chain in Costa Rica. Based on a literature review and direct interviews of actors in the coffee sector in Costa Rica, the paper presents the main evolution of the structure and functioning of the Costa Rican coffee commodity chain during the last decade. It shows that early certification channelled through local organizations, especially in organic and fair trade, helped the coffee growers of the marginal coffee production areas to cope with coffee market crises in the early 2000s. Later, after the coffee crises, the multiplication and development of
environmentally friendly voluntary standards appears as one of the elements of the strategies of producers and producers’ organizations to cope with increasing production costs and market competition. Nevertheless, the impact on final producers’ income has been limited. Finally, private standards in the coffee sector increase the resilience of coffee producers to market shocks and have contributed to the consolidation of producers’ organizations and the maintaining of coffee-based agroforestry systems.

**Exploration of lac cultivation on the non-traditional host *Flemingia macrophylla* (willd.) Kuntze ex merr. and its possibility in the understorey plantations of *Dalbergia sissoo***

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**Session** 01 Multistrata agroforestry systems with perennial crops

**Abstract**
Lac is a natural resin of animal origin derived from protective body covering of tiny insect *Kerria lacca* Kerr. (*Tachardiidae: Homoptera*). Lac is commercially cultivated on traditional hosts like *Kusum* (*Schleichera oleosa*), *Palas* (*Butea monosperma*) and *Ber* (*Zizyphus mauritiana*). To overcome the problems of long gestation period, scattered distribution and high crown of these traditional hosts, considerable efforts were made to explore suitable non-traditional host plants of short gestation period and low crown. In this context, *Flemingia macrophylla* is one of the promising non-traditional host species was explored as intercrop in understorey of *Dalbergia sissoo* and control condition. The experiment conducted in Aghani and Katki seasons for Kusumi and Rangeeni strains respectively. Survival per cent of *F. macrophylla* was higher in understorey (100) as compared to control (96). The mean plant height of *F. macrophylla* in understorey is 141.87 cm, whereas it is 237.46 cm in control. Average inoculable shoots per plant were 4.41 and 2.77 under control and in understorey respectively. After 75 days of inoculation, density of settlement was higher under control (45.71/cm², 16.2/cm²) than in understorey (38.05/cm², 13.5/cm²) for Aghani and Katki crop respectively. Sex ratio at 45 days of inoculation was higher in understorey in Aghani (13:95 M: F/cm²) and control in Katki (14:84 M: F/cm²). Lac shell weight after emergence was higher under control for both Aghani (0.02012 g) and Katki (0.0313 g) with 307 and 315 insects respectively. The average ‘scrap lac’ yield in control was 166.64 g/plant, which is 2.6 times to that in understorey (63.63 g/plant) for Aghani crop. Experimental results revealed that though there was significant reduction in the scrap lac yield, lac cultivation is feasible on *F. macrophylla* in under-storey. With proper canopy management, there is potential of increasing not only its economic viability, but also ecological development via Joint Forest Management through peoples’ participation in resource generation, management and sharing of benefits.

**Key words:** Lac, Aghani, Katki, *Flemingia macrophylla*, *Dalbergia sissoo*, *Kerria lacca*.

**Identifying ecosystem hotspots in coffee-dominated landscapes of Costa Rica for targeted payment for ecosystem service schemes.**

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**Session** 01 Multistrata agroforestry systems with perennial crops

**Abstract** Payments for ecosystem services (PES) have generated much excitement in conservation and production organizations because of their potential to simultaneously protect biodiversity and improve farmers’ livelihoods. The capacity of a farm to provide specific services is a function of land management (agroforestry versus conventional agriculture) and the
landscape context. The degree of slope, soil type, and topographic position will affect soil erosion functions, whereas the location, size, and shape of the farm in relation to adjacent natural vegetation will determine conservation value. Current PES schemes are not spatially explicit and all farmers are eligible for payment regardless of where their farm is located, and its actual ability to provide the service in question. With limited funding for PES schemes, identifying ecosystem service hotspots can help target farms where the greatest service per dollar can be obtained. We model conservation and erosion hotspots in the Volcan Central Talamanca Biological Corridor to target PES schemes on farms where the services are critically needed. To identify the conservation hotspots we used models of functional connectivity for three species of bird found in the corridor (scarlet rumped tanager, yellow warbler and the ochre-bellied flycatcher) identifying critical gaps in the corridor for each of these species. For erosion, we used the revised universal soil loss equation (RUSLE) to identify areas within the corridor where potential erosion is greatest. Finally, we calculated the value of each service provided by multistrata coffee agroforests. In order for PES schemes to continue to be successful, they must demonstrate that the service being paid for, is actually being provided. We demonstrate that spatially explicit modelling of the provisioning of such services is the first step in identifying where these services are most critically needed, where agroforestry interventions will have the greatest impact, and where payments should be made.

Integrating shade trees into new cocoa farms: the ethnographic, ecological, and economic factors driving shade management in Ghana’s Ashanti Region

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Session
01 Multistrata agroforestry systems with perennial crops

Abstract
There is a body of literature which suggests that cocoa farmers in West Africa are increasingly intensifying their farming practices through the adoption of no-shade systems, and thereby abandoning the practices that create more diverse and complex cocoa agroforests. A study of 89 6-year-old cocoa farms in Ghana’s Ashanti Region contests these claims by demonstrating that shade is in fact an integral component of young cocoa farms; 99% of farmers have shade trees on their farms, with an average of 112 non-cocoa tree stems per hectare. The study also shows that farmers are not widely adopting practices associated with intensification. Less than 1/4 of the farmers planted hybrid cocoa trees, 91% of farmers had never applied fertilizers, and during the past season, farmers only sprayed pesticides an average of 2.5 times, less than the recommended 4 times per year. Still, notions of no-shade cocoa plantations are not completely unfounded as farmers’ perceptions and discourses about shade overwhelmingly view it as negatively impacting on yields. Further, these descriptions highlight the fact that there is a disconnection between cultural perceptions and farmer knowledge of shade, and farmers’ actual shade management practices. Consequently, the study tries to offer a more nuanced picture of contemporary shade management by citing the ethnographic, ecological and economic factors that influence farmers’ decision processes about shade tree density.
Living on the edge – tree arrangement, forest edges and mammal conservation in coffee agroforests of Costa Rica

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Session: 01 Multistrata agroforestry systems with perennial crops

Abstract

Mesoamerica has been critically identified as one of the world’s biodiversity hotspots. The largest threat to the conservation of this biodiversity is the conversion and fragmentation of native forest areas to agriculture land uses including pasture and coffee. In light of the on-going global pressure to increase food and fuel production in terrestrial landscapes, the conversion of semi-natural and natural areas outside of reserves into agricultural land uses is certain to increase. Certification of coffee by conservation organizations such as the Rainforest Alliance is one mechanism for improving the conservation and economic value of coffee production. But what is the best tree arrangement for conserving mammal biodiversity? We monitored mammal diversity and abundance on two farms in the Volcan Central Talamanca Biological Corridor in central Costa Rica using six 400 m transects running from 100 m in coffee, to 300 in adjacent forest. In over 8352 trap nights we captured 1380 individuals from 15 species. Mammal diversity and abundance was significantly different between the two farms, with abundance values twice as high on the Rainforest Alliance certified farm. However, diversity and abundance remained critically low in the coffee habitat for both farms, increasing significantly within the forest habitat. Diversity and abundance increased gradually with increasing distance into the forest, but the biggest change was found directly at the edge. Our results suggest that coffee does not provide good habitat for mammal diversity, but that it does provide a good buffer to forest reserves, reducing edge effects. We suggest that for mammals, maintaining forest fragments, or buffers around coffee farms may be more valuable than maintaining tree cover in coffee fields.

Management of Grevillea robusta shade trees in tea (Camellia sinensis) plantations in humid tropics of Western Ghats of India

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Abstract

Studies were conducted during 2002-2004 on nutrient cycling, decomposition rate and the root distribution pattern of 20-year old Grevillea robusta shade trees in tea (Camellia sinensis) plantations in Munnar, located in the tropical humid zone of the higher elevations of Western Ghats. Grevillea robusta contributed around 4150 kg ha⁻¹ yr⁻¹ of leaf litter, which in terms of NPK was estimated to be 75.2 kg N ha⁻¹ yr⁻¹, 41.2 kg K ha⁻¹ yr⁻¹ and 3.5 kg P ha⁻¹ yr⁻¹. While litterfall contributed nearly 61% of total N, 74% of P and 38% of K to the soil nutrient pool, loppings contributed only 12% N, 11% P and 19% K. The contribution of throughfall to the soil nutrient pool was relatively higher (24.6% N, 13.7% P and 38.7% K). Litter dynamics worked out using standard litterbag technique revealed that decomposition of litter was found to be faster in the initial stages of decomposition. The decomposition of tea litter was more rapid and was complete within 11 months as it had a higher decomposition rate as compared to G. robusta. Root compatibility studies conducted on tea bushes and associated G. robusta using root excavation techniques, measurement of starch concentration and root cation exchange capacity (CEC), indicated the possibility of a complementary relationship for nutrients and soil moisture. The majority of feeder roots (47%) of tea were found near the soil surface (0-45 cm depth) while a smaller proportion (33%) of feeder roots of G. robusta was observed in that layer, while the maximum proportion (67%) of feeder roots were confined to below-surface layers. The inverse relationship between starch concentration in
Patterns of tree biodiversity in coffee agroforestry systems of the Kodagu District, Western Ghats, India

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Abstract Coffee is a major world commodity and its production zones overlap with key biodiversity hotspots. The value of the coffee agroforestry systems (CAFS) as reservoirs of biodiversity and buffers for protected areas is well established in Central America and East Africa, but comparatively few studies have been undertaken in India, despite the fact that it produces 4% of the world’s coffee. Indian coffee is traditionally grown under shade. Located in the biodiversity hotspot of the Western Ghats, the district of Kodagu produces one third of Indian coffee in complex multi-strata agroforestry systems. The tree cover was traditionally made of thinned-down forest species, providing suitable microclimate to prevent the desiccation of the floral buds, abundant litterfall for nutrient cycling and some degree of control over pests such as the white stem borer (Xylotrechus quadripes) and diseases such as leaf rust (Hemileia vastatrix). New management practices including sprinkler irrigation and the conversion from Arabica (Coffea arabica) to Robusta (Coffea canephora) have resulted in important changes in coffee AFS features. Among them were a decrease in canopy cover that enhanced coffee yield, and a gradual replacing of the complex native tree cover by a monospecific cover of Grevillea robusta. While this intensification has increased farmers’ income, it has also had detrimental effects on the conservation value of the landscape. Through an integrated approach combining large-scale biodiversity assessment and socioeconomic surveys across the landscape, we documented the tree biodiversity associated with coffee AFS of the Kodagu district and explored the socioeconomic drivers behind the species arrangements that compose the canopy cover of these plantations. We identified key management practices and thresholds that could be targeted by public policies for the refining of payment for environmental services and certification schemes aiming at linking livelihoods, provision of ecosystem services and biodiversity conservation.

Perennial crop growth and interactive response to nutrient-loaded shade seedlings in multi-strata systems

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Session 01 Multistrata agroforestry systems with perennial crops

Abstract The beneficial effects of trees in fallow and agroforestry systems have been well documented. However, accelerated growth in agroforests may be offset by competition for limited resources on nutrient-poor sites and during the establishment phase. Strategies for precision in nutrient application and diagnosis are required to minimize interspecific nutrient competition and to optimize growth of target species, particularly as the use of expensive and environmentally hazardous external inputs declines. Nutrient loading, an accurate fertilization technique used in greenhouses to elevate nutritional status of seedlings for increased out-planting success, is used extensively for boreal species in plantation systems. To date, no work has applied nutrient-loading techniques to tropical species, particularly for multi-strata systems, or investigated its application in agroforestry systems at the farm level. Greenhouse nursery trials were established with nutrient-loaded shade trees, Terminalia superba, in Kumasi, Ghana. We hypothesized that the internal accumulation and retention of nutrients associated
with nutrient-loaded seedlings will lower stress on native soil resources after out-planting. This will permit increased nutrient availability for crop growth. After 4 months of bi-weekly additions, preliminary results showed *T. superba* seedlings produced significantly greater shoot (P = 0.0037) and root (P = 0.0143) biomass to exponential fertilization in comparison to the control, and corresponding sufficiency in nutrient uptake presumably occurred under exponential fertilization. Seedlings were then out-planted in monocultures and intercropped with cocoa seedlings. Effects of nutrient-loading level and species assemblage on individual plant performance and nutrition will be examined after 6 months. As the need for improved agricultural practices at the local level increases, this research will firstly develop precise and environmentally friendly plant nutrition technology for on-farm use in the tropics and improve out-planting performance in agroforestry systems, particularly on degraded or nutrient deficient sites.

**Smallholder farmer survival strategies in Arabica coffee agroforestry farming systems of East Africa**

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**Session** 01 Multistrata agroforestry systems with perennial crops

**Abstract** Smallholder coffee farmers in producing countries face many uncertainties given the nature of their product. In East Africa specifically, the domestic consumption is under 2%, ensuring that the farmers are subjected to the volatility of global markets. This also means that currency fluctuations affect smallholder farmers. Given information asymmetry, farmers are at the receiving end of the transaction costs of a constantly changing global market. At the farm level, the yields are not consistent either, based on access to inputs, labour and externalities like weather, pests and plant diseases. And when other factors like population and social pressures are added, the farmer is in a regime of very limited choice. Based on a farmer’s survey in the Arabica growing areas of Mt Kenya (Kenya), Lake Kivu (Rwanda) and Mt Elgon (Uganda), this paper attempts to assess farmer responses to externalities and limited choice in order to survive and better their lives. The paper briefly characterizes the pressures on farmers and evaluates in depth how farmers respond differently at different times to these pressures. It also compares and discusses the difference in the agroforestry farming systems and farmer survival strategies across the 3 countries. The results suggest that the farmers are finding it increasingly difficult to cope with the coffee markets and are trying to shift to other crops. But for many smallholders coffee is the only means to access cash because, along with having an assured market, the crop allows farmers to access credit from the coffee value chains or as an advance on the next coffee crop. Also, given the inconsistencies of local labour markets and limited access to off-farm sources of income, coffee is a significant part of the annual income of the farmer, hence maintaining its importance within the agroforestry systems in the region.

**Spatial decision support for coffee pests and diseases risk management in Costa Rican agroforestry systems**

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**Session** 01 Multistrata agroforestry systems with perennial crops

**Abstract** The occurrence and intensity of an epidemic are determined by the interactions of the host with the pathogen or the pest, the environment and the agronomic management (as shade management in coffee agroforestry systems). As a consequence of the spatial
heterogeneity of these factors, patchiness is the rule in the distribution of plant pests and diseases. Environmental information is now readily available in high resolution and can be combined with spatial analyses to determine potential pest and disease distribution due to environmental factors, and subsequently lead to better decisions and improved risk management. The objective of this paper is to show how better decisions and disease risk-adapted agroforestry practices, for entire coffee growing regions, can be derived based on spatial decision support tools and a minimum of ground data evidence. We used ground data, on coffee pests and diseases, collected in previous surveys conducted in Costa Rican coffee plots within a range of shade density. The diseases retained for our analyses were coffee rust (*Hemileia vastatrix*), American leaf spot disease (*Mycena citricolor*), and coffee blight (*Phoma costarricencis*). We first used the environmental data for the coffee plots with less shade density, and generated for the different diseases the decisive environmental driving factors by means of Geographical Information System (GIS). The climatic data such as radiation, precipitation and temperature are derived on a 1 km resolution. We used algorithms based on maximum entropy, Bayesian statistics, and spatial analysis to delimit areas with distinct risk potential. The results appraise the disease risk of coffee growing areas associated with their physical characteristics. For the areas where the results were significant, the decisive factors for each disease are identified and shade-management strategies are suggested according to their known effect on these factors.

The influence of shade trees on coffee quality in small holder AF systems in southern Colombia

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**Session**
01 Multistrata agroforestry systems with perennial crops

**Abstract**
Production of coffee, especially by small holders, is often associated with various forms of shade management. To analyse the effects of shade on physical coffee quality and on sensory cup quality of *Coffea arabica* L. cv. Caturra KMC, a study was carried out with 94 plots on 16 farms in 2 municipalities, Timaná and Oporapa, located at elevations from 1272 to 1730 m above sea level in Huila, Colombia. The study was designed with emphasis on shade cover variation within each of the 2 study areas, while minimizing the variability of environment, agronomic management other than shade, and post-harvest processing. Forty-six samples of shade coffee and 46 samples of sun coffee were evaluated for physical and sensory attributes using 3 professional coffee cuppers (assessors). A principal component analysis including all quality and environmental variables showed that sensory attributes were influenced negatively by shade, and that physical attributes were influenced positively by altitude. A mixed linear model, with coffee cupper and farm as random variables, revealed different shade effects on coffee quality in the 2 areas. In Oporapa, situated at high altitudes, shade had a negative effect on fragrance, acidity, body, sweetness and preference of the beverage, while no effect was found on the physical quality. In Timaná, situated at lower altitudes, shade did not have a significant effect on sensorial attributes, but significantly reduced the number of small beans. At high altitudes with low temperatures and no nutrient or water deficits, shade trees may thus have a partly adverse effect on *C. arabica* cv. Caturra resulting in reduced sensory quality. The occurrence of berry borer (*Hypothenemus hampei*) was lower at high altitudes and higher under shade. Further shade effects were assessed, such as influence on coffee plant health, though not quantitatively. The results led to immediate benefits to some farmers through improved marketing.
Use of CAF2007, a process-based model of coffee agroforestry systems, to represent and understand the evolution of coffee productivity in two long term trials in Mesoamerica

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Session: 01 Multistrata agroforestry systems with perennial crops

Abstract: Coffee is frequently cultivated under shade in Mesoamerica. The effects of shade trees on coffee productivity depend on the environmental conditions: mainly temperature, humidity, solar radiation and rainfall patterns. Crop models may be useful to assess current systems and modify their shade management, to improve productivity and provision of environmental services. The CAF2007 model was recently developed to simulate coffee growth and yield elaboration under shade at plot scale, under Mesoamerican environmental and technical conditions. The model was first compared with the scientific and local knowledge on coffee productivity under shade. Our results show that coffee phenology is correctly accounted for in the model, although the module that simulates the effects of light and water stress on flowering needs adjustment. The water module, carbon accumulation module and N balance module were then tested in coffee plantations, using 2 experimental data sets. When adequately parameterized, the modules did simulate correctly the variables measured, with a few exceptions. Proposals were formulated to develop or modify modules, to improve the simulations. The model was then parameterized to reproduce 2 data sets from two 7-year-old experiments of CATIE, with coffee cultivated under diverse shade trees and N management: one in Turrialba, Costa Rica, under humid conditions, with no definite dry season, and one in Masatepe, Nicaragua, with a very pronounced dry season. The model was able to reproduce the evolution of coffee bean production and the accumulation of biomass in the experiments. Functional explanations for observed evolutions, related to excessive shade and to insufficient N inputs, were proposed from the model. The implications of these results for future model improvement and applicability are discussed.

Using agroforestry to mitigate crop damage by grasshoppers, invasive weeds and other plant pests

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Session: 01 Multistrata agroforestry systems with perennial crops

Abstract: Grasshoppers are seasonal insect pests which resurface at the start of rainy season, the farming season and sprouting of new vegetation, feeding on almost all green plant material, damaging food crops, economic plant species and destabilizing ecological systems. Their actions are rapid, devastating and difficult to control. About 58 chemical control methods have been found to successfully eliminate grasshoppers, but chemical actions are extensive and will kill many other useful plant and animal species. An agroforestry approach using Cassia semen was adopted as a process that is cheap, environmentally safe, increases benefits, maintains ecology and biodiversity, eliminates other invasive weeds and pests such as Centrosema pubescens etc. Three trial plots of 1hectare each, hedged around with Cassia semen were set up. Plot I was an abandoned fallow, spot planted with Cassia semen; Plot II was cultivated, monocropped with maize and furrow line planted with Cassia semen; Plot III was cultivated and planted with assorted crops, maintaining existing economic trees in a mixed-cropping fashion with Cassia semen. Physical observation during 5 year periods on Plot I, indicated grasshoppers isolated Cassia semen and fed on the other plants. In Plot II, damage was high during the first 2 years and diminished as Cassia semen sprouted and...
developed, while stock borers appeared to increase over time. Plot III, had no damage or significant disease effects, instead productivity increased. *Cassia semen* was observed to have a toxic and repellent effect on grasshoppers as those that fed on it died. Mixed-cropping with trees prevented the spread of disease and pest epidemics in plant communities, ameliorated microenvironment and production. Non-determination of the chemical components or elements in *Cassia semen*, noted to be toxic or repellent to grasshoppers is a gap to be filled.

Keywords: agroforestry, biodiversity, cassia semen, ecosystems, pest control, plant pests.

**World-wide data meta-analysis confirms the advantages of shade-cacao**

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**Session**
01 Multistrata agroforestry systems with perennial crops

**Abstract**
Global change, biodiversity reduction and food security reduction due to soil-fertility losses are worldwide accepted arguments to encourage shade-cacao, but few global-level studies have explored why. Between 1973 and 2006, twelve published studies reported pH, total Nitrogen (Nt), available phosphorus (Pav) and exchangeable potassium (K) and organic matter (%OM) in cacao-soils. We standardized these results for the A-horizons by using bulk densities. Latitudes, altitudes, soil types, annual rainfalls and mean air temperatures were registered. Multiple linear regressions and non-parametric correlation for soil fertility categories in an ordinal scale, were run using Nt, Pav, K and %OM as response variables. Annual rainfall and soil pH were correlated (R=0.74, P<0.01) and used for regressions separately; autocorrelations were avoided. Agro-ecosystems were grouped into young (7-17 years) and old (>20 years), and shaded/non-shaded cacao. Two-way fixed-factor AN(C)OVA were used to test the effect of these treatments. Altitude, latitude, temperature and soil type had no effects (P>0.5 for almost all cases) supporting the proposition that pooling data for ANCOVA were correct. Greater annual rainfall reduced Nt (R=0.41, P=0.02) suggesting leaching, but increased %OM and thereby soil carbon-dioxide capture (R=0.53, P=0.03), and did not affect Pav and K. Cacao age had no effects in most of the analyses (P>0.05). Shade-cacao’s Nt averaged 7684.0 (SE=63.4) kg ha-1; six-fold non-shade cacao’s value (P=0.003), even when using rainfall and pH as co-variables (P=0.001). Shade-cacao’s Pav averaged 33.2 (SE=5.2) kg ha-1, three-fold non-shade cacao’s value (P=0.003) probably due to microorganisms. Acid soils had slightly more Pav than neutral soils (R= 0.51, P=0.06). As well as soil %OM, soil K was similar for shade versus non-shade cacao (about 300 kg ha-1, P>0.1) suggesting that cacao trees ‘pay-back’ the supplies of N and P to shade trees by uplifting K. Summarizing, shade-cacao are carbon sinks, and soil-improvers. However, many benefits remain in addition to those of forests suggesting that shifting agriculture should remain for a better food security.
Session 02
Agroforests in humid tropical Africa
Agroforests in African highlands: Dynamics and potentials in community land-use patterns

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Session
02. Agroforests in humid tropical Africa

Abstract
The African highlands are mostly found in Fouta Djallon-West Africa, in the western region of Cameroon in Central Africa, and a large ecological band covering East African counties such as Burundi, Rwanda, Uganda, Kenya and also Ethiopia. Those ecosystems reportedly comprise mosaics of crops and forested fallows and have rural communities that are dynamically concerned with integrating and conserving trees in their agricultural landscapes. Forests cover conversion into farmlands is therefore high with long-term fallows and interesting practices in mixed cash crops, such as communities growing trees for multipurpose uses in coffee, cocoa, tea or cashew plantations. However, for decades scientists have concentrated efforts on agroforests in other parts of Asia and Latin America and recently African lowland humid zones, ignoring similar systems in high-altitude landscapes found in many countries of Africa. As controversial debates are ongoing about the African agroforests in contrast with those of Southeast Asia and Brazil, this paper adds to the existing knowledge coherent descriptions of existing agroforests in African highlands while discussing the socioeconomic and ecological potential to deal with outstanding environmental and livelihood challenges of the rural poor in these overpopulated landscapes. In the study sites (Fouta Djallon of Guinea, Burundi and West Province of Cameroon), homegardens and traditional agroforests are scattered in the agricultural landscapes. Three categories have been revealed: semi-artificial agroforests, parkland-based traditional agroforests, and exotic tree plantation-based or artificial agroforests. Installation dynamics are similar to those in the low humid tropics, sometimes with less structural complexity. Plots sizes are ranging between 0.5 and 3.5 ha with very significant level of trees diversity and crop species. Finally, it is noted that African highlands host agroforests with valuable agrobiodiversity worthy of future interest for researchers and environmentalists especially for assessing ecological functions and socioeconomic performances.

Agroforests in the humid tropics: vanishing in Southeast Asia, expanding in Africa?

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Session
02. Agroforests in Humid Tropical Africa

Abstract
Agroforests are forest structures planted and managed by farmers for the production of various forest and agricultural products on the same piece of land. Usually established through a complex succession of development and production stages involving the planting of crops as well as of various commercial and useful tree species, agroforests mimic natural forest structures, with a complex multistuctura structure and a closed or almost closed canopy usually dominated by a few tree species. One of the important characteristics of agroforests – which makes them unique among the array of existing forestry systems – is their capacity to conserve a large part of forest biodiversity, as farmers do not systematically eliminate unused species, thus allowing the regeneration of numerous forest species. In Southeast Asia, where they were first described and characterized, most agroforests are currently under pressure and are gradually being replaced by other more productive and more profitable production systems. In Africa, recent research on agroforests shows that these systems are mostly expanding even though they are vanishing in a few places. In this paper, we review the literature on agroforests in Southeast Asia and in Africa, and we present a few hypotheses related to the apparently contrasted dynamics of agroforests in the 2 regions. While looking
at one region only may lead observers to view agroforests either as a remnant of the past or as a system of the future, this comparative review leads to a more balanced view, allowing us to define the overall social, environmental and economic conditions to which agroforests are adapted.

Coffee and cocoa base agroforests in the southern Côte d’Ivoire: evaluation of their diversity.

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Session 02. Agroforests in humid tropical Africa

Abstract The first producer of cocoa in the world, Côte d’Ivoire has developed huge plantations through national and foreign industry and multinationals. Alongside these huge plantations, the peasants produce some cocoa on a smaller scale. This occurs on farms belonging to individual farmers and their families. These plantations of smallholder producers are located on land around villages. Through their vertical and horizontal structures, these farms can be said to be agroforests. Most of them contain a significant number of trees, shrubs, palms, bananas and other fruit trees. This study attempted to describe and analyse these coffee and cocoa-based agroforests. It showed that agroforests of Cote d’Ivoire come from either the conversion of a natural forest or the conversion of secondary vegetation and fallows. They involve food crops and perennial crops such as coffee and cocoa. Botanical inventories achieved in 12 coffee and cocoa-based agroforests show that they are composed of 87 plant species and 10 species of birds, small mammals and insects. Among the plants, 5 species are identified as vulnerable on the IUCN’s Red List of endangered and rare species. The plant species recorded are used in medicinal, food, construction and for other mystical purposes. Finally, the study concluded that the sample of agroforests studied have a conservation value for biodiversity.

Keywords: agroforest, biodiversity, coffee, cocoa, Côte d’Ivoire

Comparative analysis of spatio-temporal dynamics in agroforestry systems in African peri-forestral zones: the case of Guinea and Cameroon

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Session 02. Agroforests in humid tropical Africa

Abstract In recent decades rural areas in the forest regions of West and Central Africa have been subject to rapid changes in their physical, social and economical environment. In some cases, local exploitation strategies have evolved towards agroforestry-based cropping systems like coffee and cocoa. The spatio-temporal dynamics of these systems are still poorly understood, however. To better understand these dynamics in the rural zones of two countries, in 2008 a comparative analysis was conducted of two situations in West Africa (Guinea) and Central Africa (Cameroon), both of which are located on the peri-forestral Guineo-Soudanian savanna. A geo-agronomical approach was adopted, combining aspects of territorial geography and agronomy of farmers’ practices. In both cases the evolutionary spatio-temporal dynamics of agroforestry systems was described and quantified. The results of this study confirm that over the last 3 decades the spatial footprint of agroforestry systems has heavily increased. In particular, coffee-based agroforestry systems have developed at the expense of annual crops in Guinea, while in Cameroon cocoa-based agroforestry systems have spread widely over the savanna. A better understanding of the dynamics of
agricultural practices and their impact on peri-forestial land in Africa is indispensable for a more thorough evaluation of the contribution of agriculture to the evolution of rural areas and their sustainable management. These changes urge a rethinking of analytical tools and intervention evaluations in the face of the challenge of sustainable development.

Keywords: agro-forestry systems, satio-temporal dynamics, coffee, cocoa, Guinea, Cameroon

How can agronomy deal with agroforests?

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Session 02. Agroforests in humid tropical Africa

Abstract

Agronomy is a scientific discipline whose main object of study is the cultivated field. It usually includes the biophysical functioning of the field seen as an agrosystem and the reasoning of actions applied on this agrosystem by the farmer. This second aspect leads to an up-scaling process towards wider levels of organization such as farm and landscape, through farming system research and land-use management. In the humid tropics, agroforestry systems (AFS) are the result of farmers’ actions and can be considered as cultivated fields characterized both by the combination of biophysical interactions and farmer practices. To study these complex systems, concepts and tools of agronomy should be applicable, but the majority of them were constructed from and applied to temperate agriculture. Moreover temperate agriculture is based on the rotation of a reduced number of annual monocrops. As a result, most of the concepts and tools of agronomy aimed at maximizing the productivity of simplified systems, nowadays in a sustainable way. But AFS have opposite characteristics, that is, i) the presence of perennial and ligneous species, ii) a high number of cultivated and/or harvested crops, iii) a high specific botanical richness, iv) a high structural heterogeneity, and iv) a significant renewal of species on a long time scale. These characteristics generate a more complex functioning, based on emergent properties, and various ecological and social services. In this context, are concepts and tools of agronomy applicable to AFS? What are the limits, interests, and necessary adaptations to use them in order to understand and optimize AFS? This paper analyses such limits and interests and offers directions for improvement. The concept of cropping systems, the basis of agronomy, is analysed for that purpose, from case studies on cocoa and coffee agroforests in Africa and Central America.

The money-tree and the safety net agroforest: cocoa cultivation in southern Cameroon

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Session 02. Agroforests in humid tropical Africa

Abstract

Classical economic models persist in analysing the performance of smallholder cocoa production only in the light of its contribution to international cacao trade, thus arguing for drastic technical transformation aiming to maximize the yield of systems that are conveniently viewed as basic cash crop plantations. But when analysed from the perspective of its historical adoption, the cultural features of cocoa cultivation emphasize the fact that these agroforests should be given priority consideration as an integral part of an overall diversified agro-ecosystem. Indeed, cocoa trees are intercropped with several high value tree species that provide shade to the cocoa tree and additional resources for the farmers. When conceptualized in the context of the whole agro-ecosystem dynamics, the persistence of very conservative technical practices has proved to be environmentally sustainable. We carried out extensive ethno-ecological studies on the land-use systems in two distinct
regions of cocoa producers in Cameroon: the humid forest zone inhabited by the Mvae and Ntumu, corresponding to the earliest area of smallholder cocoa cultivation, and the forest/savannah boundary where cocoa was adopted only in the 1980s by Eton and Tikar migrant communities. These two contrasted cultural and ecological environments highlight distinct land tenure strategies that directly affect the composition of the agroforests and consequently influence the yield and the role of cocoa in the land-use system. The paper explores the possibilities of enhancing the profitability of the existing cocoa production in ways that should not overshadow the resilience and the safety net role of such agroforests.

**Tree crop portfolios, life cycles and commodity markets in West Africa**

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**Abstract**  
In the humid tropics, a ready-market environment for export-oriented tree crops may lead to farming systems generating one overwhelming source of monetary revenues. This has been the case for cocoa for decades in West Africa. Whatever the complementary role of food crops and the use of shade trees, cocoa provides more than 90% of the monetary revenues to migrant cocoa farms in Côte d’Ivoire and Ghana. The first aim of this study was to update the information available about forms of intercropping or monocropping of the ‘big five’ tree crops in the humid tropics, cocoa, coffee, oil palm, coconut and rubber. They are considered here as ‘shares’ at the only ‘stock exchange’ available to smallholders in the humid zone: tree crops. How do smallholders combine the advantages and disadvantages of these shares to build a portfolio? The second objective was to identify the market factors interacting with other determinants that lead farmers to intercrop these trees in the same farm plot or a different plot. Surveys were conducted with some 500 farmers in the forest zones of Ghana and Côte d’Ivoire. Farm structure data were first recorded, followed by farmers’ opinions about advantages and disadvantages of various tree crops, and about the choice of intercropping. Farmers logically tended to opt for ‘shares’ that bring returns as early as possible. Monthly revenues, adapted to a modern life, was also very much searched for. Food security was not neglected. Some food crops were maintained in mature cocoa farms and still play the local role of ‘grocery’. Mainstream markets for the ‘big five’ do not seem to encourage smallholders to associate tree crops in the same plot, as if farmers were more confident in one share than in a trust fund. However, this leads to a kind of mosaic landscape which is not that far from agroforestry land use.
Session 03
Agroforestry in landscape-scale conservation strategies
Agroforest and other land-use types adjacent to protected areas on the dynamic of Sumatran tiger population

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Session 03 Agroforestry in landscape-scale conservation strategies
Abstract
The last 25 years of deforestation has shown a dramatic change of land use on Sumatra Island. The deforestation on Sumatra Island has caused a rapid loss and fragmented tropical forest into smaller blocks through the development of settlements, palm oil plantations, agriculture land, as well as agroforestry land. Currently, those land-use types exist in buffer areas of protected areas such as national parks and wildlife reserves. Conservation of the Sumatran tiger demands large areas to allow dispersal and maintain home ranges as well as genetic flows among sub-populations. Will existing land-use types adjacent to protected areas secure the persistence of the Sumatran tiger? Does agroforestry provide ecological benefits for the population dynamics of this big cat? We developed an individual-based model (IBM) on the dynamics of the Sumatran tiger population in Tesso-Nilo national park and adjacent areas. We simulate key behavioural aspects of the Sumatran tiger as well as potential conflict with humans through the adaptation of the existing TIGMOD model (Ahearn, 2001) which was successfully used to simulate the conflict between humans and tigers in Chitwan National Park, Nepal. We measured the number of tigers that survived, the number of new tigers born, and number of tigers lost due to human-tiger conflict as our main parameters in simulations of 20 years. We ran several scenarios on the effect of different land-use types, prey density in each land-use type to be tested, with our main parameters. The possible gaps of knowledge in the model, roles of different land-use types in particular agroforests on the persistence of Sumatran tiger are discussed. The developed model is expected to provide an understanding of the processes involved and roles of agroforests in the conservation of endangered species, as well as to guide the implementation of management strategies for the landscape.

Agroforests as a tool for sustainable landscapes or as intrusion into forests: landscape trajectories and negotiated development

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Abstract
Complex agroforests are often seen as providers of livelihoods while maintaining environmental services at levels close to that of natural forests. The alternative view, of agroforest as frontiers of a logically inevitable process of intrusion into forests and subsequent intensification leading to loss of environmental services, has received attention in the scientific literature, but less attention in public discourse. This paper draws on six ongoing case studies from the Landscape Mosaics Project, a collaborative project between the Center for International Forestry Research (CIFOR) and the World Agroforestry Centre (ICRAF), which conducts empirical and action research activities in frontier landscapes. The case studies from Africa and Asia illustrate diverse stages of human pressure and agricultural intensification. Agroforestry is part of the forest transition theory that emphasizes the return of tree cover after initial deforestation and a phase with low tree densities. In the Asian countries (Lao PDR, Indonesia), intensive tree crop systems such as rubber and oil palm plantations are currently replacing complex agroforests (Indonesia) and natural forests (Lao PDR), supported by national policies, with negative effects on biodiversity conservation. In the African countries studied, the existing agroforestry systems remain more diverse and extensive but signs of changes are emerging. The views of respondents revealed that
the majority of the demands from local stakeholders was for agricultural extension support, primary services or infrastructure development, and appreciation for maintenance of biodiversity was low. It may seem inevitable that participatory land-use planning processes and policies in search of improved livelihoods will lead to the demise of diverse ‘tree-rich’ landscapes and their ecological functions, and segregation of ‘forest’ and ‘agriculture’.

Two potential answers are: strategic spatial configuration of investments to maintain complex agroforests at a landscape scale, and the development of realistic incentives to keep biodiversity-rich (agro-) forestry systems as part of a regional portfolio.

Agroforestry as a tool in protected areas management in the Brazilian Amazon

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Session 03 Agroforestry in landscape-scale conservation strategies

Abstract Inhabited reserves cover over 37% of the Brazilian legal Amazon. Together with strict protected areas, they form landscape corridors covering millions of hectares that offer a framework for the large-scale, integrated conservation of natural resources and human livelihoods. However, the question of how to provide the inhabitants of remote reserves with sustainable development opportunities is still unanswered. Extraction of non-timber forest products rarely offers a way out of poverty, and the ‘sustainable’ management of timber by communities is a complex proposition with uncertain ecological consequences. Agroforestry has been advocated as an intermediate land-use form, potentially more profitable than extractivism and ecologically more sustainable than agriculture, but many agroforestry projects have also faced technical and marketing challenges. Inhabited reserves offer a framework for environmental service payments, but these alone will not sustain their inhabitants. We worked with riparian communities in the Tapajós National Forest and the Tapajós-Arapuins Extractive Reserve in the central Brazilian Amazon for over seven years to understand their land-use practices, the constraints and decision-making processes imposed by their biophysical, socioeconomic and political environment, and to propose development trajectories to improve their livelihoods while conserving their forest environment. The project evolved from community capacity building in techniques to increase the productivity of traditional rubber agroforests (which despite their abandonment during the 1990s still widely characterize the river banks) through the diversification of land-use systems, to the establishment of a community enterprise that allows reserve inhabitants to reforest their land and sell reforestation credits, a product for which remote reserves have a comparative advantage over wood-consuming enterprises. By making land-use practices economically and ecologically more viable, the project shows ways to strengthen the system of inhabited reserves that protects millions of hectares of Amazon forest with the consent of their communities.

Can golden-headed lion tamarins survive in cabruca agroforest? Management implications for an endangered species and habitat

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Session 03 Agroforestry in landscape-scale conservation strategies

Abstract Cabruca is a type of agroforest with planted cocoa trees and a native forest overstorey. It has been considered an important habitat for conservation of Atlantic Forest biodiversity in southern Bahia State, Brazil. Cabruca is the predominant forest habitat throughout the range of golden-headed lion tamarins (GHLTs), Leontopithecus chrysomelas, an endangered primate endemic to this region. Cabruca and the biodiversity it contains are now under threat in Brazil due to economic crisis in the cocoa industry. Understanding
how GHLTs use this agroforest and how the species is affected by cabruca management emerges as an important conservation objective for both species and habitat. We evaluated demographic and ecological parameters for GHLTs in different areas of cabruca agroforest. We captured and monitored four groups of GHLTs in four privately owned farms. Two of the areas were covered only by cabruca. The other areas were a mix of cabruca, primary and secondary forest. The groups were monitored using radio-telemetry for a 6-month period. At 20 min intervals we recorded the position of the group and the habitat type. Encounters with conspecifics were also recorded. In those encounters the group sizes of the non-focal groups were also recorded. Groups varied in size from 5 to 12 individuals. The largest groups include offspring of several generations and were observed in cabruca agroforest (10 to 12 ind. group-1). The average home range size was 115 ha (27 ha to 211 ha). Home ranges of two of the monitored groups included only cabruca forest and were smaller than those groups living in areas with different habitat types (92.5 and 136.5 respectively). These preliminary results suggest that GHLTs can live and reproduce in cabruca agroforests, with demographic and ecological aspects apparently similar to groups that live in primary forest. Thus conservation of cabruca agroforests directly contributes to conservation of this endangered primate.

Conservation of Prunus africana in agroforestry systems: effects on genetic resources.

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Session 03 Agroforestry in landscape-scale conservation strategies
Abstract
The Afromontane forest tree species Prunus africana has become highly valued for its bark extracts, resulting in unsustainable harvesting practices. It has been proposed that incorporation of the species in agroforestry systems could play a role in the conservation of its genetic resources. However, modification of the habitat context of tree species through clearance or plantation may have substantial and variable impacts on the mating system, resulting in increased inbreeding levels or altered diversity levels in seed crops. If incorporation of trees into agricultural systems is to be successfully used for the conservation of genetic resources, such effects must be taken into account. We use a fine-scale study of genetic variation and spatial genetic structure in a natural population and a plantation of Prunus africana, combined with spatially-explicit computer simulations of population genetics to explore the consequences for genetic diversity, of modifying population structure. Using these data and the literature, we suggest ways in which agroforestry use of Prunus africana might be modified to ensure sustainable genetic resource conservation.

Enhancing diversity of trees on farms proximal to a wildlife sanctuary: lessons from working with small farmers in the BRT Wildlife Sanctuary

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Abstract
Enhancing diversity of farms in forest-fringe areas has several potential benefits to the farmers and to the conservation of wild-biodiversity. Species and structural diversity not only increases biodiversity on farms but also may enhance habitat for diverse wildlife. Diversifying farms may provide marginal farmers with a higher degree of resilience against the vagaries of the market, climate and wildlife depredation. However, achieving increased diversity on farmlands of small-scale farmers in areas proximal to wildlife-rich areas has its own unique challenges. In this paper we report on the lessons learned over a 5-year
period with a goal to increase on-farm tree diversity of small tribal farmers in the Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary. The farmer’s choice of trees does not necessarily correlate with ‘our’ objectives of biodiversity enhancement. Farmers plant species that provide non-timber forest products, although the preference was more for fruit-bearing trees. Over the years, several thousand individuals of 13 native species of trees have been planted in cultivated landscapes. Farmers grow sun-loving cereal crops of finger millet and maize, therefore space for trees with larger shade-giving canopies is highly limited. The demand for grafted trees with smaller canopies is increasing. Grafting of native fruit-bearing trees was attempted with variable success. With an increasing number of farmers changing their primary crop to coffee, enhancing diversity of shade trees is not easy, as *Grevillea robusta*, an exotic fast-growing tree is preferred over native shade-tree mixtures. Also, policies that protect native trees from felling may lead to preference for exotics that have minimal felling restrictions leading to decreased diversity. In this paper we discuss the complex socio-ecological dynamics of practising agroforestry by small farmers proximal to wildlife-rich areas in South India.

Holistic analysis of coffee-based agroforestry and management priority setting in the northeast Atlantic Rainforest of Brazil

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**Session** 03 Agroforestry in landscape-scale conservation strategies

**Abstract**

A case study, funded by the Brazilian Ministry of the Environment in the Atlantic Rainforest, was conducted in the Baturité Highlands, Ceará State, to identify innovative farmers’ solutions with agroforestry system (AFS) practices. The site is an island of rainforest emerging from the semi-arid lowlands, and harbours 5000 hectares of shaded coffee dating from the end of the 18th Century. With 13% of forest cover remaining and harbouring a Critically Endangered 2008 IUCN Red List Category endemic parakeet (*Pyrrhura griseipectus*), this is a high-priority case for conservation. The performance of farm and AFS economic and ecologic indicators was explored by principal components analysis, aiming to identify variables to support policies. These shaded coffee farms contain 160% more native forest cover than is demanded by Brazilian law. Coffee produces an average of US$ 15 gross income (GI) per unit of human labour (UHL) invested, a value 1.8 times that of a competing subsystem – cattle ranching. Farms with a higher density of shade trees (340 versus 120 trees/ha) produce 15% less GI, but equaled GI per UHL invested in the system; and fruits in the AFS increase farm incomes. Projections considering improvements in coffee processing quality, shade and timber management indicate a 3.7-fold increase in the current GI (US$ 627 ha-1 year-1). With larger forest remnants to take care of, coffee productivity under 100 kg ha-1, an aging rural population, and real estate speculation as a negative outside vectors, farms over 50 ha are specially prone to conversion to banana farming, cattle ranching or real estate for tourism. Investments of US$ 173 to US$ 557 ha-1 year-1, financed over a period of up to 15 years, could competitively promote the recovery of these shaded coffee farms and their role in conservation-through-use of this Brazilian Atlantic Rainforest hot spot.

Incorporating agroforestry approaches into commodity value chains

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**Session** 03 Agroforestry in landscape-scale conservation strategies
Abstract

The productivity of tropical agricultural commodities is affected by the health of the ecosystem. Shade tolerant crops such as coffee and cocoa benefit from environmental services provided by forested landscapes, enabling landscape design that meets biodiversity conservation and economic needs. What can motivate and sustain adoption of such landscape approaches? Rather than a proliferation of externally funded projects there are major new opportunities through the international market that buys these commodities. Companies are promoting agroforestry approaches through their supply chain, requiring producers and traders to demonstrate that the source of their commodities complies with a set of principles that conserves forested landscapes and improves local livelihoods. This paper will present examples of international companies that are moving in this direction, analyse why and how they are doing it and discuss the impact that has been measured in coffee and cocoa communities in Latin America and Africa. It will particularly consider the role of standards and certification systems as a tool for promoting profitable production, environmental conservation and social responsibility, and for enabling the international market to communicate its commitment to its customers as the most responsible way to source goods from fragile tropical ecosystems. It will further argue that such approaches are already being taken to scale and are not operating only in small niches of the market.

Land use, AF and conservation in Sierra Madre Chiapas, Mexico

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Session 03 Agroforestry in landscape-scale conservation strategies

Abstract

The Sierra Madre (SM) is an unevenly inclined block mountain range of geologically old crystalline rocks rising sharply from the parallel pacific coastal plain. It is a highly biodiverse area resulting from holartic and neotropical provinces and dry-hot to humid temperate climates, and from seasonally deciduous through evergreen and cloud forest to Pinus Quercus forests. Three major biosphere reserves located in the SM were studied to identify the causes and actors of deforestation and possible ways to mitigate it. The SM is a historically isolated region that is set apart from main roads, scarcely populated, except in the SE tip. Inroads into this area came from adjacent livestock haciendas, from the depression till the end of the 19th Century, when several large coffee-producing estates were settled. The population around the reserves increased as a consequence of land reform from the mid 20th Century, generating a varied smallholder production. At present, the variability of coffee prices and the milpa (maize) crisis resulting from low crop prices and increasing input needs, have fostered a change in land use, with a tendency towards cattle raising and emigration. Immigration from the densely populated highlands by former coffee workers who are settling and opening new areas for agriculture has exerted an additional pressure. Highly weathered material, hurricanes, earthquakes, landslides and forest fires resulting from human activities, combined with deficient infrastructure, poverty and governmental policy coordination that is contradictory to production, conservation and settlement, pose a complex situation, the threat of land use change and fragmentation of natural reserves. Various mechanisms are being tried to counter the situation such as reforestation and diversification programmes, and environmental service payments for carbon, water and biodiversity. Conservation, ‘best coffee practices’ and organic coffee have been promoted. Soil and water conservation practices and strategies involving AF are fundamental in SM. Opportunities still exist to maintain and/or enhance biodiverse areas through improvement of productive and socioeconomic conditions in people’s livelihoods.
Large mammals in traditional cacao plantations and forest remnants in the Una-Lontras Corridor, southern Bahia, Brazil

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Abstract
Traditional cacao plantations (cabrucas) are a common habitat in southern Bahia and the mainland used in the corridor between two of the largest forest blocks in the region: Una Biological Reserve and remnants at Serra das Lontras. Given the high forest loss and fragmentation, cacao agroforests are considered critical environments for the native flora and fauna. Although large mammals have been previously recorded in cabrucas, little is known about which species are able to use these habitats and which landscape factors influence their use. We recorded large mammals in 31 cabrucas and in forest remnants adjacent to nine of these plantations using camera-traps to: 1) compare large-mammal frequency of occurrence between environments, and 2) investigate the influence of the amount of forest cover in the surrounding landscape on large mammal frequency in cabrucas. Eighteen native mammals were recorded in cabrucas, including four threatened species; six of these mammals (two of which were threatened) were seldom recorded, and five had sufficient records to allow comparisons. Two primates (Leontopithecus chrysomelas and Callithrix kuhlii) and the opossum (Didelphis aurita), a generalist species locally threatened by hunting, were widespread, being more frequently recorded in forest than in cabrucas, and/or more frequently recorded in cabrucas if these were surrounded by larger amounts of forest. Contrary to this observation, the frequency of occurrence of two common generalist carnivores (Cerdocyon thous and Procyon cancrivorus) in cabrucas was negatively influenced by the amount of forest, probably benefiting from the scarcity of specialist carnivores. Our results indicate that although cabrucas are a relatively permeable habitat for large mammals, including some threatened species, their frequency of occurrence in cabrucas depends on the amount of forest in the landscape. This suggests that the role of traditional cacao plantations in corridor conservation strategies will depend on the maintenance of forest patches at the landscape scale.

Poverty alleviation and environmental restoration through agroforestry

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Abstract
Poverty, hunger and increasing demand for agricultural land have driven local communities to over-exploit forest resources in Ethiopia. Forests surrounding the township of Humbo, 420 kilometres southeast of the Ethiopian capital, Addis Ababa, were largely destroyed by the late 1960s. In fact, across Ethiopia, less than 3% of native forests remain today. In 2005, World Vision Australia and World Vision Ethiopia, identified forestry-based carbon trading as a means to stimulate ongoing community development while engaging in environmental restoration. After two years of consultation, planning and negotiations, the Humbo Community-based Natural Regeneration Project was born – World Vision’s (and Ethiopia’s) first carbon trading initiative. The Humbo Project assists communities significantly affected by environmental degradation with an opportunity to benefit from the global carbon market while simultaneously reducing poverty and restoring the local agro-ecosystem. The project involves regeneration of 2,728 hectares of degraded native forests. Forest regeneration brings direct social, economic and environmental benefits to local communities facilitating adaptation to a changing climate and generating certified emissions reductions (Carbon Credits) under the Clean Development Mechanism. A key
feature of the project has been to focus on creating a favourable or enabling environment in which communities can readily embrace new techniques and take responsibility for large-scale environmental change, the most important of which is Farmer Managed Natural Regeneration (FMNR). This technique is cheap, replicable, and provides early benefits. For example, communities commenced harvesting fodder and fuelwood within a year of project initiation, and the harvest of wild fruits and other non-timber forest products is increasing. Farmers are using agroforestry as a means of environmental restoration and income generation. Effectively, the establishment of user rights and local cooperatives has laid a foundation for community ownership and even enthusiasm for this project empowering the community to manage and sustainably harvest tree regrowth.

Shifting cultivation landscapes: the impact of land-use dynamics on the contribution of fallows to biodiversity conservation.

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Abstract
Fallow vegetation within landscapes dominated by shifting cultivation is often considered as a successional phase towards forest restoration. It also represents a woody species pool of critical importance with considerable potential for biodiversity conservation. Here, through integrated analysis of land-use changes over time and space in three contrasting forest margins in southern Cameroon, we reveal that plant species diversity in fallows is declining. At the two sites with higher population pressure and greater market orientation, the area under short fallow increased over a fifty year period, and individual patches became consolidated as the dominant matrix. This was coupled with degradation of the remaining forest patches. A high variability in woody species composition and abundance of similarly aged fallows occupying different spatial locations reflected the consistently significant effect of the spatial heterogeneity and stability of the surrounding agricultural matrix. Overall, intensification of land use, in tandem with expansion of the cultivated area, led to a decline in the fallow species pool, with composition becoming increasingly dominated by species adapted to recurrent disturbance. It is clear that without intervention, the potential of fallow vegetation to contribute to biodiversity conservation will decline because of a reduced capacity to 1) recover forest vegetation with anything like its original species composition, and 2) connect less-disturbed forest patches for forest dependent organisms. Strategies to combat biodiversity loss, including promotion of agroforestry practices and the increase of old secondary forests cover, will need not only operate at a landscape scale but also need to be spatially explicit, reflecting the spatial pattern of species reservoirs and dispersal strategies and human usage across landscapes.

Smallholder cocoa production systems and biodiversity conservation in West Africa

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Abstract
Environmental and productivity trade-offs between agroforestry systems of tropical perennial crops versus intensified full sun production systems are crucial for land use land cover change (LULCC) management in the forest landscape of the humid tropics. Certification of the environmental attributes of shade-grown coffee and cocoa is rapidly developing into an important niche market as some consumers demonstrate a willingness to pay premi-
ums for these attributes. We examine whether agroforestry systems with low productivity actually increase the overall levels of global environmental goods such as sequestered carbon and biodiversity as compared to higher yielding intensified systems. The focus of our empirical enquiry is the West African cocoa sector where a range of production systems are found. We assess the environmental trade-off between agroforestry systems and intensified systems by considering the quantity of environmental services foregone per ton of cocoa produced. The economic tradeoffs are evaluated using enterprise budgets. The study considers Cameroon, Nigeria, Ghana, and Côte d'Ivoire whose combined production accounts for over 2/3 of global supply. The results of a long term (12 year) fertilizer plus shade trial conducted on-station in the 1960s in Ghana form the basis for pondering what today's landscape might have been like if intensified systems had been adopted by smallholder cocoa farmers a generation earlier. The study is concluded with a discussion about cocoa production and biodiversity conservation strategies examining their overlap and interactions.

Key words: Guinean moist forest, biodiversity conservation, development/environmental tradeoffs, conservation corridors, buffer zones, global public goods, niche markets.

The conservation value of the shade cacao plantation for the atlantic forest biota in northeast Brazil

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Abstract
In Brazil, shade cacao plantations – known as cabrucas – comprise most of the current forest cover left in the most representative remnant of the northeast Atlantic forest, and here we discuss two main topics related to the potential value of cabrucas for regional biodiversity conservation. First, by assessing selected groups (ferns, frogs, lizards, birds and bats) in forest fragments (< 300 ha) and cabrucas located in two contrasting landscapes, one dominated by forest with some interspersed cabrucas, and one dominated by cabrucas with dispersed forest fragments, we attempted to address the influence of the presence of primary forest in the landscape on the ability of cabrucas to harbour forest-dependent species. Secondly, we addressed the contribution of cabrucas, and the impact of an increasing intensification of management practices, on the conservation of tree species at the landscape scale, by assessing trees in 12 cabrucas (2.4 ha). Our results showed that plantations located on landscapes with a greater representation of native forests hosted at least 10% more forest-dependent species compared to the less forested landscape (63.25 and 74.09%, respectively). Landscape context also influenced the species composition and the spatial partition of species diversity of some biological groups. For trees, cabrucas represent a major suppression of the original forest structure, with species composition being very similar among different cabrucas, particularly those under a more intense management. In all cases, cabrucas are dominated by pioneer and exotic trees, with rare individuals representing species of important conservation value such as threatened species. Although cabrucas can contribute to the conservation of many forest species, on the basis of our results we propose a cautionary view on the cabrucas’ role in tree species conservation in a landscape scale, pointing to the need to preserve sufficient areas of primary habitat in the local landscapes.
The role of cardamom agroforests for biodiversity conservation in Tanzania

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Abstract:
Is shade-grown agriculture an ecologically viable answer to tropical forest restoration and connectivity? The East Usambara Mountains of Tanzania contain what may be the most biologically rich forests in Africa. Within the current era of promoting conservation incentives for expansion of forest cover, encouraging shade-grown cardamom is proposed as a method to utilize private land to expand forest cover in order to increase ecosystem services and habitat for biodiversity. Most of the ecological research in this area has occurred within protected government forests. This study fills a critical data gap by providing empirical floristic evidence of the role of cardamom farms in biodiversity conservation and the ecological functionality of cardamom forests as corridors and habitat for forest species. Floristic data from protected areas, mature secondary growth, and active and recently inactive cardamom farms are analysed to determine the ecology and conservation value of cardamom forests. The results are discussed in the context of current economic and development realities in the East Usambaras, and related to relevant literature from other tropical agroforestry systems. Although, cardamom farms on average are only slightly poorer than natural forest in some biological aspects including species richness and endemism, they differ in attributes of canopy structure and size-class composition, and are dominated by an invasive exotic tree. Agroforestry may not be the best method to increase connectivity of a biodiversity and endemic species hotspot. However, compared to the sun-grown crops that are replacing the cardamom forests due a number of converging factors, agroforestry is seen as having a role in the East Usambara landscape.

The wicked elephant of the east: Coping with human elephant conflicts in coffee agroforestry landscapes in Kodagu (India)

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Abstract:
Human elephant conflicts (HEC) occur when both species’ habitats overlap. These conflicts cause detrimental effects on human social, economic or cultural life, on elephant conservation and on the environment. In Kodagu district (India) such conflicts have caused 6 deaths and 1 USD 000 of damage on average per year over the last decade, compromising the conservation of this flagship species. Kodagu produces 1-2% of the world’s coffee, in complex multi-storied agro-forestry systems. The district forests harbour a large population of the Asian elephant (Elephas maximus). The combined effects of high elephant density and major landscape changes due to the expansion of coffee area appear to influence the intensity of HEC. Mitigation strategies, including electric fences and compensation schemes through the Forest Department have shown limitations. Building on previous studies, we assess the current spatial and temporal trends of HEC, analyse local stakeholders’ perceptions and identify the factors attracting the elephants into coffee estates. Our study shows: 1) established elephant dietary preferences for paddy and coffee; 2) a lack of coordinated action among the stakeholders; and 3) elephant movement along corridors connecting the eastern and western forests of the district are the major drivers of HEC intensification. The multiplicity of stakeholders involved, the difficulty in defining the problem, and the limits of the technical solutions proposed, suggest that HEC in Kodagu is a complex problem. We propose alternative strategies such as development of insurance schemes or an elephant-friendly coffee label that could raise public tolerance towards elephants. Conflict resolution in Kodagu requires a combination of deterrent, compensation and tolerance-raising strategies and the acknowledgement by the stakeholders of the true nature of the problem at hand.
Session 04
Agroforestry in Mesoamerica: current perspectives and challenges
Agro-ecological systems functions and their role in restoration in tropical degraded areas

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Session 04 Agroforestry in Mesoamerica: current perspectives and challenges

Abstract The county of Zozocolco in Veracruz, Mexico, is mainly inhabited by indigenous people from the totonaca ethnicity. In 2003, our team initiated a participative research project that focused on analysing and changing productive process dominated by maize crops, cattle ranching and citrus fields. Our results showed that some of the traditional totonaca agroforestry practices such as pepper and vanilla cultivation are still part of many productive systems. We found that the vanilla cultivars are re-emerging and they have a good potential for conservation. Our study also shows that coffee plantations are being subjected to new processes of management. Growers are abandoning their coffee plantations due to very low prices and therefore secondary forest area is increasing. However, a detailed diversity study on secondary vegetation showed biodiversity losses in tree species. This situation was a constant challenge for restoring degraded areas, because there is not enough diverse germplasm available. Therefore, our research also included the ecological study of native species for restoration purposes and agroforestry systems. Some of the species that we studied included Brosimum alicastrum, Carpodiptera ameliae, Castilla elastica, Ceiba pentandra Cojoba arborea and Diospyros digyna. All these activities have showed that restoration implies consideration of several factors such as traditional practices, market influences, public policies for land use and biodiversity issues. This project also proposes land planning actions to restore a more ecological land use for the near future.

Agroforestry systems and their contribution to the maintenance of biodiversity in arid areas: the case of Tehuacán Valley, Mexico

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Session 04 Agroforestry in Mesoamerica: current perspectives and challenges

Abstract We examined the ability of the main agroforestry systems of the dry Tehuacán Valley, Central Mexico, to maintain species richness and diversity of native vegetation and genetic variation of some key species. We identified the agroforestry system called ‘chichipera’ which maintains on average 72% of the plant species richness, and the system called ‘jiotillal’ which maintains 58%; no significant differences in species diversity were found between the wild vegetation and agroforestry systems (t=3.3471’ p=0.0886 in chichipera; and t=0.9659’ p=0.2453 in jiotillal). On average the agroforestry systems retain 54% of native perennial plant species, 94% of the genetic variation of species of columnar cacti existing in wild populations, and the population growth rate (?) of one species studied is >1. The traditional agroforestry systems therefore are able to maintain biological diversity and processes of recovery of populations of key species that are impacted by land clearing practices. However, their ability to preserve rare and endemic species is limited. Processes influencing the maintenance of perennial species in agricultural parcels include: i) collective rules; ii) training and dissemination of information by the staff of the local Biosphere Reserve; and iii) the exchange of information for researchers between different institutions. However the agroforestry systems are under a process of loss, mainly influenced by: i) government programs aimed at removing patches of vegetation within agricultural land; ii) inequity in the amount of land managed by households; and iii) introduction of technologies to intensify agriculture. Policies to stop the negative processes and enhance the positive ones are discussed.
Agroforestry garden design within an archaeological site to reinforces environmental culture in Mexican tourists.


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Session: 04 Agroforestry in Mesoamerica: current perspectives and challenges

Abstract

The opening of archaeological sites near the biggest Mexican cities represents a diversified attraction for tourists of all ages, 98% of national origin and 2% foreigners. However it is known that development has been sustained in Mexico with the excessive use of natural resources, giving origin to the present degraded landscape. The establishment of a thematic agroforestry garden was started in July 2007 within the prehispanic archaeological site Cañada de la Virgen in the municipality of Allende, Guanajuato; the main objective are to: reinforce abilities and attitudes that allow the understanding and appreciation of man, culture and surrounding biophysical resources relationships; and to harmonize didactic material (non-formal environmental education) with the assessment of natural resources and biodiversity on employees, neighbours and visitors. The garden was established over a surface of 4900 m2 (70 x 70 m wide and long), divided into seven thematic areas according to the use and environmental services offered by the native vegetation to the prehispanic people: non-wood products, domestic utensils, fuel and food, construction, ornament and environment, medicine and ceremonies. Shown in each area are: concepts on symbolisms or ritual meaning, and cosmic conception; relation and meaning of the atmosphere-prehispanic man (tolteca-chichimeca culture); natural meaning of caves, hills, mountains and other resources; and calendar on the basis of the horizon. The garden was planted with 306 native multipurpose shrubs or trees in rainfall conditions, under a xerilandscape concept. Until the present, 95% of the species have survived and 50% of the infrastructure construction has been obtained. In July 2009 the archaeological site will be opened to the public and we are going to evaluate the impact of the thematic garden on the perceptions of the visitors related with the value of native vegetation and educational agroforestry designs in landscape restoration of semi-arid regions.

Decision-making processes for incorporating Leucaena leucocephala in silvopastoral systems by participants in livestock farms

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Session: 04 Agroforestry in Mesoamerica: current perspectives and challenges

Abstract

Leucaena leucocephala is native to Guatemala, as well as other Mesoamerican countries, but it was not commonly used in livestock systems in Petén. Livestock farmers who participated in farmer field schools (FFS) aimed to promote sustainable land-use options in degraded pasture lands, attended several group-learning sessions on Leucaena establishment, management and utilization as part of the FFS curricula; but after these sessions, each took their own decisions on applying spatial arrangements, planting methods, utilization, etc. in their own farms. In order to analyse the decision-making process to adopt the Leucaena technology, 29 adopters (30% of the early adopters) and 6 non-adopters were chosen, applying a non-probabilistic by convenience sampling method. The decision-making trees were organized using cause effect models applying the software Netica Version 1.12. Among the most limiting factors for the incorporation of Leucaena were: limited seed availability; high labour demand; and capital limitations for land preparation and management during the establishment phase. Weed competition and insect attacks – mainly ants were the main limiting factors during the establishment phase (for 43 and 29% of farmers, respectively). Fifty-nine percent had to replace plant losses due to insect attacks. Most farmers (69%)
intercropped *Leucaena* with either annual crops (mainly maize and beans), pastures, or both, in order to reduce weed competition and eventually recover planting costs. Ninety-seven percent decided to use *Leucaena* under browsing, but only 41% percent wanted to daily move the animals to protein banks. The diversity of spatial arrangements, planting methods and management strategies applied by FFS participants differ from the less variable options used by farmers under traditional technical assistance for establishing *Gliridia sepium* as protein banks in southern Nicaragua, suggesting that the FFS approach trains farmers to adapt innovations to their own farm conditions, increasing the potential for adoption of silvopastoral technologies.

Evaluation of four PES schemes for landscape connectivity in the Mesoamerican Biological Corridor

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**Session** 04 Agroforestry in Mesoamerica: current perspectives and challenges

**Abstract**

The payment for environmental services (PES) is a popular policy instrument for biodiversity conservation in Central America. The main concern when designing PES is to estimate a cost-efficient monetary payment that assures the provision of the environmental service. In Central America, the design of monetary payments has been done based on tree plantation costs (DIAZ 1998; PAGIOLA 2002) or based on the cost of the agroforestry/forest management plan (PAGIOLA 2002). These simple approaches, although practical, cannot guarantee that the policy will succeed in providing environmental services. This paper analyses the economics of four PES payment schemes for landscape connectivity in Central America. It is done by using a non-linear bioeconomic model, which simulates a silvopastoral system of three components (grass, cattle and trees). The simulation also considers three kinds of producers, which are representative of the study area. The four PES payment schemes are: payment for standing trees; payment for standing trees per diameter class; payment per changes in basal area; and payment per planting trees. The PES scheme that yields the lowest financial budget is paying for changes in net basal area; this payment is also administratively friendly because the basal area indicator is easier to estimate in the field. In contrast, the PES for planting trees yields lower canopy levels with similar budgets than a PES that pays for standing trees or for changes in basal area. A PES for silvopastoral systems focused on increasing tree cover in agricultural landscapes has economic and social advantages compared with a PES for forest plantation. The PES for silvopastoral systems for landscape connectivity, however, may have a reduced impact on poverty alleviation.

Improving farmer livelihoods by increasing agrobiodiversity: a case study in the state of Veracruz, Mexico

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**Session** 04 Agroforestry in Mesoamerica: current perspectives and challenges

**Abstract**

This research was conducted during 2007 with the aim of contributing to livelihood improvement of citrus producers through increased agrobiodiversity in the state of Veracruz, located on the Atlantic coast of southeast Mexico. Citrus-based agriculture is the principal economic activity in the agricultural sector of the state of Veracruz. It is practised in monocrop plantations by the majority of farmers, who are rendered vulnerable to price depreciation resulting from simultaneous harvest and over-supply of a single commodity. Some innovative farmers have therefore associated multiple crops in citrus farms (agroforestry techniques)
as a strategy to improve their livelihoods. The results indicate that farmers who increased agrobiodiversity in their farms have significantly improved their livelihoods compared to mono-crop plantation owners. Further, the associated benefits can be classified in three ways, which correspond to the tripartite goal of sustainable development: (i) ecological sustainability (through increased ecosystem resilience); (ii) economic stability (through diversified, less risk-prone sources of income); and (iii) social well-being (through lower unemployment and increased reliance on indigenous knowledge). Conclusively, it is argued that increased agrobiodiversity can serve as an important strategy to improve the livelihoods of citrus producers in the state of Veracruz. However further research is required to recommend appropriate plantation crop combinations suitable for different biophysical conditions and easy adoption by different categories of farmers.

Keywords: agrobiodiversity, rural livelihoods, citrus plantations, citriculture, agroforestry, multiple cropping, Veracruz, Mexico.

**Participatory domestication of an under-exploited fruit/oil tree: *Persea schiedeana***

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**Session** 04 Agroforestry in Mesoamerica: current perspectives and challenges  
**Abstract**

*Persea schiedeana* (chinene), a relative of avocado is a commonly utilized shade tree in indigenous coffee groves in the Gulf of Mexico-facing slopes of southeast Mexico from 400 m to 1300 m. In most local areas it is an important part of the diet and in some areas it is an important item of commerce, at times fetching prices as high as or higher than avocado. However, the fruit is essentially unknown outside its native range, except for the limited work carried out to screen it as a Phytophthora-tolerant root stock for avocado (*Persea americana*). The study presented here looks at the ethnoecology and management of *Persea schiedeana* in the Chinantla area of Oaxaca, Mexico. It also documents the morphological diversity of the fruits in the area, which is quite high. The study finds that those trees that were intentionally planted have larger and better tasting fruits when compared to trees that came up alone in the forest or coffee groves. This suggests that human selection on *Persea schiedeana* has been successful. A participatory domestication project was initiated by the researcher and local resident research assistants. Seedlings were planted in six villages to serve as root stock. While morphological data were being collected on the fruits of mature trees in each village, ‘chinene fairs’ were held and in each village, at which the best fruits were chosen. Bud wood from these best fruited trees will be grafted onto the planted root stock in upcoming grafting workshops. This project seeks to instill in villagers the skills (grafting), the techniques (selection of best fruits) and the desire to conduct such improvement schemes not only with *Persea schiedeana* but also with other local fruits that are important in local diets and/or have market potential.

**What will drive the expansion or contraction of agroforestry systems in Central America in the next decades?**

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**Session** 04 Agroforestry in Mesoamerica: current perspectives and challenges  
**Abstract**

Agroforestry systems, such as shaded coffee, multi-strata cacao, and the diverse use of trees in cattle ranching, have played prominent economic and biophysical roles throughout Central America. Global, regional and local changes are impacting or will probably impact
performance of these systems and, hence, their expansion or contraction at the landscape or farm levels. We used a participatory prospective process, adapted from the Delphi method, to analyse the perceptions and appreciations of stakeholders and experts in the areas of coffee-shaded, silvopastoral and multi-strata cacao systems in the region. Iterative interviews and focus groups concentrated on the stakeholders’ and experts’ identification of the principal factors driving change in agroforestry systems and their appreciation of the influence these will have on the systems in the future. Political, economic, biophysical, and sociocultural factors were identified as the main drivers of change. Political drivers included, but were not limited to, bilateral and multilateral free trade agreements as well as government programmes related to food security and biofuel production, aiming at reduced dependence on imports of basic grains and fossil fuels, respectively. Predominant economic or market drivers included price trends of major agroforestry crops or products, such as coffee, cacao, beef and dairy products, as well as opportunity costs of their production in view of increasing prices of land, fertilizers and basic grains. Climate change figured prominently as an important biophysical factor given its anticipated impact on which plants can be grown, the incidence of pests and diseases, as well as changes in soil characteristics. Among the sociocultural factors, demographic changes, rural-urban migration and alternative aspirations of the younger generation, were identified as relevant drivers. We conclude that depending on different factor combinations certain agroforestry systems in given regions are likely to expand while others are likely to contract.
Session 05
Ecological sustainability: panacea or Pandora’s box?
Agroforestry management systems for biofuel production and environmental services in Minnesota, USA

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Session  05 Ecological sustainability: panacea or Pandora’s box

Abstract

Minnesota is recognized as one of the leaders in advancing the use of biomass feedstocks for energy in the United States and is also a proponent of promoting agroforestry for economic and environmental services. With continuous demand of feedstocks for energy, several policies and mandates exist from both the federal and state governments. One of the mandates includes a dramatic increase in the production of crops used as biofuel feedstocks. The dramatic expansion of lands used for agriculture to satisfy the mandate could degrade environmental quality. For instance, production of common biofuel feedstocks such as corn and soybean require significant inputs of fertilizer, pesticides and water for irrigation. Increased fertilizer use associated with these biofuel feedstocks production can lead to nutrient pollution of waterways due to high risk of soil erosion. Increasing biofuel production capacity will necessitate bolstering biofuel production from corn and soybean in the Midwest with crops grown in other regions of the country and with crops other than those conventionally used as biofuel feedstocks. Agroforestry systems and practices such as alley cropping, riparian buffers and windbreaks are now considered as potential land-use systems that can help address the biomass energy requirement in Minnesota while addressing some of the environmental problems in the state. Agroforestry systems also provide key ecosystem services, such as increased carbon sequestration, reduced nitrogen pollution of waterways, and increased wildlife diversity while producing biofuel feedstock that can be harvested for bioenergy. This presentation will focus on the current agroforestry projects and initiatives in Minnesota that address the issues on biomass feedstock production for energy and issues associated with environmental quality and protection, such as water quality improvement, soil erosion prevention and carbon sequestration enhancement.

Contribution of multipurpose trees to dairy cattle production and nitrogen balancing in crop and fodder fields in Uganda

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Session  05 Ecological sustainability: panacea or Pandora’s box

Abstract

Multipurpose leguminous trees are an important resource for ruminant livestock feed and natural resource management in the tropics. Leaves of Calliandra calytrhorsus, Gliricidia sepium and Sesbania sesban contain 18-23% crude protein (CP). In addition, these trees can control soil erosion by 50% and have the ability to fix up to 25 kg ha-1 year-1 of nitrogen. Based on this potential, the importance of the need to sensitize farmers about their benefit and use was realized. However, it was found necessary to first assess the current status of the use of these plants and their current effect on livestock performance and nutrient balancing within production systems. A study was therefore done in the districts of Masaka and Jinja among intensive and semi-intensive dairy farms. Data collected over a period of 3 growing seasons showed that multipurpose trees were used on 45% of dairy-intensive dairy farms, however, they constituted only 13% of dairy cattle feed, while in the field they covered 5% of the farmland. Milk production (kg TLU-1 day-1) on farms feeding multi-purpose tree fodder was 17% higher (P<0.01) than farms were MPTs were not being fed. In terms of natural resource management, multipurpose trees contributed up to 10 kg Nha-1 season-1 in fields where they were established, and as a result they had a tendency of raising field nitrogen balances. In addition, yields for bananas were 26% higher where in plantations where multipurpose trees had been interplanted compared to those where there were no multipurpose trees.

Keywords: Multi-purpose trees, cattle feeds, nitrogen balances
Ecologically sound poplar-based agroforestry models bringing revolutionary economic returns in the Indo-Gangetic Plains

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Session 05 Ecological sustainability: panacea or Pandora’s box

Abstract Poplar-based agroforestry models have been widely accepted by farmers and have emerged as one of the viable options for overcoming problems caused by intensive rice wheat based cropping systems. Site specific poplar clones have been developed having a higher productivity and resistance to pests and diseases. Farmers successfully grow annual crops and seasonal crops. The reduction in wheat-grain yield, under poplar, varied from 10.2 to 46.6% from 1st to 6th year as compared to an open field. Selection of a shade-tolerant crop variety, appropriate sowing time, irrigation, seed and fertilizer dose help to mitigate yield losses of intercrops sown in poplar block plantations. Wheat sown during the first fortnight of November produced a significantly higher grain yield than other sowing periods. Wheat variety PBW 502 performed best amongst the six wheat varieties tested under poplar. Tree crop interactions influence the damage caused by insects and diseases. Cultural practices reduce the number of hibernating pupae of poplar leaf defoliators (PLD) which subsequently lead to a lower incidence of these defoliators. The percentage of damaged leaves was more in fallow (5.44 - 60.53) and less in intercropped plantations (2.49 - 49.20). The PLD adult emergence percentage was significantly less in intercropped and ploughed (49.5 and 67.5) than in fallow (83.0) plantations. The litterfall and nutrient return through litterfall increased with increase in plantation age. The total quantity of 20.1 t/ha leaf litter and 176, 21.7, 133 and 368 kg/ha N, P, K and Ca, respectively were returned through litterfall in 6 years. The organic carbon and available nutrient (N, P and K) status after six years was higher in the agroforestry system (poplar plus crops) thank in the control (crops only). The comparative economics of the poplar-based agroforestry model in block and boundary plantations revealed that these were 2.8 and 1.6 times more profitable respectively, than the rice wheat rotation.

Ecological sustainability: Lessons from alley cropping research in the US southeast

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Session 05 Ecological sustainability: panacea or Pandora’s box

Abstract The use of alley cropping systems in temperate regions has gained popularity as farmers and scientists have recognized the ecological and economic advantages of these systems. Alley cropping systems have been shown to have positive impacts on both crop yield and site environmental quality, and thus represent potentially sustainable means of agricultural production. These systems can offer appeal to temperate region farmers, given that they can be adapted for large-scale mechanized production. Moreover, they provide unique opportunities to satisfy several agricultural and environmental objectives simultaneously, such as erosion control, soil fertility, pest management, and crop diversification. However, the complex biophysical interactions of trees, plants and fauna that determine the ecological sustainability are still not fully understood. Although scientific principles developed in the tropics may be applicable in other locales, site-specific research and demonstration are needed for the broad spectrum of environmental conditions found across the temperate world. Lessons learned through two alley cropping trials, pecan cotton and pine cotton, in the southeast United States will be presented with the goal of developing indices for ecological sustainability.
Food security and agroforestry tendencies of slash-and-burn agriculture as a transitional land use

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Session: 05 Ecological sustainability: panacea or Pandora’s box

Abstract
Field evidence and local knowledge revealed the ecological nature of swidden or slash-and-burn agriculture (SBA) in the biodiversity-rich corridor of southern Batangas, Luzon Island, the Philippines. Swidden fragments between 400-700 m altitude were analysed through semi-structured interviews, direct observation and photographs; and the information gained was used to account for cropping diversity and reconstruct the swidden evolution and further land-use conversion. SBA practitioners: create diverse food-crop production; sustain indigenous varieties; allow for the natural agents of seeds and fruit dispersal to happen; recycle phytomass; and encourage micro-climate change mitigation. In contrast to mealy bug-infested sugar apple plantation, SBA is found to maintain higher levels of plant diversity and to produce a number of potential niche products. Swiddens were found to be an important reserve for at least 10 species and 6 families of vegetables, 7 species and 6 families of root crops, 13 fruit trees in 10 families, 5 species of legumes and pulses in 2 families, 7 spices in 4 genera and 3 families, 4 forage and pasture species belonging to 3 families and 7 species of other valuable crops. The post-swidden alternative land-use such as a palm-based agroforestry system and fodder plantation can then compensate in the long run for the ecological impact of slash-and-burning during swidden conversion from secondary forest thus providing economic benefits to mountain farmers and ensuring ecological benefits.

Keywords: food security, indigenous species, mountain agriculture, secondary forest, swidden

Microbial properties of soil as affected by intercropping Fraser fir (Abies fraseri) and cover crops

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Session: 05 Ecological sustainability: panacea or Pandora’s box

Abstract
Soil microorganisms play a key role in nutrient cycling in low-input management systems, and their responses to groundcover management practices may critically contribute to agricultural system sustainability. In order to understand the effect of groundcover management on soil microbial properties, soil microbial biomass carbon (SMB-C) and nitrogen (SMB-N) were investigated in an intercropping system involving Fraser fir, two leguminous (Dutch white clover and alfalfa) and a non-leguminous (perennial rye grass) covers, where cover crops were intercropped between the tree rows. Three management practices including banding and no banding and a conventional control were evaluated. SMB-C and SMB-N (by chloroform fumigation direct extraction) were assessed from soil samples collected at three soil depths (0-15, 15-30 and 30-35 cm). Results obtained indicated that both legume cover crops with banding yielded high SMB-C and SMB-N compared to the non-legume cover crop. SMB-C and SMB-N significantly decreased with soil depth. Plots managed with bands averaged 558.83 C kg-1 dry soil for SMB-C and SMB-N compared to the non-legume cover crop. SMB-C and SMB-N significantly decreased with soil depth. Plots managed with bands averaged 558.83 C kg-1 dry soil for SMB-C, and plots without bands averaged 535.84 mg C kg-1 dry soil. For SMB-N, plots managed with bands averaged 83.23 mg C kg-1 dry soil, while plots without bands averaged 79.27 mg C kg-1 dry soil. Both legume cover crops yielded significantly higher microbial biomass C compared to plots with the grass cover crop and conventional plots. The amount of SMB-C was similar in Dutch white clover as well as perennial rye grass plots, irrespective of banding treatments. However, in the alfalfa treatments, plots with banding had statistically greater SMB-C than the no
Rereading the economics of agroforestry – liking the time it takes to grow quality

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Session: 05 Ecological sustainability: panacea or Pandora’s box

Abstract
Farmers control 70% of our landscape. Though much of it needs trees, most has little prospect of ever being profitable for agroforestry because of the way we measure the cost of time. Whilst a mature forest is worth owning, the time it takes to grow makes planting trees unprofitable. This conflict, between what we know is quality and what is perceived as profitable, is arguably the greatest challenge facing those in a deforested landscape. It’s a stalemate that has thwarted agroforestry development for decades and led to a succession of useless publications, demonstrations and subsidies aimed at trying to entice farmers to commit to what, for them, is essentially an ‘ugly’ investment. Rather than fight against time, we must work with those who are willing to harness it as an opportunity. With time on their side they would select species on the basis of product quality, not just growth rates. They could justify planting on low-quality sites. Their long rotations would support greater biodiversity, use less water and store more carbon. I’m passionate about agroforestry because farmers who have secure property rights are possibly the only people in our community who have the time, and the liking, to grow quality forests where we need them most. Farmer participation in forestry is significant and it is making a difference but not always for the reasons, and certainly not based on the measures, that most of my peers currently use to define value and quality. I challenge conventional forestry economic wisdom and present an alternative that acknowledges that, for a farmer growing trees, waiting is not just a cost, it is unavoidable time still needs to be lived. Fortunately, if designed and managed for quality, agroforestry can make that living more fulfilling.

Search for sustainable cattle stocking densities: impacts on selected woody species measured in forest grazing areas in Bolivia

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Abstract
In Southern Bolivia transhumance is still practised, with cattle grazing the grassland during the rainy season and the mountain forests during the dry season. For evaluating browsing intensity and damage caused to young trees and shrubs, an experiment was conducted during 3 months in 2006 and 2007 by applying three different cattle stocking densities. Three similar paddocks of about 3 ha (about 25% grassland, 75% woodland) were stocked with 0.9, 1.6 and 2.6 tropical livestock units per ha (=250 kg body weight) reflecting low, medium and high cattle densities. Within each paddock, six parcels of about 5 x 5 m were installed; these were complemented by three additional parcels in 2007. Within parcels, the individuals, 18 woody species in total, were coded and subjected to weekly evaluations of browsing intensity. Browsing intensity was measured by using a five-scale classification with categories reflecting steps of 25% of plant tissue removed (0=no browsing). Overall, and across all plant species, browsing intensity (category) as determined in the post-grazing evaluation differed in a widely linear manner from 1.58, 2.18 and 2.77 with low, medium...
and high stocking density. No significant difference among years occurred. The more abundant species generally followed this pattern of response to stocking density, while some species were only browsed noticeably at high stocking density, and a few others such as *Piper tucumanum* were intensively browsed at any stocking density. The proportion of fatally damaged trees as assessed about 8 months after grazing seemed to be not affected by stocking density and averaged out at about 10% of the individuals inside the parcels. The percentages of completely defoliated species were increasing with stocking density, but overall about 80% of those plant individuals recovered within the 8 months. Although most shrubs and trees recovered from browsing, and fatal damage remained low, changes in plant species structure cannot be excluded.
Session 06
Ecophysiological bases of agroforestry-system design
Are pruning of tree roots, no tillage and mulching improving yields? Ten years research on water competition in two rainfed agroforestry systems

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Session: 06 Ecophysiological bases of agroforestry-system design

Abstract
Trees and live fence elements in agroforestry systems (AF) generally diminish losses of water through evaporation due to their shading and wind shelter effects. However, their own water consumption may compete with that of the crop plants. The effect of pruning shallow tree roots on the water availability for crop plants was studied in an AF system at two sites of the Laikipia, northwest of Mount Kenya. The sites are characterized by a semi-humid to semi-arid highland (1800-2000 m asl.) climate, deep clay soils and rainfed cultivations of small-scale farmers. At both sites, the AF system consisted of Grevillea trees inter-planted with no-tillage mulched maize cultivation, and was compared with no-tillage mulching (M) and local (deep) tillage (L) maize cultivation in open fields. The experiments were installed in 1985. Monitoring until 1999 included daily meteorological observations, weekly soil water content measurements at several depths and distances from the trees, measurement of maize yield, tree growth and harvested tree biomass. A detailed analysis of the soil moisture illustrated water use and competition between trees and maize. The AF system showed higher water availabilities than the local tillage (L) cultivation and impact on the yields. In most years, the no-tillage mulching cultivations (M, AF) produced more maize crop yields (mean 17 %). Maize yield of the AF treatment was often slightly lower than that of the M treatment (without trees) but had the advantage of the additional tree biomass harvest. Pruning of shallow tree roots successfully increased the availability of water for maize especially in the first few meters from the trees without an effect on tree growth. The benefits of root pruning were high compared to the labour costs except in years of complete crop failures.

Cereal productivity in the shade, a key to the success of temperate agroforestry systems

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Session: 06 Ecophysiological bases of agroforestry-system design

Abstract
Cereal varieties were selected in full sun conditions, and models of crop productivity were also designed and validated for full sun conditions. Both may therefore not be adapted to agroforestry cultivation and simulation, respectively. Durum wheat productivity was monitored in agroforestry systems with deciduous broadleaved tree species during the last ten years in southern France. Dedicated experiments with artificial shade were also set up to control light availability. Yield components (plant density, number of tillers, number of ears, grains per ear, grain weight, protein content of the grains and qualitative parameters) were measured in both full light and reduced light conditions. Beyond a threshold of 70% radiation during the flowering and grain filling stages, the cereal yield was not decreased by the shade. For heavier shade conditions, the cereal yield was significantly reduced. A crop model (STICS) was used to simulate the crop productivity in both full light and shaded conditions. Leaf area indexes were not much reduced by deciduous tree shade, as most the leaf growth was finished before significant shade occurred on the plot. The main impact of the shade was on the fertility of the ears. The grain weight was not modified, while the protein content was significantly increased in shaded conditions. The protein yield per hectare was therefore not much reduced by the shade, even when the dry matter grain yield was significantly reduced. Some processes were not correctly simulated in the shade,
such as crop temperature and soil temperature, and improvements of the crop model are suggested. The optimization of temperate agroforestry systems would require the selection of cereal varieties less sensitive to a deficit of radiation at flowering, and the genetic variability of cereals should be explored for this new criterion.

Ecological and human impacts on stand density and distribution of tamarind (Tamarindus indica L.) in Senegal

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Session 06 Ecophysiological bases of agroforestry-system design

Abstract

The reduction and unpredictability of rainfall and poor soil fertility in developing countries in sub-Saharan Africa imply that good management of natural plant resources for the provision of food, fodder, fibre, shelter, wood and services is becoming increasingly important. As part of a regional project which aims to improve and domesticate tamarind and baobab in West Africa (www.dadobat.soton.ac.uk), tamarind's (Tamarindus indica L.) actual and potential distribution was modelled and its density around villages was measured across Senegal. Data on presence and absence were recorded across Senegal based on National Forestry Ministry information, and the latter’s validation in the field. Presence and absence locations were recorded using a global positioning system (GPS) (the Ziguinchor region was excluded for security reasons). Density around villages was recorded by following the transect method (Assogbadjo, 2006) around 30 villages in locations where tamarind had previously been identified as being present. Data were managed by some statistics and GIS software as SAS (9.1) and SPSS (16.0). Results show a decreasing gradient of tamarind density from the Soudano agro-ecological zone (in the south) to the Sahel (in the north). Moreover, tamarind density decreased as the distance from the village increased. The most important climatic factors explaining tamarind’s distribution within Senegal were identified as: amount of rainfall during the rainy season, hottest period in the year and temperature range. These results indicated the importance of human presence with regard to density of tamarind stands, and the importance of rainfall and temperature patterns for explaining presence or absence of tamarind within the natural vegetation systems of Senegal.

Incorporating plant plasticity in agroforestry simulation models

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Session 06 Ecophysiological bases of agroforestry-system design

Abstract

Phenotypic plasticity is defined as the plastic responses of plant phenotypes to the abiotic and biotic environment. Very little is known about the consequences of phenotypic plasticity for plant communities in general, and agroforestry systems in particular. We put in evidence key aspects of plasticity in some temperate agroforestry systems, including the dramatic distortion of the tree root system as influenced by crop competition or the asymmetric extension of the tree canopy in wide-spaced tree plantations. More subtle aspects of plasticity may also be operating such as the adaptation to shade of ecophysiological processes for crops. Models should incorporate plasticity mechanisms to account for the outcomes of agroforestry systems. However, most process-based models do not account explicitly for plasticity mechanisms. Crop models or tree-based models usually do not take into account such processes. We incorporated in the Hi-sAFe process-based model of agroforestry systems, plasticity formalisms for tree balance and growth, both above and below-ground. An opportunistic tree root growth was obtained with the use of a 3D voxel automata. Some aspects of canopy plasticity were poorly explained, such as the reduced east west canopy
extension of north-south aligned trees. A virtual experiment plan was then performed to explore the sensitivity of the system to the phenotypic plasticity of trees by comparing simulations including or excluding plasticity.

**Light and water use interactions in silvopastoral systems in a seasonally dry region of Costa Rica**

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**Session** 06 Ecophysiological bases of agroforestry-system design

**Abstract**

Silvopastoral systems are proposed to enhance productivity and provide environmental services, but little is reported about the ecological and biophysical interactions between grasses and native timber tree species. The management and design of silvopastoral dry tropical systems needs to consider the competitive ability and resource partitioning of interacting species in water-limited seasons. Two contrasting grasses: an improved one (*Brachiaria brizantha*) and a naturalised grassland dominated by *Hyparrhenia rufa* were studied growing alone and in silvopastoral systems with three native timber tree species (*Pithecellobium saman, Diphysa robinioides* and *Dalbergia retusa*). Light interception and water-use interactions between grasses and trees were studied using hemispherical photography, light measurements, sap flow gauges and simplified water balances. *P. saman* transmitted more light than *D. retusa* and *D. robinioides* (65.5, 47.5 and 39.4%, respectively) to grasses. The biomass production of *B. brizantha* was three times that of *H. rufa* (14.7 vs 5.3 Mg DM ha⁻¹ year⁻¹) with no effect of trees. The efficiency of radiation use contrasted between *B. brizantha* and *H. rufa* with trees and in treeless plots (0.55 versus 0.20, and 0.27 versus 0.10 g DM MJ⁻¹, respectively). Trees did not affect water use of grasses. *B. brizantha* had significantly higher water use efficiency (WUE) than *H. rufa* (3.7 versus 1.2 g DM kg⁻¹ H₂O). *D. robinioides* used more water than *P. saman* and *D. retusa* (0.20 versus 0.07 vs 0.08 mm day⁻¹, respectively). The WUE of *D. robinioides* was not affected by grass species (1.1 g DM kg⁻¹ H₂O); whereas *P. saman* had a higher value with *B. brizantha* (2.6 vs 1.7 g DM kg⁻¹ H₂O transpired) and *D. retusa* used water more efficiently growing with *H. rufa* (4.8 versus 2.3 g DM kg⁻¹ H₂O transpired). *B. brizantha* used the same water as *H. rufa* but produced three times the biomass.

**Phloem-derived diagnostics for the rapid assessment of tree health**

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**Session** 06 Ecophysiological bases of agroforestry-system design

**Abstract**

Developing tools for the assessment of plant and ecosystem health is of considerable interest to land managers. Understanding core processes of plant function is central to the development of such tools. Profiling of plant metabolites offers valuable information for our understanding of plant adaptability and is now an established tool in systems biology. The use of phloem sap as an integrated measure of plant physiological and nutritional status has great potential for use in plant and ecosystem management. With a focus on parameters that are independent of flux, we have produced several integrative tools for the rapid assessment of plant water and nutritional status. Here I will discuss the basis of these tools, and opportunities for further development of these technologies.
Understanding vegetable tree interaction is a key to successful vegetable agroforestry systems

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Session: 06 Ecophysiological bases of agroforestry-system design

Abstract

Intercropping trees on intensive vegetable production systems in the Philippine uplands is becoming popular practice. In an intensive commercial vegetable production system, a monoculture system is not sustainable but integrating trees is feasible and offers better prospects. Our overall objective was to integrate trees into intensive vegetable farming systems with minimal negative interaction, thus increasing productivity, profitability, nutrient use efficiency and environmental services. An assessment of farmers’ vegetable agroforestry (VAF) systems was conducted in Lantapan, Bukidnon, Philippines, covering 21 farms: two agroforestry systems, six tree species, eight vegetables and four aspects. Data collected were tree parameters, spatial performance of vegetables, and spatial light transmission. Focus group discussion was also conducted with VAF farmers on ways of integrating trees into vegetable farms. Furthermore, a field experiment was established to evaluate 30 different indigenous and commercial tree, fruit, leafy, root and climbing vegetables, perpendicular to six-year old Eucalyptus torillana hedgerows. Crop growth and yield data were collected spatially relative to tree distance in order to determine productivity, adaptability, competition and complementarity. Net complementarity index (NCI) was used as a tool for assessing appropriate tree vegetable integration. We found that the optimum tree hedgerow spacing was 25-30 meters apart. Tree species suitable for VAF systems were Eucalyptus robusta, Eucalyptus torillana and Acacia mangium; commercial vegetables were cabbages, cauliflower, carrots and bell pepper; leafy vegetables were Amaranthus (TOT 5474), Jute (TOT 4721), and Basella (TOT 5274); a climbing vegetable was yard-long bean (TVO 2141); eggplant (S00-633) for fruit vegetables; and Malunggay (Moringa oleifera) for indigenous vegetables. There was a positive relationship between NCI and tree height and amount of canopy left after tree pruning, but there was a negative relationship with canopy width. Vegetables grown on the east or south side had better yields than those planted on either the west or north side of the tree line.

Variation in baobab leaf morphology and its relation to drought tolerance

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Session: 06 Ecophysiological bases of agroforestry-system design

Abstract

The baobab tree (Adansonia digitata L.) found in the drier parts of the savannah, is highly valued for its multiple uses. Apart from food, the species supplies medicine, livestock fodder, shade, fibre, clothing and material for hunting and fishing for local people. Although variation has been noted for baobab fruit, no studies have been undertaken on leaf morphological variation which can be linked to drought adaptation mechanisms. A study involving 3 experiments was carried out in Benin: A) an in situ leaf characterization of 8 study sites following a latitudinal gradient (north-south); B) a leaf characterization of 12-month-old seedlings grown in an experimental farm in south Benin; and C) a leaf characterization of 10 trees partially pruned. Significant differences were observed in stomatal density and guard cell length in experiments A and B. Trees from northern study sites had higher stomatal density and smaller guard cell length. There were significant differences in median leaflet length and specific leaflet mass between north and south in experiment A, but no significant differences were observed in experiment B. In experiment C, leaves from pruned branches...
were significantly smaller and thinner than those from non-pruned branches. However, no significant differences were found in stomatal density or guard cell length in experiment C. The results show that as pruning has a significant effect on leaf size, stomatal assessment may be a more reliable method to assess baobab drought tolerance. Trees from northern study sites (the Sudanian zone) showed more xerophytic characteristics than those from the south (the Guinean zone). The study suggests that genetic and physiological effects may play a role in baobab drought adaptation. It seems that there is variation in the degree of baobab drought tolerance, thus locally desirable types could be selected and incorporated in new areas.
Session 07
Integrating genomics in agroforestry
Conservation genetics of baobab (Adansonia digitata L.) in the parklands agroforestry systems of Benin (West Africa)

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Session 07. Integrating genomics in agroforestry
Abstract Baobab (Adansonia digitata L.) is a multipurpose tree used daily by rural African communities. The present study aimed at investigating the level of morphometric and genetic variation and spatial genetic structure within and between threatened baobab populations from the 3 climatic zones of Benin. A total of 137 individuals from 6 populations were analysed using morphometric data as well as molecular marker data generated with the AFLP technique. Five primer pairs resulted in a total of 217 scored bands with 78.34% of them being polymorphic. A two-level AMOVA of 137 individuals from six baobab populations revealed 82.37% of the total variation within populations and 17.63% among populations (P < 0.001). Analysis of population structure with allele-frequency based F-statistics revealed a global FST of 0.127 ± 0.072 (P < 0.001). The mean gene diversity within populations (Hw) and the average gene diversity among populations (Hb) were estimated at 0.309 ± 0.000 and 0.045 ± 0.072, respectively. Baobabs in the Sudanian and Sudan-Guinean zones of Benin were short and produced the highest yields of pulp, seeds and kernels in contrast to those in the Guinean zone, which were tall and produced only a small number of fruits with a low pulp, seed and kernel productivity. Statistically significant correlation with the observed patterns of genetic diversity was observed for three morphological characteristics: height of the trees, number of branches and thickness of the capsules. The results indicate some degree of physical isolation of the populations collected in the different climatic zones and suppose a substantial amount of genetic structuring between the analysed populations of baobab. Sampling options of the natural populations are suggested for in or ex situ conservation.

Keywords: Adansonia digitata, population structure, morphometric variation, climatic zones.

Forest tree genomics: A worthy investment for developing countries?

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Session 07. Integrating genomics in agroforestry
Abstract Planting trees on farms has been recognized as one of the main ways of increasing the global forest cover, which has continued to decline in developing countries, due to clearance for settlement and agricultural expansion. This has had several consequences on biodiversity and the environment. Indeed, reduced forest cover contributes to global warming, which through changing climate, adversely affects agriculture. In order to develop suitable strategies for the use of previously undomesticated tropical trees as new crops, knowledge of the biology of a species is crucial. However, often very little is known about particular species. Application of biotechnology can play a great role in speeding up tree-domestication processes. There is great potential for more rapid tree improvement by applying new breeding strategies based on progress in genomics. As proven by genome projects on other organisms, substantial resources in technology are required for this type of work. In developed countries, several large programmes have recently been initiated that are aimed at large-scale analysis of tree genomes. Through the application of cutting-edge tools of genome analysis, a comprehensive picture of the genes and cellular processes involved in many aspects of tree growth and development is emerging, and a suite of tools are being developed that will be critical in the sustainable management of forest trees. Knowledge obtained points to the way forward for improving quantity and quality of trees for desired end uses or enhancing the ability of trees to adapt to environmental stresses such
as pollution and climate change. Developing countries cannot afford, therefore, to be left behind, considering that most of these countries fall within the tropics and consequently have specific habitats for certain tree species. The paper explores possible genomic research interventions for tropical trees and suggests the way forward for developing countries.

**Genetic variation in *Cordia africana* between trees in traditional agroforestry systems and continuous populations in Ethiopia**

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**Abstract**  
Scattered trees in traditional agroforestry systems are very common in tropical Africa. In Ethiopia, deforestation has left the country with a natural forest cover of only 3.6% from the originally estimated 35 to 40%. The earlier continuous forest landscape of the country has been replaced by mosaics of forest patches, farmlands, wooded grassland and secondary evergreen bushland. The genetic variation of 8 farmland populations was compared with 4 continuous forests in a tropical broad-leaved tree species, *Cordia africana* Lam. (Boraginaeae), in Ethiopia. DNA was extracted from dried leaves of the species, and fingerprinted using the amplified fragment length polymorphism (AFLP) technique. The analysis of the genetic variation revealed that the percentage of polymorphic loci (PPL) varied from 82.2% at some farmland populations to 92.2% at Wondogenet, a natural forest, and the Nei’s genetic diversity from 0.26 at Butajira, a farmland population, to 0.32 at Sheko, a continuous population. The mean percentage of polymorphic loci and the mean genetic diversity were 85.4% and 0.29 within the farmland populations, and 90% and 0.30 within the forest populations, respectively. The ranges of the rankings for the forest and the farmland populations overlapped for both PPL and diversity. The findings reveal that the scattered trees on farmlands harbour substantial genetic variation comparable to the continuous populations, and can be used as sources of genetic materials for tree planting, tree improvement and conservation activities in areas where the natural forest has been denuded such as in northern and eastern Ethiopia.

**Isolation of gene and gene-near regions associated with biosynthesis of sesquiterpenes in *Warburgia ugandensis***

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**Abstract**  
The East African greenheart (*Warburgia ugandensis Sprague*) is one of the highly valued medicinal plant species within the traditional health systems of the communities where it naturally occurs. The tree has high pharmaceutical value both for humans and livestock; this is attributed to the abundance of drimane and colorotane sesquiterpenes. The unsustainable utilization of its products for medicinal purposes as well the encroachment of its natural habitat by expansion of farmlands is endangering its future existence. The goal of this study was to therefore create a better understanding of the biosynthesis of sesquiterpenes by isolating and partially characterizing the *Warburgia sesquiterpene* synthase gene as well as generating gene and gene near region fragments as putative candidates for marker development. We have successfully developed a simple, rapid and effective nucleic acid protocol. The extraction buffer maintained the integrity of nucleic acids over a period of time prior to isolation hence the system offers a possible temporary storage means. The study also offers the first sequence information on the *W. ugandensis* sesquiterpene synthase gene, an important starting point for further analyses of the gene itself, other related studies
with respect to its biosynthesis as well as its biochemical properties. The isolation of pulegone reductase-like and cytochrome P450 monoxygenase-like genes offers additional information on enzymes involved in modification of the products of terpene synthases. Several genes and gene fragments specifically expressed in certain tissues form putative candidates for markers assisted the selection of ideal Warburgia phenotypes for propagation purposes.

Phylogenetic diversity and relationships among Acacia senegal accessions using RAPD and AFLP molecular markers

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Abstract

The main objective of this study was to understand the genetic relationships and variability of A. senegal using molecular markers. Acacia mellifera (Kitir) and Acacia leata (Shubahi) were used for comparisons. Twenty-eight Acacia senegal germplasm samples were collected from different localities of the Gum Arabic belt, which extends from the west to the east of Sudan with different ecological zones. DNA was isolated from Acacia genotypes according to phenol: chloroform protocol. A total of 15 RAPD primers were tested with the 30 genotypes of Acacia spp. (28 A. senegal, 1 A. mellifera and 1 A. leata). The results indicated that seven primers (60%) showed at least 1 consistent polymorphic band. The seven informative primers were selected and used to evaluate the degree of polymorphism and genetic relationships within and between all the Acacia spp under study. A total of 51 amplified fragments were distinguished across the selected primers and the statistical analysis showed 47 polymorphic bands among 30 genotypes with an average of 7.2 polymorphic per primer. The maximum numbers of fragment bands were produced by the primer OPA-09 with 90% polymorphism while the minimum numbers of fragments were produced by the primer OPA-1 with 80% polymorphism. A total of 45 AFLP combination primers were tested with the 28 Acacia senegal genotypes. This resulted in 9 primers (20%) showing at least 1 consistent polymorphic band among 30 Acacia senegal genotypes. The AFLP primer pairs detected 431 polymorphic bands among 30 genotypes resulting in an average 47.9 polymorphic per primer. The primer combination E-ACC×M-CAA gave the highest number of fragments (71), with 90% polymorphism. While the minimum number of fragments (27) was amplified with primers E-AGG×M-CTC with 59% polymorphism. The study provides an independent approach for the authentication of the Gum Arabic tree and will be more fruitful if concerted efforts are make to integrate the existing molecular fingerprints data with other molecular authentication programs of Gum Arabic tree. For instance, this molecular study could be utilized in correlation with quantitative and qualitative studies and the loci responsible for drought resistance and salinity or alkalinity tolerance.

Population genetic analysis of African willows (Salix spp.) using nuclear microsatellite and chloroplast DNA markers

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Abstract

Salix is a large genus (400 500 species) of woody plants that is famous for its taxonomic ambiguity and for its ecological importance in floodplains. Furthermore, hybridization and introgression are reported to exist between Salix species making the situation more complicated. To clarify the complex behaviour of these species and to suggest conservation management strategies, it is important to study the respective distribution area and population dynamics based on different molecular markers. Two African Salix species were
studied. \textit{S. subserata} is widely distributed in Africa and \textit{S. murielii} is reported to exist only in Sudan. In the region of Khartoum both species co-exist along the River Nile and the Blue Nile River. We proved that both species are diploid using Flow cytometry. Six developed and selected chloroplast DNA markers (four targeted PCR-RFLPs and two primers for INDELs) showed that both species have separate haplotypes and effectively co-exist in the region. Canonical correspondance analysis between the leaf morphology matrix and the haplotypic identification matrix did not give clear segregation between both species, which suggest the possible presence of hybrids. No geographic structure was obtained since only a single haplotype was detected for each species (GST=0). Nine out of 37 nSSR markers were successfully cross transferred, of which 29 were developed for \textit{Populus} and eight for European \textit{Salix} species. Clones are most likely present and vegetative reproduction occurs mainly between populations. The principal coordinate analysis showed no segregation in the samples, confirming that both species hybridize. It seems that the distance of the populations to the river stream might also influence the genetic diversity. This study is the first, and the informative chloroplast and nuclear markers that were obtained encourage further investigations on more \textit{Salix} populations in the future.

\textit{Tamarindus indica} niche tree species diversity in East Africa: guidelines for conservation

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\textbf{Session} \quad 07. Integrating genomics in agroforestry

\textbf{Abstract} \quad Research on impacts of global warming since the mid 20th Century has consistently shown that resilience in agricultural production systems will in part depend on tree resources. In East Africa there are no conservation strategies yet in place for most tree species. This is generally the case, even for the few economically important species such as tamarinds, which are identified to have conservation threats. Knowledge on niche-level species associations and diversity for these tree species will be useful for identifying holistic economic-ecologically sound conservation strategies. Our objective was to characterize tree species diversity in tamarind niches on farms, woodlands and riverbanks. We hypothesized that species associations and diversity within tamarind niches is similar among habitats within and between similar habitats among East African countries therefore regional conservation strategies are applicable. We inventoried tree species within 18 m radius plots in 117 farms, 57 woodlands and 23 riverbanks. Overall Shannon diversity index $H$, calculated from 725 individuals of 171 species in 57 families sampled, was 4.07, evenness $E_H=0.79$. Species diversity varied significantly among habitats within countries (Uganda $H_m=2.7633$, $P=0.009$; Kenya $H_m=3.4593$, $P=0.000479$; Tanzania $H_m=3.31467$, $P=0.001963$) and among similar habitats among countries (on farms $H_m=3.36935$, $P=0.002686$; woodlands $H_m=3.30967$, $P=0.001672$; riverbanks $H_m=2.85267$, $P=0.01334$). These results imply that localized habitat specific and not cross border regional conservation strategies will be needed for tamarind and associated tree species (overall, \textit{Senna spectabilis}, \textit{Cascabella theveta}, \textit{Mangifera indica}, and habitat-wise, Acacias in woodlands and riverbanks; \textit{Musa} species, \textit{Cocos nucifera}, \textit{Carica papya} among others on farms).
Tracking the original gene source of a *Juniperus procera* Hochst. ex Endl. population at Menagesha-suba, central Ethiopian highlands

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Session 07. Integrating genomics in agroforestry

Abstract According to legendary history, the Menagesha-Suba *Juniperus procera* Hochst.ex Endl. population in the central highlands of Ethiopia is said to have been established as plantation of about 600 years ago. A recent study based on carbon dating supported the claims of this legend. However, the source of the founder seeds of this population was not clear to researchers. In order to track the original gene source and to reaffirm the history of Menagesha-Suba Juniper population, 20 24 individuals from each four major *Juniper* populations in the central highlands of Ethiopia, namely, Chilimo, Menagesha-Suba, Wef-Washa and Ziquala, were investigated based on an analysis of 116 polymorphic AFLP band positions. The results indicated that the genetic structure of the Juniper population at Menagesh-Suba is significantly (p<0.05) and highly (p<0.01) differentiated from the populations at Chilimo and Ziqual respectively. Nevertheless, the Chilimo and Ziquala populations are geographically at a closer distance to the population at Menagesha-Suba where reproductive contact is likely. On the other hand, despite the fact that there is a marked geographic distance between them, the *Juniper* populations at Menagesha-Suba and Wef-Washa appeared to be genetically undifferentiated (p<0.34). This clearly attests that the original gene source of the Menagesha-Suba *Juniper* population is Wef-Washa. Hence, this study reaffirmed the validity of the aforementioned legend and it showed unambiguous historical genetic linkage of the Menagesha-Suba and Wef-Washa Juniper populations.

Key words: AFLP, central highlands of Ethiopia, gene source, genetic differentiation, *Juniperus procera*, Menegh-sha-Suba, population, Wef-Washa
Session 08
Dryland agroforestry research and development
Boundary tree management for optimizing fuelwood, maize, and pigeonpea yields at Ihumwa Dodoma, Tanzania

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Session 08. Dryland agroforestry research and development

Abstract
On-farm wood production can reduce harvesting pressure on natural forests. In semi-arid areas with land scarcity this practice requires appropriate management to reduce tree-crop competition and optimize productivity. Integrating boundary tree planting with approaches to improve soil fertility may address this problem since well-managed trees do not adversely affect crop growth. Split plot experiments were established to assess effects of spacing and shoot pruning of Acacia polyacantha and Eucalyptus camaldulensis, soil nutrient management practices (Pigeonpea and Tephrosia-maize intercropping systems, inorganic fertilizers, and cattle manure), and distance from border trees, on soil fertility and yields of wood, maize, and pigeonpea. After 24 months, spacing did not affect DBH and crown diameter of tested species suggesting that competition had not set in. Eucalyptus camaldulensis doubled DBH (4.4 cm) and wood yield (4.4 Mg/ha) compared to A. polyacantha indicating high fuelwood production capacity. Wood yield was the highest at 2x2 m for both species (4.4 and 7.7 Mg/ha) because survival and yield per tree were not affected by spacing. Apparently, this amount can satisfy household fuelwood demands for 1.4 to 2.5 years. Pruning A. polyacantha increased maize and pigeonpea yields in the second and third seasons due to reduced competition for light. Corresponding yields for E. camadulensis were unaffected, reflecting belowground competition due to the extensive root system. Significantly lower maize yield at 1 m (0.50 to 1.16 Mg/ha) compared to 3 m and 6 m (0.62 to 1.32 Mg/ha) from the boundary implies that belowground competition limited crop growth. Fertilizer and manure additions enhanced soil nutrients, maize and pigeonpea yields compared to intercropping systems or the unfertilized control. Apparently, 2x2 m spacing maximizes fuelwood supply without experiencing intra-specific competition. Root pruning, which may be labour intensive, is not necessary within 3 years after planting since shoot pruning and planting crops 3 m from border trees may control inter-specific competition.

Bridging rural-urban income inequality through fruit and fodder tree-based agroforestry systems in rural South Africa

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Abstract
A conspicuous socioeconomic duality characterizes the dichotomy between the highly mechanized commercial and the impoverished agricultural systems among whites and blacks respectively in South Africa. The Limpopo, Mpumalanga and Kwazulu Natal province ecosystems best present the glimmer of hope that would bridge this duality in social and agricultural systems. Wild-growing trees produce large quantities of high-value fruits and nuts in the three provinces. The provinces are also the natural breeding areas for diverse species of goats used for different sociocultural and economic functions in the society. This paper examines the prospects of domesticating two of these many fruit tree species namely the manketti nut (Ricinodendron rautanenii) and the marula (Sclerocarya birrea subsp. caffra) for food, medicine and income generation, and Acacia and Prosopis spp as fodder for goats. Empirical evidence shows that the R. rautanenii kernel contains as much as 40 57% fat and 26 60% protein. S. birrea fruit is an important source of vitamin C and is used in the manufacture of the popular Amarula liquor considered to be South Africa’s largest single-product export. The paper posits that through selection and domestication in an integrated agroforestry system, farmers would increase their outputs of fruits, nuts and
goats to earn higher income, and create all-season employment for youths and women. Integrating this system to all-season rural markets and marketing infrastructure would improve rural livelihoods and thereby bridge the widening rural-urban income gap.

**Forage potential of shrubs for dryland agroforestry**

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*Abstract* There are several trees and shrubs with potential for development of agroforestry technologies in the dry areas of Central and West Asia and North Africa (CWANA), but quantitative information on their fodder yield and nutritive value is limited. This paper will summarize fodder yield and quality of trees and shrubs with potential for development of agroforestry technologies in dry areas of CWANA.  
*Keywords*: edible fodder, yield, chemical composition, digestibility, non-legumes, legumes, saline soil

**Institutional innovations in harnessing dryland agroforestry potential – a case study of the Nyumbani village.**

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*Abstract* Conventional land use systems are grossly inadequate in addressing the numerous challenges of the drylands. Low annual precipitation, limited choices for appropriate crop cultivars, non-existent and/or insufficient infrastructure, are a few of these challenges. Nyumbani Village is an emerging drylands land-use model showcasing innovative choices in co-opting the vast resources found in the dry lands for livelihoods and environmental enhancement. Situated in the arid district of Kitui (Kenya), the village is well endowed with various agroforestry resources – rich soils, dry river courses, seed-bearing mother trees and a passionate and enthusiastic community. Through harnessing of these resources, the eco village is trail blazing in drylands agroforestry production systems. The village’s overall goal is to provide care and dignified existence to two generations of residents affected by the HIV/AIDS scourge. This noble objective is undertaken and integrated with agroproduction systems for income generation, environmental conservation and knowledge diffusion. The agroforestry system harnesses a dry river course for sub-surface water storage via a cascade of sand dams. The stored water is tapped through shallow wells from where it is pumped to elevated storage units using solar-powered pumps. The water is finally delivered to agroproduction zones through gravity and drip-fed water systems. Community members that are allocated serviced production zones, grow food using organic permaculture techniques while the village establishes forestry crops along theirs. The perennial crops established in this way include trees for timber, for solid and liquid fuels as well as for fodder. The agroforestry species selected have also been used in reclaiming the six-kilometre-long riparian belt. Progressive but environmentally friendly soil amendment strategies are employed – intensive composting, recycling of the residents’ solid waste (humanure) and synergistic rotational culture.
Introducing cactus-based agro-forestry practices in the drylands of Northern Ethiopia

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Abstract
The Tigray region of Ethiopia has poor vegetation cover, probably due to continuous cultivation of crops and free-grazing. In addition, the area has an annual rainfall not exceeding 500 mm. Cactus, *Opuntia ficus-indica* (L.) (Mill), has adapted to many parts of Tigray. In this region alone, natural cactus covers about 32 000 ha of land. Cactus fruits are eaten fresh in the months of July to September. Cladodes are used as livestock feed and for soil and water conservation purposes. Recently other uses such as nopalitos, jam and carmine have been introduced. Currently, cactus is growing wild and must be cultivated if the benefits from the plant are to be sustained. One likely option would be introduction of cactus into farmlands as hedges or intercrops and, of course, with improved orchard management. This approach could help in climate change adaptation. In this study an orchard of 11 cactus pear varieties was established and the spaces in between plants were used for production of beans. Five cm deep trenches were dug in between the cactus plants to harvest water for use by component crops. Reduced tillage was employed when planting beans. The biomass of cactus cladodes, fruits and yield of haricot bean were then estimated. Significant biomasses of cactus pear cladodes (914.63 kg) and fruits (268.3 kg) were produced in addition to a significantly higher bean yield (1333.3 kg) per hectare. The biomass and the fruit harvest are going to increase every year. Bean plots with no cactus intercrops gave significantly lower yields (7 kg/ha). Intercrops had the additional benefits of trapping moisture in the trenches and this should have augmented the poor rains of the 2008 rainy season (345mm). Cactus does have the potential for an alley and the combination helps increase biomass produced per hectare in addition to increasing the vegetation cover. It can therefore be considered as one adaptation option to climate change in the drylands.

Potential of three *Grewia* species for fodder production in semi-arid environments

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Abstract
This study assessed the potential of *Grewia mollis*, *Grewia tenax* and *Grewia villosa* for fodder production and agroforestry under semi-arid environments. The three Grewias are indigenous to Sudan and are underutilized as wild foods. Their fruits are used as a source of food in many parts of Sudan and they have the potential as valuable animal fodder. This experiment was designed to study the growth characteristics and the nutritive value of fodder of the three species in sole plots using randomized complete block design with three replications. Proximate analysis was carried out to estimate the nutritive value and mineral contents of leaves and small branches of the three species. Samples were taken in June 2008, September 2008 and January 2009. The results showed significant differences among the three species in dry matter (DM), ash content, nutrient detergent fibre (NDF) and ether extracts (EE) kg/ha; while no significant differences were found among the three species in crude protein (CP) contents and acid detergent fibre (ADF) kg/ha. On the other hand, NDF and EE showed significant variations among seasons with the dry season displaying lower values. The minerals contents (i.e. K, Ca and Na kg/ha) were significantly different among the species and seasons. No significant difference was observed among the species in P, N and Mg kg/ha. Basic information on the nutritive value of fodder trees/shrubs is an important step towards the domestication and introduction of these tree species into farming systems.
Spatial and temporal water distribution patterns in a *Leucaena*-based alley-cropping system

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**Session**  08. Dryland agroforestry research and development

**Abstract**  Complementarity of root systems between hedgerow tree species and alley cash crops in alley-cropping systems is considered a cornerstone of the success of these systems. While this is often achievable in areas where water supply (through precipitation and/or irrigation) is adequate to replenish soil zones depleted of water by hedgerow and alley species, it remains a challenge in geographical zones where water is limited. In these zones, one or both species may suffer from water stress as they compete with each other for this scarce resource. This study sought to quantify water extraction patterns in a semi-arid area, where the average annual rainfall is lower than that experienced in tropical areas typically appropriate for alley cropping. Maize, cowpeas, and sorghum were cropped in alleys between hedgerows of *Leucaena*. Water was quickly depleted from deeper soil zones in the first season, but rainfall in the following seasons was insufficient to recharge water levels in these deeper depleted zones. The inability of precipitation in semi-arid areas to recharge water depleted from deeper soil zones negates the benefit of intercropping species with complimentary root distribution, making an improvement in water-use efficiency through spatial and temporal crop diversification unlikely in these areas.

Taungya as a means of low-cost tree establishment and a sustainable land use system

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**Session**  08. Dryland agroforestry research and development

**Abstract**  The objective of this research was to carry out a financial cost benefit analysis of Acacia nilotica plantations grown along the Blue Nile for sawlog production, and to assess the effect on the returns to land of its establishment through taungya that involved *Citrullus lanatus* as an intercrop. Returns to land (USD/ha) were assessed in with-taungya and without-taungya treatments for stands of site indices 28, 25 and 22 from the perspective of Forest National Corporation (FNC) using net present value (NPV) per ha as a decision criterion. Results indicated that establishment costs were reduced by more than 50% in the first and second years, and establishment of *A. nilotica* plantations with the aid of taungya practice improved the NPV per ha relative to the base model. It is concluded that the practice of taungya for establishment of *A. nilotica* improves land-use profitability, provides investment opportunities for the landless, provides the opportunity to fully utilize the site potential, relieves the FNC from sizeable establishment spending, helps achieve prescribed stand development and sustains the land-use system.
The role of mangrove forests in sustaining development in drylands

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Session 08. Dryland agroforestry research and development

Abstract Due to the increasingly harsh climate, only a few species of halophytic plants are able to survive in such a harsh environment and high solid and water salinity that prevails in the study area of this research project. The area is an arid desert in Sinai where drylands and wetlands sit side by side. Mangrove (Avicennia marina), even though there is less awareness about it, showed potential indicators for useful functions in environments of both coastal and arid regions. Therefore, this paper aims to investigate the impacts of A. marina functions which contribute to dryland development sustainability compared to other abundant plants. The study implemented GIS analysis which was carried out in the Agriculture University of Iceland and Soil Conservation Services in Iceland, while field visits and data collection were carried out in the study area in Egypt. Investigations, showed 3 main types of vegetation, of which A. marina was predominant. In some sites, it has adapted to become a completely terrestrial plant and an efficient instrument in biological dune fixation against sand encroachment and wind erosion; it was a valuable contributor to associated economic activities such as eco-truism and several emergent indigenous activities. It was concluded that A. marina might be an alternative and/or additional species of vegetation in drylands near coastal regions where other species are difficult to grow, it can provide environmental and economical benefits, including the control sand encroachment, and biodiversity depletion, and to promote living standards of the local community. It is therefore, recommended to consider embracing A. marina vegetation in dryland management strategies where it is applicable.
Session 09
Silvopastoral systems: restoring ecosystem functions and productivity from farms to landscapes
Beef cattle grazing of British Columbia, Canada’s forested rangeland

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Session: 09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract

In British Columbia forested rangeland grazing is practised on about 11 million ha. Forest grazing takes place either in open forest stands and/or replanted and naturally regenerated cut-blocks where trees have been harvested. A recent mountain pine beetle (Dendroctonus ponderosae) epidemic has led to high mortality of lodgepole pine (Pinus contorta Dougl. ex Loud. var. latifolia Engelm.) throughout the province. This creates more open canopy conditions and increased opportunities for future forest grazing by cattle and wildlife. In 1988, a study was initiated on 3 sites that were winter harvested, seeded with forages, and planted to lodgepole pine to evaluate the effects of beef cattle grazing. Each site was fenced into 5 ha grazing pastures and a 0.5 ha grazing exclosure. Grazing took place during July-August for 10 years, with 50% forage utilization. Only 2% of seedlings encountered browsing, while trampling damage was more common for young trees. The highest trampling damage (30%) was observed during the first 3 years after planting and dropped to <10% by the 4th year. Not all trampled trees died. Evaluation of timber harvesting and cattle grazing impacts on soil occurred 11 years after the initiation of grazing. Soil conditions on the ungrazed and grazed forest pastures were compared to the adjacent mature forest. Greater cation exchange capacity, calcium, carbon and nitrogen levels on treatments disturbed either by harvesting or grazing, indicates that these soils have a better rooting media relative to the undisturbed forest. Soil bulk density and mechanical resistance, although less favourable for the two disturbance treatments than the mature forest, showed that a majority of the soil profile was not compacted severely enough to restrict root growth. Low to moderate detrimental impacts of combined timber harvesting and grazing on regenerating cut-blocks indicate that cattle grazing is a feasible practice under appropriate management.

Connecting sustainable livestock production with the global market: can we certify beef produced in silvopastoral systems?

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Session: 09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract

Cattle production has significant impacts on the environment: it affects land use and soil, climate change, water, and biodiversity. Deforestation is largely caused by the expansion of cattle production. The efforts to reduce negative impacts of cattle production on forest resources have been carried out by technical support to enhance productivities, financial support by micro credit and/or environmental services, and livelihood development by income diversification. In order to mitigate climate change, the Clean Development Mechanism under the Kyoto Protocol has approved a guideline for livestock production. However, the dissemination is unknown. On the other hand, the demand for organic beef has increased in developed countries particularly after the outbreak of mad cow disease. The certified beef provides security of food quality for consumers. Research proved that beef produced in silvopastoral systems with limited undesirable inputs is sustainable and naturally ‘organic’, potentially maintains remaining forest resources, conserves biodiversity and protects water resources. The key criteria for such a production system is to have a certain level of tree cover, use nitrogen fixation techniques and maintain medium to low stocking rates. Beef produced in such systems may serve as organic beef in developed countries and contribute to the reduction of poverty in developing countries. However, the import regulations as
well as organic standards in developed countries are rigorous, therefore they may not be easily met by producers in developing countries. In order to develop a new certification mechanism, a pathway needs to be demonstrated. The objective of this paper is to elucidate the potential of a certification scheme for beef produced in silvopastoral systems. In the paper, standards and markets of organic beef in developed countries are reviewed. Then the paper discusses: political strategies to harmonize standards; criteria for beef production in silvopastoral systems; and institutional mechanisms for developing a certification scheme to connect beef production in silvopastoral systems with global markets.

Effects of trees on pasture ANPP in silvopastoral systems in the neotropics

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Session 09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract
Silvopastoral systems (SPS) in the neotropics have the potential to sustain long-term livestock production as well as to provide other important ecosystem services. Trees may be beneficial to understorey vegetation but could also limit pasture growth. The degree of competition and facilitation by trees on pasture plants may depend on the attributes of the tree species, e.g., the size of the crown and density of the foliage, leaf deciduousness, and whether they fix N or not. We studied the effects of two common SSP tree species in central Nicaragua, Saman (Albizia saman Jacq.) and Coyote (Platymiscium parvillorum Benth.) on above-ground net primary productivity (ANPP) of semi-natural grasslands. A split-plot design was used, with the factorial arrangement of tree species (2) x position with respect to the tree (2) in the whole-plots, and sampling periods (4) in the split-plots. Biomass compartments were used to calculate biomass changes between sampling periods. Samples were protected from grazing animals by metal cages. ANPP was significantly higher (ca 35%) in Saman than in Coyote sites and the differences were maintained both in the dry and rain periods (no significant tree species period interactions). Differences in ANPP could be associated with the soil properties of the sites. Saman sites had soils with higher contents of P and K, and lower pH. Within sites, the presence of trees had a significant effect on pasture ANPP. ANPP was lower both under Saman and Coyote than in the open pasture. However, the effect of Saman trees on ANPP tended to be greater at the start of the rainy season, whereas that of Coyote trees was observed in the mid-rainy season.

Forage Trees and Shrubs – Integrating Livestock and Landscape Rehabilitation

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Session 09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract
Herbivorous livestock, in particular goats, are generally seen as the natural enemy of woody vegetation and disrupting factors in landscape rehabilitation efforts. Several interrelated studies focussing on semi-arid rangelands in Northern Kenya have demonstrated the suitability of woody vegetation as feed source for different species of livestock, the intake preferences of domestic ruminants, dromedaries and donkeys in terms of botanical composition and nutrient density of the ingested plant materials, and the seasonal changes of harvesting patterns in response to seasonal changes in availability and quality of various range plant species. Dietary overlap between herbivore species was calculated within and between seasons to describe the degree of competition and complementarity as well as their seasonal variation. In a parallel effort vegetation data like type, species composition, standing...
Biomass and range condition were collected. Likewise a considerable body of information on seasonal changes of the nutrient content of numerous herbaceous and woody range species was established by chemical analysis and in-vivo digestibility trials with various individual plant species. All these data are used to suggest range utilisation patterns which will allow rehabilitation of degraded vegetation with simultaneous grazing/browsing by domestic herbivores. Emphasis is placed on the combination of different herbivore species in the local herd allowing maximised but benign off-take of biomass leading to sustainable range utilisation.

**Quantifying ecoagriculture: methods and proxies for tracking conservation outcomes in complex agricultural landscapes**

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Session: 09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract
Throughout the tropics, regions of smallholder agriculture frequently consist of fine-grained mosaics of pasture, cropped land, human settlements and natural and semi-natural habitat. These complex, heterogeneous landscapes are important for conserving biodiversity and ecosystem services that support rural livelihoods, yet their performance in terms of conservation, food production, and livelihood outcomes is highly variable in space and time. This heterogeneity makes it difficult to track the specific causes and consequences of landscape change and it makes it challenging to identify optimal management solutions to bring about desired conservation and production outcomes. To shed light on the key controls of conservation values in agricultural mosaics, we conducted a landscape-scale analysis to evaluate the relationships between land use, vegetation characteristics, landscape structure, and biodiversity of birds and butterflies in pasture-dominated mosaic landscapes of 4 Latin American countries: Honduras, Nicaragua, Costa Rica, and Colombia. This longitudinal methodology allowed us to evaluate the degree to which these relationships can be generalized across a range of geographic and socioecological contexts. Our results indicate that land use is an incomplete predictor of key landscape outcomes, despite its widespread use for this purpose. Site-scale vegetation characteristics and landscape-scale structure are also important predictor variables, not fully represented by land-use classifications. The results reveal a promising set of cost-effective proxies for landscape outcomes, some of which can be quantified and tracked with mid-resolution ASTER imagery.

**Reclamation of Grazing lands and community-based management of fodder-based agroforestry systems**

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Session: 09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract
In Andhra Pradesh State, the Panchayats (local governance institutions) were provided with common lands for the purpose of grazing. The Panchayats were expected to maintain and manage such lands. The village maps (known as ‘naksha maps’) contain the details of the location and boundaries of such lands. However, most often these lands were left unattended and/or encroached upon by the neighbouring land owners. In quite a few locations, ‘pattas’ over the lands were also given to the landless, by the Government. The fodder needs in such situation are being met, i) by sending the cattle to the nearby forests, thus contributing to forest degradation, and ii) by growing fodder and/or using crop residues of the landed class. The unproductive cattle of the landed class and the cattle of landless have to depend
completely on the nearby forests which are already degraded. In recent times, the Andhra Pradesh Government took the initiative to distribute cattle to one lakh persons belonging to landless class and the process has been initiated at some places. This may add further to the existing fodder-related crisis. In this context, the Centre for People’s Forestry initiated a project (supported by Winrock India and the Ford Foundation) which aims at facilitating the process of reclaiming grazing lands of the Panchayats and grounding community-based management of fodder-based agroforestry systems as a pilot project in the drought prone Mahabubnagar district. Seven villages of 5 Panchayats were selected for the purpose. This paper shares experiences of the project since inception in April 2006. These include, the process of institution building at community level, collaboration with research and Government agencies for technical and financial support, and the management practices developed and being practised by the community.

Silvopastoral system with *Pinus contorta*: the possibility of sustainable development for farmers in the Patagonian region of Chile

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**Session**
09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

**Abstract**
In the year 2003 research was carried out in order to assess the potential of silvopastoral systems with *Pinus contorta* (Dougl. ex Loud), in the Aysen Region of Chile (Chilean Patagonia). For the purpose of evaluating the use of silvopastoral systems in this region of Chile, a traditional livestock farming model was compared with two silvopastoral models and a pure forestry management model with *Pinus contorta*. The study considered the intervention of a 12-year-old plantation with an original density of 1514 trees ha⁻¹, managed under 4 different treatments to be compared with each other. Treatments were: T1, a forestry management model, with a thinning intervention from 1514 to 800 trees ha⁻¹, and pruning to 40% tree height; T2, a traditional agroforestry model, based on a density of 400 trees ha⁻¹ evenly distributed and pruned to 40% of tree height; T3, a strip agroforestry model with 400 trees ha⁻¹ distributed in three rows of trees along altitude curves, distanced at 21 meters from one another, and both silvopastoral systems were combined with a fertilized natural prairie, using local cattle of the area; and T4, a traditional cattle-grazing model with natural fertilized prairie without the protection of trees. The results of this study suggest that silvopastoral systems are an interesting alternative for farmers in the Chilean Patagonia, as they allow them to create intermediate income by selling meat as well as timber from the thinning interventions, with a major final income from the final harvest of the forestry component. Meat production from livestock during the first three production seasons was similar between T3 and T4, and higher than T2, showing the beneficial influence of the trees on climate factors such as wind and low temperatures, and in reducing erosion and increasing soil productivity.
The functional role of silvopastoral systems in biodiversity conservation: from farms to landscapes.

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09. Silvopastoral Systems: restoring ecosystem functions and productivity from farms to landscapes

Abstract
Conservation of biodiversity at both the regional and global scales must take into consideration the contributions of agroforestry systems. Sustainable farming systems are also dependent on biodiversity for providing ecosystem services. In this study we summarize the results of 11 studies and the impact of silvopastoral systems on the conservation of biodiversity and the improvement of farmer livelihoods in Copan Honduras, and Matiguas, Nicaragua.

At the farm scale, silvopastoral systems were found to make significant contributions to reptile, amphibian, epiphyte and bird conservation by providing critical habitat with species richness and abundance increasing with tree cover and richness. Farmers had a positive perception of these systems, with over 90% of farmers using live fences and 84% indicating a strong interest in increasing tree density in live fences. Farmers were less receptive to increasing tree densities in pastures (55%), but indicated that financial incentives and better extension information could serve to increase interest in this system. Both farmers and local communities showed a strong interest in riparian buffers, but indicated that they were cost prohibitive and that local institutions supporting their conservation are absent. All farmers indicated that silvopastoral systems contributed positively to measures of livelihood, particularly natural, social, and financial capital. We also explored the role of silvopastoral systems at the landscape scale using structural connectivity models in Matiguas and functional connectivity models in Copan. In both cases silvopastoral systems made critical contributions to increasing connectivity. The results of the landscape study emphasize the critical need to develop institutional mechanisms that facilitate landscape-scale interventions driven by the farmers and the communities to which they belong. In Copan for example, our modelling efforts suggest that protection of riparian corridors, and implementation of silvopastoral systems on steep slopes can increase habitat by up to 16% and connectivity by 26%.
Session 10
Quantifying the role of agroforestry in modifying watershed functions
Biophysical gains of participatory agroforestry: evidence from Integrated Watershed Development Project, Hills – II, India

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Session 10. Quantifying the role of agroforestry in modifying watershed functions
Abstract
The Integrated Watershed Development Project (IWDP), Hills-II was implemented to rehabilitate the degraded Shivalik hills for poverty alleviation and livelihood improvement. In addition to biophysical rehabilitation and improving the productive potential of the Shivaliks, the project also intend to meet the fuelwood, fodder, minor forest produce and other requirements of the smallholders. Thus, the objective of poverty alleviation emerges very clearly as concomitant with the objective of biophysical rehabilitation. In the present paper, an attempt has been made to assess the biophysical gains of participatory agroforestry in the context of IWDP (Hills-II), Jammu and Kashmir, using both secondary and primary data sources. The study revealed that agroforestry interventions have been implemented more intensively in severely degraded agricultural watersheds than forested watersheds by using a variety of methods and accomplished by strong farmers’ participation. Over the period, project interventions have resulted in horticulture rejuvenation, afforestation in contour trenches, and improved silvi-pasture practices. There has been significant improvement in vegetation cover and biomass thereof, a multifold increase in the production of local as well as high-yielding varieties of grasses, a decrease in biotic pressure on the natural forests, a reversed the trend of deforestation, a slowing down of water run-off and an increase in water regime of the catchments, and an increase in yield of different crops, milk, wool and meat. At the farmers’ level, the heterogeneity and fragility of land resources along with the variable rainfall made it difficult to fully harness the potential of agroforestry and adequately meet the environmental risks through private resources based on crop farming alone. The balancing of intensive (by cropping) and extensive (by agroforestry) use of land, as required by the resource characteristics became a part of collective strategies for risk management and production enhancement.

Buffering water flows through agroforestry management: quantifying the influence of landscape mosaic composition and pattern

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Session 10. Quantifying the role of agroforestry in modifying watershed functions
Abstract
Buffering of surface flows in relation to the variability of rainfall occurs at multiple spatial and temporal scales. Expectations of modification of flow regimes by tree management need to be reconciled with the simple logic of water balance models, and the realities of climate variability and change. A number of quantitative indicators of flow buffering at seasonal and daily scale have been proposed and can be used to disentangle climate and land-use change contributions in watershed functions. Net effects of increased tree population density on ‘low flows’ depends on the severity of preceding soil degradation, with a criterion that relates the additional water use by trees to the actual decrease in surface runoff by enhanced infiltration. Buffering of sediment flows requires a multi-year perspective, as temporary storage of sediment in surface positions may reduce short-term soil movement but not reduce it at once ‘extreme events’ are included in the analysis. Data will be summarized from two catchments in Indonesia.
Collective action in integrated soil and water conservation: the case of Gununo watershed, southern Ethiopia

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Session: 10. Quantifying the role of agroforestry in modifying watershed functions

Abstract: Collective action (CA) was initiated to manage natural resources in Gununo watershed in southern Ethiopia. Initially, problem exploration was conducted. Then issues requiring CA were identified through community meetings. Similarly a local institution that could effectively lead the CA was selected. The CA was conducted on different natural management issues; of these, soil and water conservation (SWC) was the focus of this paper. The CA of SWC was accomplished for two years in 2005 and 2006. Participatory monitoring and evaluation was conducted at different stages of the CA, and processes were eventually documented. Close to ten kilometres of SWC structures were constructed in the two seasons. Seedlings of elephant grass and banana were planted as bund stabilizers. Farmers also adopted and constructed additional length of soil conservation structures individually, and also planted sugar cane and elephant grass as bund stabilizers. The soil started changing and crop productivity improved within a short period. However, the achievements were associated with challenges mainly attached to the dependency of farmers on food incentives.

Conversion of forest to coffee-based agroforestry in Indonesia: Litter layer, residence time, population density of earthworm

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Session: 10. Quantifying the role of agroforestry in modifying watershed functions

Abstract: Forest conversion to coffee-based agroforestry leads to rapid disappearance of the litter layer and a decrease in the rate of litter fall, reducing food for ecosystem engineers such as earthworms. With time, however, a new litter layer is created potentially returning to forest-like conditions at the soil surface. This research quantified litter fall, litter thickness, earthworm populations, soil macroporosity and soil infiltration in response to land use change in Sumberjaya, (West Lampung, Indonesia,) and in Kali Konto watershed (East Java) by comparing: (a) remnant forest (control); (b) multistrata shaded coffee with fruit and timber trees, as well as nitrogen-fixing shade trees; (c) shaded coffee (nitrogen-fixing shade trees, but less than 5 tree species per plot); and (d) sun coffee (‘monoculture’) with coffee forming more than 80% of total stem basal area. The measurements were performed in selected plots with tree ages of 7–10 years; the results were used to test a simulation model “SoilStructDyn” (as a part of WaNuLCAS model) to estimate soil macroporosity and soil infiltration. The model output suggests that the standing litter in the various land-use systems was consistent with measured litter inputs and decay rates, but that the soil organic matter content and macroporosity of the shade and multistrata systems were less than predicted. The recovery of a surface litter layer in sun coffee systems can provide protection from erosion with time, but will not be sufficient to restore macroporosity at the level of forest soils, leading to hydrologic alterations that favour overland flow.

Keywords: litter thickness, ecosystem engineer, macroporosity, litter residence time, forest conversion.
Effects of rainforest conversion to cacao agroforestry on river discharge and nutrient output in Central Sulawesi (Indonesia)

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10. Quantifying the role of agroforestry in modifying watershed functions

Abstract
Forest conversion in the inner tropics plays an important role for the water balance of tropical catchments. Distributed hydrological modelling that relates land cover changes and climate changes with river discharge changes for humid tropical catchment areas at the mesoscale level are rare. In Sulawesi after one to two years with slash and burn (maize) agriculture, smallholders are planting mainly cocoa as a cash crop (cacao boom for 10 years). Since 2001, we investigated the impact of forest conversion on the water balance, on nutrient loss and soil erosion of a small mesoscalic tropical catchment within the long-term interdisciplinary collaborative project STORMA. Vertical water and nutrient fluxes are measured for natural rainforest, cacao agroforestry (7 and 18 years old) and slash and burn (maize) plots. Components of the water balance were measured since 2001 for the sub-catchments: natural forest, forest conversion to cacao agroforestry, cacao agroforestry for 15 20 years. We compared the changes in soil moisture, river discharge and nutrient output. For three scenarios (forest/cacao/slash and burn) we applied the water balance model WASIM-ETH with simulation results, which support the experimental results (increase of total discharge, higher peak discharges after forest conversion). Both experimental measurements and the scenario analysis indicate after 1 2 years of cacao plantation a ‘stabilizing effect’ for the watershed functions with (reference natural forest): increase of total discharge +17%, due to an increase in interflow and baseflow and only a slight increase in surface flow, (slash and burn +42%, mainly due to an increase in surface flow); soil erosion only 0.8 t ha\(^{-1}\) yr\(^{-1}\) (forest 0.5 t ha\(^{-1}\) yr\(^{-1}\)). After cacao planting (2003 2004) the suspended sediment yield in the forest conversion sub-catchment decreases from 2.9 to 1.7 t ha\(^{-1}\) (2007 2008). Smallholder cacao agroforestry in mountainous catchments can reduce the risk of unbalanced river discharge (risk of flooding) and soil nutrient impoverishment by soil erosion and nutrient leaching.

Impacts of shade trees on hydrological services and erosion in a coffee AFS of Costa Rica; Scaling from plot to watershed

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Session
10. Quantifying the role of agroforestry in modifying watershed functions

Abstract
Environmental services (ES) provided by agroforestry systems require accurate evaluation in order to encourage their payment and the adoption of appropriate practices by farmers. We aimed at quantifying the hydraulic erosion and its subsequent sediment yield in a 900 ha homogeneous watershed of Costa Rica, displaying adult coffee plants shaded by high Erythrina poepiggiana. This watershed is connected to a large hydropower project, where reservoir sedimentation could become a critical economical issue. At the outlet of the watershed we monitored the river runoff (using calibrated hydraulic flume and pressure transducer) and water turbidity (using optical turbidimeter) over 8 months and correlated them with rainfall. We calibrated in situ the turbidimeter rating curve, which relates its measurements (NIR backscatter detected between 140° and 180°) with reference to suspended sediment concentrations (laboratory analyses), and calculated the instantaneous and accumulated sediment transport. In order to assess the impact of shade trees, and to compare with the full-sun situation, we monitored surface runoff and turbidity at the outlet of 2 neighbouring coffee plots (1600 m\(^2\) each, with and without trees). This, together with ancillary measurements, allowed us to test the hypothesis about the reduction of: a) splash...
erosion by canopies; and b) sheet and rill soil transport capacity, by either larger infiltration (less surface flow), larger surface roughness (due to leaf litter) or the increase in soil retention (by rooting systems). Various flow separation methods and models were tested, in order to scale-up from shaded/full-sun plots to the whole watershed. The partitioning of base and storm sediment contributions was inferred. These results are a first step towards the development of objective criteria to assess the impacts of agroforestry practices in coffee plantations, their cumulative effect at watershed scales and their future for hydrological and sediment ES in Costa Rica.

Modelling water dynamics in coffee systems: parameterization of a mechanistic model over two production cycles in Costa Rica.

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Session 10. Quantifying the role of agroforestry in modifying watershed functions
Abstract Coffee (Coffea arabica) is one of the most economically important agricultural crops in Central America where it is generally grown under shade trees. In Costa Rica, large amounts of fertilizers, particularly nitrogen, are applied under intensive coffee cultivation with potential harmful contamination of groundwater. Shade trees improve coffee soil fertility, but can provide some disadvantages such as competition for soil water, notably during the dry season. Consequently, modelling the water balance is essential in order to predict water fluxes, particularly water drainage and possible water table contamination. Thus, the objective of this study was to calibrate a mechanistic model in order to simulate and compare the water fluxes over two consecutive years in two coffee agrosystems with shade of Inga densiflora and in full sun, in the Central Valley of Costa Rica. To do so the following field and laboratory measurements were taken: i) soil water content monitored by TDR measurements over the 2 production cycles; ii) soil properties at various depths, including bulk density, soil retention curve and saturation hydraulic conductivity; iii) meteorological data and calculated ETP; iv) water consumption of coffee and trees; v) rainfall interception by the canopy of shade trees and coffee plants; vi) trunk flow of coffee and shade trees; and vii) surface runoff. The model satisfactorily simulates soil water content over the year at different depths down to 200 cm. The model also simulates the dynamic water partitioning between components of the coffee system (vegetation transpiration, soil water content, runoff) and hence can be a useful tool in recommending selection and management of shade trees with respect to rainfall and soil water availability. Furthermore, this work permits the calculation of the amount of water drainage and hence provides a sound basis for calculation of nitrate leaching out the system into the sub-soil and aquifers.

Tree roots anchoring soil and reducing landslide risk during high rainfall episodes, as basis for adaptation and mitigation to climate change

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Session 10. Quantifying the role of agroforestry in modifying watershed functions
Abstract Landslides killing hundreds of people have become an almost yearly phenomenon in Southeast Asia and have a high profile in public debate. High rainfall events on wet soil generate shallow slope failures by elevating pore pressures, but site-specific factors, such as preferential hydrologic flow-paths, slope steepness, soil thickness, and existing plant root systems, influence the potential for slope instability. Tree roots play an important role for ‘anchoring’ as a component of overall shear strength, while the ‘binding’ in the topsoil
can prevent the more disruptive types of landslides and replace them by ‘landslips’. Trees, however, add weight and the positive or negative net effect on landslide risk depends on root strength and weight. As there is a need for a generic rapid appraisal tool for site-specific assessment of impacts of trees and tree management on landslide risk, we tested methods for: A) rapid survey of tree species and population density in the landscape in relation to signs of preceding landslides; B) inventory of proximal tree root architecture to assess binding and anchoring; C) standardized strength measurement of tree roots in relation to their lignin content; and D) estimation of dynamic root pattern at hill-slope scale using the ‘spatially explicit individual tree-based forest simulator’ (SEXI FS) model. Case studies in West Lampung, Ngantang (East Java) and Sentul (West Java) suggested a number of options for ‘right tree in right place’ management in mixed agroforestry systems to reduce landslide risk on slopes, in the context of adaptation strategies to climate change, combined with biomass carbon storage as a contribution to mitigation.

Key word: litter thickness, ecosystem engineer, macroporosity, litter residence time, forest conversion
Session 11
Agroforestry for salinity control and land rehabilitation
Afforestation for reclamation of degraded cropland in northwest Uzbekistan


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Session: 11. Agroforestry for salinity control and land rehabilitation

Abstract:
Salinization of irrigated cropland results in a reduction of land for agricultural production in arid regions worldwide, requiring mitigation and adaptation efforts. Afforestation, as an alternative land use and reclamation option for marginal agricultural land, was assessed in northwest Uzbekistan. Experimental plantations including *Elaeagnus angustifolia* L., *Populus euphratica* Oliv. and *Ulmus pumila* L. were monitored on 2 hectares of degraded cropland over 5 years. Following a pre-planting leaching and deficit irrigation of 80–160 mm yr⁻¹ during the first 2 years, the trees entirely relied on the shallow (0.9–2.0 m) slightly-to-moderately saline groundwater table. The soil salinity remained high and by the 5th year averaged 10 dS m⁻¹ in the root-zone. Over 5 years, conversion to tree plantations increased soil organic carbon (C) stocks by 20%, contributing to soil fertility. *E. angustifolia* contributed the most due to nitrogen (N) fixation (60–470 kg ha⁻¹ yr⁻¹) which increased soil N stocks by 30%. Gradually thinning the plantations to one half (2,300 stems ha⁻¹) of their initial density in the 5th year generated energy value equivalent to 6–10 tons of oil per hectare. This amount could satisfy the annual energy need of 50–115 persons. The leaf nutritive value of *E. angustifolia* and *Ulmus pumila* ranked 87–89 relative to barley (100), indicating that tree fodder is a potentially suitable complement the low-quality wheat and rice straw, commonly used as livestock feed. Carbon sequestration in remaining plantations amounted to 10–20 t C ha⁻¹ in the 5th year. At this C sequestration rate, about 1000–2000 ha of land would potentially be sufficient to apply for a small-scale afforestation project under the Clean Development Mechanism for obtaining C credits. The findings showed that conversion of degraded cropland to tree plantations can help to ease environmental deterioration and to benefit rural livelihoods.

Agro-silvipastoral model for improving productivity of marginal salt-affected lands in the Aral Sea Basin

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Abstract:
An agro-silvicultural model of trees intercropped with complementary crops was evaluated on marginal lands in an arid climate in Central Asia. Herbaceous fodder crops planted within the inter-spaces of salt-tolerant tree or shrub plantations improved productivity of saline-prone soils, solved the animal feed gaps in the lands degraded both by overgrazing and salinity and increased the profits for farmers. Wild halophytes planted in widely spaced patterns allows for easy mechanical cultivation and harvesting of forage grass and legumes. Our findings from the screening of 16 multipurpose tree species (MTS) showed a high survival rate, quick relative growth rate, high adaptive features and utility value of fuelwood and/or foliage. The most promising species were *Haloxylon aphyllum*, *Populus euphratica*, *P.pruinosus*, *P.nigra var.pyramidalis*, *Elaeagnus angustifolia*, *Robinia pseudoacacia*, *Tamarix hispida*, *T. androsowii*, *Salix babylonica*, *Cynadon oblonga*, *Armeniaca vulgar*, *Malus silvestris*, *Acacia amicpeps*, and shrubs *Atriplex canescens*, *A. nitens*, and *A. undulata*, *Hippophae rhamnoideae* and *Ribes niger* including native rangelands halophytes, either on their own or mixed with various traditional salt-tolerant fodder crops. Tree or shrubs plantation requires limited irrigation during the initial stage of growth before sole reliance...
on available drain water (Ec ? 4.0 6, 3 dS m?1) resources become possible. Species of Tamarix, Elaeagnus and Salix having an exceptional ion-salt translocation/bioremediation mechanism are often referred to as aggressive colonizers since they tend to invade natural habitats and push out less salt-tolerant species. E. angustifolia, Morus alba, M. nigra, Acacia ampliceps and Atriplex species are possible alternative supplementary feed to low-quality roughages throughout the off-season. The expansion and commercialization of non-timber forest products has the potential to increase the cash income of rural households.

Assessing the potential for small-scale afforestation on the saline irrigated drylands of Central Asia: an economic analysis

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Session 11. Agroforestry for salinity control and land rehabilitation

Abstract Worldwide, evidence confirms the benefits of afforesting degraded, marginal lands owing to direct (feed, mulch, fuelwood and timber) and indirect (carbon sequestration and ecosystem sustainability) benefits of trees. Nonetheless, its adoption by farmers is hampered by high initial investments. A financial analysis of afforesting marginal lands in the Khorezm region of Uzbekistan, an area representative of the irrigated lowlands in Central Asia, was analysed. Biomass collected over four consecutive years from Elaeagnus angustifolia, Ulmus pumila, and Populus euphratica experimental plantings was complemented with data on 15 20-year-old trees growing naturally on marginal land. The 20-year established growth functions for these species and their fractions, allowed an analysis of the benefits for capital investment in small-scale plantations by considering annual fuelwood, fodder and fruit production, plus the stumpage value after 20 years. The benefit-to-cost ratio (BCR) and net present value (NPV) were compared at three discount rates. With a multi-period, linear programming model, the benefits from six land use systems on marginal land were then compared over 20 years, including cotton, winter wheat and rice, and plantations of each tree species. At a discount rate of 16% (base case), the NPV for E. angustifolia was greatest, followed by P. euphratica, and U. pumila showing a benefit-cost-ratio equal to 7.8, 2.2 and 1.8, respectively. The results demonstrate that afforesting marginal lands is a feasible land use option, which does not compete with food crop production. Moreover, after year 1, the gross margin of all tree species exceeded those of all crops, owing to the annually recurring benefits from fuelwood and fodder and the low crop yields. A change in land use policies of marginal land would thus provide direct economic benefits to rural farmers, provide income for the government via taxes, and lead to an overall improvement in ecological conditions in the region.

Impact of forest tree plantings on soil salinity in Uzbekistan

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Session 11. Agroforestry for salinity control and land rehabilitation

Abstract Due to transpiration, wind break forest tree belts prevent the rise of mineralized groundwater and salinization of neighbouring crop fields. A study of soil content in irrigated light sierozem (grey desertic) soil in an agroforest landscape with woodiness of 8.6% was carried out in Golodnaya Steep in Uzbekistan. Forest tree plantations in this location contain forest tree species such as Ulmus pumila, Fraxinus pennsylvanica, and Platanus orientalis. The study was carried out in four trial sites: 1) in the windbreak belt itself; 2) in the crop field 50 m
from the windbreak belt; 3) in the crop field located 100 m from the windbreak belt; and 4) in an open field (control). The groundwater level was 2.0 m in the studied area. The study showed that forest tree plantings contributed to a decrease of soil salinity. In the windbreak belt, the content of chlorine solids and ion in the soil at the depth of 60 cm did not exceed 0.372 and 0.436% respectively. In the open field content of chlorine solids was 0.430 and 1.190% and chlorine ion was 0.092 and 0.108%; these figures are classified as average and strong soil salinity. In spring the content of salt solids in soil is 0.468% in the windbreak belts, 0.304% at distance of 50 m from the windbreak belt, 0.806% at distance of 100 m, and 0.911% in the open field. In summer a considerable decrease (1.27 - 2.74 times) of soil salinity was observed in protected landscapes while in open field this decrease was 1.03 times. In autumn soil salinity was 2 - 3 times lower in protected landscapes than in open fields. Content of humus in soil at the depth of 0 - 16 cm in protected landscapes (0.94 - 1.46%) was up to double that of the open field (0.77%). A similar tendency is observed for nitrogen accumulation in the soil.

Opportunities for judicious use of saline water for agroforestry in water scarcity areas of India

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Session 11. Agroforestry for salinity control and land rehabilitation
Abstract Agroforestry is a most desired land use, especially for reclaiming and rehabilitating the degraded (including salt-affected) lands in water scarcity areas. Apart from salty lands (6.7 million hectares in India), it has been estimated that poor quality water constitutes a major portion (30 - 84%) of ground water development, especially in dry regions of Rajasthan (84%), Haryana (62%), Punjab (41%), Karnataka (38%) and Gujarat (30%). The combination of judicious irrigation, suitable salt-tolerant plant species and ideal management options using proper techniques, can help increase sustained productivity of degraded lands through agroforestry in dry regions using saline waters. In one field experiment 31 tree species were evaluated for their establishment and wood production with saline water, and most suitable species for wood production were identified. Nine grass species were grown successfully with saline water particularly during the fodder scarcity period when Conpeople lead nomadic lives in search of fodder for their livestock. Many medicinal and aromatic, oil and spice-yielding, non-conventional and petro-crops suited to biosaline agriculture have been evaluated, and suitable species identified. Agronomic practices have been developed for potential and high-remunerative species such as medicinal psyllium (*Plantago ovata*) irrigated with saline water. The performance of agroforestry systems involving fruit tree species such as kaith (*Feronia limonia*), ber (*Zizyphus mauritiana*), karonda (*Carissa carandas*), anwla (*Emblica officinalis*) and bael (*Aegle marmelos*), and rain-fed or low water requiring crops such as cluster bean and barley, irrigated with saline water, have been evaluated. Results of a series of experiments conducted on calcareous sandy loam soil irrigated with saline water in water scarcity regions of northwest Haryana have also been reported in this paper.

Agroforestry model of biodrainage for combating waterlogging in northwest India

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Abstract Waterlogging has become a serious problem in canal command areas located in arid and
semi-arid regions of the world. To combat the problem, four parallel strip plantations of clonal *Eucalyptus tereticornis* (Mysore gum) were raised in December 2002 on ridges constructed in a north-south direction in 4.8 ha waterlogged area of Haryana state (northwest India) in which 10% of the area (0.44 million ha) has already become waterlogged resulting in reduced crop yields and abandonment of agriculture lands. The strip plantations were spaced at 66 m and each strip plantation contained 2 rows of plants at a spacing of 1 m x 1 m resulting in a density of 300 plants ha⁻¹. Levels of ground water table were measured over 4 years in 22 observation wells installed in 2 transects across the strip plantations. The groundwater table underneath the strip plantations remained lower than the groundwater table in the adjacent fields without plantation. Rate of transpiration of strip plantations, measured with a sap-flow meter, was 50 litres day⁻¹ plant⁻¹ which was equal to 438 mm year⁻¹ against the mean annual rainfall of 212 mm. Benefit-cost ratio of first rotation of strip plantations was 3:1 against 1.3:1 of agricultural crops in Haryana and it would be >100:1 for next 3 to 4 rotations, each of 5 years, due to negligible cost of maintenance of coppiced *Eucalyptus*. Wheat yield in the inter-space of strip plantations was 3.34 times the yield in adjacent waterlogged areas without plantation. This agroforestry model proved an ideal option for higher returns, in situ utilization of excess groundwater and reclamation of waterlogged areas.

Opportunities and plausible benefits of biodrainage over conventional drainage in combating waterlogging and salinity

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Session 11. Agroforestry for salinity control and land rehabilitation

Abstract

Waterlogging and salinity have become a serious threat for more than 1/3 of the irrigated area of the world. The conventional engineering based sub-surface drainage systems are so costly that they cannot be installed on a large scale in developing countries such as India. Results of these systems already installed on a pilot basis at few sites in India are also not encouraging, due to their short life, environmental problems, very high cost of operation and maintenance, and a lack of farmers’ participation. Contrary to this, the biodrainage system in the form of agroforestry is relatively low cost, long life, environmentally friendly, highly remunerative and acceptable to farmers, as is evident from the studies conducted in 22 waterlogged villages of 7 districts of Haryana state (northwest India), in which 10% of the area is already waterlogged. The investigations carried out at a couple of sites have shown that the groundwater table beneath 20 year-old *Eucalyptus tereticornis* plantations on sandy loam soil remained lower than the adjacent fields; the area of influence was more than 730 m from the edge of plantation, the water table was maintained below 5 m depth, sinker roots reached the zone of capillary fringe above the groundwater table, and the soil and ground water salinity underneath the plantations was lower than in the adjacent fields. At some waterlogged sites the water table, which was within 1 m at the time of strip plantation, has fallen down below 2.5 m after 5 years and farmers have harvested 39 t ha⁻¹ wood biomass in addition to enhanced yields from arable crops. The plantation sequestered 18 t ha⁻¹ of carbon in the above-ground biomass and 7 t ha⁻¹ in the below-ground biomass. It could be concluded that biodrainage has a great potential for: increasing the production of crops and wood in waterlogged areas; and sequestering carbon.
Smallholder agroforestry models of biodrainage for reclamation of waterlogged areas in semi-arid regions of northwest India

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Session  11. Agroforestry for salinity control and land rehabilitation

Abstract  A farmer’s model of biodrainage was developed in waterlogged area at Hisar, in northwest India. Twelve bunds 150 m long, 2.6 m broad and with 45 cm height, were raised in a north-south direction in a 10 ha waterlogged field on the university campus. The distance between the two bunds was 60 cm and this size of plot represents the actual plots of the farmers. Eleven tree species i.e. Melia azedarach, Eucalyptus tereticornis clone-10, Terminalia arjuna, Pongamia pinnata, Casuarina equisetifolia, Tamarix aphylla, Callistemon viminalis, Eucalyptus tereticornis clone-130, Eucalyptus tereticornis clone-3, Eucalyptus hybrid and Prosopis juliflora, were raised on bunds with two rows of plants. At the age of 3 years, Eucalyptus tereticornis clone-10 showed the best growth followed by E.tereticornis clone-130, E.tereticornis clone-3 and Eucalyptus hybrid (E. tereticornis x E. camaldulensis). Tamarix aphylla, Melia azedirech and Pongamia pinnata also showed excellent growth on bunds, however, the growth was much lower compared to the eucalypts. The canopy of young eucalypts (leaf area index 3 to 4) was more effective in lowering the water table up to 30 50 cm than other broad leaf species. The comparative potential of biodrainage of these broad-leaved species was also studied more accurately through the lysimeter technique. The rates of transpiration in Prosopis juliflora and Casuarina equisetifolia, were significantly higher than eucalypts although the later group has higher rates of photosynthesis. The model of biodrainage described above has also been developed at farmers’ fields, and was found cheaper in establishment, environment friendly and economically viable. The effectiveness of the farmers’ model of agroforestry to ameliorate the waterlogged or shallow water able soils is discussed in detail. The strategies to promote such models are also discussed.
Session 12
Riparian system effects on soil and water quality
An assessment of the riparian zone of the Paradeke Oya in Sri Lanka

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Session: A3. Role of agroforestry in landscape-scale conservation strategies
Abstract: Riparian zones harbouring rich assemblages of flora and fauna are critical for watershed and wildlife management, and serve as indicators of global environmental change due to hydrological cycle variations. In the face of severe degradation, restoration of riparian vegetation is critical for sustainable management of watersheds. This assessment involved diverse studies of the prevailing riparian condition with relation to plant cover, erosion, pressures and flow regime, including areas occupied by the tea estates and village homegardens, with an inventory of biodiversity and an evaluation of habitat quality. The study area had a limited diversity of aquatic and land species due to loss of vegetation cover, soil erosion and poor water quality. In 2007, areas within the Gampola District of Sri Lanka were affected by the spread of the Hepatitis A virus. Out of 1975 cases reported from the whole of the Kandy district, 825 cases were from the Udapalatha area indicating contamination of the streams that flow into the Paradeke Oya. The National Water Supply and Drainage Board that harvests water for distribution to downstream communities contracted the Neo Synthesis Research Centre (NSRC) to develop a sustainable plan for the ecological restoration of the watershed. Less than 45 percent of the riparian zone is under vegetation cover. Further, over 80 percent of the vegetation is composed of exotic species with the most dominant being Camellia sinensis or tea. In terms of erosion, over 50 percent of the riparian zone suffers from exposed soil. The study demonstrates the immediate need for restoration using perennial forest species to improve water quality, coupled with improved management of sewage, waste materials, and agricultural practices.

Mitigation efficacy of vegetated buffers in reducing non-point source pollution: A critical review and meta-analysis

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Session: 12. Riparian system effects on soil and water quality
Abstract: Vegetated buffers are one of the most studied and widely used agricultural management practices for reducing non-point source pollution. A wealth of existing literature provides experimental data on their mitigation efficacy. This paper aggregated many of these results and performed a meta-analysis on them to quantify the relationships between pollutant removal efficacy and buffer width and buffer slope. Theoretical models for removal efficacy (Y) versus buffer width (w) were derived and tested against data from the surveyed literature using statistical analyses. A model of the form, \( Y = Kb^w \), is shown to successfully capture the relationship between buffer width and pollutant removal, where K reflects the removal capacity of the buffer and \( b \) reflects its probability of removing any single particle of pollutant in a unit distance. The estimates of K are 90.9, 93.2, 92.0, and 89.5 for sediment, pesticides, nitrogen (N) and phosphorus (P), respectively. Buffer width alone explains 37, 60, 44 and 35% of the total variance in removal efficacy for sediment, pesticides, N and P. Buffer slope is linearly associated with sediment removal efficacy either positively (when slope < 9%) or negatively (when slope > 9%). Buffers composed of trees have higher N and P removal efficacy. Soil type did not show statistically significant effects on pollutant removal efficacy. Models for all the studied pollutants are statistically significant with P-values < 0.001. Based on our analysis, a 30 m buffer under favorable slope conditions removes over 85% of all the studied pollutants. These models predicting optimal buffer width and slope could be instrumental in the implementation and design of vegetated buffers for treating agricultural runoff to meet specific water quality objectives. The quantitative relationship established, also provides valuable information for modeling buffer efficacy at the watershed scale.
Rehabilitation of degraded riparian forests and watersheds based on useful trees: issues and lessons from Benin

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Session: 12. Riparian system effects on soil and water quality

Abstract

Riparian forests (RFs) and their watersheds are of extreme ecological and economic value for local people. Their rich biological resources are now disappearing before they can be inventoried and assessed. The forest law in Benin recognizes the uniqueness of RFs, and clearance of wood and shrubs is not allowed within 25 m on both sides of any water course and stretch of smooth water. Meanwhile the implementation of the protection rules in these particular ecosystems, especially in non-protected areas, leaves a lot to be desired. It is planned in Participatory Management Plans (PMP) for forest reserves that RFs will be left uncut. Unfortunately for biodiversity conservation this measure in RFs is not implemented. Most recent PMPs include RFs as “priority zones for protection” with a 500 m wide buffer at each side of major waterways, and strict conservation rules are intended to be applied. Apart from sacred stands of RFs and water sources where indigenous rules are respected, nothing is done for RF and watershed rehabilitation in rural lands. Most municipalities do not implement zoning plans that protect marginal vegetation and hot spot biodiversity ecosystems, such as RFs and their watersheds. They are more interested in selling all their land including floodplains, marshes, and waterways with their forested banks. Therefore, simply protecting RFs in a buffer zone may not be adequate to ensure their existence in the long term. Instead, the integrated management of RFs must be a component of good landscape management plans that take into account agroforestry systems with the conflicting needs of all stakeholders. Trees, such as Pterocarpus santalinoides, Cola laurifolia, Syzygium guineense, Berlinia grandiflora, Elaeis guineensis, Manilkara multinervis, Xylopia parviflora, Dialium guineense, Diospyros mespiliformis, etc. can be used for the rehabilitation of degraded RFs and watersheds.

Keywords: Riparian Forest, Biodiversity, agroforestry systems, useful trees, rehabilitation.

Examining the nexus between depletion of wetlands, forests and the deepening water crisis in Uganda

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Session: 12. Riparian system effects on soil and water quality

Abstract

Uganda, like the rest of the world is grappling with the problem of environmental degradation and its attendant negative adjuncts. Yet the state of the environment in Uganda’s pre-independence period was the most ideal in the whole of Africa. Once described as the ‘Pearl of Africa’ and a fairly tale by Sir Winston Churchill, the former Prime Minister of the United Kingdom and Second World War hero, Uganda now lies at the brink of environmental catastrophe. The paper has the following aims: to document evidence about the decrease in water availability and its linkage with the environment; to evaluate the effectiveness of government policies on restoration and conservation of water catchments systems; to provide policy actions that need to be included in the new Land Policy to address the situation; and to document the role of farmers in conservation and restoration of water catchments systems. With every wetland encroached on, every swamp drained, every parcel of top soil eroded, with river drying up and lakes shrinking, desertification becomes more of a reality in Uganda. The culprits and victims for this environmental catastrophe are largely the farmers who interact with the environment on a daily basis. Yet
if educated and given capacity, farmers can be the best protectors and custodians of the environment, especially through robust agroforestry practices. The study notes that despite the fact that the Government owns over 80% of the land occupying water catchment, these areas continue to be encroached upon due to weaknesses in law enforcement, corruption, political interference and impunity. The study contends that instead of drafting more laws and policies to protect and conserve the environment, the Government should focus on implementing and monitoring the enforcement of the already existing laws. The need to mainstream restoration efforts in all existing and upcoming environment policy-related regimes is also emphasized.

**Riparian systems as sinks and sources of N and P: a review**

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**Session**  
12. Riparian system effects on soil and water quality

**Abstract**  
Riparian systems are widely recognized as effective in reducing nutrient and sediment input into water bodies in different land-use systems. Their effectiveness depends on: 1) the type of pollutants; 2) the hydrologic connection between pollution source, riparian system and the water body; 3) characteristics of the riparian system (connectivity, riparian patch size and uniformity); 4) characteristics of the riparian vegetation (species composition, stand age, vertical stratification and root system characteristics); 5) topographic features such as slope gradient; 6) riparian soil characteristics; and 7) occurrence of flood events (frequency, size and timing). For N retention and reduction, denitrification in riparian zones has been shown to be the most important mechanism for reducing the input of nitrate from non-point sources into water bodies. The major limitations for denitrification are watertable (soil aeration) and availability of nitrate and C source. Plant N uptake is also important, particularly when soil N availability is high. Riparian systems are generally less effective in removing P, as no mechanism such as denitrification is available for net removal of P out of the system. For riparian systems dominated by annuals or short-lived perennials, harvesting of vegetation and their removal out of the system is essential to maintaining the efficiency of N and P retention as the system could otherwise become N and P saturated. Accumulation of N and P in riparian zones and their saturation can make them net sources of N and P, particularly when coupled with disturbances. It is clear that while riparian systems can be effective in retaining N and P they should be used as a secondary method for soil and water quality improvement and emphasis should be placed on reducing pollution at source through techniques such as improved agricultural practices.

**Soil nitrogen and carbon cycling in African savannah riparian ecotones**

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**Session**  
12. Riparian system effects on soil and water quality

**Abstract**  
The role of riparian ecotones as buffer zones where nutrients originating in terrestrial areas are modulated and immobilized through various processes is well established in mesic regions. However relatively little is known about how these processes operate in riparian woodlands in the semiarid southern African savannah. We determined baseline values for nitrogen and carbon cycling processes in riparian ecotones and compared them to adjoining terrestrial areas in Kruger National Park, a large savannah park where anthropogenic influences are purported to be minimal. Field and laboratory measurements were carried out to determine field and potential denitrification, nitrogen mineralization and soil respiration. The rate of
N2O emissions from terrestrial savannah soils tended to be low, even during the rainy season. The wetter riparian zones showed higher field denitrification rates, and also showed much higher potential denitrification rates. However, these values are very low compared to similar savannah regions and mesic regions, possibly due to the relatively low available nitrogen levels in these soils. In the southern African savannah, soil respiration also showed the highest values in the riparian zones. Soil moisture showed the highest correlation with soil respiration, thus indicating that the latter is likely to be a major environmental control on soil respiration. We conclude that riparian zones, despite their small acreage in savannah ecosystems are nevertheless important hotspots where nutrients such as nitrogen are immobilized, and CO2 produced. However, we have established that the rates of soil nitrogen cycling are low when compared to riparian areas in mesic areas, even during the wet summer season. Other processes whereby nitrogen could be immobilized, such as microbial and plant uptake may also be important and deserves further investigation.

Taungya system in the Blue Nile Riverine Forest Reserves, Sudan

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Session 12. Riparian system effects on soil and water quality
Abstract
The study deals with the taungya system in the blue Nile Riverine Forests with special reference to Gazair Forest, Sennar State, Sudan. The first objective of the study was to test the effect of intercropping on growth of Acacia nilotica (Sunt). The second objective was to test soil moisture during the cropping period since flooding was the only means of irrigation. Theta probe devices were used for this purpose. Pit sowing was applied to Sunt at a distance of 2x2 m using complete randomized block design. The crops involved were chickpea, haricot bean and watermelon. Results show no significant difference in Sunt growth (using parameters of height and diameter) between the control and under the different crops after 2 cropping seasons. The yield of crops was fairly considerable during the first season when compared to similar conditions of dry tropical zones, except for haricotbean. There was a reduction in yield of all crops during the second season of intercropping due to influence of trees. Results of moisture content show that it was very ample and adequate for all crops and Sunt seedlings during the study period. Throughout the Taungya experiments results show a reduction and saving in the initial cost of the plantation for the forests department of up to 114 person- days/ha/yr.

Vegetation, water quality and benthic invertebrates in response to riparian cattle exclusion fencing

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Session 12. Riparian system effects on soil and water quality
Abstract
A multidisciplinary project was established in the Salmon River watershed in the interior of British Columbia in 2004 to evaluate BMP impact. The Salmon River has a drainage area of 1500 km2 and is 120 km in length. The watershed supports agriculture, forestry, recreation and urban development, with beef ranching, diary and forage crop production the most common agricultural activities. In 2004 three beef farm sites were selected to evaluate the impact of riparian fencing and off-stream watering of beef cattle on vegetation at the stream’s edge, water quality, sediment and macro-invertebrates. For the first few years of the study the upstream halves of the farm sites were fenced to exclude cattle from the riparian area while the lower halves of the sites were left unfenced. Water quality was determined
upstream, midstream and downstream at each farm site. Bacteria and sediment were shown to respond favourably to exclusion fencing with lower E. coli numbers (p<0.023) in sediment samples and (p<0.018) within water samples. The sediment particle size analysis of sediment collections from the fenced areas had a significantly greater percentage of fine sand (p< 0.040) fractions and lower percentage of silt and clay (p<0.028) fractions during the September to May period. The green-line method developed was used to assess vegetation within the fenced and unfenced riparian areas. The riparian impacts of exclusion fencing were evident with less bare soil and a greater amount of vegetative cover. Impacts of cattle were observed at one farm site from cattle breaching the fenced area. Biomonitoring of benthic macroinvertebrates determined anthropogenic impacts and mitigation of BMPs on aquatic ecosystem health. This study demonstrates that land-use activities are having a significant impact on the benthic macroinvertebrate community and that the health of the riparian buffer zones play a role in mitigating the negative impacts of riparian degradation.
Session 13
Agroforestry in Europe and other temperate regions
Alley cropping – an option to combine crop and woody biomass production at degraded post-mining sites in Germany

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Session: 13. Agroforestry in Europe and other temperate regions

Abstract: The post-mining landscape of the Lusatian lignite mining district in northeast Germany is characterized by low precipitation and marginal soils at the initial stage of soil development (low water-retention capacities, low humus and nutrient contents). Due to these conditions crop yield stability is relatively low. Establishing an economically feasible land use on such sites is a challenge for farmers and foresters. Alley cropping systems (ACS) for biomass production offer a promising land-use alternative to enhance the economic value of such sites. The integration of hedgerows can improve the microclimate by shading and the reduction of the wind speed. As a consequence soil moisture and soil temperature will be more balanced and hence crop yield stability could be increased. Furthermore, the additional utilization of the hedgerows as energy wood can be a profitable source of income. In order to assess the overall impact of hedgerows in ACS on crop yields at poor sandy soils, an ACS was established in 2007 in the Lusatian lignite mining district. Hedgerows consist of four double rows of black locust and have a width of 12 m. Alfalfa was established in the alleys with a width of 24 m. Weather and soil data will be determined in different distances from the hedgerows in order to characterize their effects on microclimate and soil properties such as nutrient availability or C sequestration. In addition, crop yield and woody biomass data will be collected. Based on these investigations we expected a precise characterization of effects of hedgerows in ACS on microclimate, crop yield and soil properties. The results will be the basis for recommendations for an optimization of the tree-crop interaction in order to increase the reliability of plant production as compared to mono-cropping systems.

Landscape change and dynamics in Mediterranean evergreen oak woodlands in the southwest Iberian Peninsula

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Session: 13. Agroforestry in Europe and other temperate regions

Abstract: Mediterranean agroforestry landscapes with open evergreen oak woodlands in the southwest of the Iberian Peninsula, experience important structural changes that could affect their sustainability. These regions are characterized by high sensitivity to global warming, desertification processes, land-use transformations due to rural depopulation, abandonment of traditional activities and substitution of agriculture land uses and native oak woodlands by Pinus pinea and Eucalyptus spp. plantations. The goal of this study is to provide quantitative information on the landscape dynamics, resulting in a shifting mosaic landscape, by quantifying regression and recruitment areas and determining fragmentation and dispersion indices over a 50-year period (1958-2005), in three regions in south Portugal, Alcoutim, Chamusca and S. Bartolomeu da Serra, with different intensification and extensification of land uses determined by national and EU agricultural policies. Aerial photography was processed in a geographical information system (GIS) and landscape pattern metrics on landscape composition were applied in order to determine the shape and size of patches and patch isolation. The main result of high average yearly rates of landscape change support the view that opposite trends of land abandonment and intensification of land uses arise, with shrubland, extensive agriculture and new forest plantations as key factors in the ongoing fragmentation on evergreen oak woodlands in the south-west of the Iberian Peninsula, Portugal.
Phytoremediation of a metal-contaminated industrial soil of Porto Marghera

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Session: 13. Agroforestry in Europe and other temperate regions

Abstract
A field test to evaluate the phyto-remediation technology used to mitigate As, Cd, Pb and Zn contamination in an industrial area located in Porto Marghera (Venice Lagoon, Italy) was studied. The polluted area is an artificial island, 41 ha wide, built using different materials, including industrial by-products. Two clones of Populus deltoids (Dvina, Lena) one of P. x Canadensis (Neva) two of Salix matsudana (S76-005 and S76-008) and one of Salix alba (S164-017) were planted in an experimental area of 1600 m² in a randomized block design with four replications at a density of Short Rotation Coppice (6000 plants/ha). The different clones were evaluated for growth, photosynthesis, transpiration rates and re-growth capacity after cutting in order to select the best suited to the specific environment. For each clone, metal accumulation capacity was measured in roots, stems and leaves. The hydrological balance of the tree stand was also calculated, to evaluate the reduced risk of metals leaching into the water table. Poplars proved to endure soil contamination better than willows, having a higher photosynthesis, transpiration rates and metal extraction capacity, with some variability within clones. Considering all clones together, poplar trees on average accumulated per plant: around 5 mg Pb, 12 mg Cd, 825 mg Zn and 1 mg As in leaves; 824 mg Pb, 62 mg Cd, 2343 mg Zn and 16 mg As in stems; and 365 mg Pb, 8 mg Cd, 439 mg Zn and 6 mg As in roots. The plantation was efficient in removing the rainfall available in the soil, in excess of the field capacity, during the vegetative season. Metal accumulation was also assessed in indigenous weeds and some species have been taken into consideration for a co-cultivation within the rows of the Salicaceae stand, to accelerate the reclamation of the polluted site.

Agroforestry adoption in France: A take off

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Session: 13. Agroforestry in Europe and other temperate regions

Abstract
Since the first world congress of agroforestry at Orlando in 2004, the agroforestry adoption process has made huge steps forward in France. Four key events opened the way to the wide-scale adoption of agroforestry in France. First, intercrops in treed systems were recognised as eligible for the support schemes for crops of the European Common Agricultural Policy. Previously, intercrops were often considered as ineligible, which made them not commercially profitable, and blocked any will to adopt agroforestry by farmers. Second a European Regulation (Council Regulation No. 1698/2005) was adopted that includes the possibility to support farmers that want to plant trees in their fields (Article 44); however, this article was not compulsory, and few European states have so far included this possibility in their national schemes. Third, the French State will implement this regulation in 2009, allowing local communities to help farmers to plant trees. And finally, the specificity of agroforestry schemes was recognized by a specific French regulation that is expected to be published at the beginning of 2009. As a consequence, the number of farmers involved in agroforestry plantation has increased steadily over recent years, and prospects for planting half a million hectares of agroforestry systems in France during the next 25 years are now considerable. The key to succeeding in disseminating agroforestry technology in countries without any previous practice is the availability of convincing demonstration plots. Therefore, a national network of demonstration plots was established in 2006 and 2007 throughout France, with more than 40 sites in almost all French provinces. This network will be monitored to provide a regional database on the management of modern agroforestry systems.
Agroforestry systems - an option for Central Europe?

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Session: 13. Agroforestry in Europe and other temperate regions
Abstract:
Within the ‘Agroforest’ project funded by the German Federal Ministry of Education and Research a combination of agricultural and forest management concepts were examined. The production of valuable timber is combined with energy wood production, agriculture and grass land and the impact of these land uses on the landscape aesthetics and nature production was evaluated. The results of the project will be presented.

Establishment of alley-cropping systems with short rotation woody crops in Germany

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Abstract:
Agroforestry systems came into focus in Germany because they can combine the cultivation of short-rotation woody crops for the production of wood fuels with benefits for microclimate and biodiversity. However, only with an appropriate design and management will such systems be compatible with traditional land-use systems. In order to develop recommendations for design and management of alley-cropping systems in 2007 and 2008, 3 experimental alley cropping systems were established in northern and central Germany covering typical site conditions as well as different tree species (Populus spp., Robinia pseudoacacia L., Salix spp.), crops, design and management options. Among the experimental sites, the site at Dornburg represents typical properties of arable land in Central Germany. It is characterized by a pH of 7.1, an organic carbon content of 1.5 %, element contents for P and K of 0.12 and 0.23 mg g⁻¹ soil and an N content of 49.9 kg ha⁻¹. The GPS-based mapping of the wheat yield for 2007 showed an average of 8.3 t ha⁻¹. After site preparation in March 2007 poplar clones Max 1, Max 3 and Max 4 (Populus nigra L. x Populus maximowiczii Henry) were planted in 12 m wide hedgerows. The distances between trees were optimized for a fully mechanized management. However, although mechanical weeding was done 4 times between April and August 2007 weed could not be controlled sufficiently. Survival rates were ranging from 41 to 74 %. As a consequence in the year 2008 the management was advanced including the use of 2 m long cuttings as planting material for gaps, fencing, mice control and the use of herbicides in order to establish dense and highly productive hedgerows. Including the results of the other study sites it can be concluded that the establishment of alley-cropping systems still needs adaptation to different site conditions and objectives. Recommendations for an optimized establishment will be further developed based on ongoing research results and an economic assessment.
**Forest farming in Appalachian hardwood forests: opportunities and constraints**

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Session: D1. Forest farming of non-timber forest products in N America

Abstract

The Appalachian hardwood forests are some of the most biologically diverse temperate ecosystems in the world. The socioeconomic conditions in this region have many similarities to those found in developing countries. The first European settlers were drawn to this region by its vast natural resources, and communities evolved around the forests and continue to depend on these natural resources for their sustenance. Although people have been informally farming their forests for generations, only in recent years has attention been directed at formalizing this land-use practice through research and development. Forest farming is becoming popular for landowners to diversify income opportunities, improve resource management, and increase biological diversity. The social, ecological and economic implications of private landowners farming their forests are significant. Forest farming focuses on producing herbaceous plants that traditionally have been wild-harvested for food, medicine, and other income generating opportunities. There are many opportunities and challenges that face landowners interested in forest farming. Many new forest ventures may require additional skills and expertise. There may be additional capital or labour requirements. Market demand and competition may be such that profit margins reduce the attractiveness of alternative forest enterprises. Technical challenges of cultivating native herbaceous plants under forest canopies may be daunting, as well. This presentation examines opportunities and challenges of developing forest farming into a viable land-use practice for landowners in the Appalachian hardwood region. Implications of these findings could help stimulate forest farming in other regions, as well.

**Short-rotation forestry (SRC) on agricultural land: Ecological benefits and limitations**

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Session: 13. Agroforestry in Europe and other temperate regions

Abstract

A rapid increase in agricultural land cultivated with willow and poplar for the production of biomass for heat or electricity is projected in the short term for northern Europe. However, short-rotation forestry (SRC) will have implications on a range of environmental issues (e.g. water use, phyto and zoodiversity, landscape ecology) but positive aspects might be limited due to the dominance of common land-use techniques. Thus agroforestry approaches in a broader sense might be a serious alternative, but respective applications and techniques are rare, not yet well recognized and established. This presentation will focus on newly gained field data from ongoing SRC projects and will discuss promising examples and options especially adapted to the climate conditions in northern Europe.
Silvo-arable agroforestry in Europe: accommodating new land-use requirements with good practice and resource efficiency

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Session 13. Agroforestry in Europe and other temperate regions

Abstract Silvo-arable agroforestry (SAF) integrates the use of trees and arable crops in fields. In Europe, some traditional SAF systems still persist, but in most arable landscapes, trees have been cleared in the last 50 years, with resulting problems in terms of soil erosion, groundwater pollution, and decreasing biodiversity. As well as helping to tackle such issues, an important benefit of SAF is that it can make more efficient use of environmental resources and produce more biomass, than when trees and crops are grown separately. Also, appropriate SAF systems provide greater environmental benefits and improved profitability in comparison with conventional arable cropping and forest monocultures. Many featureless agricultural landscapes in Europe could benefit from integrated tree and crop systems and both field experiments and multi-scale modelling suggest that SAF may be a good option for about 40% of European arable landscapes. However, the performance of SAF in Europe is variable and methods that combine environmental and economic indicators are needed to evaluate in which circumstances SAF offers a viable alternative. Institutional barriers still persist, including biased payments for conventional agricultural systems and lack of support at national government level, despite the benefits of SAF being recognised in European policy. This presentation will summarise findings on the environmental and economic valuation of modern SAF systems in Europe.
Session 14
Agroforestry as a tool for landscape restoration
Agroforestry education: the education of multiplying agriculturists involved in biodiversity conservation and landscape restoration

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Session
14. Agroforestry as a tool for landscape restoration

Abstract
The “Y Ikatu Xingu Campaign” (www.yikatuxingu.org.br) was created, based on the principle of shared environmental and social responsibility among all stakeholders in the Xingu watershed. Its main objective is to preserve and restore the riparian forests and springs that are part of the Xingu River, one of the principle tributaries of the Amazon River, in the Brazilian Amazon. The objective of this work is to present the ‘Xingu Social-Environmental Agents Education Program’ as a tool for changing the business-as-usual agriculture to a more sustainable and responsible use of natural resources. We have created a continuous education program that develops the conceptual, social and technical abilities of those small producers involved; it aims for the creation and the support of projects that put together biodiversity conservation and riparian forest restoration while valuing local initiatives and the agroforestry culture. The Program is being carried in stages (modules) and activities between those stages developed to suit the circumstances of each individual, from a project designed by them during the module, with our support. The learning process occurs in 3 components: knowledge; technical and social abilities (to listen, to express themselves, to coordinate spaces, to take decisions and solve conflicts). They also learn agroforestry techniques based on experimentation and research. They learn how the individual influences his or her own life situation, passively or actively. Therefore, the construction of social abilities, the promotion of agroforestry culture and the process of decision making are the basis of the program. These experiences show that all small-scale producers, teachers have learned agricultural techniques and have used the agroforestry knowledge and methods on the restoration of the degraded riparian forest, and on the enhancement of agricultural systems. This methodology has been very efficient as an education process and in the creation of social-environmental agents who want to change their realities.

Agroforest landscape ecosystem analysis in Mindanao, Philippines

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Session
14. Agroforestry as a tool for landscape restoration

Abstract
The study dealt with the dynamics of agroforest landscape ecosystem and watershed protection and rehabilitation in Cagayan de Oro City, Philippines. Specifically, this assessed: a) the diversity of agroforest species in the watershed and their ecological status and economic importance; b) composition of phytoplankton species diversity in the watershed as a biological indicator for water pollution; and c) the status of soil in the upper and middle stream portions of the watershed. Standard protocols were used in the methodology in taking measuring agroforest/floral diversity of species, phytoplankton species composition and soil test analysis. General findings revealed that there were thirty-six agroforest species identified in the urban watershed of Cagayan de Oro City, Mindanao, Philippines, which are economically important, endemic, rare and endangered species. The phytoplankton were dominated by Nitzchia and Navicula species in the middle stream and Microsystin auruginosa and Nitzchia species in the downstream. These species are pollution-tolerant and are known to release red-tide-causing toxins which are major causes of fish kills. Soil test analysis generally showed a very good range of soil pH values (6.8–7.36) which is appropriate for agriculture and cash crops. For both the middle and upper stream portions of the watershed NPK content was moderately high and appropriate for the crops.
The agroforestry multispecific project of Fundación Danac in Venezuela

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Session: 14. Agroforestry as a tool for landscape restoration

Abstract:
In 1996 Fundación Danac began the project, ‘The Agroforestry Multispecific Forest’, which included as the main component, fine wood species such as Swietenia macrophylla, Cordia thaisiana, Tectona grandis, and Tabebuia roseae and several bamboo species (Bambusa vulgaris, Guadua amplexiícola and Guadua angustiícola). A plot of 101 hectares was established, intercropped with leguminous species as Cajanus cajan and Crotalaria juncea for soil management. The management of the project integrated the use of agronomic and silvicultural practices. Nine different systems were developed, the main functions of which were wood production, soil conservation, protection of water river courses and generation of socioeconomic benefits for families of the local Danac surroundings. The outstanding SAF are the associations with Cajanus cajan, juncea Crotalaria and Crysopogon zizanioides and the multilayer silvipastoral system of 4.5 hectares with 11 species of leguminous trees, wood species, grass and forages in four vertical layers. The thinning of the plantation began in 2004, from 14.791 falling trees several products were obtained, such as poles used in the construction of fences and like structures for houses and other building constructions. To protect against the erosion of the margins of the Yaracuy River and neighbouring creeks, 1.5 km of bamboo were planted along the margins, this was also to ensure the provision of raw material for the craftsmen of the area. The positive impacts of the project are demonstrated in biodiversity recovery, improvements of the rural landscape, reduction of agricultural soil losses, improvement of family incomes and development of the commercial sector and services in neighbouring communities.

Environmental services by agroforestry systems: how to operationalize them?

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Session: 14. Agroforestry as a tool for landscape restoration

Abstract:
Agriculture is among the main sources of income in developing countries, as well as being an important driver of environmental disturbance. Agroforestry, by combining agricultural and forestry components, with specific management strategies at plot, community and landscape scales, can satisfy multiple demands, among which is the provision of environmental services. Environmental services are proposed as compensation mechanisms to revert negative ecological impacts; these incentives must be based on an adequate understanding and evaluation of the services provided. For this purpose, based on multicriteria and multivariate analyses, we have devised a protocol that addresses the assessment of environmental services provision, through an integrative insight on influential components, but without neglecting the farmers’ productive priorities. The approach combines productive, ecological and operational indicators, and aims to identify the management decisions that encourage overall system performance. The protocol was focused on biodiversity as a case study and it was carried out in northern Brazil. The sample considered 3 groups of farmers, based on the time of settlement, property size, technological know-how, organization and access to market, that is, ‘CAMTA partners’, ‘immigrated’ and ‘newcomers’. The study revealed the following factors as the most relevant in encouraging biodiversity: (a) the farmers’ technical qualification and their preference for low-impact techniques; (b) their capacity to adapt to environmental, social and political changes; (c) the diversification of species composition at plot level and the increase in the use of perennial ones; and (e) the financial profitability of the system. Concerning the assessed groups, the ‘CAMTA partners’ perform significantly better than the other two, due mainly to their technological backstopping, and post-harvest organization and commercialization. The proposed protocol might provide a supportive
platform for the environmental services assessment, and eventually can be used to optimize farmers’ decisions; nevertheless, its further validation, testing and adaptation as a monitoring tool seem necessary.

Imitating natural ecosystems through successional agroforestry for the regeneration of degraded lands in northeast Brazil

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Session 14. Agroforestry as a tool for landscape restoration

Abstract
Agroforestry techniques to restore degraded lands and environmental functions and services are an important issue for achieving sustainable land use and improving rural livelihoods. Agroforestry systems differ basically in diversity and complexity. The following approach aims to imitate the structure and function of the local ecosystems to restore degraded lands through successional agroforestry systems providing subsistence to smallholder farmers within locally adapted forest-like agro-ecosystems. The conversion of the natural vegetation cover to pastures and farmlands on more than half of the northeast Brazilian region has led to a serious degradation of soils, and furthermore to the desertification of about 181,000 km² in the semi-arid part of the region. About 88% of the population depends on smallholder agriculture, and are directly dependent on the conservation of soils and the efficient use of water. This case study compared three climatic regions in the northeast, where smallholders applied the method of successional agroforestry. This cultivation system imitates and actively accelerates the natural succession by planting locally adapted edible plants with similar functional characteristics to those of the same successional level of the locally adapted ecosystem. In the first successional step the main focus is on the elevation of organic material, opening the possibility to integrate at the next step plants of a higher successional level. With increasing development of the successional system, a higher diversity of plants with different functional and structural characteristics lead to short cycles of nutrients and water. With this method, highly degraded areas have been regenerated, leading to an increase of agricultural production of about four times that of the former annual cropping systems, also reducing the risk of drought-related harvest loss due to diversification and perennialism.

Landscape restoration in model forests of Ibero-America: actual initiatives and perspectives

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Session 14. Agroforestry as a tool for landscape restoration

Abstract
Model forests are both a landscape-scale area and a partnership-based approach to sustainable forest management in which a diversity of stakeholders representing the forest’s uses and values (from an environmental, social and economic perspective) work toward a common vision. Through the development of a participative governance structure, a variety of partnerships, capacity building, knowledge sharing and networking, the inhabitants of the model forests increase their level of resilience and improve the time of response to climate change and other unpredicted adversities that can affect their area. Model forests are part of national, regional and international networks that provide an opportunity to share experiences and knowledge, and they have the particular quality of possessing politic incidence at different scales (from local to international). Agroforestry systems are frequently among the mosaic of land uses observed in the model forests areas. There are
also degraded lands that receive or require some type of restoration activities. This study presents the situation and importance of land restoration practices and agroforestry systems in the model forests of the Ibero-American Model Forest Network (IAMFN) as well as two regional initiatives actually coordinated by the IAMFN which promote and contribute to the tree-based rehabilitation of degraded lands and watersheds as well as environmental and economic sustainability. The first project relates to analogue forestry as a method to biodiversity restoration and rural livelihood improvement. It is implemented in three model forests from Central America and the Caribbean: Reventazon (Costa Rica), Atlantida (Honduras) and Colinas Bajas (Dominican Republic) Model Forests. The second regional initiative is the Ibero-American Network on Landscape Management which links seven countries in which model forests are established and that provide a platform to exchange investigation experiences and knowledge from landscape-scale restoration activities.

**Living fences as linear extensions of forest remnants: a strategy for restoration of connectivity in agricultural landscapes**

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**Session**  14. Agroforestry as a tool for landscape restoration

**Abstract**

As the intensification of agriculture continues to threaten the survival of wildlife, enhancing the connectivity between remnant forests patches may be an important conservation strategy to counteract the loss of biodiversity. In order to evaluate the contribution of living fences adjacent to forest patches to improving the connectivity of the agricultural matrix, this study examined species composition (forest specialists, savanna specialists, and generalist species) of birds that use living fences as habitat. Living fences in Espanza, in the Pacific lowlands of Costa Rica, were classified as connected, intermediate or distant from secondary forest patches. Bird species composition changed as a function of distance to the forest patch; yet species richness, number of individual birds and Shannon Diversity indices were similar between forest interiors (control) and living fences. The results suggest that living fences near forest patches provide habitat to many bird species including forest specialist. However, fence structure and composition significantly influence usage by birds. The presence of diverse native tree species in fences and increased vegetative cover may counteract the effect of distance to the forest patch, promoting greater bird species diversity in living fences and in the landscape.

**Non-wood products from native multipurpose tress from agroforestry homegardens at the semi-arid Mexican Plateau.**

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**Session**  14. Agroforestry as a tool for landscape restoration

**Abstract**

The multispecies home gardens cultivated by women and children are useful sites that contrast with the desertified landscape resulting from the degradation of soils and the reduction of the biodiversity in the region known as Southern Semi-arid elevations of North America. In spite of the benefits that the native multipurpose shrubs and trees offer in rural areas, it is observed that governmental reforestation has been directed to promote mainly introduced commercial tree species. This situation has an environmental impact due to the fragmentation of the landscape and the reduction of native vegetation, with additional negative effects on natural resources and productive potential of homegardens. In this
paper a local action is proposed that allows the restoration of degraded lands located in rural communities, through the plantation of adapted native semi-arid multipurpose trees or shrubs, promoting soil fertility and reducing climatological impacts. In addition, this local action will allow, in the short term, the production of vegetables and medicinal or aromatic plants essential in Mexican homes. The information presented in this paper was acquired in the agroforestry homegarden of the experimental station at INIFAP, and is an example of the benefits and non-wood products that could be obtained in a period of 5 years to enhance the rural economy, and which is equivalent to the subsidy granted by the government for 5 ha of basic crops under rainfed conditions. Also it is emphasized that the historical function of the agroforestry home gardens is to conserve traditional knowledge, promote environmental education and conserve the biodiversity of Mexican ecosystems.

Plant diversity effects and productivity in coffee agroforestry systems in Costa Rica

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Session 14. Agroforestry as a tool for landscape restoration
Abstract
Agroforestry systems (AFS) can be productive while protecting soils and maintaining a fraction of the biodiversity that normally occurs in tropical forests; therefore AFS constitute an alternative for sustainable land use and restoration. To study the effects of management regime and intensity on long-term productivity and sustainability of coffee AFS, a set of experimental AFS was established at CATIE, Costa Rica in 2001 2002. Treatments included three native tree species alone and in combination: *Terminalia amazonia* (Combretaceae), *Erythrina poeppigiana* (Fabaceae) and *Abarema idiopoda* (Mimosaceae); coffee monoculture (non-shaded); and management regimes of organic and chemical nutrient inputs of two levels of intensity. To describe the relationship between plant diversity and coffee productivity we quantified herbaceous plant diversity and recorded the productivity (bean yield) of the coffee across all shade types, management regimes and input levels. Our results indicate that: 1. Herbaceous plant diversity is highly correlated with coffee productivity under most experimental combinations. 2. Organically managed plots have higher herbaceous plant diversity and can be almost as productive as chemically fertilized plots. 3. Shaded coffee AFS can be almost as productive as non-shaded, high input systems. 4. Preliminary data indicate that the leguminous shade tree *Abarema idiopoda* constitutes a viable option for coffee AFS in Costa Rica, however breeding and selection programmes are needed to improve tree form, and increase availability of good quality seed. We recommend the inclusion of more than one shade tree species in coffee AFS to maintain or recover ecosystem biodiversity and obtain competitive yields. Since organically managed coffee systems require additional labour it is necessary to quantify the labour costs associated with shade tree establishment and management. Our results suggest that when economic and environmental trade-offs are considered organically managed AFS are highly competitive.

Predicting the effects of landuse on runoff and sediment yield in selected subwatersheds of the Manupali River using the ArcSWAT

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Session 14. Agroforestry as a tool for landscape restoration
Abstract
The quantitative prediction of environmental impacts of land-use changes in watersheds could serve as basis for developing sound watershed management schemes, especially for Philippine watersheds with agroforestry systems. ArcSWAT, a river basin-scale model...
developed to quantify the impact of land-management practices on water, sediment, and agricultural chemical yields, was parameterized and calibrated in selected Manupali River sub-watersheds with an aggregate area of 200 ha to simulate the effects of land use on runoff volumes, sediment yield and stream flows. Calibration results showed that ArcSWAT can adequately predict peaks and temporal variation of runoff volumes and sediment yields with a Nash and Sutcliffe coefficient (NSE) ranging from 0.77 to 0.83 and 0.55 to 0.80, respectively. When the calibrated model was run to simulate land-use change scenarios, it indicated an increase of runoff volumes and sediment yields by 3% to 14% and 200% to 273%, respectively, when 50% of the pasture area was converted to agricultural lands. Consequently, these results decrease stream flows by 2.8% to 3.3%. The upper limit indicates condition of the watershed without soil conservation intervention. More seriously, an increase of 15% to 32% in runoff volume is likely to occur when whole sub-watersheds are converted to agricultural lands. This accounts for 39% to 45% of the annual rainfall to be lost as surface runoff. The simulated effects of forest conversion to agricultural crops clearly indicate an alarming phenomenon of watershed degradation. In our test watershed, we recommend an intensive information and education campaign be conducted on the consequences of forest conversion and ways of rehabilitating the watershed. Finally, this study recommends that alternative livelihood opportunities be considered in policy implementation.

Rehabilitation of degraded forests with the collaboration of local communities using the Taungya system in Ghana

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Session 14. Agroforestry as a tool for landscape restoration
Abstract Most of Ghana’s 238,500 square kilometres is savannah (56%) and closed forest (35%). All the vegetation types in Ghana, play very important roles in supporting the livelihood of 21 million Ghanaians, in both urban and rural communities. However, the combined effect of over-exploitation of forest resources, unsustainable farming practices, wild fires and mining activities have significantly reduced the forest area and degraded nearly 32% of the reserved forests and over 70% of the forests outside reserves. The density of many important timber species is now low in these forests, sometimes less than one commercial tree per ten hectares in the ‘primary’ forests. The continuing forest loss, currently at an annual rate of 1.7%, threatens the existence of the indigenous tree species and associated biodiversity through habitat loss and accelerated soil erosion, thus affecting the agricultural productivity on which the livelihoods of rural people depend. Sustaining the diversity of the tree species and the value of the natural forest is a matter of increasing concern not only to Ghana but for the entire West Africa region. In order to address this concern the Government has encouraged community-based forest rehabilitation with plantations and agroforestry systems, increasingly using indigenous tree species. Thus an International Tropical Timber Organisation (ITTO)-funded project which collaborated with local communities was implemented in three ecological zones to rehabilitate 250 ha of degraded areas with indigenous species and using taungya system. This paper discusses the planning and implementation of the project with local communities as well as the recruitment and growth of naturally regenerating species and that of the planted species. Also discussed are: the improvement that the project has brought to the livelihoods of the local communities; the lessons learned during the project implementation; and recommendations that will improve such projects.
Rehabilitation of degraded pastures with agrosilvopastoral systems using native trees in tropical Latin America

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Session: 14. Agroforestry as a tool for landscape restoration

Abstract:
Conversion of forests to pastures has been one of the most widespread land-use changes in the Latin American tropics in the last 20 years. A large proportion of pastures in the neotropics are under varied states of degradation due to inadequate management. Agrosilvopastoral systems can contribute to increased productivity and sustainability, while also helping to conserve biodiversity and sequester carbon in vegetation and soils. In research to develop alternatives for the rehabilitation and use of abandoned pastures in the neotropics, tree growth, soil chemistry and nutrient cycling were measured in sites planted with indigenous tree species and in abandoned pastures in the Caribbean lowlands of Costa Rica. In just 3 years soils improved under the native trees compared to abandoned pasture. Soil nitrogen and organic matter were higher under the trees than in the degraded pastures, with values similar to those in adjacent 20-year-old forests. Among the tree species tested, *Vochysia guatemalensis*, *Calophyllum brasiliense*, *Terminalia amazonia*, *Virola koschnyi*, *Dipteryx panamensis*, *Hieronyma alchorneoides* and *Vochysia ferruginea* have good growth and good timber quality. Some of these species have high rates of litter decomposition, with fast nutrient release from litter to soil, while others with slower litter decomposition protect soils against erosion. These species are used in silvopastoral combinations with beef cattle when the trees reach 3 5 years of age. Natural grasses such as *Cynodon nlenfuensis* (pasto estrella), *Paspalum fasciculatum* (gamalote), and the exotic *Panicum maximum* (Guinea grass), *Pennisetum purpureum*, *Brachiaria spp.*, *Melinis minutiflora* (calinguero or San Juan), and *Ischaemun indiana* (retana) grow well under the canopy of these species. These grasses are grazed by cattle, although improved pastures are needed to increase cattle productivity. A mixture of tree species may combine beneficial effects of the different species’ characteristics, with the additional advantage of product diversification, an important factor among farmers of the region.

Rehabilitation of degraded river-line in Mount Kenya Region

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Session: 14. Agroforestry as a tool for landscape restoration

Abstract:
River Rutui has its source in Mount Kenya forest and has eight tributaries. The river is the source of 55 registered water intakes and supplies water to over 1,258 rural households and the Kerugoya town population. Built along the river, are seven micro hydro power plants. Further, it is a tributary of river Thiba, which is a tributary of river Tana. The later is an important source of water for the Seven Folks Dam, which generates most of the national hydro power.

However, pollution and declining water volume posed challenges to the River Rutui users, resulting in the formation of the River Rutui Water Users Association. Participatory ground truthing revealed the following challenges: 1) Institutions, namely schools, coffee factories and dispensaries discharged sewage into the river; 2) Pit latrines and livestock sheds were close to the river; 3) Illegal diversion of irrigation water; 4) Planting exotic trees including eucalyptus close to the river-line, and 5) Cultivating too close to the river.

A multi-institutional and multi-disciplinary team, formed thereafter, spearheaded an awareness campaign on the need to conserve and protect the river. In partnership with the community, Africa Harvest established high quality indigenous tree seedling nurseries for
rehabilitation. The community voluntarily stopped cultivating near the river-line and the eucalyptus were replaced with indigenous trees. By 2008 Africa Harvest in collaboration with Ministry of Energy and other partners had facilitated the planting of over 25,000 indigenous trees along a 10 km stretch. The tree establishment is over 80% and its success is from site matching and community ownership. Key outcomes are: the community has income from sale of seedlings; enhanced skills on silvi-culture; access to clean water throughout; and fully functional micro-hydro dams supplying clean electricity to about 400 households. At the national level, there is increased supply of water to the hydro dams.

Key words: Outcomes, partners, rehabilitation, river, water

Riparian reforestation and wildlife habitat enhancement of Beaverlodge Watershed - Phase I

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Abstract
The Beaverlodge River Watershed’s riparian areas, bordering woodlands and wetlands have experienced extensive deforestation and habitat degradation that has led to poor water quality, significant bank erosion, higher water temperatures and the loss of many native fish and wildlife species such as Arctic Grayling and Northern Pintails. This project hopes to build awareness of how habitat adjacent to the river can be restored through reforestation to improve riparian health and wildlife habitat. The goal is to demonstrate the restoration of riparian buffers and upland forests within the Beaverlodge River Watershed. The project aims to work with landowners in this watershed to reforest degraded riparian and buffer zones. Overgrazed pastures and cultivated farmland with no trees along the waterways are the primary focus of this work. The Woodlot Extension Program has prior experience with smaller (3 5 acres) riparian planting projects in the Peace Region and sees great value in doing a larger multi-year planting project with more landowners and organizations working together across property lines. With this scale of project there is great potential for positive impact on the landscape and water quality. In phase I we plan to coordinate the reforestation 50 acres along the Beaverlodge River and its tributaries. Our goal would be to continue this work for a total of three years until approximately 150 acres are planted. Our hope is to inspire other municipalities, landowners and organizations to consider projects similar to these ones in other areas of Alberta.

Tavy boka: a Malagasy alternative to slash and burn agriculture

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Abstract
Traditional, shifting agricultural systems employing fire continue to ravage hilly landscapes throughout eastern Madagascar. This practice is also the main pressure on remaining, biodiversity-rich, natural forests. The Ecoregional Initiatives project was conceived by USAID to promote alternatives to slash and burn agriculture. One of the most promising techniques – promoted by the project – for stabilizing and intensifying land use and providing biodiversity conservation benefits in these areas builds upon a largely forgotten traditional practice known as tavy bôka, or humid, slash agriculture. Combining this technique with woody, contour hedgerows can lead to an increasingly sedentary agricultural system. Training sessions during the establishment of demonstration plots stress the principles of keeping the soil covered and eschewing fire. Demonstrations of this technique have been
established at many agricultural diffusion points around the Ankeniheny-Zahamena forest corridor. The first season consists of creating a thick mulch out of cleared vegetation and installing contour hedgerows with *Gliricidia sepium*, *Flemingia congesta*, or *Tephrosia vogelii*. Contours are located using simple, A-frame tools and woody components are often combined with vetiver grass. Crops such as rainfed rice, cassava and maize are directly seeded or planted in the mulch. Leguminous cover crops such as *Stizolobium atterinum*, *Vigna unguiculata*, and *Vigna umbellata*, are introduced between the hedgerows during the second season. Crops are rotated and again directly seeded or planted into the vegetative cover. Depending on growth, shrub hedgerows can be pruned and their biomass used to create mulch in some areas of the parcels. In areas closer to the natural forest, farmers are experimenting with planting fruit trees, cloves and black pepper on *Gliricidia* stakes in the bands between the hedgerows. This land use can create a permaculture or perennial tree-crop buffer zone in areas adjacent to the natural forest corridor.

**Trees establishment constraints and role in rehabilitating degraded dryland in Sudan**

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**Session** 14. Agroforestry as a tool for landscape restoration

**Abstract** A crop production land-use system is problematic in semi-arid areas where drifting sand is a prevailing condition. Creating obstacles or decreasing soil surface roughness enhances sand settlement, which changes the soil level critical for gravity irrigation systems. Therefore where protection is questionable, sustainability of crop production is at risk. This study was carried out at Umjawasir, north Sudan, on irrigated, 1000 Fadden, with wheat as the main crop. The study consisted of three phases: phase zero (unprotected), I and II (protected). The research aimed to assess the risk to sustainability presented by drifting sand, and to investigate the efficiency of earth embankments (used as a protection measure) compared to the role of selected trees species. The results indicated that the cultivated areas that had been abandoned due to sand invasion were 100%, 35% and 25% of the total cultivated areas of phase zero, phase I and phase II respectively. It showed that the earth embankments gave effective protection, but over 13 years sand developed into dunes in the vicinity of the farm and these served as secondary source of sand and a potential major hazard.

The effectiveness of *Leptadenia pyrotechnica*, *Prosopis juliflora*, and *Panicum turgidum* in trapping drifting sand was studied (by the author elsewhere). *Leptadenia* and *Prosopis* species have the capability to capture moving sand providing good protection, while *Panicum* was very efficient given its small size. The establishment, survival and growth of *Leptadenia pyrotechnica*, *Prosopis juliflora* and *Panicum turgidum* were investigated with and without protection from sand blasting and deposition. Unprotected soil had rain water run-off, while protection was not very effective, but irrigation was effective. Establishing trees without irrigation appeared impossible. This suggests that irrigated shelterbelts could be the solution in the study area and other similar areas in Sudan.

**Restoration of degraded pastures using agrosilvopastoral systems with native trees in the Neotropics.**

**Presenter:** Florencia Montagnini
Session 15
Biofuel production systems
Comparing life cycle assessments of tropical biodiesels: *Jatropha* versus oil palm

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Session 15. Biofuel production systems

Abstract Biofuels are globally under considerable pressure, caused by sky-high expectations on the one hand, and serious concerns of environmental and social impacts on the other hand. Concerning environmental impact, biofuels essentially need to meet two minimum requirements: (i) be produced from renewable feedstock; and (ii) have an impact which is less negative than their fossil-based alternatives. An environmental impact assessment for these two requirements needs in-depth analysis of (i) impacts on soil, water and genetic resources, and of (ii) impacts on global warming, acidification and eutrophication. Life cycle assessment (LCA) is the appropriate tool to make such quantitative evaluation of a production process. LCA produces generic and non-site-specific results of environmental impacts (energy balance, global warming potential, land-use impact, eutrophication, etc.) of production processes. The impacts caused by alternative production scenarios are easily compared. In this paper we compare the LCAs of two booming tropical biofuels: (i) *Jatropha* biodiesel and (ii) oil palm biodiesel. Both feedstocks have their specific potentials and risks. *Jatropha* (*Jatropha curcas*) is a drought-tolerant tree producing seeds bearing toxic oil. *Jatropha* is mainly aimed to simultaneously reclaiming wasteland and producing biodiesel. Oil palm (*Elaeis guineensis*) is a perennial crop of the humid tropics. The trees offer a high oil yield which is useful as both kitchen oil and for biodiesel production. The study presents the positive and negative effects of shifting from fossil diesel to either biodiesel production systems. The environmental impacts of both *Jatropha* and oil palm biodiesels are calculated against the reference system, which is a fossil-based system producing the same amount of energy as the systems of interest. The results of this method allow comparison of the environmental impact of the two biodiesel production systems. Further interpretation of the results on impacts and comparisons enables us to identify points of attention, trade-offs and potential ways for improvement.

Establishment and early field performance of *Jatropha curcas* l at Bindura University Farm, Zimbabwe.

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Session 15. Biofuel production systems

Abstract Agroforestry plays significant environmental roles both directly through is effects on ecosystems and indirectly through utilization of eco-friendly agroforestry products such as biofuel. *Jatropha curcas* is an example of a key agroforestry species that can perform the dual roles of ecosystem maintenance and sustainable development. However, in order to realize the species’ full potential, there is need to provide relevant agronomic information. The performance of *J. curcas* propagated through pre-cultivated seedlings, non-rooted cuttings and direct seeding, established at 3333, 2500, 1333 stems/ha and subjected to spot weeding, slashing, and both spot weeding and slashing, was evaluated. The trial was established on the 20th of December 2006, in a 33 factorial completely randomized block design with three replications. Each plot consisted of 16 trees. Data were collected from the entire population. Height, root collar diameter (RCD) and survival were determined using standard forestry procedures. Data were analysed through one-way analysis of variance (ANOVA) at 95% confidence level using SPSS version 15 (2003). *Jatropha curcas* established through pre-cultivated seedlings outperformed (P<0.05) non-rooted cuttings...
and direct seeded plants in terms of survival. There were no significant differences (P>0.05) among saplings established at 3333, 2500 and 1333 stems/ha planting densities or among those subjected to spot weeding, slashing, and both spot weeding and slashing, in terms of survival and growth in height and RCD. This research concludes that pre-cultivated J. curcas seedlings perform better in percentage survival than non-rooted cuttings and direct seeded plants in agro-ecological conditions similar to those of the study site.

Genetic improvement of Jatropha curcas

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Session 15. Biofuel production systems
Abstract Developing countries such as India are experiencing an energy security crunch mainly because of the fast depletion of fossil fuels. Out of many non-edible tree-borne oil-seed species Jatropha curcas is recognized as having the greatest potential for biodiesel production in India. There is lot of variability for growth and seed characteristics in this species. Hence, exploration trips were carried out in during 2003 to 2006 to collect the germplasm from various parts of the country. The collection of 284 accessions from Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Chhattisgarh, Uttar Pradesh and Uttranchal was conducted. A wide range of variability was recorded for fruit and seed characters among all accessions. The range of oil content in seeds was 22.79–47.12%. Eighty-seven accessions were recorded for oil content of more than 35% in seeds. All accessions have been planted in the field in form of progeny and provenance trials to assess growth and seed and oil yield. The plantations are at the spacing of 2x2, 3x3, 4x3, 4x4 and 5x5 m. Initial observations reveal that seed yield varies with respect to genotypes and spacing. The accessions with high seed and oil yield at the National Research Centre for Agroforestry were sent for a multilocation evaluation trial in varied agroclimatic conditions. Ninety intraspecific crosses have been developed and are being evaluated in experimental fields for seed and oil yield. A study on reproductive biology reveal that the ratio of male to female flowers was from 14:27 male:1 female, in case of accessions, whereas in the case of crosses the ratio was 8:10:1. A number of crops in rabi and kharif were raised under agri-silvicultural trials with Jatropha plantation. Accessions were analysed for biochemical activity and are being characterized at molecular level.

Jatropha curcas, the wonder biodiesel plant: fact or fiction?

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Session 15. Biofuel production systems
Abstract Global attention on biofuels has led to interest in the potential for Jatropha curcas to produce biodiesel from marginal land. This has resulted in the planting of large areas of J. curcas in Asia, Africa and America. In South Africa the government has placed a moratorium on J. curcas due to concerns about excessive water use, alien invasiveness and lack of knowledge about its yield and economic potential. This paper reports on the water dynamics and productivity of J. curcas in a silvopastoral experiment with Pennisetum clandestinum. Measurements of daily total evaporation rates during summer ranged between 3 to 4 mm day-1. Due to the deciduous nature of the species, water use was negligible during winter (<1 mm day-1). The results confirmed that two-year-old to four-year-old J. curcas trees were conservative water users. However, high oil yields are unlikely due to the low seed production (89.9 kg ha-1). The time taken to harvest and de-husk one kilogram of seed was three hours, suggesting that mechanical harvesting may be necessary. Jatropha curcas showed a low tolerance to
pests (e.g. Golden flea beetle) and diseases in this silvopastoral system. This significantly increased the input costs for insecticides and fungicides. These costs, together with the low seed production indicated that four-year-old J. curcas trees are unlikely to fulfil the claims that it is a wonder biodiesel plant.

**Pongamia pinata** – propagation through vegetative means

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**Session**
15. Biofuel production systems

**Abstract**

*Pongamia pinnata* a medium-sized evergreen tree with a spreading crown and a short bole, which belongs to the family (Papilionaceae). It is one of the few nitrogen-fixing trees producing seeds containing 30–40% oil. It thrives in areas having an annual rainfall ranging from 500 to 2500 mm, in its natural habitat, the maximum temperature ranges from 27 to 38 °C and the minimum from 1 to 16 °C. This species grows to an elevation up to 1200 m. It can grow on most soil types ranging from stony to sandy to clayey. It is among the few species in India, which can yield oil as a source of energy in the form of biodiesel. The present paper deals with the standardization of vegetative propagation techniques for *P. pinnata* through stem cuttings and through air layering. By treating with different concentrations of IBA, NAA and combination of IBA and NAA, including a control. Among the 4 seasons, Spring (February cuttings) was the best for achieving maximum sprouting and rooting success. IBA was found to be the best auxin for the treatment of cuttings in reference to all the parameters, followed by the combination of IBA+NAA and NAA alone, respectively. Among the different concentrations of growth hormone, the concentration of 400 ppm was found to be the best. For air layering studies different concentrations of IBA were used. The data were recorded for sprouting, rooting percentage and rooting-related parameters. The biochemical changes occurring during rooting, and effect on rooting success were studied. The results showed that *P. pinnata* can be successfully propagated vegetatively through stem cuttings as well as through air layering.

**Research experiences of biofuel plantations in farmers’ fields**

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**Session**
15. Biofuel production systems

**Abstract**

These experiments were initiated in farmers’ fields during kharif, 2005 on 63 acres in three districts of Andhra Pradesh in India with 3 levels of irrigation, 3 levels of nutrition, 3 levels of pruning and 4 levels of spacing. The sites were selected mostly from degraded/wastelands belonging to small-scale and marginal farmers with and without irrigation facilities. The soils are shallow, gravelly, marginal in fertility and possess low water holding capacity. The average rainfall of most of these districts is around 650 mm while for Anantapur it is 510 mm. Added to this, the topography is undulating with a 3 to 6 percent slope. The initial studies on plant geometry in Jatropha showed more management problems and a higher cost of cultivation due to manual weeding in closer planting (2x2 m) than in 3x2 m or 4x2 m spacing. The wider spacing also enabled intercropping, partial mechanization, and response to irrigation in *Jatropha*. The inflorescence and also the capsule bearing bunches were more, when the plants were pruned at 45 cm or 60 cm height. In order to provide immediate income to the farmer, besides improving soil fertility, legume intercropping with pigeonpea, blackgram and horsegram was successfully employed. Major pests observed in Jatropha were leaf and inflorescence webber (*Pempelia morosalis*), red hairy caterpillar (*Amsacta albistriga*), whereas in Pongamia leaf galls (*Eriophyes cheriani*) was commonly observed. Some farmers started uprooting the *Jatropha* for lack of market linkage and withdrawal of government support.
Sustainable biofuel production systems on marginal lands: fiction or fact?

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Session
15. Biofuel production systems

Abstract
The objective of this paper is to critically address sustainable biomass production for future bioenergy and the role of agroforestry by using marginal lands. Whereas a promising future has been sketched for the role of biofuels in development, serving a dual role in the Millennium Development Goals on poverty reduction and climate-change mitigation, there is also increasing skepticism. Critics speak of the ‘biofuels myths’, referring to the lack of evidence of biofuels benefits and pointing at biofuels and their inefficiency in reducing greenhouse gas emissions and reducing climate change. Likewise there are reports on production of biofuels leading to competition with land used for food crops, rising food prices, dependency on subsidies, conflicts with land-use rights, conversion of natural forests and impacts on biodiversity and ecosystem services. The use of unproductive marginal lands may provide an outcome for the issue of land competition, particularly in Southeast Asia where idle grasslands cover 34 (4% of total land area) to 54 million ha. Moreover, the generation of land-use avoiding co-products may put first-generation biofuel crops, that also serve as food crops, again in a different perspective particularly where planted in an agroforestry setting. Yet, also with biofuel crops on marginal land, the debate on perspectives of sustainable biomass production continues, with theoretical considerations stressing large-scale, high-production potentials being confronted with questions about smallholder production potentials and ecological, social, economic and technological limitations. In order to cope with these criticisms, integrated research on the sustainability of the biofuel value chain and its driving forces is needed to be able to grasp a complete picture and distinguish fiction from facts.
Session 16
Participatory tree domestication (PTD) for land rehabilitation
**Allanblackia, a new tree crop for the edible oil industry: developments in domestication and implications for biodiversity**

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**Session**
16. Participatory tree domestication (PTD) for land rehabilitation

**Abstract**

*Allanblackia*, a dioecious fruit tree native to the sub-Sahara, is the subject of increased international interest for oil production for the global food market. As a wild and previously little-used genus, it represents an excellent case study when considering the constraints faced in developing sustainable tree-based enterprises for small-scale farmers in the tropics. Here, we report on the activities of a novel private public partnership known as the Novella initiative that has been designed to help overcome the bottlenecks faced by African smallholders in the cultivation, harvest and sale of the genus. Research indicates high-yielding genotypes suitable for cultivation, appropriate vegetative methods by which superior trees can be propagated and made to fruit quickly, and community-based approaches by which seedlings may be delivered to farmers’ fields. Domestication of the genus is however in its infancy, and significant constraints to efficient production remain, e.g., in currently little-researched areas such as the management methods appropriate for farm landscapes. Market supply chains for *Allanblackia* seed harvested from natural stands are being developed, and ex ante assessment indicates cultivation as a profitable business venture compared with other perennial crops. The regions in which *Allanblackia* is found are high in biodiversity, rich in endemic species and subject to deforestation and habitat fragmentation, while three species of the genus are considered vulnerable from a conservation perspective. The *Allanblackia* business could contribute greatly to driving the participatory practices needed in managing forest biodiversity hotspots, and could enhance ‘biodiversity-friendly’ methods that contribute to habitat and species conservation in farmland. Analysis suggests, however, that favourable outcomes for biodiversity – for the genus itself, and for associated plants and animals – will require careful management. We here address key means by which the effects of the *Allanblackia* business on the environment can be monitored, possible negative impacts minimized, and positive effects promoted.

**Domestication of indigenous fruit and nut trees for agroforestry in the Solomon Islands**

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**Session**
16. Participatory tree domestication (PTD) for land rehabilitation

**Abstract**

In the Solomon Islands subsistence agriculture, monoculture plantations, new settlements and commercial timber extraction have resulted in indiscriminate deforestation. Agroforestry is an approach to sustainable land use aimed at reversing these land degradation processes. In recent years, the domestication of indigenous fruit and nut trees has been added to the techniques to make agroforestry more effective, and especially to increase the livelihood benefits arising from agroforestry. In this way agroforestry is contributing to the alleviation of ecological and socioeconomic problems in developing countries. This paper describes research to develop techniques for the domestication of indigenous fruit and nut tree species in the Solomon Islands. The first step was to determine the species that local communities consider to be priorities for domestication. Consequently, the survey identified *Barringtonia procera* (Cutnut) and *Inocarpus fagifer* (Tahitian chestnut) as important sources of food and income, and as species that fit critical niches in the farming systems. The next step was quantitative characterization of the phenotypic variation in the dry matter partitioning between different components of fruits and nuts. This study found highly significant ($P=0.001$) and continuous intraspecific variation in all the measured traits within each village population. Interestingly, site-to-site variability was not significant. These quantitative data
were also used to identify the market-oriented traits which could be combined to describe the ‘ideal tree’ or ‘ideotype’, in which ‘Harvest Index’ is maximized through the partitioning of dry matter to the commercially and domestically important kernel. Using this as a guide, the trees that most closely fit this ideotype were identified as the elite trees, for vegetative propagation to form putative cultivars. This study was complemented by molecular study of the genetic variation which revealed significant genetic diversity within and between the five populations of *Barringtonia procer*a. The final section of this research examined the factors which affect the rooting ability of cuttings from both *B. procer*a and *I. tagifer*. These results were then used to define the most appropriate material and techniques for the development of robust vegetative propagation protocols for village scale nurseries. Both species were found to be easily propagated by single-node, leafy, stem cuttings and air-layering.

**Domestication of Vanuatu sandalwood (*Santalum austrocaledonicum*) for improved conservation of wild stands and smallholder income**

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**Session** 16. Participatory tree domestication (PTD) for land rehabilitation

**Abstract** Vanuatu is a Pacific Island nation with a wealth of forest resources that provide benefits to local communities on both subsistence and commercial levels. Sandalwood (*Santalum austrocaledonicum*) is sought for its fragrant heartwood oils and is harvested primarily from wild stands and sold to local exporters. It is the most lucrative of all forest products in Vanuatu and has been exploited commercially since the 1820s. Recent assessments of wild populations reveals that resources are now limited and, with current harvesting practices, are expected to further decline. Considerable smallholder interest in establishing sandalwood plantings, however, is being sustained by the current high international values for sandalwood products, which are expected to continue into the future. Recent research has revealed significant tree-to-tree variation in important commercial oil fragrance characteristics (α- and β-santalol) and a potential to improve product quality in planted sandalwood. There are still low numbers of mature sandalwood accessible for seed collection and considerable shortages of planting material to meet smallholder planting goals, which has resulted in significant price increases for seed in all areas of Vanuatu. While sandalwood has been exploited from wild stands for almost 200 years, only a very few number of smallholders have experience propagating and growing the trees. The development of a viable sandalwood agroforestry industry therefore requires a means to increase the availability of planting material and build farmer capacity for appropriate tree management. This paper outlines a domestication strategy that includes provision for rapid deployment of improved germplasm through both clonal and sexual propagation, inter-island germplasm exchange and extension and awareness activities.

**Economic evaluation of tree domestication techniques**

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**Session** 16. Participatory tree domestication (PTD) for land rehabilitation

**Abstract** Techniques to vegetatively propagate tropical trees producing marketable products have been developed as an important driver for the domestication of high-value agroforestry trees. Nevertheless, no economic analyses of these innovations have been done so far. This paper used the case of the African plum tree (*Dacryodes edulis*) to investigate the potential profitability of seedlings, cuttings and air-layering techniques. The methodology used for this purpose was the cost-benefit-analysis (CBA), using for decision criteria: net
present value (NPV), internal rate of return (IRR) and benefit cost rate (BCR). An analysis of the production costs of the African plum through seedlings, cuttings and air-layering was carried out. The field production and integration of trees from different sources were also studied. Preliminary findings show that the productivity of trees reproduced through air-layering was higher and generated more income than trees obtained through seedlings and rooted cuttings. Air layering was also the only technique that met the (NPV > 0 and IRR = 20%) under monoculture conditions. The production by cuttings and seedlings, though easily accepted and practised by farmers, are not profitable in a monoculture situation (IRR = 28.82%) at year 4. However, when these methods are practised in an integrated system (integrated with intermediary crops such as maize), they become as profitable as the air layering technique (IRR = 35.32%). In conclusion, farmers are faced with the choice of practising the easier techniques of reproduction (cuttings and seedlings) in an integrated system of production, or taking up air layering in a monoculture situation to make optimum benefits.

Efficiency of small-scale rural nurseries in the production and distribution of improved tree germplasm in West and Central Africa

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Session 16. Participatory tree domestication (PTD) for land rehabilitation

Abstract Participatory tree domestication aims to diversify farming systems through the cultivation of indigenous trees to increase farmers’ income and reduce deforestation. Results in West and Central Africa suggest that tree domestication can make a difference to the livelihoods of poor people. However, one of the prerequisites for larger uptake of tree domestication is the availability of tree plantings of suitable quality, in sufficient quantities, within proximity at affordable prices. To this effect, ICRAF and partners have encouraged the establishment of small-scale tree nurseries in rural areas. In 2007, about 111 nurseries were propagating agroforestry trees for planting on group members’ farms and for sale. This study examines the efficiency of 12 such nurseries in the production and distribution of improved tree planting material, by comparing them with 12 nurseries in similar conditions, but not in contact with participatory tree domestication in the west and northwest provinces of Cameroon. Information was collected on quantity and quality of the material produced, geographical coverage, number, type and satisfaction of clients. The results show that nurseries using the domestication approach provide tree planting material that responds to farmers’ needs in terms of quantities, species and propagation methods used. Their clientele is more diverse, including farmers from the communities where the nurseries are located, but also from far beyond. Clients are said to be satisfied with the services rendered, such as technical information, assistance with planting and replacement of dead plants. Nevertheless, prices of vegetatively propagated material, especially marcots, were considered too high by the majority of clients and are the most prohibitive factor for non-clients. The study suggests that tree planting initiatives should refocus efforts towards technical training and business support for small-scale nurseries to increase efficiency. On the other hand, research should look for ways of reducing production costs and/or improving nursery productivity.
Native timber trees for agroforestry in Africa and Latin America: research needs for tree improvement and conservation programmes

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Abstract
Native timber-tree species are common in agroforestry systems in Africa and Latin America, and provide a range of useful products for local use or sale. However, there has been very little research on variation in adaptive and commercially important traits in these species. Timber-tree improvement and conservation programmes need information about: geographic, genetic and environmental variation in tree growth, stem form, survival, wood density and other wood-quality traits; radial and vertical variation in wood-quality traits within tree stems; and correlations between tree growth and wood quality traits. Understanding geographic variation related to rainfall gradients is particularly important in order to develop proactive strategies in response to climate change. Tree growth, stem form and survival are key traits because they determine the potential volume of merchantable wood produced in a given period of time. Density is a key wood-quality trait because higher-density wood tends to be stronger and stiffer, but it also has greater volumetric shrinkage compared with lower-density wood. Density, and other wood quality traits correlated with density, vary within the tree stem (e.g., from pith to bark and from lower to upper stem), and this affects the uniformity of the wood. Understanding the correlations between growth and density (and other wood-quality traits) is essential in order to assess if faster-growing trees can be selected without significantly reducing wood quality. In this paper, we illustrate these issues with examples from Africa and Latin America, discuss some practical implications and provide recommendations for tree improvement and conservation programmes.

Variation and correlations in traits of Prosopis africana and Balanites aegyptiaca in the West African Sahel: implications for tree domestication programs

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Abstract
Given the strong rainfall gradients in the Sahelian zone, one might expect clinal genetic variation in tree-growth and wood properties. Information about these relationships would provide a baseline for development of domestication strategies. Prosopis africana and Balanites aegyptiaca are native trees that rural communities use for construction, fuel, etc. Denser wood tends to be stronger, stiffer and have higher calorific value, and these are important properties if the wood is used for construction and fuel. Provenance/progeny tests of Prosopis africana and Balanites aegyptiaca were established at one relatively dry site in Niger: the tests included 28 provenances of P. africana from Burkina Faso and Niger, and 12 provenances of B. aegyptiaca from Niger. Tree growth and survival were evaluated at 11 years, and wood density and calorific value were evaluated at 13 years. The objectives were to determine: if there was significant genetic variation in tree growth and wood density; if growth, density and calorific value varied with rainfall gradients; and if they were positively correlated. There was significant variation in tree growth and wood density due to provenances and families within provenances of P. africana but not B. aegyptiaca. Provenance means for tree growth of both species, and wood density and survival of P. africana (but not B. aegyptiaca) increased from the more humid to the drier parts of the sample region. In contrast, provenance means for calorific value of both species increased in general from the drier to the more humid parts of the sample region. Larger trees of both species tended to have denser wood and higher calorific value, but density and calorific value were not significantly correlated. Results suggest that selecting faster-growing trees could indirectly increase both wood density and calorific value; but selecting trees with greater density would not affect calorific value.
Session 17
Collective action for tree-based rehabilitation of degraded lands
Bioreclamation of degraded lands: a new agroforestry system for land reclamation and women’s empowerment in the Sahel

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Abstract
More than 50% of the land in the Sahel is degraded and much of this degraded land is crusted laterites. The crust significantly reduces water infiltration resulting in a bare landscape. The laterites are potentially more fertile than the predominantly sandy soils. It has both higher water holding capacity and a higher cation-exchange capacity than the sand. These lands can be reclaimed through the use of water harvesting techniques such as planting pits (zaï holes), micro-catchments (demi-lunes) and trenches. Past attempts to reclaim degraded laterites were based on the construction of the above structures for water harvesting and planting with traditional crops in the zaï holes and *Acacia senegal* in the demi-lunes. Most of these degraded lands were community owned. Even though yields were increased, these technologies were not adopted on a large-scale because the return to labour was small and the young *A. senegal* plants were destroyed by grazing animals. The bioreclamation of degraded lands system (BDL) is based on planting high-value hardy vegetables in the zaï holes and high-value trees in the demi-lunes. The land is fenced and is allocated to women’s associations that subdivide it to individual plots for distribution to the individual association members. The most successful traditional vegetables are okra (*Albemochus esculentus*), Roselle (*Hibiscus sabdariffa*) and *Senna obtusifolia*. Tree species under investigation are the domesticated *Ziziphus mauritiana*, *Moringa stenopetala*, sweet varieties of *Tamarindus indica*, high gum-yielding varieties of *A. senegal*, selected varieties of marula (*Sclerocarya birrea* subspecies ‘Caffra’, Saha senegalensis, and the Australian *Acacia tumida*). A hardy Indian variety of Henna (*Lawsonia inermis*) is planted as a hedge. The BDL is being tested in a three-hectare experimental field. Yields are recorded and growth rate of trees is monitored. Rainfall, soil moisture and run-off are recorded to produce a water balance for the field. In addition, a trial for selection of best rootstock for Pomme du Sahel is being conducted together with a long-term breeding programme to produce and select the best okra varieties for the system. Results of all the above studies will be reported. The socioeconomic aspects and the economic outputs from five pilot-tests in farmers’ fields will also be discussed.

Clean development support for tree planting in mixed gardens (‘Kebun lindung’) in Paninggahan (West Sumatra, Indonesia): experience with JIFPRO FF and RUPES Singkarak

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Session
17. Collective action for tree-based rehabilitation of degraded lands

Abstract
Environmental services can be provided by the trees that farmers want and the trees farmers manage, complementing the services from state-controlled ‘protective forests’ or ‘hutan lindung’. Where farmer communities manage and benefit from the trees, clear incentives exist for the longer term. Assistance in the early stages is still needed, however, to support the level of collective action needed to protect the land from fire and to provide the spirit needed to make a change. Paninggahan one of 13 villages surrounding Lake Singkarak, located in Solok District, West Sumatra Province, has been one of the action research sites of the RUPES (Reward Upland Poor for Environmental Services) programme coordinated by the World Agroforestry Centre (ICRAF) since 2004. JIFPRO, an NGO from Japan has provided funding since 2005 to support the tree planting in the ‘kebun lindung’ zone. Up to 2008 JIFPRO funded the conversion of 140 ha of grassland, and by 2011 it is hoped this figure will be 320 ha. These good results are in strong contrast to previous ‘top-down’ reforestation
projects. The socio-cultural approach of collective action is linked to an economic and technical approach. In the socio-cultural approach the RUPES Singkarak Team follows the Paninggahan structure of traditional leadership systems called KAN (Kerpatan Adat Nagari) as well as PN (Pemerintahan Nagari), within the Minangkabau culture with its matrilineal inheritance systems of land tenure. Economically, the focus is on the types of trees farmers want for subsistence and market-based benefits. Trees selected include the ‘naturalized’ exotic mahoni (*Swietenia mahogani*) and the local surian (*Surio sureni*) as a timber trees; clove (*Syzygium aromaticum*), candle nut (*Aleurrites moluccana*), Pinang (*Pinanga sp*) and cacao as a multipurpose trees and avocado (*Pseudium guajava*) as a fruit trees. Technically, the team considered the suitability of conversion techniques related to slope, elevation, and chemical and physical properties of the soil.

### Community-based rehabilitation of degraded lands through agroforestry in India

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**Abstract**  
According to the Forest Survey of India, forests accounted for about 22 per cent (67.8 million hectares) of the geographic area of India, with dense forests constituting only 57 per cent of the forest area. Overall India is estimated to have between 14.22 and 24.602 million trees outside forests, spread over 17 million hectares and supplying 49% of the 201 million tonnes of fuelwood, 48% of the 64 million tonnes of timber consumed annually. Yet, vast areas of both legally declared forests and marginal agricultural lands are not optimally utilized and are available for tree cultivation. There is also a large dependence of local communities and their economies on forest and tree resources. The rapid growth of the Indian economy is creating a huge demand for wood and wood products for construction timber, bioenergy, paper pulp and other wood products. The low emphasis on production forestry in India has laid a tremendous pressure on the meagre forest resources and consequently aids their degradation. This has adversely affected the livelihoods of the dependent population. The answer lies in promoting tree farming on degraded and marginal lands through community-based agroforestry. The paper discusses the pivotal role that agroforestry systems of mixed agricultural crops, NTFP and tree species can play in not only providing the much-needed wood for various uses but also in providing livelihoods to the large dependent community, with a sustainable environmentally friendly approach that utilizes the hitherto underutilized or unutilized vast land resource of the country.

### Creating new commons: rehabilitating barren lands with multiple use agroforestry in Nepal’s Terai for better local livelihoods

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**Abstract**  
It was until the last decade in Nepal’s Terai that public lands without trees were regarded as ‘waste lands’ or ‘barren lands’. The creation of multiple use agro-forestry in the public lands under a common property regime has opened avenues for enhanced livelihoods for marginalized local people and for increased environmental services to the community at large. Formation of user groups from the poor and landless, followed by the handover of open public lands to these groups with a title of more than 20 years under the recommendation of village councils, are the common practices to instigate the agroforestry intervention. The user groups practice diverse modalities of agroforestry, such as farm forestry, silvo-
fishery, silvi-pasture and agri-silvi-pasture. This study explored the available public lands for agroforestry in three Terai districts and found that at least 30,000 hectares could be brought under such systems involving 40 percent of the poor and landless households of the area. Hitherto, only two percent of the potentially manageable public lands have been brought under agroforestry, while the rest is still barren. The willingness of marginalized people to manage common agroforestry, weakening feudal control over the public lands, growing voices for the rights of landless people and pro-poor development projects, are some supportive factors for the intervention. The initial financial cost of converting the land into an agroforestry system, lack of elected political representatives in the village council, lack of tenure security and absence of policies for agroforestry in communal lands, are some hindering factors. The paper concludes that managing barren public lands with agroforestry by the local poor and landless could contribute to rural poverty reduction and environmental augmentation, which could be achieved through strong advocacy for policy/legal backing.

Earning carbon credit through plantation and restoration of land and biodiversity in sand dune-affected lands:

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Abstract
International efforts on climate change mitigation under the Kyoto Protocol offer three market-based mechanisms, among which the Clean Development Mechanism (CDM) is of particular importance to the developing world and can provide impetus to the efforts of local communities in conservation of biodiversity. Of all the CDM projects to date registered through the UNFCCC, only one is classified as an afforestation or reforestation project. It is surprising to learn that so little progress has been made in this sector, which offers enormous potential to cut down CO2 emissions and help the host country attain sustainable development through community participation. The possible reasons for the poor performance of the forestry sector include: a lack of knowledge and technical resources of the local communities; a complex registration process, procedures and methodology; and high project transaction costs. We organized 227 farmers from 8 villages in Ellenabad Block of Sirsa district in Haryana, India, to form a society and take up a small-scale A/R CDM project. These farmers were very poor as their lands were close to the great Indian Thar desert and affected by shifting (wind blown) sand dunes. They contributed 370 hectares of land collectively for a period of 20 years. These lands were degraded by sand dunes and had very low productivity due to erratic rainfall. Now they are planting these lands with native trees that are tolerant to such conditions. It is one of the very few projects in the world that has been through validation and has good chances of being registered. A total of 231,920 tonnes of CO2 is expected to be removed by this effort and the credit generated in this process is expected to earn a revenue of USD 11 million over 20 years. This project is very sustainable and will help in mitigation of global warming; improve soil quality by increasing the biodiversity, water-holding capacity, soil organic matter and stabilizing the sand dunes, and converting marginal and degraded croplands into forested lands. This project can serve as a pilot project and its success will encourage many other such projects to take place in poverty stricken areas of the developing world.

Enhancing vertical and horizontal integration for sustainable land management through the Landcare approach

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Abstract

Initiatives for the improvement of conservation and sustainable use of natural resources in sub-Saharan Africa have illuminated weak institutions and inadequate institutional arrangements. This paper describes the conservation and livelihood initiatives in Uganda, where land degradation is made evident by soil erosion, declining soil fertility, low yields and increasing incidences of landslides. The consequence of land fragmentation on the livelihoods of an increasing population further exacerbates natural resource exploitation. The paper describes the process undertaken in the adoption of the Landcare approach. It illustrates the African Grassroots Initiative for Livelihood and Environment (AGILE) concept that was used to inculcate and disseminate Landcare ideals amongst communities in Uganda. Through specific case studies the paper examines the role of the Landcare approach in tackling specific high-priority issues and the implication of the resultant outcomes. It describes the development of the AGILE process which was holistic, involved various community groupings who felt they owned the process, and were empowered enough to not only seek assistance from government but also lobby for policy changes to address their circumstances. Finally, the paper illustrates the role of district landcare chapters as an innovation platform allowing district-level integration of institutions, the scaling-up of best practices and influencing ownership of initiatives from development partners to the community.

Participatory approaches in integrated watershed management: lessons from the central highlands of Ethiopia

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Session 17. Collective action for tree-based rehabilitation of degraded lands

Abstract

This study was conducted in Galessa Watershed in the central highlands of Ethiopia. The paper presents the major steps and approaches employed in participatory integrated watershed management (PIWM). The watershed was selected by the Ethiopian Institute of Agricultural Research in collaboration with African Highlands Initiative (AHI) as pilot site to study approaches, tools and methods in integrated natural resources management. The major methods employed in this study were focus group discussions, transect walks, household interviews, key informant interviews, community meetings, process documentation, participatory monitoring and evaluation, to explore the socioeconomic situation. Secondary data was obtained using literature review and use of topographic maps and geographic information systems that were also crucial methods. The major procedures followed were (i) site selection, (ii) delineation, (iii) identification of community entry points, (iv) identification of watershed issues, (v) generating a consolidated list of watershed issues, (vi) ranking of watershed issues, (vii) clustering identified watershed issues, (viii) identification of objectives and research questions, (ix) development of research and development (R&D) interventions, (x) participatory action planning, (xi) implementation, and (xii) participatory monitoring and evaluation. It is difficult to strictly follow hydrological boundaries in delineating watersheds. Delineation undertaken with local leaders enabled them to take cognizance of the landscape dimensions to their problems and the magnitude of degradation experienced in their villages, and heightened their sense of ownership in the activities to come. The approach can be determined by socioeconomic factors, administrative boundaries, hydrological boundaries, boundaries of landscape-level NRM problems that do not conform to hydrological boundaries, or any combinations of these approaches.
Rehabilitation of degraded forest landscape in Chittagong hill tracts of Bangladesh using community management practices

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Abstract: Chittagong Hill Tracts (CHT) in southeast Bangladesh represent the most significant upland watersheds of the country, and are inhabited by 13 indigenous communities living in forests and using them for their livelihoods. Decades of clear-felling of trees by government agencies for establishment of monoculture plantations has destroyed the natural forest ecosystem that supports community subsistence farming called jhum, which led to agricultural intensification in the hills causing environmental degradation. In a highly degraded forest landscape, a few community-managed landscapes called village common forests (VCFs) occur in smaller watersheds that contain rich biodiversity, headwaters of streams and natural springs. The objective of the study was to investigate the potential of livelihood strategies and conservation practices of the VCF communities in rehabilitation of degraded hilly watersheds. A structured questionnaire survey was administered with 140 households from 13 villages in the VCF areas of Rangamati and Banderban, to study household livelihoods, and a few selected VCFs were visited for a physical survey. Bamboos are the most important forest produce in the livelihoods of the VCF communities, and are harvested all year round. Trees, particularly of the native hardwood species which are rare elsewhere in the hills, are protected in VCFs, VCF homesteads and agroforestry plots. Cultivation of rice paddy is prevalent in jhum, hill terraces and slopes, and in valleys and plain land. Among the vegetables the most extensively grown are sweet pumpkin and cucumbers in agroforestry plots while among the fruits, jackfruit, mango, banana, pineapple and papaya are the most commonly grown. Communities actively conserve perennial water sources for use in households and in their farms. They strictly maintain seasonality in harvesting of forest products, which is good for resource conservation. The resource management practices of the VCF communities have a strong potential for rehabilitating degraded forest landscape in CHTs, and should be evaluated by government agencies.

Role of collective action and policy options for fostering participation in natural resource management

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Abstract: The processes of community-based management and empowering local communities are based on co-management, using local/indigenous knowledge, recognizing local institutions and the establishment of common property regime. Local users often have intimate knowledge of resources and because their livelihoods depend on them, they have the greatest incentive to maintain the resource base. However, community-based natural resource management can only succeed through building social capital, enhancing collective action, and empowering communities to be involved in policy and decision making. Therefore the objective of this study was to illustrate the importance of local collective action institutions, their contribution to natural resource management and policy options to foster their participation in natural resource management. Data used to support the argument in this paper were compiled from different studies on collective action in Kenya, Uganda, Tanzania and Ethiopia. Various participatory methods and tools were used to collect information from the four countries including PRA methods, meetings, group discussions, and participatory
action research. Studies indicated that groups are gradually evolving from informal local groups to formal institutions such as community-based organizations (CBOs), local non-governmental organizations (NGOs) and other legal entities involved in natural resource management. Policy considerations should therefore focus on fostering the growth of such associations and strengthening their involvement in decision making. Results also indicated that these institutions have been involved in various modes of collective action ranging from innovations and use of traditional indigenous knowledge, to conflict resolution, management and networking. Results from Uganda indicate that all groups evolved into institutionalized entities. In Ethiopia, farmers managed to solve age-old problems through collective action. The study therefore concludes that governments should institute legal and policy frameworks that recognize local institutions, and should also strengthen their capacities. This would require public sector resources and action plans to address the specific needs and constraints.

Why is marketing of agroforestry tree products a social and gender-blind technology? The case of Cameroon

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Session 17. Collective action for tree-based rehabilitation of degraded lands

Abstract The last two decades have seen the emergence, spread and institutionalization of participatory processes. In the natural resource management sector, it has taken various forms under the terms participatory tree domestication of agroforestry species (in Cameroon), joint forest management (in India), community forestry (in Nepal) or more generically, participatory forestry. As this model is built around the concepts of participation and partnerships, there is an assumption that everybody in the community would have an opportunity to participate and benefit. Yet, evidence emerging from the field shows that this is not really the case. The social reality of rural communities and their relationships with natural resources are more complex than first recognized. This paper, based on relevant literature and recent fieldwork during three years in nine villages of three provinces of Cameroon, will attempt to address the reasons for some failures of institutional models, such as group sales of agroforestry tree products, to fully integrate gender as a fundamental variable. Results indicate that at the level of traders, very few women are wholesalers (1/6) while at the level of producers many women are involved. Women have very strong knowledge of harvesting methods and techniques, are more involved in very tedious steps than men, but receive the lowest price during sales. With many daily needs for the families of which they are in charge, and sometimes due to ignorance, women sell at very low prices to men who can store goods better and for longer and more appropriate periods for good market. During group sales, moving from cup measurement utilization (for small quantities) to larger-scale measurement utilization (for huge quantities) requires physical strength to facilitate weighing. The decision-making power of very poor family members (with very old but hard-working women) is almost never considered before that of rich family members (generally with strong and intellectual men).

Selecting framework species to restore subtropical forest ecosystem in buffer zone, Southwest China.

Presenter: He Jun, World Agroforestry Centre (ICRAF-China)
Session 18
Agroforestry, climate change and biodiversity conservation
Agroforestry as a way forward to mitigate climate change and loss of biodiversity in the development of tropical peatland

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Session: 18. Agroforestry, climate change and biodiversity conservation

Abstract: The conventional way of peatland tropical development has resulted in a loss of biodiversity and an increase in emission of carbon dioxide. An agroforestry approach is considered one of the best development practices for meeting economic and ecological objectives. This study, carried out at Sessang MARDI Research Station in Sarawak, aimed to quantify the impact of human activities on biodiversity and climate change. The pattern of biodiversity (microbial, plant, and insect) and CO2 flux was monitored over three types of peatland ecosystem: natural, conventionally developed and agrofrestry-developed areas. In conventionally developed areas, natural peatland was cleared by felling and burning. In the agrofrestry areas, natural peatland was selectively cleared and big trees were left standing. Our preliminary results indicated that clearing of peatland resulted in reduction of biodiversity and emitted more carbon. However, minimal disturbance activities through selective clearing reduced these negative impacts. The results imply that an agroforestry approach may be adopted to develop peatland ecosystems in a more sustainable manner. Current and future research activities are investigating the selection of the potential short-term crops to be planted within this new ecosystem.

Agroforestry coffee systems provide adaptation to climate change while conserving ecosystem services

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Session: 18. Agroforestry, climate change and biodiversity conservation

Abstract: Family farmers in the Brazilian Atlantic Rainforest region are anticipating adapting their systems to the impacts of climatic change. Living in the middle of a biodiversity hotspot under threat of biodiversity loss, they are producing marketable products and food while preserving biodiversity and other ecosystem services. Guided by agro-ecological principles, they have developed agroforestry coffee systems using native trees since 1993. The aim of our research was to gain understanding of different agroforestry management systems within the complex landscape matrix with respect to their capacity to diminish impacts of climate change and to preserve biodiversity. The optimum temperature for Coffee arabica is between 18 and 23 °C and temperatures higher than 33 °C cause serious reductions in coffee production. The average local temperature in the Zona da Mata is 18°C, with high local variation due to the diverse topography of the region. Hence, large parts of Zona da Mata will become unsuitable for full-sun coffee cultivation with a predicted increase of temperature of 3 °C due to climate change. Besides providing other environmental benefits, trees in agroforestry systems moderate microclimatic conditions, thus providing better conditions for coffee production. Maximum temperature in full-sun coffee systems reached 30 °C compared to 24 °C in agroforestry systems. The difference between maxima and minima was 6.4 °C. The trees species used also have the potential to preserve on-farm biodiversity as well as regional biodiversity by providing corridors between small fragments of native forest. Around 90% of the genera and 70% of the tree species in agroforestry systems also occurred in forest fragments. More than 80 species of trees are used in agroforestry systems.
for various purposes. The average number of trees in agroforestry systems is 100 ha⁻¹ and local differences are due to preferences and management. Furthermore, agroforestry systems promote nutrient cycling, control of erosion and have higher productivity.

**Below-ground ecology and some related useful approaches for agroforestry management and sustainability**

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**Session** 18. Agroforestry, climate change and biodiversity conservation

**Abstract** Agroforestry has mainly dealt with above-ground organisms. Nevertheless, soil organisms form the richest component of forest biodiversity, accomplishing fundamental functions and processes. Unfortunately, these services are almost neglected in common analyses, mainly due to the difficulties in classifying and evaluating soil biota. However, several natural or human-induced disasters might be prevented and attenuated if an interdisciplinary approach, considering both above-ground and soil components of biodiversity, is used and applied. Italy’s rich biodiversity and its intense assortment of land cover units, soil types and land management practices are increasingly interacting with a dense and disrespectful human population, leading to serious problems of management and sustainability in the long term. A synthetic index based on soil micro-arthropod populations is giving useful support to new holistic investigations, and thanks to its easiness and fast and reliable results, is providing interesting results for a more effective management of soil resources, including long-term sustainability, disturbance resilience and environmental assessments. The methodologies and strategies for its application are illustrated in this paper. Moreover, parallel investigations on microbial and fungal biodiversity are providing useful insights for a more complete and dynamic comprehension of agroforest ecosystems, focused on all components of the ecosystem. Some enlightening examples of this kind of analysis are provided. The interaction of these methods, although at an early stage of development, are promising interesting results which might lead to a more respectful, wise and long-lasting interaction between human activities and the environment.

**Biodiversity conservation and carbon sequestration in cocoa agroforest in southern Cameroon.**

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**Session** 18. Agroforestry, climate change and biodiversity conservation

**Abstract** This study took place in the semi-deciduous rainforest zone of southern Cameroon. The main objective was to appreciate the impact of cocoa agroforest on plant biodiversity conservation and carbon sequestration. Twenty-four transects of about 1.5 km long and 10 m wide, established in 8 villages, were used to evaluate the cover percentage of cocoa compared to other land-use systems (LUS). Forty-five plots of 625 m² (25 x 25 m) were surveyed in these villages. In these plots, all the individuals with DBH greater than or equal to 4 cm were recorded. The destructive method was used to evaluate carbon sequestration in different LUS for herbaceous plants, small woody plants, litter and roots, while the Brown allometric equation was used for all individuals with DBH > 4 cm. Seven LUS were identified in Yaounde region: 23% of these were cultivated land, 36% were fallows, 16% were cocoa field and 5% represent the secondary forest derived from slash and burn practices. In the regions of Mbalmayo and Ebolowa, 8 LUS were identified, of which 6 were shared with the region of Yaounde and 2 were different, these being degraded forest and swampy forest.
Species encountered in cocoa agroforest represent 33.78% of the total flora of the area. Fruit trees were abundant in those villages that had access to the market (e.g. Persea americana, Dacryodes edulis, Citrus spp.) while in Ambam region, original forest species, mostly timber, were encountered (e.g. Baillonella toxisperma, Guibourtia tessmannii, Terminalia superba, Milicia excelsa). This agroforest can accumulate about 251.14 t C/ha. Theobroma cacao hosted about 21.51 t C/ha. The root system of cover species stocks an important quantity of carbon.

Keywords: cocoa agroforest, land use system, biodiversity, carbon sequestration

Can European traditional agroforestry find a source of revitalization in climate change?

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Session C1. AF, climate change, biodiversity conservation
Abstract In southern Europe, traditional agroforestry systems with an animal husbandry component such as chestnut groves, dehesas, meadows with orchards, are nowadays subject to abandonment in spite of their multifunctional values. In the context of increasing demand for high-quality food and for high-value landscapes, these types of traditional agroforestry landscapes can provide the choice of local products or quality labels such as PGI (Protected Geographical Indication), which represent good commercial opportunities for the producers. But the farmers remain reluctant to maintain them, and gradually move to intensive treeless agriculture or give up. In the future, if global warming happens to put an excessive water stress on treeless pasturelands, the traditional agroforestry systems could gain a renewed value due to their ability to better preserve water, soil, grass and essential resources for animal husbandry. This paper is based on ongoing research on “The trees outside forest’s landscapes in South Europe” (PAHF project) financed by the French Ministry of Environment and Sustainable Development (MEEDDAT). It will discuss the traditional agroforestry systems with an animal husbandry component in France, Spain and Italy, and the causes of their decline. It will then examine their ecological capacity to cope with environmental changes resulting from global climate change and the resulting socioeconomic openings that could curb their present decline.

Climate change mitigation and adaptation through agroforestry

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Session 18. Agroforestry, climate change and biodiversity conservation
Abstract The 2007 report of the Intergovernmental Panel on Climate Change concludes that “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level” (IPCC WG I, 2007). For the Philippines, it is projected that the country will have wetter wet seasons and drier dry seasons. This will mean the occurrence of landslides in steep areas, flooding in the flatlands and low crop production especially for upland farmers who rely heavily on rain. Agroforestry plays a key role in both mitigation and adaptation aspects of climate change. For instance, in the study we conducted in Mount Makiling, Los Banos, Laguna, Philippines, to investigate the amount of carbon that the multistorey agroforestry system stores, results show that there is around 76 Mg of carbon per hectare stored in this ecosystem. The study established sample plots to estimate the carbon stored in the above-ground, ground and below-ground pools. Aside from agroforestry’s contribution to mitigate climate change, it also enhanced the adaptive
Carbon storage and health of cocoa agroforestry ecosystems in Ghana

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Session: 18. Agroforestry, climate change and biodiversity conservation

Abstract: Agriculture is one of the main drivers of the loss and degradation of humid forests in West Africa. There is little economic incentive for small-holder farmers to protect agroforestry ecosystems and their associated services, resulting in the intensification of production methods for commodity crops such as cocoa. Agroforestry ecosystems store significant amounts of carbon. Diversifying rural livelihoods through carbon trading might change the economic incentive to farm intensively, thereby protecting ecosystem health and improving agricultural sustainability. The aim of our study was to estimate the magnitude of carbon stores in different cocoa agroforestry systems, and relate these to agricultural commodity production (cocoa) and measures of ecosystem health. We studied a gradient of increasing cocoa production intensity in the Eastern Region of Ghana. We quantified the cocoa standing crop, above-ground and below-ground carbon stores, soil nutrients, nutrient cycling and forest biodiversity along this gradient over a 3-year period (2005-2007). The above and below ground carbon stores declined significantly along the intensification gradient. Cocoa standing crop was significantly greater on the unshaded farms, so there is a trade-off between cocoa productivity and carbon stores. Soil nutrient status and nutrient cycling deteriorated along the gradient, making intensive farming less sustainable. Forest biodiversity (the species richness of mammals, birds, butterflies and plants) showed a comparable pattern to carbon stores. Considering carbon stores and cocoa productivity in tandem could have important implications for land-management strategies. Ecosystem health and biodiversity value are related to carbon stores, providing a potential economic mechanism for wider ecosystem protection if carbon stores could be traded. Comparable integrated studies within Ghana and across the entire West African region are needed to provide baseline data. Work to enable smallholder cocoa farmers to engage with the emerging carbon market is urgently needed.

Distribution of trees and the socioeconomic status of farmers growing them in a rainfed agro-ecosystem of South India

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Abstract: Various species of trees are incorporated in various ways in farming systems under rainfed semi-arid agro-ecosystems in India. The choice of trees and where they are grown is influenced by both ecological and socioeconomic factors, however it is dominated by the goal of sustaining basic livelihoods. This study aims at assessing the tree resources of three villages in Kanakapura region of Karnataka, South India. Trees were identified and recorded to assess the on-farm tree richness, diversity, density and biomass. A socioeconomic assessment of farmers in relation to the kinds of trees they maintain on their farms revealed interesting reasons for growing trees. A total of 1285 individuals belonging to 72 tree species were recorded in homestead gardens, agricultural bunds, stream banks, tank bunds...
and avenues of these villages. The dominant species among these villages were *Melia dubia*, *Eucalyptus torticorni*, *Thespesia populnea*, *Pongamia pinnata*, *Wrightia tinctoria*, *Tamarindus indica*, *Artocarpus integrifolia*, *Albizia amara*, *Ficus benghalensis*, and *Cocos nucifera*. Among the ten top species eight are local and two are exotic. Eucalyptus has been observed to be the top dominant exotic in the region because of its promotion during 1980s under social forestry programme. The *Aeagle mermeolous*, one of the threatened species and one of the few keystone species were also recorded in the region. The usage patterns of trees were related to socioeconomic characteristics such as occupation, land size, food habits, extension contacts, education status, and protective functions. High species diversity and biomass in non-forest land categories in the study area indicate these species’ potential for promotion of species diversity and their inclusion in local afforestation programmes to enhance the native biodiversity and carbon sinks as suggested.

**Do coffee-dominated landscapes support mammal biodiversity? Costa Rica 2005-2008**

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**Session** 18. Agroforestry, climate change and biodiversity conservation

**Abstract**

The primary objective of our research was to assess the value of coffee fields and nearby forest tracts as habitat for mammals. From 2005 to 2008, we inventoried the mammal communities on the 500 ha La Hilda Farm near San Pedro de Poas in Costa Rica. We employed 6 x 6 trapping grids (50 m x 50 m), with paired Sherman traps at stations that were spaced 10 m apart. At each trap grid, 4 Tomahawk traps were set to capture medium-sized mammals. Grids were located in sun-grown and shade-grown coffee and in adjacent forests. In the first three years (2005-2007), trap grids were located in coffee (n = 8), and adjacent to native forested habitats (n = 8). In 2008, 4 additional coffee grids were established near existing coffee grids, but not adjacent to forest. Over the four years we amassed a total of 60, 540 and 3025 trap-nights with Sherman and Tomahawk traps, respectively. Each year we completed a vegetation analysis of all grids, measuring cover, basal area, and tree height and density. Although shade coffee evidenced more mammals than sun coffee, the abundance of small and medium-sized mammals was dramatically higher in forest grids. Species richness and diversity were generally higher in forest compared to coffee, however the reverse was true in several instances. Models of site occupancy revealed that the only variables that contributed significantly were basal area and canopy cover of trees. Overall, the coffee-dominated landscape that we examined supported 30 species of mammals, about 60% of the maximum that could possibly be expected to occupy the location. Thus, the coffee-dominated landscape that we studied supports a substantial portion of the native biodiversity of mammals. We suggest best management practices that are based on our results that will enhance mammal biodiversity in coffee-dominated landscapes.

**Evaluating ecosystem function and conservation potential for birds in cacao agroforests of Cameroon**

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**Session** 18. Agroforestry, climate change and biodiversity conservation

**Abstract**

The cocoa agroforests of southern Cameroon are known for their tree diversity and are seen as a potential model for sustainable cocoa production systems across West Africa. There is an interest in identifying the ecosystem services these agroforests provide at a larger landscape
Baseline data are needed to understand which birds are ecologically important in cacao agro-ecosystems. In addition, documenting management practices and resource availability for birds is an important first step to evaluating the conservation potential from cacao agro-ecosystems. To assess the conservation value of Cameroon cacao agroforests, we used mist-netting and area searches at the farm level (~1 ha) to survey birds found in 7 cacao-producing villages (4 farms per village, 28 in total). We found that Cameroon cacao agroforests support a high diversity of birds (150 observed species with 56 species in the cacao layer). This is not surprising considering the high diversity of trees observed in these farms (112 species). A high proportion of the birds found in the cacao vegetative layer were insectivorous and could help reduce pest outbreaks for farmers, providing an incentive for farmers to have an interest in their birds. In addition, many of the shade trees found in these cacao agroforests were also observed being used by hornbills in previous research in the nearby Dja Reserve. Many of these trees also provide economic value for farmers creating the possibility of a ‘win-win’ scenario where farmers’ economic interests are in line with conservation. This research demonstrates the potential value of cacao agroforests for biodiversity conservation.

Opportunities and challenges for agroforestry to mitigate climate change, conserve biodiversity and alleviate poverty

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Session 18. Agroforestry, climate change and biodiversity conservation

Abstract

Agroforestry systems could potentially play a key role in efforts to address climate change, conserve biodiversity and improve human well-being. Agroforestry systems can contribute to climate change mitigation both by sequestering carbon within living biomass, soils and wood products, and by reducing emissions from deforestation and forest degradation. However, the net mitigation impact of agroforestry systems will depend on a variety of factors, including where these systems are established, which types of agroforestry systems and which species are used, and how the systems are managed, among others. These design, management and implementation factors also influence the ability of the agroforestry system to provide other benefits, such as biodiversity conservation and poverty alleviation. In this presentation, we highlight both the opportunities and challenges for agroforestry systems to contribute to climate change mitigation, biodiversity conservation and poverty alleviation, based on field experiences with agroforestry carbon projects that either seek to enhance carbon uptake or reduce emissions from deforestation and degradation. We also explore how recent climate change policy developments (such as REDD, reducing emissions from deforestation and degradation) could influence the importance of agroforestry as a multibenefit, mitigation tool. Lastly, we highlight the lessons learned from carbon field projects regarding the appropriate design and management of agroforestry systems for climate change mitigation, as well as the institutional and social contexts that help enable the use of agroforestry systems as multibenefit, mitigation tools.

Potential of agroforestry systems to conserve biological diversity in Peruvian Amazon

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Session 18. Agroforestry, climate change and biodiversity conservation

Abstract

The Amazonian rain forest forms one of the most precious ecosystems, however currently it is highly disturbed by human activities, which causes biodiversity loss. Our study was focused
on the assessment of species diversity and species richness in various land-use systems around Pucallpa city in Peruvian Amazon. The class Insecta was chosen as the biodiversity indicative group. Insects were collected at six localities (a secondary forest, two types of agroforestry systems, a cassava monoculture and two deforested and degraded sites covered by weed vegetation) using 24 h-pitfall traps and sweeping nets. Our presumptions were that the species richness and diversity of secondary forest and agroforestry systems are higher than in monoculture cropping and degraded sites. We also supposed that in secondary forest and agroforestry systems there are fewer pest species. The insect morphological species were determined and data evaluated according to standard methods and indexes. Our hypotheses were fully confirmed by our study excluding the biodiversity indexes. The species richness was highest in the secondary forest and agroforests, but the values for biodiversity index were highest in the secondary forest and surprisingly on degraded sites. The lowest values for biodiversity index were calculated for both agroforestry systems. The values were probably distorted by the dry season and higher occurrence of anthropo-tolerant and pest species on degraded soils. Those species can survive the dry season without high losses and also produce more generations. According to the index of similarity, the species composition of secondary forest is highly similar to the agroforestry systems. The composition of ant species is also helping to control the pests in the agroforestry systems. Based on our results we can say that agroforestry systems can form insect species reservoirs after forest disturbances, which is very important for overall biodiversity conservation.

Reduced deforestation and degradation in protected areas: legal issues for harnessing forest biological diversity and mitigation of climate change

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Session
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Abstract
An upcoming option for a Post-Kyoto legal instrument is the reduction of deforestation and degradation (REDD) of forest ecosystems. According to Stern and recent IPCC Reports, 20% of total annual global CO2 emissions come from deforestation. In turn, climate change is having profound negative effects on forest ecosystems. Generating Certificates of Emission Reductions, CERs, or other types of credit for the recognition and valuation of ecological services of carbon storage provided by forest ecosystems may generate opportunities for increasing financial flows towards more effective conservation of protected areas and deter deforestation through better governance of tropical forests. According to the FAO, over one seventh of the world’s forests are in the category of protected area formally recognized by law. That figure increases in tropical forests, precisely where deforestation is taking a higher toll. An effective design of a policy instrument for reducing deforestation and degradation should observe certain basic rules to ensure that biodiversity values are considered throughout the instrument and that such an instrument would not generate perverse incentives prior to its entering into operation. Effective policy instrument design should ensure that reduced deforestation in protected areas qualifies for REDD CERs, taking into consideration forest biological diversity in terms of the Convention of Biological Diversity, in particular with respect to the Ecosystem Approach and the Jakarta Mandate for coastal areas. This paper will address some of the fundamental policy issues regarding baseline design, scale, permanence and leakage, and relate those issues to biodiversity law and policy discourse. The study will provide an overview of ongoing projects for reducing deforestation in Mexico in and around protected areas and explore experiences in agroforestry in developing land-use governance policies.
Using cocoa-agroforests for biodiversity conservation around protected areas: the case of the East Nimba Nature Reserve (Liberia)

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Abstract: Cocoa agroforests constitute a land-use system, which mimics the forest and can buffer protected areas and help avoid edge effects. It can also create corridors between fragmented forest stands and allows cocoa farmers to earn diverse incomes through the sale and use of multiple produce while conserving nature. This also lays the basis for any payments for environmental services produced by the systems. The East Nimba Nature Reserve (ENNR) in northeast Liberia is part of the Upper Guinean Forests of West Africa and it is considered a biodiversity hotspot. The ENNR faces complex environmental and developmental challenges due to a marked trend of deforestation and land degradation. Population growth, increasing deterioration in existing agricultural lands, coupled with poverty of the local peoples, have resulted in severe pressure on resources in the reserve. To reverse this trend, the Sustainable Tree Crops Program (STCP) with support from the World Bank and USAID initiated a biodiversity conservation project in 2007 that seeks to use cocoa agroforestry to reduce the intensity of encroachment on the reserve. One of the main objectives is to improve cocoa farmers’ awareness of the importance of biodiversity conservation since cocoa is one of the main cash crops in the landscape surrounding the reserve. This presentation discusses biodiversity conservation models that hinge on the local values of the area while relating them to universal issues. It also describes a participatory learning and demonstration approach proposed by STCP to encourage mutual learning between farmers and experts to create and share knowledge on the different (traditional and scientific) concepts of biodiversity conservation. It goes on to discuss processes used to train farmers and forestry authorities as community conservationists for the reserve. Finally, it ends with a recommendation on the idea of payment for environmental services to farmers in conservation.

What are the added ecological values of multipurpose agroforestry trees for conservation of endangered arboreal wildlife species

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Abstract: Ecological values of multipurpose agroforestry tree species for the conservation of endangered arboreal forest-dwelling wildlife species were assessed in three non-contiguous habitat types within deforested habitats of southern Nigeria to establish their role in sustaining the resident wildlife population of the area. Intensive dendrological surveys within five purposively selected 100x100 m plots was carried out to identify and enumerate merchantable forest and agroforestry multipurpose trees combined with broad-sweep and rapid animal assessment of all studied sites from June 2007 to May 2008 using standard field equipment. Results show that the rainforest area under study has been denuded of 95% of merchantable indigenous trees, living oil palms and fruit trees as the only sizeable tree species available for wildlife species. Tree hyraxes, bush babies, galagoes, parrots, hornbills and wood peckers have disappeared with deforestation and are rare sights in the area. Whereas, farmsteads, regenerating forests and suburbia are dominant habitats and are unsuitable for endangered forest birds, reptiles and mammals. However, wild turacos, hornbills, wood peckers and parrots (birds); squirrels, bats, bush babies and hyraxes (mammals) and tree frogs, chameleons, varanus and snakes
(herpetofauna) found refuge within agroforestry project sites where old stands of *Gliricidia sepium*, *Luceana leucocephala* and *Acacia auriculiformis* are the predominant trees forming the last viable habitats for ranging, roosting, perching and nesting. Squirrels competed with hornbills and woodpeckers for nesting sites on agroforestry tree species bearing holes on their trunks while tree seeds provided additional food sources for endangered forest wildlife of the area. Aside from the well-documented multipurpose values of agroforestry species, this article identifies agroforestry trees as ecologically significant and hereby recommends their integration in all habitat restoration activities to secure habitats for sustainable endangered wildlife species conservation where native forests have disappeared.

**Wildlife diversity and farmer livelihood in rural landscape mosaic at the forest margins of southern Cameroon**

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18. Agroforestry, climate change and biodiversity conservation

**Abstract**
One of the challenges faced by landscape managers in the Congo Basin fringe is the difficulty in separating land for biodiversity conservation from land useful for farmer livelihoods. Smallholder multi-strata agroforestry practices such as cocoa agroforestry have been cited as potential land use that can integrate both biodiversity and farmer livelihood considerations at the landscape scale. In order to assess the potential of the rural landscape mosaic for the conservation of wildlife as well as farmer livelihoods, this preliminary study consists of (1) wildlife transects (n=35Km), (2) hunter-follow surveys (n=14), and (3) socio-economic interviews (n=42) in four villages across a gradient of human population density (from peri-urban to remote), in a rural land-use mosaic consisting of (a) cocoa agroforest, (b) food crops, (c) fallow fields, (d) secondary forest and (e) primary forest. We observe, among other results, that (i) mammalian diversity increases with village remoteness, (ii) secondary forest has the largest proportion of animals signs of all land uses, (iii) cocoa and cassava are the most important sources of income, (iv) cocoa and hunting are increasingly important parts of the household annual revenue (as a percentage of total contribution) in more remote locations (that is, if cocoa income were to decline due to decreasing prices/demand, income would need to be substituted from other sources, with the possible effect of increasing pressure on wildlife). The study ends with a discussion on the potential role of smallholder cocoa agroforestry for biodiversity conservation and support of rural livelihood in the forest fringe.

**Key words:** rural landscape mosaic, wildlife diversity, livelihoods, southern Cameroon
Session 19
Carbon sequestration in agroforestry systems
Agroforestry and biochar potential for carbon sequestration

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Session
19. Carbon sequestration in agroforestry systems

Abstract
The biosphere faces imminent, irreversible and potentially catastrophic climate destabilization. Anthropogenic greenhouse gases have been unequivocally confirmed as the driver of these changes. Recently, a growing number of climatologists have revised estimates for the safe upper-limit of atmospheric CO2 levels downward to between 300 and 350 parts per million (ppm), whereas the current levels are around 378 ppm. It is becoming increasingly clear that we will not only need to reduce present emission levels (6.7 Pg C year\(^{-1}\)) radically, but that we will also have to sequester large amounts of carbon dioxide out of the atmosphere. Biochar has been proposed as a unique approach to establishing sustainable, verifiable and long-term carbon sinks with the ancillary benefits of renewable energy production and soil fertility enhancement. The scale and rate at which biochar production will need to be ramped up in order to sequester large amounts of carbon dioxide, however, is a significant challenge that will depend on a wide range of complex social, political, technological and economic factors. Therefore, a sustainable and comprehensive ‘systems approach’ to mitigating and adapting to climate change is being proposed, of which biochar plays a central, but non-exclusive, role. Sustainable agroforestry methods are essential to informing the overall biochar soil sequestration strategy. The initial findings of this paper suggest that a draw down of 5 Pg C year\(^{-1}\) (roughly 74% of annual global fossil fuel emissions) is possible using sustainable agroforestry methods in combination with biochar production.

Agroforestry in the Western Ghats of peninsular India and Satoyama in Japan: a comparison of two sustainable agricultural systems

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Abstract
Western Ghats in peninsular India and the Satoyama landscapes of Japan are geographically diverse regions. Yet there are remarkable similarities in the physiographic features as well as the traditional land-use systems followed in these territories. A series of rolling hills and plateaus intersected by deep valleys characterize both. The hill and valley farming system of Western Ghats (HVC) and the Satoyama system of Japan also have major similarities. Rice forms the predominant crop in the lowlands and on the often-terraced plateaus, bordered by homesteads and various forms of managed woodlands. Traditionally, the farmers in southern Western Ghats owned land parcels at different altitudinal zones within a micro watershed: paddy fields (providing a significant part of the food and feed requirements), ‘garden land homesteads’ close to the paddy lands sustaining a mixed plant/tree crop system (producing tubers, nuts, fruits, vegetables, timber, fuel, etc.), and upland plots with mixed-tree cover, including forest trees (meeting the grazing and organic manure needs). The multistrata ‘garden land homesteads’ and the upland plots are thought to be ‘relics’ of forests left behind during the process of land clearing, but evolved subsequently under variable planting and/or extraction regimes. The woody perennial-based systems in both HVC and Satoyama also serve as sinks of atmospheric CO2 and conserve biodiversity. Both HVC and Satoyama are seemingly sustainable production systems. Commercialization and urbanization are, however, major banes of both, which have resulted in considerable loss of tree cover and cultivatable areas. While significant efforts to conserve the Japanese Satoyama lands are being made, little or no such efforts are visible in the HVC context. An attempt is made to compare the species richness and carbon sequestration potential of these two noteworthy traditional land-use systems.
Balance between soil N$_2$O emissions and above-ground CO$_2$ uptake in coffee monocultures and agroforestry plantations in Costa Rica

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19. Carbon sequestration in agroforestry systems

Abstract  
Soil N$_2$O emissions and C storage were measured in coffee monocultures and coffee agroforestry systems (AFS) with N$_2$-fixing shade trees, under two agricultural managements. Two of the coffee plantations (monoculture and AFS with Inga densiflora) were conventionally managed (250 kg mineral N ha$^{-1}$ y$^{-1}$); the two others (monoculture and AFS with Erythrina poeppigiana) were organically managed (150 kg organic N ha$^{-1}$ y$^{-1}$). Measurements of soil N$_2$O emissions, litterfall, litter and biomass were achieved when the plantations were 7-8 years old (conventional management) and 6 years old (organic management). Soil N$_2$O emissions over the life time of the plantations (32 years) were simulated as a function of N inputs through fertilization and litterfall. Over the same period, CO$_2$ uptake by aboveground biomass was calculated by simulating the growth of the coffee plants and shade trees. The annual rate of the litterfall was assumed to be proportional to the above-ground biomass and the standing stock of litter was calculated as a function of litter inputs and decay rate. For both types of agricultural management, measured annual N$_2$O emissions were higher in the AFS (5.8±0.3 and 3.7±0.5 kg N$_2$O -N ha$^{-1}$ y$^{-1}$, in the conventional and organic managements, respectively) than in the monocultures (4.3±0.1 and 1.8±0.3 kg N$_2$O -N ha$^{-1}$ y$^{-1}$, in the respective managements), coinciding with higher N input through litterfall. The balance between cumulated N$_2$O emissions and CO$_2$ uptake over the life time of the plantations was negative in the monocultures (-25.5 and -8.2 Mg CO$_2$-eq ha$^{-1}$ 32 year$^{-1}$ in the conventional and organic managements, respectively) but positive in the AFS with a greater contribution to climate change mitigation of the organic management (37.3 Mg CO$_2$-eq ha$^{-1}$ 32year$^{-1}$) than of the conventional one (14.9 Mg CO$_2$-eq ha$^{-1}$ 32year$^{-1}$).

Carbon sequestration of smallholder tree farms and agroforestry farms in The Philippines

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Abstract  
Carbon budgets of terrestrial ecosystems and agro-ecosystems play an important part in the global carbon cycle. Recently, much interest has been focused on the role of such systems in mitigating climate change through carbon sequestration. Our aim in this paper is to synthesize ten years of research on the potential of smallholder tree farms and agroforestry systems in The Philippines to sequester carbon. Aside from published information, we included new research results and unpublished data. The first part of the paper presents and analyses carbon sequestration rates from various smallholder farms and agroforestry systems in The Philippines. In general, these systems have high carbon sequestration of up to 9.9 tC/ha/yr with a mean of 4.0 tC/ha/yr. However, there is wide variation depending on site quality. The second part of the paper explores the potential of smallholder tree farms and agroforestry systems in accessing the emerging carbon markets. Case studies of projects under preparation in The Philippines are presented. Barriers that could hinder successful project implementation are analysed and lessons are drawn.
Carbon storage in soil aggregate-size fractions under agroforestry systems

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Abstract: The impact of any agroforestry system (AFS) on soil carbon sequestration depends largely on the amount and quality of biomass input provided by tree and non-tree components of the system, and on properties of the soils, such as soil structure and their aggregations. We examined the role of tree roots in sequestering carbon in the deeper soil layers in AFSs under different agroecological conditions: subtropical silvopasture in Florida, USA; parkland and fodderbank systems in Mali in the semi-arid-to-arid West African Sahel; homegardens in the humid lowlands of Kerala, India; cacao AFS in Bahia, Brazil and in the dehesa AFS of Spain. The objective of this study was to characterize soil organic carbon pools in relation to different soil aggregate-size fractions in soil layers up to 1 m depth under the various AFSs. Soil samples were physically fractionated by wet sieving into three different size fractions (2000-250 µm, 250-53 µm, and <53 µm) and their organic C content determined. In addition, for the silvopastoral systems in Florida, the relative soil C contribution from woody vegetation (C3) versus warm-season grass vegetation (C4) was quantified using stable C isotope signatures, and compared to adjacent open pastures without trees in whole soil and the 3 soil fraction-sizes. Results suggest that tree-based AFSs have greater potential for C sequestration compared to treeless systems.

Charismatic carbon Inpang Community Agroforestry Carbon Bank, northeast Thailand

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Abstract: Tropical forests play an important role in climate change – as a source of greenhouse gas emissions from deforestation and in terms of their mitigation potential. Pressures on tropical forests by local people may, however, be alleviated through the adoption of agroforestry. Certain complex agroforestry landscapes actually mimic tropical forests in ecological form and ecosystem function. One advantage of agroforestry systems is the potential to provide farmers with a number of possible income streams from non-timber and timber products as well as resources for their own subsistence. Agroforestry landscapes that increase the long-term storage of biomass by replacing annually cropped areas with diverse production systems that incorporate perennials, especially trees, have an additional marketable commodity in carbon. The conversion of low-biomass landscapes, such as annually cropped land or grassland, to agroforestry systems with high-biomass landscapes, mitigates climate through the sequestration of atmospheric CO2 and its storage in biomass. Agroforestry, therefore, has the potential to mitigate climate change and also provide an additional income stream to farmers. Members of the Inpang Community Network in northeast Thailand have initiated an ‘Agroforestry Carbon Bank’ in line with the tenants of the ‘Sufficiency Economy’ promoted by His Majesty King Bhumibol Adulyadej of Thailand. The project is developing measuring and monitoring protocols, and a web-GIS carbon registry management application for small-holder agroforestry carbon offsets. The ‘Carbon Bank’ aims to link sequestered carbon in agroforestry landscapes to carbon buyers on the Chicago Climate Exchange or other...
credible, voluntary markets. This paper highlights the lessons learned in developing the Inpang Community Agroforestry Carbon Bank and the accomplishments to date. Arguably, agroforestry carbon is a more socially and environmentally valuable form of carbon offset than a single-species reforestation plantation, which also sequesters atmospheric CO2. It is feasible, that sequestered carbon in different landscapes, might seek differential pricing from markets.

Does tree management affect aboveground and soil carbon sequestration in *Acacia mangium* Willd in the humid tropics of India?

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Session 19. Carbon sequestration in agroforestry systems

Abstract Initial spacing and tree pruning are customary stand management strategies in silviculture to meet particular management objectives. A field experiment was conducted at Thiruvazhamkunnu, Kerala, India to evaluate the changes in above-ground and soil (0 15 cm) carbon pools of 6.5-year-old *Acacia mangium* trees; it was influenced by stand-management practices such as planting, density regulation and tree pruning. The experimental variables included four planting densities (625, 1250, 2500, and 5000 stems ha-1) with and without 50% crown pruning arranged in a factorial RBD design with three replications. The carbon-sequestration potential of *A. mangium* trees was significantly (p<0.01) altered by the planting density and pruning treatments. The low-density stands (625 trees ha-1) had higher mean tree C-accumulation (46.87 kg tree-1), which declined with increasing density (21.68 kg tree-1 for the 5000 stems ha-1 stand). However, the stand-level trend followed a contrasting pattern. The above-ground C-sequestration on a per hectare basis was significantly higher for the 5000 trees ha-1 (108.42 Mg ha-1) compared to 29.3 Mg ha-1 for the 625 trees ha-1. Tree pruning in general reduced the rate of C-sequestration. Pruned trees had lower biomass C (57.18 Mg ha-1) than unpruned stems (73.57 Mg ha-1). Soil C stocks in the *Acacia mangium* stands also indicated considerable variations with planting densities. Treeless control plots registered the lowest soil C stock (24.7 Mg ha-1 for the 0 15 cm layer) while the stand with 2500 stems ha-1 showed the highest soil C content, implying some negative effects of very high stand densities (for example, 5000 stems ha-1) on the soil C pools. Nevertheless the *Acacia mangium* trees in general had considerable potential to enrich the C status of the top soil layer.

Keywords: *Acacia mangium*- C-sequestration- stand density-pruning- soil C

Forest carbon, land tenure, and carbon revenue distribution

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Session 19. Carbon sequestration in agroforestry systems

Abstract This paper analyses the iterative relationship between land tenure, the design and success of community-based forestry carbon finance projects (reforestation activities) and the carbon revenue distribution mechanisms. The paper is a comparative case study of 4 forestry carbon-sequestration projects in sub-Saharan Africa currently being implemented under the Clean Development Mechanism (CDM). Following a brief presentation of the 4 projects in Kenya, Ethiopia, Niger, and Madagascar, the paper discusses: changes in the land tenure situation among those involved in the projects during project design and implementation; how the land tenure situation impacts project design; and the carbon revenue distribution mechanism at the project level. As part of this analysis, the paper looks at how the land tenure situation in the different projects affects its institutional set-up, including the functions...
of a carbon aggregator, contractual arrangements for the purchase and selling of carbon credits, and flow of carbon revenues to individual project participants at the community level. The paper also analyses the extent to which a change in the land tenure situation, if one occurred, can be attributed to the implementation of the project itself or whether it was rather a necessary pre-condition for implementing the project. Based on the analysis of the 4 case studies, the authors provide some general observations on the links between land tenure, the design of forest carbon projects and the carbon revenue distribution mechanism adopted by the country.

Estimating the carbon sequestration potential of short rotation coppice on marginal sites - a model approach

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Session 20
Agroforestry and environmental amelioration
Agroforestry for reducing nitrogen pollution: from research to the field.

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Abstract
Nitrate is a significant water pollutant in a large part of French agricultural soils. It becomes a serious problem because of the high cost of water depuration it represents to the communities. Many studies have demonstrated the importance of silvo-arable systems in nitrate removal from non-point sources. From these results, first collection installations have been established in France, in different provinces, especially in zones of water collection. But developing a collective project requires a certain methodology, sensitizing the farmers and communities to setting up each project. Thus agroforestry like other innovations shouldn’t be considered as technical goal but above all as a socio-technical goal. To support the project, we have to take into account the interactions between technical practices and professional groups, resulting in a certain dynamic of information and norms of conceiving. The production and sharing of knowledge are one of the keys to success. In our example, near the town of Béziers, in the south of France, a community decided to support agroforestry for protecting ground water. After the first phase feasibility study, identification of adoption factors and sensitizing farmers and all the rural actors of the target zone, almost one third of the farmers decided to set up some silvo-arable projects.

Efficacy of teak (Tectona grandis) and dahoma (Piptadeniastrum africanum) heartwood water extracts on the durability of five LUS

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Abstract
Although conventional wood preservatives such as CCA, Pyrinex 48EC and creosote are found to be very effective against wood-destroying organisms, they are known to cause environmental pollution, carcinogenicity, liver damage and teratogenicity and ultimately climate change. A few of them are lethal to animals and human beings at certain doses. Even chromated copper arsenate (CCA), the most widely used preservative in Ghana, which was thought to be non-toxic to humans and animals because of its permanence and stability in wood, has now been revealed by research to leach into the environment over time. In an effort to find new preservatives which do not pose these problems, efficacy of teak and dahoma (highly and moderately durable timber species respectively) heartwood water extracts (0.60 g/ml), was tested on selected lesser-utilized timber species (LUS), Sterculia oblonga, Antiaris toxicaria, Canarium schweinfurthii, Celtis zenkeri and Cola gigantea of varying natural durability, by non-pressure impregnation and buried in a termite prone field for 8 months following EN 252. The effect of teak and dahoma heartwood water extracts were tested based on visual durability ratings, percentage hardness and mass losses of impregnated selected LUS after burial. Regardless of retention levels, teak heartwood water extract improved the natural durability of selected LUS to a greater extent than dahoma heartwood water extract. Improved durability of LUS was ranked as follows: Sterculia oblonga = Cola gigantean > Celtis zenkeri > Antiaris Toxicaria > Canarium schweinfurthii. Though extracts showed reduced efficacy over time, indications were that extracts from the heartwood of tropical timber species such as teak could be employed to preserve their low-durability counterparts eluding such problems that come with conventional wood preservatives.
Riparian zone health identification utilizing remotely sensed imagery and object orientated analysis

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Session 20. Agroforestry and environmental amelioration
Abstract

The ability to identify riparian areas and assess their characteristics addresses some long-standing information requirements regarding riparian health. We recognize the positive impacts that healthy riparian zones have on water quality of rivers, lakes and other major receiving basins. We also recognize the potential of operational earth observation-based ecosystem monitoring as a means to develop this type of information and do so at a low cost alternative to on-ground field assessments. The geomatics-based riparian health assessment pilot project in the Upper Assiniboine Conservation District of Manitoba, Canada, will provide sound, science-based information on the feasibility of classifying riparian areas using remote sensing technologies abroad. The project aims to establish an object-orientated methodology to identify riparian zone attribute values to classify riparian areas across the landscape using spectral, spatial and relational riparian zone characteristics. Attributes are derived from synthetic aperture radar (SAR) imagery and orthophotos for moisture, vegetative type and health identification of riparian zones. The new quad-polarization and ultra-fine beam modes provided by RADARSAT-2 imagery will be examined to identify moisture levels of riparian zones and provide a measure of vegetation volume structure, biomass and canopy structure. High resolution orthophotos will provide vegetative type and health criteria statistical information. Findings will be further supported by supplemental ground assessments. Once the riparian health identification information gap can be addressed effective agroforestry and water-quality management practices can be implemented on a watershed scale.

Short-term effects of compost and N-fertilizer inputs on maize performance and nutrient uptake in agroforestry parklands

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Abstract

We investigated the effects of urea and compost on maize yield and soil characteristics in Faidherbia albida and Vitellaria paradoxa parklands in Burkina Faso. The recovery of 15N was also investigated on parkland soils under greenhouse conditions. Urea and compost were applied separately underneath and outside the canopy of each tree species studied at the rate of 80 kg N ha⁻¹, or in combination each at the rate of 40 kg N ha⁻¹. The fertilized areas were compared with unfertilized control treatments. The field experiment was conducted from 2004 to 2006. In both parklands, all the treatments resulted in higher maize yield than the control at the same canopy position. In the F. albida parkland, the urea treatment had the greatest effect on maize yield. In the V. paradoxa parkland, the combined compost and urea treatment produced the highest increase in yield in the driest year. In the wettest year, the urea-only treatment resulted in the highest maize yield. Maize yield under the canopy of F. albida was higher than outside it. In contrast, maize yield under the V. paradoxa canopy was lower than outside it. Yield under canopy was relatively better in dry years. In the greenhouse study, maize shoot biomass had a similar pattern as the field. Also, soil-borne N dominated the N uptake by maize shoot biomass. Recovery of 15N (Ndff) and the recovery of compost-N (Ndfc) were lower in the soil collected from under the F. albida canopy than outside the canopy, but was similar for the soil under and outside the canopy of V. paradoxa.
Combining compost and urea is an effective way of reducing the fertilizer application rate. Our results also suggest that the application of compost may alleviate problems of future climate forcing, since compost application increased yield in dry years.

Synergy between green charcoal and agroforestry development

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Session: 20. Agroforestry and environmental amelioration

Abstract
Soil fertilisation by charcoal (biochar) is an ancestral practice initiated thousands years ago by pre-Columbian Indians who applied fields with a mixture of carbonized matter and organic waste. This led to the formation of ‘Terra Preta’, a deep-colour soil with remarkable fertility, recently rediscovered by scientists. They observed that these qualities result principally from the presence of numerous carbonized particles that act as a ‘nest’ and facilitate the fixation of water and nutrients and the development of a rich and beneficial population of microorganisms. Not only agricultural crops but also trees such as acacia (Ogawa, 2004) or meranti (Forda, 2005) have been growing better with biochar amendment. However, a lot more research on the effectiveness of biochar in agroforestry systems has still to be done. Pro-Natura, with a long agroforestry experience, is encouraging research on biochar that particularly suits the production and promotion of its green charcoal. The Pro-Natura International green charcoal technology is well suited because the process can use agricultural residues in place of wood and does not emit methane. While initially only used as domestic fuel, green charcoal can perfectly serve as biochar. Pilot projects have therefore been established on sites where the substitution of wood charcoal for green charcoal already brings benefits to the environment by avoiding deforestation. Terra Preta assesses a very long duration of carbon sequestration in the soil and can thus be considered as ‘carbon sink’. Therefore, besides potentially fighting against poverty and hunger by improving the soil, biochar also offers an effective and sustainable solution to mitigate climate change. The generation of substantial carbon credits can help fund the development of agroforestry around the green charcoal machines.

The role of trees for N leaching after organic and mineral fertilization

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Session: 20. Agroforestry and environmental amelioration

Abstract
In recent years, new techniques and forms of sustainable agriculture have arisen, because intensive agriculture is causing several environmental problems. Among these problems, nitrate leaching and surface water eutrophication deserve much interest in the scientific community and among politicians. Agroforestry systems could be used for reducing nutrient lixiviation because tree roots develop deeper than those of grass. At the same time, tree growth can be increased, due nutrients provided by fertilization; and quality wood, that is in demand, can be produced. Actually, in the European Union, limitations for sewage sludge production and disposal were increased due to EU policy. Organic matter and nutrient sewage sludge contents, principally nitrogen, indicate it can be used as fertilizer. The objectives of this project are to study the viability of the establishment of agroforestry systems in irrigated grassland in the Mediterranean area, where the risk of environmental hazard is high, to determinate its efficiency in the control of nutrient lixiviation, mostly nitrate, and finally to check the effects of trees on grass production and quality. Four vegetation systems (grass, tree and grass-tree and control) and five fertilization treatments (no-fertilization and two doses of organic and inorganic fertilization) were tested under irrigation. Tree presence reduced nitrate concentration in soil with organic and inorganic fertilization, especially at
depth, with respect to pasture systems. Fertilization treatments should be determined for reducing tree-pasture competition.

**Integrated oil palm-based agroforestry systems in South East Asia: production and environmental sustainability.**
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**Beef cattle production in a silvopastoral system in Brazilian Cerrado and its environmental implications.**
Presenter: F.S. Bernardino, Univ. of Viçosa, Brazil
Session 21
Mitigation and adaptation to climate change
Bringing the trees back: farmers adapting to climate change in the Offin River Basin, Ghana

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Session: 21. Mitigation and adaptation to climate change

Abstract: The Offin River basin is in the moist semi-deciduous forest region of Ghana. Communities in the basin are mainly rural and predominantly rain-fed crop farmers. Farmers in the Offin River basin are experiencing crop loss, damages and low yield and they attribute this to recent observed changes in climate. The rainfall pattern has changed drastically: it is either too little or too much and highly unpredictable. Mean annual rainfall has generally decreased by over 20%. Sunshine duration and intensity has increased and mean temperatures in the Offin River basin have increased by over 1%. These changes coupled with intense deforestation have resulted in crops failing due to: little or no rainfall or storms destroying farms; lack of moisture in the soil for root uptake; hard, cracked and degraded lands with low fertility; and wilting of crops from high incidence of sunshine. Adaptation to the effects of climate change has not been very successful for many farmers, but a few who are now either incorporating trees in their farms, had left trees on their farms, or re-planting trees they once removed form their farms, have a success story to tell. The trees are playing important roles such as: providing shade for tree crops such as cocoa; improving soil fertility through nutrient cycling; enhancing rainwater infiltration; and improving the microclimate. In this era of climate change, agroforestry systems will not only help to mitigate climate change through carbon sequestration but they also offer a relatively cheap means of adaptation to climate change by the poor farmers in the Offin River basin. A successful replication of the success in other areas requires more research into the best tree species to plant and which agroforestry system to adopt - improved fallows or simultaneous tree crop systems, which best suits the agro-climatic zone and meet the farmers’ needs.

Carbon isotope composition in tree rings of agroforestry species and their potential for climate reconstruction

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Session: 21. Mitigation and adaptation to climate change

Abstract: In the face of climate change, information on plant responses to their environment offers the potential to trace the course of environmental and climatological fluctuations. In this context, annual stable carbon isotope patterns were measured on tree rings from evergreen *Balanites aegyptiaca* (Balanitaceae), and deciduous *Acacia senegal* (Fabaceae) for the years 1973-2002 from the acacia woodland of the Upper Rift Valley Lakes region in the central lowlands of Ethiopia. Three to four tree disks were sampled for each species grown on the same site. We measured individual 13C series on annual rings for each stem disk using mass spectrometry. The mean 13C values differ between species, with *Acacia senegal* isotopically depleted relative to *Balanites aegyptiaca*. However, the annual 13C patterns are similar between species. A declining trend with time was observed in 13C, notably for *B. aegyptiaca*, which could be due to anthropogenic increases in atmospheric CO₂ concentration and decrease in atmospheric 13C. Tree ring 13C values of both species revealed significant negative correlation with amount of precipitation, but not with temperature and relative humidity. The more enriched carbon isotope values correspond with the extreme drought years, for instance 1984-85 and 1991. The 13C of *Acacia senegal* shows a better correlation.
Climate change adaptation and mitigation synergies in smallholder agriculture

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Session: 21. Mitigation and adaptation to climate change

Abstract
One-third of greenhouse gas build-up in the atmosphere is estimated to result from changes in land use. A new project, ‘Western Kenya Smallholder Agriculture Carbon Finance Project’, developed by SCC-Vi Agroforestry, BioCarbon Fund and the World Bank shows that sustainable land use management (SALM) practices on smallholder farms in Western Kenya will increase staple food production and generate carbon revenues. Simultaneously, the project will help strengthen farmers’ capacity to adapt to climate change. The project encompasses 116,387 hectares, upon which SALM practices, which increase carbon stocks, will be adopted on approximately 60,000 hectares. The project is assisting poor rural communities participating in climate change mitigation (expected carbon emission reduction is 490,500 tCO2-e) and thereby deriving additional revenues through SALM practices. The practices include agroforestry, conservation agriculture, nutrient management (mulching, improved fallow, green manure, composting), tillage/residue management (trash lines, drainage channels, ridging), soil and water management (erosion control), restoration/rehabilitation of degraded lands and livestock management (zero grazing, farmyard manure). At the moment these activities are ineligible in the first commitment period of the Kyoto Protocol. The project is a ground-breaking initiative that provides strong arguments for inclusion of agricultural and soil carbon projects to be integrated in a post 2012 climate regime. The project provides a new methodology for establishing baseline scenarios, which are necessary to calculate the emission reductions attributable to projects and for monitoring emission reductions from projects. Seventy percent of carbon revenues, 1,030,050 USD, will be distributed to farmer groups involved in the project and the remaining 30% will be used to provide extension services. Hence, the project will benefit the poorest communities in Africa by taking advantage of the international carbon market. The project is the first of its kind to be approved by BioCarbon Fund.

Climate change and tree genetic resources: maintaining the productivity of agroforestry landscapes in the tropics


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Session 21: Integrating Genomics in Agroforestry

Abstract
Humans are altering climate, with significant consequences for the sustainability and productivity of agroforestry ecosystems, upon which millions of people depend. Here, we address the following questions: Why is it important to manage tree genetic resources in these landscapes? What are the consequences of climate change for these resources? And, what interventions can be made to address the emerging challenges presented? Maintaining and enhancing tree genetic variation in farmers’ fields – through improving farmers’ access to a range of planting materials and by devising ‘intelligent markets’ that support diversity – is essential in order to sustain the productivity of individual tree species, of species complexes and of agroforestry ecosystems in the face of current threats from deforestation, land degradation and crop intensification. Climate change reinforces the importance of these
interventions and brings additional challenges, as planting domains shift, as completely novel environments are created, and as droughts and floods become more common. At a genetic level, these changes bring particular opportunities for intervention, through the selection and introduction of better-adapted tree provenances to new conditions. To ensure future productivity, key gaps in knowledge must however be addressed: How will climate change impact on the ‘connectivity’ between trees, which influences the level and structure of genetic variation found in farming landscapes? What is the best approach for introducing better-adapted provenances to farmers, and how does this differ from currently favoured decentralised models for delivering germplasm? How can ‘domain mapping’ be carried out effectively at a population level, so that the high adaptive variation found among different provenances of a species is managed efficiently? A better understanding is needed of how to design, undertake and interpret ‘transplantation’ experiments, in which provenances for possible farm planting are tested over a range of conditions, and of the specific characteristics that should be prioritised during selection.

Climate change in Bangladesh: Can homestead agroforestry mitigate?

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Preferred Session 21. Mitigation and adaptation to climate change
Abstract

Though Bangladesh is predominantly a riverine country, the northwestern region is threatened by desertification. In addition to the environmental consequences, desertification is also threatening the livelihood of rural people. This is also one of the forest poor regions of the country. Hence, it is urgently required to increase vegetation cover through development of smallholder agroforestry traditionally adopted by rural people within their homesteads. This agroforestry system in drought-prone areas provides a healthy ecosystem for humans, animals, birds, livestock and miscellaneous flora and fauna. The present study has been conducted to explore the people’s perception towards the trend of desertification and identify the role of homestead agroforestry in adaptation to and mitigation of desertification. A questionnaire survey among randomly selected householders, key informants’ interview and expert level consultation had been administered throughout the study. Results of the study show that in the absence of government forests, rural people are highly dependent on homestead agroforestry to meet their demand for forest products, including timber, fuel, fruit, and non-timber stuffs. The study estimated that about 85% of the timber and 90% of the wood fuel consumed in the area are produced in these agroforestry systems. The study found that the people hold various perceptions towards the trend of desertification in the study area. But they hold a common perception that smallholder agroforestry can play vital roles both in greening this drought-prone region and ensuring an alternative livelihood. The study concludes that household level coping and adaptation strategies may include livelihood diversification through intensification of traditional homestead agroforestry and massive homestead afforestation with indigenous species to increase tree cover. In view of the findings, national policies might focus on promotion of inhabitants’ indigenous knowledge regarding environmentally friendly agroforestry land use in drought-prone areas.

Climate change mitigation through agroforestry in South Sorong District, Papua

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Abstract

Agroforestry practices could be used in developing adaptation and mitigation strategies for climate change. In Papua, agroforestry has been developed for social and community forest
purposes, to increase income of local communities, ensure environment sustainability and maximize opportunities to get international funding. However, very little research has been conducted regarding agroforestry practices particularly endemic species choice for climate change mitigation (carbon sequestration) and for income generation for local people. The objective of this study was to develop a mitigation effort in the forestry sector through the establishment of agroforestry-based community forest management. The evaluation of the mitigation potential of selected endemic species, and community income were also examined in South Sorong District. A comprehensive mitigation analysis process (COMAP) model was used for data analysis. Three categories of community forestry were evaluated: simple agroforestry systems (patterns 1-4), complex agroforestry system type 1 (pattern 5) and complex agroforestry system type 2 (patterns 6 and 7) respectively. The result show that the simple agroforestry system gave mitigation potential value of ~500 tC/ha, the complex agroforestry type1 system was ~550 tC/ha), and the complex agroforestry type2 system was ~700 tC/ha. Both simple style agroforestry system and complex agroforestry systems produced positive financial impacts, with a range from USD 16 752 to USD 62 775 per ha/rotation. The benefit from agroforestry systems is double that of a monoculture system (forest plantation). The total area available for agroforestry system implementation is approximately 226 259 ha in South Sorong District alone.

Design and use of affordable rain shelters for drought experiments on maize-Gliricidia and maize-Tephrosia intercropping in southern Malawi

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Session 21. Mitigation and adaptation to climate change

Abstract Farmers in southern Africa face challenges of low soil fertility, unreliable rainfall, and limited access to inputs. Climate change is expected to reduce rainfall and alter its distribution in the region, exacerbating vulnerability of rainfed agriculture. Agroforestry technologies, such as intercropping of maize with the nitrogen-fixing trees Gliricidia sepium and Tephrosia candida, can improve soil fertility and food security in the region. However, performance of these technologies has not been tested under future adverse climatic conditions. To date there have been few climate manipulation experiments on agroforestry systems, especially in developing countries where costs may be prohibitive. Here, we present a new experiment using rain exclusion shelters to induce artificial drought in Gliricidia and Tephrosia intercropping systems in southern Malawi. We describe the design, construction and performance of the rain shelters: they are affordable (USD 300 each), made of locally available materials, adaptable (with removable roofs to control total interception), and sufficiently robust to withstand heavy rain and wind events. We demonstrate that the shelters are highly effective at reducing soil moisture and inducing plant water stress, though a buffer zone is needed to compensate for absence of roof gutters and below-ground barriers. Side effects on air temperature and solar radiation are minor. We also discuss preliminary effects of the induced drought on a mature Gliricidia system and on newly established Gliricidia and Tephrosia systems. We examine patterns of drought impact (maize yield, tree biomass yield, seedling survival and growth) and mechanisms of drought impact (soil moisture, soil biochemistry, decomposition, rooting patterns). These early results will, we hope, stimulate discussion and inform subsequent climate manipulation experiments on agroforestry systems. Agroforestry may facilitate climate adaptation in southern Africa and other vulnerable regions, but only if tree-crop-environment interactions are appropriate for future climates.
Drought response of a cacao agroforestry system, Sulawesi, Indonesia

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Session: 21. Mitigation and adaptation to climate change

Abstract: Socioeconomic surveys revealed that strong droughts in 1997 and 2002 led to a considerable reduction in cacao yield in Indonesia. However, detailed experimental studies on the ecological consequences of droughts on cacao agroforests are still limited. The objective of this study was to assess the impact of an experimental drought on ecosystem properties. The research was conducted in a 6-year-old Theobroma cacao plantation shaded by Gliricidia sepium trees in Central Sulawesi, Indonesia. The stand was divided into six plots. On three plots (roof plots) plastic covered bamboo frames were constructed at 1.2 m above ground to partially exclude throughfall. Roofs covered 80% of the plot area and were closed for 13 months. Soil water content in the roof plots decreased considerably at all measured depth (of 10, 20, 40, 75, 150 and 250 cm). Over several months total soil water storage was close to the permanent wilting point. Sap flux of cacao and Gliricidia was on average reduced by 15%. Soil CO2 efflux on the roof plots was approximately 15% lower than the control plots. Cacao and Gliricidia litterfall and cacao yield showed no statistically significant differences between control and roof plots during roof closure. However, cacao bean yield in roof plots was substantially lower (~45%) than control plots during the main harvest following the period when soil water content was lowest. This indicates that cacao bean yield was more sensitive to drought than other ecosystem functions. We found evidence in this agroforest that there is complementary use of soil water resources through vertical partitioning of water uptake between cacao and Gliricidia. This, in combination with acclimation may have helped cacao trees to cope with the induced drought. Cacao agroforestry systems may thus play an important role as a drought-tolerant land use in those (sub-) tropical regions where the frequency and severity of droughts is projected to increase.

Evaluation of drought severity in the Mediterranean regions by using the SPI Index and its impact on agriculture

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Session: 21. Mitigation and adaptation to climate change

Abstract: There are indications of changes in rainfall patterns in Europe as indicated by the frequency of drought events during spring and early summer. An increase in frequency of droughts was observed in large parts of Western and Eastern Europe, especially in the Mediterranean region (Trenberth et al. 2007). Mean annual precipitation is increasing in most of the Atlantic and northern Europe and decreasing along the Mediterranean (Klein Tank et al. 2002). The Mediterranean region is the most vulnerable in Europe to climate change because of its sensitivity to drought and rising temperatures. Countries bordering the Mediterranean will suffer an increased risk of severe water shortages, forest fires, loss of agricultural land and an expansion of potentially invasive species from the south. Also, the economy and landscape of alpine regions are vulnerable to increased temperatures as a warmer climate causes the mountain snow lines to rise. Drought influences have been evaluated less and sometimes barely reported, since it is difficult to identify the principal occurrence and the end of the drought, except for the measurement of its intensity (Sivakumar et al. 2005). The main purpose of this paper is to analyse the drought magnitude and the impacts on agriculture in 2 Mediterranean regions of Europe (Spain and Italy). To determine the relationships between
climatic conditions and agricultural systems, several indices and simulation models were used. Simulation models and indices described the effect of climate on a specific crop and a specific process. In this way information was obtained concerning the chemical, biological and physical relationships among the system components. At the same time, this knowledge can be applied to manage the system with respect to irrigation, crop protection, harvesting, fertilization and other management tasks. The method was based on the evaluation of the past (past casting). We chose the Standardized Precipitation Index to monitor and qualify drought severity over the years.

Long-term changes in tree cover and landscape dynamics affect rainfall patterns in the coffee-agroforestry district of Kodagu, India.

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Abstract
India is the world’s 5th largest coffee producer with production areas concentrated in the Western Ghats, one of the world hotspots of biodiversity. In this region, coffee grown under the shade of multi-strata systems, predominates the landscape and plays a major role in biodiversity conservation and provision of goods and services for the local and global communities. One key service identified by local stakeholders relates to local climate and water circulation, a critical issue since the main rivers providing water for urban centres and agriculture in southern India also originate in these coffee areas. Over the last 30 years, the tree cover of coffee agroforestry systems has been profoundly affected by the development of the area under coffee cultivation and important changes to the production systems in the form of new varieties and practices such as irrigation and simplification of tree cover. In this paper, we explore to extent to which these landscape dynamics have impacted the regulation of local weather conditions. To assess the provision of this critical ecosystem service, we collected historical data (up to more than 50 years) on daily rainfall from over 100 farms along an east west transect in the Kavery watershed of Kodagu district, the most important coffee district of the region. Therefore, we covered within this watershed a range of ecological conditions going from 6000 mm of annual rainfall in the evergreen western belt to 1200 mm in the deciduous eastern belt. We related this information to the spatial dynamics described through remote sensing for the last 40 years. Taking advantage of the contrasting ecological conditions and landscape dynamics in the watershed, we explored the effects of changes in tree cover in these coffee agroforests on the rainfall pattern and identified key management practices that could lead to preserving or enhancing their role as water providers.

Negotiating carbon payments for small-scale farmers in Kalahan, The Philippines

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Abstract
Although most of the investors have no interest in financing small-scale forest carbon projects, the Kalahan Educational Foundation (KEF) has a different story to tell. This paper shares the various activities and experiences of the KEF in negotiating a community-led carbon forestry and agroforestry project for the Clean Development Mechanism (CDM). With the technical assistance of the Rewarding Upland Poor for Environmental Services (RUPES) Program in the Philippines, KEF is currently implementing reforestation and agroforestry activities as the main strategy of the carbon sequestration project. This paper describes the main
obstacles and specific transaction costs involved in securing carbon buyers. An analysis of potential financial benefits of the project, based on the negotiated price of CERs (Certificate of Emission Reductions), is also estimated. While the project is currently being processed for CDM registration, new risks and additional costs are being incurred. This paper provides lessons learned and insights as to whether the current regulatory carbon market is beneficial for small-scale farmers.

On the prospects of carbon flux studies in agroforestry systems in India for mitigation and adaptation of climate change.

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Abstract: To develop tangible strategies for mitigation of climate change through agroforestry systems, it is necessary to understand the adaptability of agroforestry systems to climate change effects. It is also important to evaluate agroforestry systems for their contribution to CO2 fluxes both from below and aboveground in a holistic manner; this has not been paid much attention, probably due to technical complications and relatively expensive instrumentation required. Considering the significance of plausible impacts of climate change globally and on Indian agriculture as well, top priority should be given to the initiation of such studies in agroforestry systems, so as to develop meaningful mitigation and adaptation strategies in a reasonable time period. In this regard, emerging direct on-site measurement techniques such as eddy covariance measurement of carbon dioxide fluxes need to be adopted. Moreover, assessment of canopy photosynthesis, canopy respiration and respiratory CO2 release by soil microbes (soil respiration) over the growing season assumes much importance. In determining the overall carbon budget, assessing variability in acclimation of canopy photosynthesis, water soluble carbohydrate accumulation, below-ground carbon balance and respiration including the energy balance of a given agroforestry system, need much more attention than they have received before. These factors will help precise determination of carbon budgeting or carbon sequestration potential of agroforestry systems in varied agroclimatic situations. Micro-environmental factors including radiation interception through tree canopy in agroforestry systems and their contributions to tree crop interactions need to be monitored along with the assessment of source or sink capacity in reference to CO2 fluxes in the long run. This should include carbon fluxes in different pruning or regrowth, felling and replantation regimes. Successful implementation of such studies may accelerate the actual benefit of carbon credits through agroforestry as framed in the Kyoto Protocol, particularly in the Indian scenario.

Phenology lags of trees and crops, climate change and the efficiency of temperate agroforestry systems: a modelling approach

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Abstract: Efficient temperate agroforestry systems often associate deciduous tree species with winter crops, resulting in a limited period of light competition, from tree bud burst in spring until crop harvest in summer. For a walnut wheat system, light competition occurs for a 3-month time span only, from April to June. Climate change may affect the timing of phenological stages of both trees and crops. Temperature increases may result in a slower mean rate of completion for the chilling requirement, and a higher mean rate of completion for the heat requirement of both trees and crops. Former investigations showed that a warming in the
early spring (February–April) by 1°C causes an advance in the beginning of the growing season of some tree species of 7 days. Differential responses of trees’ and crops’ phenologies to climate change may lead to a significant change of tree and crop complementarity for resource capture and use, and therefore affect the total productivity of the system. Conversely, the adequate choice of tree and crop varieties with properly lagged phenologies could be a way to improve the efficiency of agroforestry systems. We used the Hi-sAFe process-based simulation model to: 1) evaluate the part of the total over-yield that may be explained by phenology lags; 2) investigate the sensitivity of the performance of the agroforestry system to the tree and crop phonologies; and 3) explore the impact of global warming on the efficiency of a temperate agroforestry system. Several criteria were used to synthesize the effect of increased temperatures, total capture of resources (light and water) by the trees and crops, and global efficiency of the system as expressed by its land equivalent ratio.

Predicting suitable areas for the production of tamarind (Tamarindus indica L.) an underutilized fruit tree species

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Abstract
The benefits provided by underutilized fruit tree species, such as tamarind (Tamarindus indica L.), in combating increasing malnutrition, hunger and poverty in a changing world have become apparent. Tamarind is a high-value multipurpose underutilized fruit tree species which is drought tolerant and, suitable for rainfed agriculture on marginal land with minimum inputs. These characteristics make these species ideal for resource-poor farmers. The importance of identifying underutilized species’ environmental adaptations and their eco-geographic distribution has been identified. However the lack of physiological or empirical yield or growth data for the species does not permit the use of more traditional methods of crop modelling. Therefore an alternative method, the statistical modelling technique, ENFA (Ecological Niche Factor Analysis), was applied to occurrence data for tamarind in the form of passport information from herbarium records. This allowed the mapping of the species niche of in ecological space and the prediction of suitable production areas based on the species’ environmental requirements. Tamarind was modelled across its entire global distribution and three continental regional subsets. The models showed tamarind to respond differently on certain variables between the global and various regional extents, resulting in different patterns in the predicted distribution. Due to the domesticated nature of the species and the consequential effect of human selection pressures, it is proposed that this effect may be due to an evolutionary effect in niche characteristics. This results in geographical sub-populations. The implications of this in regard to modelling underutilized species distribution under climate change scenarios are discussed. This use of georeferenced herbarium data with statistical modelling is recommended as a relatively simple way of modelling a large number of underutilized crops, or any crop species with limited or no eco-physiological, empirical yield information. Future research is recommended to investigate niche requirements of promising landraces or cultivars under current and future climate scenarios.

Resilient Agro-landscapes to Climate Change in Tanzania

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Abstract

Rain-fed mixed crop livestock systems of north-eastern and central Tanzania are likely to be severely affected by numerous changes caused by climate change and its impacts. This project aims at assessing the regional impacts of climate change on agro-landscapes and environment in Tanzania (Morogoro) and at designing adaptation strategies for small-scale agriculture. Assessments on related land-use sectors as forest, hydrology, nature conservation and biodiversity are considered involving local partners and farmers. Driven by regional climate change scenarios, integrated agro-ecosystem models are used to assess combined climate change and management effects on crop production, water resources and soil fertility. These agro-ecosystem models are linked closely to hydrological models. Complementarily, stakeholders develop options of management practices in potential future agro-landscapes based on the same regional climate change scenarios. Historical vegetation maps and descriptions of Tanzania have been identified and are currently being evaluated to create a local database of occurring tree species. It is expected that many of the preferred tree species will be featured among the 201 tree and shrub species selected as useful to farming and pastoral communities of Tanzania, hence information on management and potential use of these species will be readily available. Readiness for adoption of the recommended species, adapted to the relevant climate scenarios, will be explored among smallholder farmers by socioeconomic surveys. Results contribute to the selection of suitable indigenous tree species in the development of the good practices. The added values of including trees into the farming systems will be evaluated using the Water, Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) model. This project will contribute to the development of farming systems and livelihood strategies that are robust across a range of possible future agro-landscapes. Introducing adapted agroforestry systems are expected to significantly contribute to the enhanced resilience of these landscapes.

Sequestering Carbon and Enhancing Livelihoods through Sustainable Agro-Sylvo-Pastoral Systems on Small Holder Farms

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Session 21. Mitigation and adaptation to climate change

Abstract

Changing rainfall and temperature patterns have increased the vulnerability of limited resource farmers and pastoralists worldwide making achieving livelihoods goals an even greater stretch. Cheap external inputs of fuel and fertilizers are no longer a reality or possibility. Growing evidence indicates that sustainable integrated farming systems based on agroecological principles can equal or surpass conventional agriculture productivity while having greater potential to improve the supporting natural resource base. Representatives of government, the scientific community, development organizations and civil society are recognizing that agroecological practices play an important role in mitigating carbon and nitrogen emissions as well as reducing the risks associated with climate change. Heifer International, in collaboration with the USDA-ARS, farmers and host-country researchers, has carried out a pilot study and indicative farming systems analyses on project sponsored integrated agro-sylvo-pastoral farming systems in 8 countries around the world. From initial analyses, we identified farming systems that contributed to enhanced livelihoods and productivity, biodiversity, carbon sequestration and adaptation capacity. These systems included a) livestock manure, compost, and crop management practices that build soil organic matter and enhance water infiltration and retention; b) utilizing nitrogen-fixing trees for forage, litter, and firewood; c) establishing fruit trees; d) growing forage grass on terraces or fodder plots; and e) incorporating improved wood-burning stoves. In many cases, when local tree species were established in hedgerows and as field borders at higher altitudes, farmers have reported considerably extended frost free days due to the micro-climate effect. This paper reports the results of indicative farming systems analyses for carbon and nitrogen on integrated agro-sylvo-pastoral systems from countries in Africa, Asia, Latin America and Eastern Europe.
The influence of a tree-based intercropping system on nitrous oxide emissions compared to a conventional monoculture in southern Canada

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Session
21. Mitigation and adaptation to climate change

Abstract
Agricultural practices to limit N2O emissions are sought as a result of the current climate change crisis. One method that has the potential to limit N2O emissions from agriculture is tree-based Intercropping (TBI). The objective of this study was to determine N2O flux in both a TBI system and a conventional monoculture located at the Guelph Agroforestry Research Station (GARS) in Guelph, Ontario, Canada. The study was a stratified random design, with three pseudo replicates and partially blocked to take into account time series effects on emissions. Gas samples were taken from June 2007 to August 2008 in both a monoculture and TBI system using the chamber method and divided into seasons according to planting and harvesting times. N2O flux was 1.07 kg ha-1 day-1 and 0.75 kg ha-1 day-1 in the monoculture and TBI system, respectively, with no significant difference in emissions between the two systems over all seasons (SE=0.3327, p=0.5281). A correlation between water-filled pore space and residual soil inorganic N with N2O flux did occur in both the monoculture and TBI system from summer 2007 to spring 2008 but not in the summer of 2008. Soil temperature did not correlate with flux across all field seasons in both fields. Although these results indicate that emissions are not statistically significant between the two fields, N2O flux was numerically lower from the TBI system by 0.32 kg ha-1 day-1. This indicates that with further research, a higher number of replicates and number of samples could show TBI systems as a potential practice for limiting N2O emissions from agriculture.

The value of old maps when planning for changing climates

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21. Mitigation and adaptation to climate change

Abstract
Agroforestry can contribute substantially to lifting tropical smallholders out of poverty through diversification of farm practices and products. One of the challenges to leverage agroforestry in promoting sustainable land use is the identification of species that are both useful and well adapted to current and future environmental conditions. Two key questions that need to be addressed are: (i) do we have an adequate understanding of present species and vegetation distribution to predict changes in distribution patterns under changing climates?; and (ii) does our knowledge of tropical woody species’ environmental growth requirements allow us to provide practical recommendations to smallholders practising agroforestry? The selection of woody species requires a good understanding of their adaptability to varying conditions – different provenances may perform differently under different environmental conditions. In temperate zones, with relatively few woody species, substantial knowledge has been gained over many years. For most tropical agroforestry species the answers are that our knowledge is woefully inadequate. Only a tiny fraction of tropical species have been studied and for most we have no or limited information on their environmental requirements. Furthermore, data on environmental variation across landscapes are very coarse compared to that of, for example, European countries. Yet, a largely untapped repository of knowledge is available, which can be used to gain a better understanding of the environmental variation of tropical landscapes and distribution of tropical woody species. In the 1950s to 1980s, botanists mapped the vegetation across Africa, combining information on environmental variation across landscapes and the potential distribution of
many woody species. Judicious interpretation of these maps provides key information for the sustained productivity of agroforestry. This knowledge can be combined with data from remote sensing and other sources on environment and vegetation to provide for stronger tools that research and development agencies can utilize to support African smallholders.
Session 22
Nutrient cycling and biological dinitrogen fixation in agroforestry systems
Effects of green manures and planting materials on maize growth and yield.

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Session: 22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

Abstract

Intensive land-use systems in the western highlands of Cameroon have resulted in the rapid decline in soil fertility and structure. The use of cheap and high-quality fertilizer sources is indispensable for sustainable food production in this area. This experiment was carried out to evaluate the contributions of some green manure sources and different planting materials to the production of maize (Zea mays L). The green manure sources were biomass obtained from inoculated and non-inoculated plants of Leucaena spp., Crotalaria grahamiana and Tithonia diversifolia. A unit plot measuring 40 m² and the selected treatments were arranged in a randomized complete block design with 3 replications. The parameters studied were: relative rate of green leaf production, relative height growth rate, partitioning of dry weight, grain yield, and correlation of grain yield with the dry weights of plant parts. No significant differences were observed between Tithonia diversifolia green manure and the green manure obtained from the leguminous species. Crotalaria green manure produced better results than Leucaena spp. green manure. The performances of the inoculated and non-inoculated Leucaena species were not significantly different. The different types of planting materials (transplanted seedlings and normal seeds) were not significantly different with respect to grain yield.

Keywords: green manure species, planting materials, growth, yield, maize.

Forest landuse and the physico-chemical and biological properties of soils in Mt. Diwata Range, Agusan del Sur, Philippines

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Session: 22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

Abstract

The Diwata range in Agusan del Sur, the subject of various forms of use and resource extraction and threatened by serious and irreversible damage, was studied to assess the state of its soil properties, both physical and biological components. Three specific mountains were sampled: Mt Sambilikan in Prosperidad; Mt. Ararat in Bayugan; and Mt. Berseba also in Bayugan. Samples were collected and brought to the laboratory for physico-chemical analysis. Nematodes and earthworms were also collected and classified, and identified where possible. The soils of the whole study area were strongly acidic (average pH 4.7). The total N was above the critical level of 0.1%, but the available P (0.23 to 0.48 ppm) was below the critical level of 15 ppm (BrayP2). The exchangeable K values were all within the critical value of 0.2 to 0.03 cmolc kg⁻¹ soil. The cation exchange capacity (CEC) values (46.18 to 56.6 cmolc kg⁻¹ soil) were high, while organic matter (OM) content (5.1 to 6.9%) fell within medium to low by NH₄OAc buffered at pH 7. The earthworm population was few with an average of 475 individuals per 1x1x 0.3 m area, and limited to three species only with Ponthoscolex corethrurus dominating the landscape. Nematode population was much lower than those recorded in Mt. Malindang, and where there was human intervention, the population was even lower. Microbial biomass values significantly correlate to the amount of OM matter in the area. Over all, the results showed that the biological community and the physico-chemical properties of the soils were in better condition in the secondary forests than in agroforest areas; O.M. and earthworms, particularly, were the components most affected by resource utilization; and earthworms and OM along with total N are potential indicators of soil degradation.

Key words: Diwata range, agroforestry, secondary forest, earthworms, physico-chemical properties.
Management and earthworm influences on soil organic matter and N dynamics in hill-slope agriculture of western Honduras

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Session  22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

Abstract  
The Quesungual slash-and-mulch agroforestry system of western Honduras has emerged as an alternative to traditional slash-and-burn agriculture in the mountainous, tropical dry forest regions across Central America. The system forgoes burning and utilizes native trees interspersed with annual crops to stabilize hillsides, promote soil biological activity and fertility, improve crop yields, and conserve vital soil moisture. The research presented here sought to elucidate mechanisms behind the system's success by examining the role of agro-ecosystem management and earthworms on soil organic matter and nitrogen fertilizer dynamics. Earthworm populations were manipulated using microcosms (with and without worms) installed within a replicated field trial comparing land management systems (Quesungual versus slash-and-burn versus secondary forest). The Quesungual and slash-and-burn treatments were further divided into sub-plots receiving no inorganic nutrient additions or standard fertilizer applications (N P K), with 15N labelled fertilizer used in the microcosms. At the end of the growing season soils were fractionated by wet-sieving into macroaggregates (>250 µm), microaggregates (53–250 µm), and the silt and clay fraction (<53 µm). Macroaggregates were further separated into coarse particulate organic matter (> 250 µm), microaggregates within macroaggregates (53–250 µm), and macroaggregate-occluded silt and clay (<53 µm). All fractions and bulk soils were analyzed for total C, N and 15N. Preliminary results indicate that soil structure and aggregate-associated SOM dynamics are impacted by cropping, relative to uncultivated secondary forest. However, the form of agricultural management employed (Quesungual versus slash and burn) does not appear to affect aggregation-associated SOM dynamics. Although earthworms do not influence aggregation or SOM dynamics, they significantly decrease the recovery of added fertilizer 15N from the bulk soil and aggregate fractions. Early results from this research suggest that short-term direct impacts of agroforestry systems on soil processes may be less important than indirect effects on soil fauna.

Soil biological properties under different tree-based traditional agroforestry systems in a semi-arid region of Rajasthan, India

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Session  22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

Abstract  
An investigation was carried out in an Entisol at farmers’ fields in Jaipur district, Rajasthan, India during 2002-2004 to evaluate the effect of traditionally grown trees on soil biological characteristics. The traditionally grown trees in farm lands studied consisted of Prosopis cineraria (L.), Dalbergia sissoo (Roxb.) ex DC, Acacia leucophloea (Roxb.) and Acacia nilotica (L.) Del., having a canopy diameter of 8 m. Results revealed significant and substantial improvement in soil biological activity in terms of microbial biomass C, N and P, dehydrogenase and alkaline phosphatase activity under different tree-based agroforestry systems as compared to a no-tree control (cropping alone). Soil microbial biomass C, N and P under agroforestry varied between 261.7–320.1, 32.1–42.4 and 11.6–15.6 µg g⁻¹ soil, respectively with corresponding microbial biomass C, N and P of 143.2, 19.8 and 6.4 µg g⁻¹ soil under the no-tree control. Microbial biomass turnover rates were slow in agroforestry systems indicating high C substrate availability under these systems. Fluxes of C, N and P through microbial biomass were also significantly higher in the P. cineraria-based land-use
system followed by *D. sissoo*, *A. leucophloea* and *Acacia nilotica* in comparison to the no-tree control. Thus, it is concluded that agroforestry systems on farmers’ fields enhance soil biological activity, and amongst trees, the *P. cineraria*-based system brought maximum and significant improvement in soil biological activity.

**Key words:** Agroforestry, microbial biomass, microbial flux, microbial turnover, soil enzyme

**Use of *Gliricidia Sepium* litter injected with labelled 15N fertilizer and subsequent recovery by Zea mays**

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**Session:** 22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

**Abstract**

This study was initiated to assess and quantify nitrogen dynamics in a *Gliricidia* maize alley-cropping system with the injection of labelled 15N fertilizer to *gliricidia* trees and subsequent cropping with maize. The experiment was conducted at the University of Peradeniya, Sri Lanka. Three-year-old isolated *Gliricidia* trees were injected with 98% 15N-enriched ammonium sulphate (1.415 g/tree) and harvested four weeks after injection. Harvested above-ground *Gliricidia* residues were applied to three equal compartmentalized sections around each isolated tree (2 m radius) to form three treatments. They are: T1 15N labelled above-ground *Gliricidia* residue added + 15N labelled *Gliricidia* roots remained in the respective soil compartment (roots were not removed); T2 a similar amount of N non-labelled above-ground *Gliricidia* residues added (as in T1) + 15N labelled roots remained; and T3 non-labelled *Gliricidia* residues added + 15N labeled *Gliricidia* roots removed.

Four weeks after incorporation of *Gliricidia* residues to respective plots, a maize crop was planted. Nitrogen cycling and corn growth and yield were recorded. The distribution of 15N among different plant parts of *gliricidia* after four weeks of injection indicated a greater recovery of injected 15N. Approximately 71%, 15% and 1.72% were recovered from the stems, leaves and roots. From the 15N injected (294.49 mg per tree), the percentage of overall 15N recovery was around 87% by the *gliricidia* trees. Recoveries of 15N by the subsequent maize crop were around 13%. Of this quantum, approximately 10% of N was recovered from leaves and stems of *Gliricidia* residues, while around 2% was recovered from root residue of *Gliricidia*. The injection of tracer N provides a relatively easy ways to determine the transfer of 15N into trees and it promises to be an effective way to evaluate N transformation and cycling in mixed-cropping systems.

**Biological dinitrogen fixation: an underestimated resource in agroforestry systems?**

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**Session:** 22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

**Abstract**

Biological dinitrogen fixation (BDF) in agroforestry systems (AFS) was enthusiastically studied in the 1970s and 1980s but it almost disappeared from the research agenda in the 1990s because of studies suggesting little benefit from BDF to AFS nitrogen balance. Recent research based on N isotopic relations in whole plants indicates that BDF has been underestimated as a N source for AFS. We present 2 conceptual models on BDF in AFS: one on the N flows in the symbiotic plant-rhizobia system and the other on the fate of N fixed from the atmosphere in the N cycle of an AFS. We used this modelling framework for synthesizing published data on BDF in AFS. Causes for underestimation of BDF include
ignoring below-ground plant organs and short-term experiments. Surprisingly often, the N2-fixers are subjected to management that impedes BDF. Careful species selection for each AFS is needed. Plants forming N2-fixing symbioses require a lot of N, and a favourable C:N ratio should be maintained under agroforestry management. Symbiotic N2-fixing bacteria belong to 12 proteobacterial genera (legumes) and 15 actinobacterial species (actinorrhizal plants) with varying host specificity. These bacteria show great genomic and physiological diversity suggesting need for in-depth studies on host bacteria interaction and selection. Crop use of N2-fixer’s root exudates and connections to common mycorrhizal networks are probably more common than assumed. This may form a direct N transfer pathway, which is not considered in studies on N recycling via soil microbial processes. Free-living diazotrophs and associative N2-fixing bacteria add N to soil in yet unquantified rates. Estimates on symbiotic N2 fixation rates based on whole plant N isotopic relations, excluding extremes, range from 70 340 kg/ha/a, and estimates based on whole AFS N balance, including both symbiotic and free-living N2-fixers, indicate rates up to 550 kg/ha/a.

Nitrogen complementarity in timber-based hedgerow intercropping systems on an acid upland soil

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Abstract: Complementarity in agroforestry systems is when trees take up water and nutrients which would not be available to the associated annual food crops. Hedgerow systems of Acacia mangium (N2-fixing) and Gmelina arborea (non-N2-fixing) were studied to determine from which soil profiles these trees take up N relative to the maize crop, and to assess their N contribution. (15NH4)2SO4 (40 atom %) was injected at 20 and 100 cm depths using a ceramic porous cup in order to assess 15N uptake by trees and crop. This study was conducted at Claveria, Philippines. Nitrogen recycled in tree systems was substantially higher than in the conventional maize monocrop system, through pruning of lateral branches and N uptake from the safety-net zone. An A. mangium system provided two times more N recycling through prunings compared to the equally fast growing G. arborea. A. mangium derived 42% of its N from atmospheric N2 fixation and 52% from the safety-net zone (>100 cm depth). This counterbalanced the mineral N uptake by A. mangium from the upper soil depths, leading to higher maize yields and a positive system N balance. A. mangium had more fine roots at even at lower depths, which provided better opportunities for safety-net and nutrient pumping functions than G. arborea. The maize in the A. mangium system benefited with 28% of its N uptake through the transfer of fixed N2, e.g., through the application of lateral branch prunings and root turnover, as indicated by the 15N natural abundance method. A. mangium was less competitive with maize than G. arborea, and was thus more appropriate as a hedgerow species. A timber hedgerow system is a better farming option than the conventional maize system due to the N uptake by trees from lower soil depths regardless of species being used.

Role of arbuscular mycorrhizal fungi in agroforestry systems

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Session: 22. Nutrient cycling and biological dinitrogen fixation in agroforestry systems

Abstract: The role of arbuscular mycorrhizal (AM) fungi in enhancing plant growth is well documented, but little is known about their interactions with agroforestry systems. Studies are being carried out in this regard at NRCAF, Jhansi, India. The results obtained so far showed the presence of AM fungi in 19 forestry trees, 7 horticultural trees, 10 field crops and 8 fodder
crops. The colonization index varied from 20% to 96%. Local soils were found to be rich in AM spore populations. Glomus was the predominant genus, apart from this Acaulospora, Gigaspora and Sclerocystis were also present. Inoculation of trees seedlings (Acacia nilotica, Pongamia pinnata, Jatropha curcas, Eucalyptus tereticornis, Albizia procera, Dalbergia sissoo, Leucaena leucocephala, Emblica officinalis, Zizyphus mauritiana, Buchanania lanzan and Cordia dichotoma) and intercrops (Phaseolus mungo, Vigna radiata, Cicer arietinum, Zea mays, Triticum aestivum and Pisum sativum) with suitable AM species recorded a substantial increase in plant growth and phosphorus uptake. This resulted in a benefit comparable to high input levels of phosphorus in P. mungo, T. aestivum, E. tereticornis and A. procera at much lower concentrations. In agroforestry systems, trees acted as a AM-inoculum reservoir for intercrops. A cross-inoculation test, performed by using AM fungi isolated from trees, showed that these could colonize the roots of important rainy season and winter intercrops. Intercropping increased AM activity in the tree-rhizosphere. Tree shade reduced mycorrhization of intercrops, especially during winter months. *Arbuscular mycorrhizal* inoculations enhanced the growth and P uptake of intercrops in shade. Tree pruning increased this advantage, but reduced their (tree) AM colonization. Excessive shading (25% of full sun or more) in nurseries reduced mycorrhization of tree seedlings. The activity of AM was greater in light soils as compared to heavy soils. Stagnation of water in plantations during the rainy season was found to be harmful for colonization of plants. Glomus was more adapted to such conditions.
Session 23
Agroforestry and reconciliation ecology
A field assessment of the actual final land equivalent ratio of a temperate agroforestry system

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Abstract: The land equivalent ratio (LER) of an agroforestry system (AFS) is a measure of the advantage of mixing species for production. LERs of annual crop mixtures are easy to measure, as each growing season provides an estimate. LERs of perennial AFS are more difficult to measure or predict. The long-term growth of the tree component must be measured, and the productivity of the intercrops must be monitored for a long time, until crop production is no longer profitable. Several pitfalls of LER calculation must also be avoided, and require data for sole crop and sole tree plots that are very often missing in many experimental designs. This explains why almost no measured LERs of AFS have been published to date. We monitored a poplar-cereal AFS from tree plantation in 1996 until tree harvest in 2008 in southern France. This allowed us to measure the actual value of the final LER of the system. This is probably the first field measurement of an agroforestry LER in Europe and in the temperate zone. Four systems were monitored, differing by tree row orientation and poplar clones. The average LER is very high compared to previously published estimates of LERs in temperate AFS. Using simulation models of the system, we tried to separate the impacts of various factors in explaining such high productivities of tree-crop mixtures. Three factors appear to be essential: phenology lags between tree and crop components, plasticity of the root systems of the tree component in response to the competition by the crop component, and the availability of a deep resource of water that is within reach of the trees’ rooting system. Such productivity data are at odds with many predictions of the value of temperate AFS, and could be a stimulus for the adoption of AFS throughout Europe.

Agroforestry systems variability in the complex–W, the lands bordering in Benin

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Abstract: This study was conducted on the agroforestry systems in the lands bordering the complex-W in order to make a structural and functional typology. It was carried out following east west transects. Six sites were sampled in order to study the structure of the different types of parklands after observing their physignomy. The parklands’ structure was studied based on 58 plots of 2500 m²: 41 plots on the agroforestry systems and 17 plots on the savannahs. Eighty farmers were interviewed through ethnobotanical surveys using a questionnaire. The objectives of this study were firstly to highlight the relationship between different agroforestry systems and peoples who manage them, and secondly to evaluate the possibilities for improving traditional agroforestry systems. Two main types of agroforestry were identified. There are homegardens and agroforestry parks. The density of native trees in parklands was about 38 trees/ha on average and varied significantly between agroforestry systems. For exotic species, both agroforestry systems also show significantly different densities. The average population density is higher in homegardens than in agroforestry parks. For management of these agrosystems, development of agropastoralism, improved fallows and multifunctional management of parklands are proposed.

Keywords: agroforestry system, complex, hunting area, native species, exotic species.
Avifaunal diversity studies in coffee plantations with different shade management in Kodagu, Western Ghats, India

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Abstract
The present study was carried out from December, 2007 to May 2008 in the coffee plantations in Cauvery watershed area, from Bhagamandala to Kushalnagar in the Kodagu district of Karnataka. This study was undertaken to: 1) estimate the relationships between bird species diversity and changes in shade-tree cover, particularly the replacement of native trees by Grevillea robusta in coffee plantations; 2) determine and compare the similarity in bird species composition in different vegetation types of the district, namely semi-evergreen and moist deciduous; 3) study the community structure and organisation of bird species based on their food and feeding habits; and 4) to prepare a checklist of birds of the Cauvery watershed area. Using line transects, a total of 109 species of birds were recorded from the study area. The Shannon-Weiner diversity index indicated the highest bird diversity was in coffee plantations with native trees. Furthermore, abundant availability of varied food resources was reflected by the presence of a higher number of food and foraging guilds in the coffee plantations with native trees and species richness. On the other hand, the diversity of birds was negatively related to the proportion of G. robusta. The diversity of birds in both semi-evergreen and moist deciduous vegetations increased with increases in tree diversity. The bird diversity inventory revealed a strong negative relationship between bird diversity and very high canopy cover. Consequently, this study indicates that coffee plantations with native tree cover in Kodagu have the potential for protecting bird diversity, predominantly because of the high proportion of native tree-cover, that provide a matrix which does not inhibit movement of birds.

Conservation of functional diversity in temperate and tropical agricultural landscapes: patterns and mechanisms at farm and landscape levels

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Session
23. Agroforestry and reconciliation ecology

Abstract
The capacity of countryside landscapes to contribute to biodiversity conservation is becoming increasingly important. Though it is clear that extensive diversity is supported by such landscapes, we are only just starting to understand how the ecology of these communities differs from those they replace. Here we present three studies that explored the contribution and loss of functional diversity to ecosystem services and discuss the role that agroforests can play in protecting functional diversity (FD). In the first study we analysed changes in species richness and functional diversity at varying agricultural land-use intensity levels where agroforestry systems represent intermediate intensities. We found that in over 25% of the bird, mammal and plant communities influenced by agriculture, declines in FD were steeper than predicted by species richness. The study demonstrates that land use intensification reduced functional diversity of communities beyond changes in species richness alone, potentially imperilling provisioning of ecosystem services. In the second study we examined functional classifications of bird communities that provide pest control functions in coffee agroforests. The biological simplification of agroforests decreases the avian pest-removal function by reducing bird taxonomic and functional diversity. Functional richness positively correlated with arthropod removal, indicating that species complementarity may be an important mechanism behind this function. However, no functional classification predicted arthropod removal better than simple species richness and individual species, or functional groups may be better predictors of function than functional richness. In the third study we
studied the effect of landscape context on conservation of functional diversity and the role of agroforests in conserving this functional diversity at landscape scales. Our results indicate that the diversity of dispersal modes represented in forest fragments is negatively related to percent of pasture in the landscape and positively related to percent forest in the landscape with particular loss of forest obligate species.

Designing agroforestry models for diversification of cotton agro-ecosystems and their impact on its sucking insect pest complex

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Abstract
Indiscriminate use of insecticides in cotton has lead to the destruction of natural control systems. Monoculture and the absence of multi-functional cropping systems have compounded the problem. Hence an attempt was made to design agroforestry models for cotton agro-ecosystems and to study their impact on a sucking insect complex at Hyderabad (17°20'N and 78°30'E). In these models intercrop cotton was raised in combination with Annona squamosa, Azadirachta indica, Dendrocalamus strictus, Emblica officinalis, and Eucalyptus tereticornis under rainfed conditions. Cotton sole crop was the control. Data were recorded in three consecutive rainy seasons during 2005 08 on aphids, Aphis gossypii G; thrips, Scirtothrips dorsalis Hood, jassids, Amrasca biguttula biguttula Ishida and predators, Cheilomenes sexmaculata (Fabricius) and spider complex. The impact of agroforestry combinations on A. gossypii incidence was insignificant. However, during 2005 06 and 2006 07 in A. indica+cotton and A. squamosa+cotton (24.4 and 9.3) aphid incidence was lower compared to control (33.2 and 13.5). Incidence of S. dorsalis was lower in A. indica+cotton (2.3) and D. strictus+cotton (2.3) in 2005 06, A. squamosa+cotton (7.6) in 2006 07 and D. strictus+cotton (8.2) in 2007 08 compared to the control (3.3, 18.7 and 30.9). The population of A. biguttula was consistently higher in the control compared to agroforestry combinations. In D. strictus + cotton a significantly lower jassid population was recorded in all three years (1.9, 0.7, and 1.1) compared to the control (4.6, 3.6 and 5.8). The C. sexmaculata population was higher in E. officinalis+cotton in all three years (2.3, 2.7 and 2.3) compared to the control (1.2, 1.1 and 1.8), though significantly higher only in year 2006 07. In A. squamosa+cotton (1.8 and 2.6) the population of spider complex was higher compared to the cotton sole crop (0.7 and 0.7) in years 2006 07 and 2007 08. These findings suggest diversification of a cotton agroecosystem will be effective in ecological insect pest management and in evolving sustainable cropping systems.

Effects of tree composition on epiphytes in coffee agroforestry systems of Kodagu, India

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Abstract
Apart from protected areas, agro-ecosystems are the most important locations for conservation of tropical biodiversity in human-dominated landscapes. Agroforestry as an integrated management of shade trees along with agricultural crops has emerged as one of the most promising land use types for biodiversity conservation while enhancing rural livelihoods. Kodagu is the smallest district in the state of Karnataka, southern India, with 29% of total geographical areas under coffee farming, and it produces about 1/3 of the Indian production. In this region, the coffee landscapes are considered to have very rich
biodiversity, and hence conservation significance, due to the complex structure and floristic diversity of the coffee multi-strata agroforestry systems. Epiphytes are one component of floristic diversity which affects the value of a plantation. In this study, we examined the effects of tree composition on epiphytes by considering different variables such as canopy cover, tree diversity, tree girth class, and host specificity under two vegetation types, namely evergreen and moist deciduous. Quantitative analyses were done to evaluate the effects of these variables on abundance of epiphytic species. The proportion of epiphytic species significantly increased up to a certain threshold of canopy cover (75%) and girth of host trees (0.30–0.81 m) and gradually declined as percentage of canopy cover and girth further increased. No significant difference between the two vegetation types was registered. Epiphytic species increased significantly with an increase in the density of individual host trees. Even though true host specificity is very rare, nonetheless epiphyte species preferred certain host tree species in each vegetation type. Thus, these results indicate that sustained management of coffee plantations helps to conserve biodiversity by acting as refuge for many epiphyte species.

How do termitaria contribute to plant species conservation in Pendjari Biosphere Reserve in Benin?

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Abstract The role of termitaria in plant species conservation was investigated in Pendjari National Park and surroundings (fields and fallows). The study objectives were to: i) compare termitaria vegetation in terms of similarity, life form and chorological composition between areas; ii) test the difference of species richness and diversity on termitaria first among areas, then living versus abandoned termitaria; and iii) predict the species richness and diversity of termitaria using their size. Plots of 0.25 ha were laid out to count termitaria and assess their life status. Around each mound, a plot of 0.09 ha was established to inventory ligneous species. For each of the 84 termitaria surveyed, we measured the height and four radii for surface calculation. All plant species on termitaria were identified and individuals counted for the ligneous species. Results show that Combretaceae species were the most abundant on termitaria and Capparaceae species were the most restricted to them. Plant communities on termitaria were different among the investigated areas and between living and abandoned termitaria. Phanerophytes were, overall, abundant on mounds, therophytes abundant on termitaria within the park and fields but co-abundant with hemicryptophytes in fallows. Sudanian species were the most abundant on termitaria reflecting the influence of climate on vegetation. The management area did not influence termitaria ligneous species richness and diversity, nor did termitaria state. No significant correlation was noticed between termitaria height and the species richness and diversity, contrary to the positive correlation with their surface.

Soil quality in cacao (Theobroma cacao), banana (Musa AAA) and plantain (Musa AAB) plantations in Talamanca valley, Costa Rica

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Abstract Soil quality was compared in agroforestry systems of cacao-laurel (Cordia alliodora) (CL) and banana-laurel (BL), monoculture cacao (MC), conventional monoculture plantain
(CMP) and fallow (FA) (control). More than 50 physical, chemical and biological soil quality indicators were measured in the dry and rainy seasons. Univariate and multivariate analyses of variance were performed and an additive soil quality index (ASQI) was calculated. According with the ASQI, the FA has the best soil quality and the CMP is similar (statistically) to the agroforestry systems (CL and BL) and MC thanks to the synthetic fertilization. The CMP presented the major content of P, K, Ca and Mg and better pH, however, an evident imbalance was noted in the microbial activity (microbial respiration, metabolic quotient, C mineralization index, catalase activity); it can be deduced that the application of synthetic fertilizers and pesticides in CMP are hazardous to the microbial biomass and this leads to ‘micro-organism stress’. Whereas, in FA, CL, BL and MC the microbial activity was stable; this indicates better conditions for the soil biology. According to the analyses, CL was the most similar to FA; these two systems are considered to have the best soil quality with regard to: major content of litter, C in aggregates and in organic matter fractions, and N; the lowest bulk density and largest percentage of 2-8 mm aggregates; and major microbial biomass, micro-organisms (micoparasites, actinomycetes, fungi) populations and earthworms. These results confirm that cacao agroforestry systems maintain a large content of organic matter, store fair amounts of C in its soil aggregates, protect soil against erosion and favour the soil biology; all of this turns these types of agroforestry systems into an appropriate option for future global land use.

*Keywords: agroforestry, fertility, organic matter, micro-organisms, microbial activity.*
Session 24
Integrating disciplines through agroforestry education
Case study approach to curriculum and teaching materials development in agroforestry education in Southeast Asia

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Session  24. Integrating disciplines through agroforestry education

Abstract
Developing region-wide curriculum frameworks and teaching materials using the case study approach is feasible. This is exemplified by the projects of the Southeast Asian Network for Agroforestry Education (SEANAFE), namely: ‘marketing of agroforestry tree products (MAFTP)’ and ‘agroforestry landscape analysis (AFLA).’ The approach also developed capacity for participatory curriculum development, experiential and peer-based learning among teachers in the region, and enhanced collaboration among SEANAFE member institutions. However, some refinements are necessary to make the process more effective and efficient considering the long duration and the relatively high cost of producing project outputs. Launched in 2004, the goal of these projects is to enhance the content of agroforestry education programmes, the teaching capacity of lecturers, and the quality of graduates among SEANAFE’s 86 member institutions in Indonesia, Laos, Philippines, Thailand, and Viet Nam. Multi-disciplinary teams of lecturers carried out the following activities over a two-year period: (a) regional training to level off the current state of knowledge on the two topics; (b) conducting national case studies; (c) a regional workshop to formulate curricular framework and teaching materials based on the results of the case studies; (d) translation of project outputs into local languages; (e) conduct in-country training for 100 lecturers on using the curriculum framework and case studies; and (f) mainstreaming of the project outputs. This paper shares the processes used and lessons learned by SEANAFE from both projects.

Keywords: case study approach, curriculum development, teaching materials development, agroforestry education, Southeast Asia, marketing, landscape analysis

Encouraging students’ competencies in agroforestry entrepreneurship

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Abstract
Recognizing the role of entrepreneurship in the promotion of agroforestry education in Mindanao, Philippines, the Misamis Oriental State College of Agriculture and Technology (MOSCAT) applied for funding support from the Department of Science and Technology (DOST). In April 2003, the Technology Application and Promotion Institute (TAPI) agreed to fund five agricultural production projects amounting to Php 417 000 (USD10 171). The Small Enterprise Technology Upgrading Program and DOST-Academe Technology-Based Enterprise Development (SETUP-DATBED) programmes aimed to provide credit assistance to students graduating from the Bachelor of Agroforestry Technology (BAFT) degree, and train them to engage in entrepreneurial activities. There were already 65 BAFT students who benefited from the SETUP-DATBED funding support from April 2003 to December 2006 amounting to between Php 5900 (USD 144) and Php 53 700 (USD 1310) for the implementation of different agricultural enterprises. Forty-four (65%) of them had already graduated. Through experiential learning, the students proved their capabilities as innovative farmer-entrepreneurs. They applied their technical skills in agricultural crop production and livestock raising on the farm, and at the same time learned how to handle large-scale agricultural crop production. They were able to develop a high sense of responsibility and ownership for the project. The two programmes strengthened the accreditation, linkages and extension programmes of MOSCAT, especially with DOST and the Accrediting Agency of Chartered Colleges and Universities in the Philippines (AACCUP). The BAFT students were
able to apply what they have learned, and showcase their entrepreneurial competencies. More importantly, the two programmes demonstrated the success of MOSCAT’s BAFT curriculum and proved that entrepreneurship is a relevant skill needed to successfully implement agroforestry farms and projects.

Enhancing integrated approaches in agricultural learning systems

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Abstract
Small-scale farmers integrate biophysical factors with social, economic, cultural and environmental considerations in their day-to-day decisions to maintain complex agroforestry systems. This approach contrasts sharply with the traditional organization of knowledge and institutional structures at universities, where reductionist approaches prevail. Teaching and quality assurance in education systems also use reductionism, leading to graduates with insufficient competence in the analysis of complex systems. Here lies the incongruity between learning systems and the actual needs of farmers. Three decades of Agroforestry research has thrown some light on tools and methods for understanding integrated systems. The landscape analysis framework used by the Alternatives to Slash-and-Burn initiative, approaches in participatory domestication of tropical fruits in Africa, and modeling tools such as WANULCAS that analyse water, nutrients and light capture, enable us to generate future scenarios in integrated land-use systems. New agroforestry education programmes in the tropics are putting such tools to use in learning systems. But in spite of this progress, there are constraints to their mainstreaming, resistance to the integration of ‘soft’ sciences and turf games at universities. On the policy side, graduates of integrated programmes have difficulties finding jobs because current institutional frameworks favour segregation of disciplines. The rising demand for environmental products and services will lead to complex landscape mosaics, shaped by farmers through agroforestry. The adaptation and mitigation of climate change effects require a holistic approach and collaboration across disciplines. We suggest that universities need to pay increased attention to understanding integrated systems. Economic realities are now forcing academic institutions to merge departments and programmes. This provides opportunities for integrated teaching and learning approaches. Our experiences in Africa and South-East Asia show that agroforestry education is contributing to a better understanding of approaches to integrated learning. This is a new innovation is preparing future graduates who have the competence to understand and advise farmers on integrated production systems.

Implementing peri-urban agroforestry in South Africa: a case study of how upscaling agroforestry impacts on policy and curricula

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Abstract
The eThekwini Rural Based Area Management Programme (RBAMP) plans and implements developments in the rural margins of the Durban Metropole. Due to the juxtaposition of urban and semi-rural locations, one of these initiatives is a peri-urban agroforestry development. This project has become a fusion of commercial forestry, horticulture, agronomy, economics, national policies and local planning imperatives. In 2005, the eThekwini RBAMP undertook a feasibility study of community woodlots in the surrounding Metropole. After subsequent literature searches, interviews and data collection, fruit trees were included in the project and the scope enlarged from community forestry to become a peri-urban agroforestry
Opportunities and challenges of mainstreaming climate change into agriculture and natural resource education in Africa

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Abstract:
Climate change is one of the most significant global challenges of our time, and addressing it requires the urgent formulation of comprehensive and effective education policies. To date, most of the international attention directed toward combating climate change has been strikingly insufficient and has focused primarily on the industrial and energy sectors. A changing climate affects nearly every sector of the world’s economy and is intricately intertwined with other major environmental threats such as population growth, desertification and land degradation, air and water pollution, loss of biodiversity, and deforestation. Africa is generally acknowledged to be the continent most vulnerable to the adverse impacts of climate change, and where adaptation is most imperative. Yet capacity building in climate change is still in its infancy in Africa. Climate change affects the poor the most and is an impediment to the achievement of sustainable development. Weak human capital and limited access to information has been consistently noted as an impediment to building the much-needed adaptive capacity in Africa. While there has been a flurry of research activities on climate change in Africa, their results are not reaching potential beneficiaries – policy makers and vulnerable communities. African tertiary agricultural education institutions are still lagging behind in developing climate change adaptation and mitigation programmes as discussed during the 2008 symposium of the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE). This paper reports on the opportunities and challenges that exist in the continent to mainstream climate change into agriculture and natural resource education.

The PIIP project innovation system approach for reinforcing AF research at the University of Niamey in Niger.

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Abstract:
From 2003 to 2006, the Faculty of Agriculture of the University Abdou Moumouni of Niamey, Niger, in collaboration with its partners from Belgium (the Catholic University of Louvain, University of Liege, the Gembloux Agricultural University and the International NGO ENDA Inter-Monde), used the innovation system approach of the agroforestry project...
PIIP (Project for Farmers’ Initiatives and Innovations) of Aguie in Niger, in which farmers play a central role in incorporating local knowledge into tertiary agricultural learning. This was a farmer-centered multi-actor system approach in which farmers, researchers, academics and the project agents worked side by side as equals. Over 25 students conducted their BSc, MSc and PhD research in Aguie under the supervision of project staff and academics. The research topics, which responded to problems identified by farmers, were mainly on agroforestry but social science and natural resources management subjects were also included. Based on these research theses, a field research methodology guide was developed with the involvement of all partners under the guidance of the International NGO ENDA Inter-Monde. The research methodology guide aims at helping the students to transform their research theses into a tool to support change at both their own level and at the community level. The interaction between the researcher/student, the local communities and the other partners is therefore of paramount importance. The use of the guide will strengthen action research at the university level especially in the field of agroforestry and natural resources management.

Keywords: agroforestry education, innovation, piip, multi-actors approach, Aguie, Niger

A public planning decision-support software in agroforestry: the farm-SAFE evolution

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Session 24. E-learning and distance education in agroforestry
Abstract
A computer-based economic model of arable, forestry and silvo-arable systems has been developed as part of the ‘Silvoarable Agroforestry for Europe’ project. The process of developing the model Farm-SAFE is described in terms of: the model background and purpose, the systems modelled, the objective of the economic analysis, the viewpoint of the analysis, the spatial and temporal scales, the generation and use of biophysical data using LER approach, and the inputs and outputs. The objectives of the economic analysis are to compare silvo-arable, arable and forestry systems at a one-hectare/plot scale, and to determine the feasibility of silvo-arable systems at a farm scale. But the main problem of this model was that it was running on a spreadsheet. The lack of user-friendliness or public interface and the difficulty of testing several scenarios (memory space, saving scenarios and data management) was preventing its future use for common users, farmers or technicians. During the last 2 years, the process of development was initiated in France inside the “National Development Program – Agroforestry 2006/08”. The main decision was to propose a free version, accessible to any users connected to the web (pHp language). A first free version of Farm-SAFE is now available (in French), constituting the first free and evolutionary software with the objective of being a planning decision-support system in agroforestry. From this software, a new program will be planned with different partners (agronomics high schools) to develop some virtual education programmes in agroforestry.

Introducing agroforestry higher education programs in Iran

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Session 24. E-learning and distance education in agroforestry
Abstract Iran has about 13 million ha of forest located in arid and semi-arid regions. In most parts of these forests, some agricultural systems are observed. In fact, from ancient times human beings in forest areas have used some agricultural systems in natural forests. According to law, activities such as agronomy, husbandry etc., in forest areas are forbidden. For this reason
up to 1995 no agricultural systems were permitted in forests, but the government couldn't prevent people from using the forest for agricultural activities. Some specialists at university research institutions and the Department of Natural Resources at the Institute of Scientific and Applied Higher Education of Jihad-e Agriculture decided to prepare agroforestry courses at technician and Bachelor of Science levels. Approximately 305 students were trained at the technician level and 56 students at the Bachelor of Science level. In these courses students study agriculture, forestry and agroforestry systems. Students were accepted from 4 higher education centres in 5 provinces. These courses were planned in technical and vocational systems, which attempted to consider the type of jobs in which students were employed. The graduates are employed in forestry departments, environment departments and the private sector. This paper explains the way in which the problem was distinguished, the method of programming of courses and the soft and hardware used in the operation of these courses are.
Session 25
Policy formulation and stakeholder engagement in natural resource management
Adaptive management of leasehold forestry in shifting cultivation areas in Nepal

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Abstract
For many indigenous people in Nepal, shifting cultivation is a major source of livelihood and a long-established traditional occupation. Shifting cultivators are among the most marginalized people in the country, partly because of policies that are insensitive to their rights and needs. This problem gained attention after Nepal ratified ILO Convention No. 169 on Indigenous and Tribal Peoples in August 2007, which protects indigenous peoples’ right to practise shifting cultivation as their traditional occupation. Policies on land, forestry, and nature conservation have drastically diminished shifting cultivators’ tenure of and access to the land and natural resources traditionally used or occupied by them. For example, the leasehold forestry programme is broadly successful for poverty alleviation, but counterproductive in shifting cultivation areas where farmers use their traditional lands but have no ownership certificate. The government has started leasing these lands to them for forestry and fodder production, but using them for annual crops is no longer allowed. This has affected people’s food security, and some farmers have even been punished for growing crops on what was always their land. The policy research initiative of ICIMOD and LIBIRD aims to make the leasehold forestry programme more responsive to shifting cultivators’ needs by involving farmers and decision makers in local-level experiments. In the case presented here, farmers developed homegardens and hedgerows as means to combine food production with forest management objectives. These options are found to be more attractive and achievable for shifting cultivators than the leasehold forestry as currently promoted, and might make decision makers more lenient towards food crops in leasehold forests. The paper will present a more in-depth evaluation of these land-use options, as is required for better-informed policy decision making.

Agroforestry research for curriculum development and national policy intervention for resource development and livelihood in northeast Thailand

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Abstract
Agroforestry is an integral strategy to maintain and develop poor and fragile resource endowment of sandy soils and erratic rainfall in the northeast of Thailand. Ironically, previous development programmes for 50 years have sequentially degraded resilient characteristic of natural supportive vegetation, and have resulted in currently bare, monocrop production systems. As a result, watersheds, water resources, soil resources and land productivity have been severely degraded to only 20-30% of newly open or slightly disturbed forest. In order to revitalize land productivity and resources, multipurpose trees must be re-introduced or integrated into current production systems. Around 20 years ago, a large number of leading farmers attempted to grow multipurpose trees for their agricultural activities for demonstration of vital and realistic agroforestry systems. The sites have, eventually, been used for researching paired-site techniques evaluating soil and productivity improvement. The result suggested that some agroforestry practices over a period of 5-7 years could rehabilitate soil and agricultural productivity to approximately slightly disturbed forest conditions. The findings and lessons learned have been integrated into national policy for community and resources development as ‘trees for loan payment’ aimed at paying back to
land (fertility) and (money) lenders commencing in 2006. Since then, the Thai government has given continual support through communities and Local Wisdom Network leaders. Until now the programme has also been supported by the national Health Promotion Institute, via ‘trees for health and livelihood’ since 2008. The success of the local practices, community research and policy intervention are a good example of integrated rural development using agroforestry as a key development option. The lessons learned on research and development have been used for teaching and curriculum development for agroforestry education at Khon Kaen University and expanding the agroforestry education networks.

Agroforestry transformation in Indonesia: characterization, constraints, opportunities

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract As a country Indonesia has a wide geographical coverage that varies in terms of ecological zones and socioeconomic and policy conditions. Whilst agroforestry systems have been playing significant roles in livelihoods of people for hundreds of years all over the country and were more recently shown to play key roles in providing environmental services, they are marginally understood within mainstream environmental academia, hardly acknowledged in poverty reduction discussion, and not formally recognized within political spheres. One reason for this is the lack of hard data, empirical definitions and understanding of the extent, landscape processes and the drivers of forest and agroforestry transformation change over time. The drivers of change interact with constraints and opportunities for local communities to base sustainable livelihoods on trees. Data and knowledge about tree cover inside and outside ‘forest’ and agroforestry transformations exist for dispersed landscapes in Indonesia but they have not been systematically presented and synthesized. This work is based on our previous district, provincial, island and watershed-level work in Java, Sumatra, Kalimantan and Sulawesi over the study period of 1990 to 2005, and it will be nested within the national-level analysis conducted using the best available secondary data. Time series of satellite imageries, other spatial data and also socioeconomic data will be the major source of data. Major constraints and opportunities within different types of agroforestry transformation in achieving sustainable livelihoods will be identified. Policy implications for land allocation and compensation/rewards for environmental services, particularly in relation to REDD, will be discussed.

Assessment of co-management and agroforestry in Barobbob Watershed, Philippines

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract This paper highlights the key results of an assessment of co-management and agroforestry in Barobbob Watershed using the LIFE framework (CIFOR, 2007). Co-management spurred the transformation of shifting cultivation in the watershed to more conservative practices such as composting, fallowing and agroforestry. Timber poaching has been substantially reduced with the stricter enforcement of regulations and partly because of the shift from timber poaching to agroforestry as source of livelihood for many community members. The average annual income before and after the co-management agreement, values appeared to have
significantly increased from P 89 000 to P 95 000. However about 1 out of two community members believe that their income increased while the rest believe that their income is the same as before. The variation in the perceived impact of co-management on their income could be indicative of the prevailing inequity in the access to opportunities for increased income generation. In addition, it could be said that the apparent increase in income did not result from the perceived increase in the purchasing power of the farmers. Deforestation decreased from 70% to 10% after the implementation of co-management. Forest cover also increased due to reforestation and agroforestry development. The frequency of fire occurrence in grassland areas and forests in the watershed was noted to have declined. The co-management was perceived to have brought fairness in the use of forest resources, more even participation in the decision-making processes and implementation of community forestry activities, relatively fair distribution of costs and responsibilities among the members, and little improvement on the fair access to leadership roles. There were those who believe that the community leaders, the more educated and more affluent members of the community continue to hold an advantage in access to opportunities and participation in decision making processes.

By-laws and community participation in natural resource management in the highlands of East Africa

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract
The poor enforcement of natural resource management (NRM)-related by-laws is a major setback in achieving sustainable natural resource management in the highlands of East Africa. The result is declining agro-ecosystem productivity and environmental health as evidenced by declining food security and rural incomes, and increasing health hazards related to environmental pollution. In this paper the formulation, implementation and enforcement of agro-based natural resources by-laws were studied in three East African countries (Uganda, Tanzania and Ethiopia) to establish major reasons for the poor performance of these by-laws and identify opportunities to enhance their effectiveness. The study is based on the hypothesis that successful NRM is strongly dependent on the presence of active by-laws at the community level and strong support by relevant district level institutions of governance in their enforcement. Secondary data, key informant interviews and a series of workshops involving different stakeholders were conducted to understand the process of NRM by-law formulation, factors affecting their implementation and how they are enforced. Results show that inadequate participation of farmers and civil society organizations in by-laws formulation, implementation and enforcement, lack of pro-poor NRM policies, poor links between different departments at district level, little awareness on the part of the local communities on processes of by-law enforcement, and outdated by-laws, are some of the major reasons for poor natural resource management in the East African highlands. Where awareness of the processes of by-law enforcement was raised and collaboration between policy makers and law enforcers enhanced, cases of abuse of natural resources went down by as much as 67%. The paper proposes some strategies for enhancing the effectiveness of NRM bylaws in the region for improved agro-ecosystem productivity and rural livelihoods.
Determinants of success of social forestry in Java: poverty, gender and institutional setting

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Abstract
Java is the most populated island in Indonesia. Population densities of more than one thousand per square kilometre are not uncommon in the rural areas. More than 60% of rural people in Java depend on agriculture as their primary source of income. Most of these rural people live in areas surrounding state forest areas, and with an average land ownership of less than 0.50 per household, the resulting low-income levels contribute to growing social and economic pressures being placed on the forest areas. However, access to the forest area was restricted at that time as most of the productive and protected forest zone in Java is under the control of State Forest Corporation (Perum Perhutani). Rural people try to access and use the forest area, resulting in a significant growth in the incidence of conflict between the people and the Perum Perhutani across all provinces in Java. To overcome these mounting problems, the Perum Perhutani has intended to implement a strategy of trying to open state forest area in Java for social forestry programmes. These programmes could provide employment opportunities and diminish the mounting problems of tree theft, forest destruction and land encroachment. It was expected that conflict within the state forest zone may well be diminished if all interested stakeholders participate in forest management. To improve the PHBM programme, our study shows that the role of institutional innovation design is the major consideration. This includes the understanding of the PHBM concept by all stakeholders, social capital of the community, the fairness of the PHBM contract, and the role of women in the programme.

Keywords: poverty, gender, institutional setting, PHBM, social forestry

Farmers’ evaluation of silvoarable systems: the case of Florina prefecture, Greece

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Abstract
Traditional silvo-arable systems are present in several parts of Greece and play a very important ecological role not only because they enhance biodiversity but also because they prevent soil erosion and surface runoff. However, new established silvo-arable systems are not very common. This paper presents an analysis of farmers’ evaluation on silvo-arable systems. The study was conducted in the prefecture of Florina, northern Greece, through the use of a questionnaire. All collected data were subjected to statistical analysis. The majority of the farmers believed that beans are the most profitable crop of the area. Only 6% of them cultivated trees. Although these systems exist traditionally in Greece, the Florina farmers did not know about their management practices. It is believed that the low establishment cost is the main advantage of these systems. Nevertheless, most of them (71%) did not want to establish new silvo-arable systems, as a result of limited knowledge. Over the last decades, these systems have been reduced due to several reasons. Incentives should probably be given to farmers in order to maintain these systems and manage them properly.

Keywords: attitudes, conservation, intercropping
Forests and land tenure policies; constraint to participatory tree domestication? 
The case of the forest zones of Cameroon

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Abstract: Participatory tree domestication (PTD) largely promoted by ICRAF and partners in West and central Africa is now developing in ways which require new markets for diverse products. Despite this linkage of PTD to production and marketing of trees, analyses show the functioning of small forest enterprises which benefit from PTD, to be strongly linked to statutory tenure regimes under which the resource base is managed. In this paper we present results of recent analyses carried-out with support from the Rights and Resources Initiative in Cameroon on the relationships between regimes of land and forest tenure in forest zones of Cameroon; and the performance of associated agroforestry tree products and services (AFTPS) supply systems. Our findings show tenure regime to be strongly related to constraints of scale and customer relations in particular. Also of strong impact on supply systems are historical, cultural, forest policy and institutional aspects of resource tenure, and how these affect the inception, functioning and viability of AFTPS supply systems. More importantly the findings provide pointers to ways in which land tenure and PTD as a supply system for AFTPS could be more viably linked. However, in establishing this linkage, some threats need to be rolled back: important clients of PTD remain politically weak small holders such as rural, resource poor women and minorities. Still PTD remains heavily reliant on increased tree cultivation, secure land ownership and long-term management of high-value trees; all of which require political voice. We therefore deduce that an expanding PTD agenda in the region must urgently and simultaneously address policy and institutional challenges of land tenure in more specific ways. The paper also provides some suggestions regarding how policy and institutional constraints to expanding PTD may be addressed.

Is conservation a sufficient incentive for community participation in forest management? Findings from a case study in the Taita Hills, Kenya

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Abstract: For many years now, community forestry has been considered a viable alternative for managing natural resources particularly in areas where socioeconomic conditions have a destructive effect on the adjacent resources. Unfortunately, many developing countries have created legal frameworks to allow broader participation, based on national and international pressure rather than based on a long-term strategy that includes environmental, social and economic sustainability. As a result, conflicts often arise between stakeholders, particularly when dealing with the ethical, moral and applicability characteristics of different (and sometimes opposite) alternatives. The initial point of disagreement among stakeholders is the prioritization of problems (the environment first, or households or the economy) and how these problems affect each other (will an improvement of environmental factors improve the welfare of people, will an economic improvement reduce pressure on natural resources?). The second point of disagreement is whether the redistribution of rights and responsibilities among stakeholders is necessary and, if necessary, how should it be enforced? It is unclear, which factors influence successful participation of communities in conservation and restoration activities, and how these factors are affected by the priorities of other stakeholders. A recent study on the motives that encourage community participation in the Taita Hills of Kenya, offers a good opportunity to discuss some of the ethical and practical issues affecting conservation efforts in the region. The results showed that the
combination of ‘will to conserve’ and material factors (such as the expectation of income and formal employment) are more relevant for community participation. Community expectations however, conflict in many cases with the government’s conservation goals and policies. Interviewed community members complained that access to economically important resources were restricted despite being under the community management programme and that decisions are not fully transparent. More conflicts and possible failure are expected if development and conservation objectives are not redefined.

Moving beyond forestry laws in Sahelian countries: bridging disconnects between legislative provisions and native tree management

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract Indigenous trees and shrubs are principal sources of natural capital for rural populations in the Sahel. They provide fuelwood, fodder, food, fibre, timber, traditional medicines and ecological functions. However, as rural populations have increased and droughts have become more frequent and persistent, the abundance of indigenous trees and shrubs has declined in the traditional parkland agroforests and state controlled ‘classified’ forests. This threatens food security, reduces income-generating opportunities, increases resource-based conflicts and limits the chance of achieving the Millennium Development Goals. Governments’ responses include stricter policies and laws aimed at organizing and regulating the access to, use and management of indigenous trees and shrubs in the parklands. Sahelian forestry laws recognize the importance of indigenous trees and shrubs to people’s livelihoods, but they do not advance approaches to promote their sustainable management. Instead access, use and management of agroforests stipulated in the forestry laws have actually contributed to deforestation. Natural resource users argue that they own the trees on their farms, but forestry laws stipulate that the state owns protected indigenous trees either grown on farms or in forest areas. This paper describes tools and processes through which the mismatches were identified. The results show that natural resource laws: are contradictory, sector-based and lack coordinated implementation; do not recognize local by-laws and conventions; focus on classified and protected forests and mostly protected tree species, but are unclear about the management of protected indigenous trees on agricultural land; and put foresters in a policing function rather than as extension service providers. This leaves both natural resource users and foresters in a dilemma and fosters suspicion among stakeholders. To address these mismatches, Sahelian governments should work in partnership with rural communities to amend their forestry laws in order to allow efficient tree management on farms.

Key words: forestry, agroforestry, indigenous trees, negotiation support, bylaws, Sahel

Natural plant commercialization enterprises as tools in agroforestry up-scaling and development in southern Africa

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract Natural plant products (NPs) are an integral and crucial component of rural livelihoods in southern Africa. Most of these wild, indigenous and naturally occurring products are gathered and collected from woodlands and savannas. The economic potential of these
products to generate income, and thereby alleviate poverty and improve rural livelihoods is well documented. The sustainable use of NPs from woodland resources by new entrepreneurs could provide one of the best opportunities for rural development in southern Africa. Effective small-scale business ventures based on the commercial use of natural plant products often promote community development, technology up-scaling and job creation in rural areas. Farmers and rural households provide raw material to these business ventures, which process it into eco-labelled products that can be sold to high-income, environmentally aware consumers on world markets. These businesses are, however, faced with challenges such as a shortage of capital, lack of equipment and limited training and skills. There are a number of key success factors that can help to make natural product businesses viable. These include, amongst others, strong entrepreneurial skills, market access and well-developed community networks for raw material procurement. Natural product enterprises in South Africa and Mozambique were studied to determine these key success factors that ‘make business work’. The information from this study can be incorporated in up-scaling and extension initiatives to help rural farmers and processing groups in the establishment of agroforestry-based business ventures.

Policies and collective action for enhancing agroforestry and NRM in Zambia: their formulation, effectiveness and impacts

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract The absence of land property rights and customary practices such as bush fires and uncontrolled browsing by livestock are important institutional constraints to effective scaling-up of agroforestry land-use practices in southern Africa. Working in collaboration with a consortium of development organizations and traditional leaders, some local policy interventions were instituted in rural communities in eastern Zambia to manage these constraints. This paper describes the process through which the local policy interventions were formulated. It also evaluates the effectiveness of the policies. It then used a sample of 200 households in eastern Zambia to assess the impacts of the policies on different social groups in the rural communities. The analyses show that traditional institutions can provide important entry points for policy interventions on agroforestry development in rural communities. The bi-laws impacted positively on agroforestry farmers and woman-headed households, but children and livestock owners were disadvantaged by them. Among the lessons learnt from the study, the following stood out: 1) the distribution of the benefits (or costs) associated with natural resource commons and, the dynamics of the power structure among stakeholders in the community are critical to enhancing or inhibiting the successful implementation of local policy interventions on agroforestry; 2) privatizing seasonal commons is an important factor for designing policy interventions on natural resource commons in rural communities; 3) successful implementation of policy interventions on agroforestry is closely linked to consensus building among different stakeholders in the community taking, being aware of the economic interests of each group and, the willingness to review the policy where necessary. The main conclusion of this study is that in addition to improving the technological characteristics of agroforestry, local institutional arrangements and the pattern of distribution of benefits (or costs) are important for a sustained and widespread adoption of agroforestry in southern Africa.
Policy formulation and stakeholders’ engagement

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract

How to link the environment with economic growth and poverty reduction in policies and programmes is an issue that has attracted the recent attention of key ministries in Viet Nam. Since 2002, ICRAF Viet Nam has been participating actively in two projects, (i) the Poverty and Environment Project (PEP) and (ii) the Payment for Environmental Services (PES) project in the country. A literature review, open-ended interviews and a stakeholder workshop were conducted to develop policy model building in PEP. Lessons learnt from seven on-going PES projects in Viet Nam were drawn. After the preparatory phase for PES during 2002-2007 and implementation of PEP during 2006-2008, focused on policy reviews, awareness raising activities, and research on different PES mechanisms and lessons learnt, the country is now entering phase I of policy intervention and programme development. By combining knowledge from various stakeholders through an applied process-oriented approach, the policy interventions are believed to be viable at local levels and approvable at the central level. New provincial-level pilot projects will seek to test this belief. The findings emphasize the important role of Government and its public administration in determining the success or failure of policy and programmes that are directed at the poor. The sector-oriented agencies and programmes tend to lead to difficulties in implementation, such as: (i) overlaps in structures and functions amongst different ministries, further adding to transaction costs; (ii) critical gaps in policies, including lack of land tenure security; and (iii) limited understanding by decision makers, the private sector and communities about pro-poor PES as well as PEP, including a lack of market orientation in thinking about PES and PEP. Multi-sectoral approaches, further studies to support policy development and capacity building at the local level and central level are necessary to develop pro-poor PES and PEP.

Policy, institutional and legal constraints for agroforestry developments in Sri Lanka

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract

Agroforestry systems have become more important to Sri Lanka than ever before due to their contributions to sustainable management of land. Despite the fact that the national forest policy of Sri Lanka (1995) recognized the importance of agroforestry, few attempts have been made to enhance and scale-up agroforestry as a land management system. In Sri Lanka, agroforestry R&D activities have been conducted by many stakeholders, although developments of programmes/projects in consultation with relevant stakeholders are scanty. The existing policy, legal provisions and institutional setup for the use of trees outside forests are scattered over several acts relating to the harvesting, transporting and marketing of trees grown on private lands. The current acts and legal provisions create disincentives for the
growing of trees and hence constrain the development of agroforestry systems. Further, ad hoc policy measures taken to resolve isolated problems of agroforestry development have failed. Thus, there is a need for coherent national agroforestry policy independent of the national forest and agricultural policies to give the required thrust to development of agroforestry. In addition, an organizational structure and management mechanism has to be developed to bring together the stakeholders to devise a cooperative plan and policies to scale-up agroforestry uses. As an initial step to develop sound policies, research and extension service, the ICRAF Sri Lanka programme brought all stakeholders into three networks representing fruit trees, timber trees and medicinal plants. Through these networks, a national agroforestry consortium and discussion group has been proposed. The increasing need for multidisciplinary research and sound technological back up, along with effective information communication systems, have been suggested for the implementation of successful projects to scale up agroforestry benefits. The need to establish procedures to reorient and strengthen institutions to enable them to accomplish their role in agroforestry development and management are discussed.

Systematization for monitoring and evaluation: the learning experience in the multi-stakeholder participatory development of the Degraded Pastures Project (DEPAPRO)

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Session 25. Policy formulation and stakeholder engagement in natural resource management

Abstract

The necessity of performing monitoring and evaluation (M&E) in agroforestry, silvopastoral or other research and development (R&D) projects has been identified as a critical issue for increasing the chances of achieving the intended objectives. However, some projects still do not implement formal M&E systems and processes, preferring instead to rely on mid-term and final-term project evaluations performed by external evaluators. This paper presents the systematization of the experiences of the Degraded Pastures Project CATIE-NORUEGA (DEPAPRO), conducted in Central America from 2003 to 2008. DEPAPRO encouraged an approach of participatory learning and experimentation, based on Farmer Field Schools principles, in partnership with livestock farmers, their families and local institutions. The objective of the present study was to systematize the experiences of DEPAPRO, focusing on the training approach, documenting the opinions of participating stakeholders, as a means to generate lessons learnt that could be used in future R&D initiatives. The fieldwork was carried out in three pilot zones (El Chal, Guatemala; Olanchito, Honduras; and Muy-Muy Nicaragua), using four elicitation techniques: informal dialogues, semi-structured interviews, systematic observation, and field trips. Informants were selected using a non-parametric purposive sampling. The sample included 108 informants (52 informants in Guatemala, 23 in Honduras, and 33 in Nicaragua), belonging to five categories: farmers, FFS facilitators, partner institutions specialist, students, facilitator’s supervisors, and leaders. Each of the interviews was transcribed and analysed using descriptive analysis and grounded theory. Based on this study, it can be deduced that the participation of different stakeholders and institutions was essential for achieving the aims of DEPAPRO, since not all the topics in the FFS curricula of training were within the expertise of project staff. The systematization can be a useful tool for M&E in agroforestry or R&D projects, because it can be implemented by insiders and promotes motivation and learning among stakeholders.
Institutional Aspects of Local Participatory Natural Resource Management

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Management of forest environments and sustaining forest-dependent communities: Options for dryland Africa based on experiences from Central Sudan

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Session 26
Local knowledge in agroforestry science
Comparative analysis of farmers’ knowledge about ecosystem services and coffee productivity across Central America

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Abstract: The extent to which coffee agroforestry systems provide ecosystem services depends on local context and management practices. There is a paucity of information about how and why farmers manage their plantations in the way that they do and the local knowledge that underpins this. This research compares knowledge from coffee-growing areas bordering key forest reserves in Nicaragua, Costa Rica and Guatemala. Knowledge was acquired from over 170 farmers in a stratified purposive sample, using established knowledge based systems methods. Farmers in all 3 countries had detailed knowledge about how trees affected ecosystem services such as soil formation, erosion control, provision of wildlife habitat and water conservation. Links between trees and biodiversity, pollination, biological pest control and micro-climate regulation were understood, and species were classified according to their role in both providing and regulating services. Trees were said to produce ‘fresh’ shade that was suitable for coffee or ‘hot’ shade that was not suitable. This was explained in relation to leaf texture and size; foliage density, crown shape and root system attributes. Much of the local knowledge about how trees could improve provision of ecosystem services, however, was not practically applied because farmers were concerned that increasing levels of shade would decrease yields. A range of trees and shrubs were maintained in coffee plantations at all sites but different tree species were dominant and diversity varied two-fold amongst sites. The degree of shade tolerated was the main difference across countries and this was strongly related to socioeconomic factors such as the prevailing demand for fuelwood. Comparative analysis allowed us to identify generally applicable knowledge across sites as well as the key factors that determine how knowledge was locally applied.

Enhancing the ecological and functional roles of shade trees in cocoa farms: participatory tree diversification in Ghana

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Session: 26. Local knowledge in agroforestry science

Abstract: In West Africa, the diversity and density of non-cocoa trees in cocoa farms is frequently the result of farmers managing natural processes of regeneration in forest-fallows. On-farm species diversity and the ecological and functional value of shade trees is therefore more a result of chance and uncoordinated decisions over a long period rather than advanced planning. In addition, there is wide variation in farmers’ knowledge of the dynamics and interactions of different tree species as they occur in managed cocoa landscapes. Relying on natural regeneration processes can limit farmers’ ability to select desirable species or arrange their distribution in time and space. Hence, the potential of diverse cocoa growing systems is limited in its ability to enhance productivity, while making significant contributions to household incomes or conservation of biodiversity on farm and in the surrounding landscape. This paper presents evidence from a study in 89 cocoa farms which shows that farmers in Ghana’s Ashanti Region are planting cocoa in fallows and degraded forest environments, but primarily rely upon forest regeneration processes to establish shade in their cocoa farms. It then demonstrates how shade management is limited by: 1) an inability to intentionally choose desirable species; 2) an inability to deliberately arrange non-cocoa trees within farms; and 3) variation in farmer’s knowledge of shade trees. As a
framework for expanding farmer knowledge and choices, the paper then presents the results of a tree diversification process that was implemented amongst 36 farmers in six farmer groups in Ashanti Region using a participatory action learning approach. This approach enabled farmers to critically characterize non-cocoa tree species according to biophysical and socio-economic attributes, and then to select and plant desirable species in order to ensure ecologically appropriate shade for cocoa and valuable sources of timber and non-timber products.

**Leveraging local knowledge systems for combating climate change: lessons from indigenous agroforestry practices in central India**

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**Session** 26. Local knowledge in agroforestry science

**Abstract**

The communities living in rural and forest-fringe villages in central India possess a storehouse of local knowledge systems and indigenous land management practices, which have been instrumental in conservation and sustainable management of forest resources since time immemorial. Although these indigenous knowledge systems and practices have been accruing multiple benefits (including: biodiversity conservation, desertification control and carbon sequestration, among others) for generations, their utility and importance have never been studied appropriately, and have remained largely unnoticed by policy makers and donor agencies. This knowledge has been passed down from generation to generation via oral traditions and practices, and has not been documented appropriately. This research paper draws on the findings of a project conducted in the central Indian state of Madhya Pradesh, where local communities have been using indigenous knowledge for sustainable land management. Using structured questionnaires, focus group discussions, participant observation and other field research methodologies, the research explores the utility of local knowledge systems for sustainable land management and climate change mitigation (that is, knowledge forms, processes, creation, sharing, storage and use). The findings also present an adaptive framework for generating and delivering local knowledge innovations for sustainable agroforestry, which may help harness the complex role of trees in livelihoods and the environments of these communities, and assist in achieving the Millennium Development Goals. The research may provide valuable information to policy makers and the scientific community and prove to be a viable model for adopting these land-use approaches for their scaling-up in other parts of the country, or elsewhere in the world.

**Local ecological knowledge in the development of reward mechanism for watershed services**

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**Session** 26. Local knowledge in agroforestry science

**Abstract**

Reward or payment for environmental service mechanisms are being tested and proposed around the world as an effective approach to watershed management. Understandably, reward mechanism should be based on local biophysical characteristics as well as socio-cultural aspects and the local ecological knowledge or LEK of the local people. It is also true that the knowledge and perception of external stakeholders that include the public represented by policy makers is also important to be considered if the reward mechanism is to be acceptable to both service providers and service receivers. Furthermore, the scientific understanding of the hydrological processes can help in the ex-ante assessment on whether the expected hydrological service is realistic or not through such reward mechanism. In the context of negotiation for reward mechanism, communication is often constrained by
gaps between three types of knowledge. Progress in the negotiation can be made if the ecological knowledge of these multiple stakeholders can be clarified and made available for discussion. The paper discusses the role and type of LEK related to local hydrology and overall watershed management. With examples from Indonesia, we highlight the importance of LEK, method for its articulation and assessment in the context of developing reward mechanisms. We argue that the local people should not be treated as an object for change that is determined by external perspective, but they should be seen a rich source of information about the local problems and their possible solutions for integrated watershed management.

Participatory design and assessment of Swiss agroforestry systems
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Session 26. Local knowledge in agroforestry science
Abstract
The objective of the Treegarden project is to explore perspectives on re-integrating trees into Swiss agricultural landscapes in close cooperation with local stakeholders and experts. We aim at identifying viable agroforestry systems for regions in Switzerland where they can potentially yield social, environmental and economic benefits. Methodologically, we follow a transdisciplinary approach combining surveys, networking and bio-economic modelling. Uncertainties concerning the viability of agroforestry systems will be reduced, using data from both pioneer farmers’ experience and modern schemes. The scientific approach supports knowledge management and synergistic learning through networking and exchange of know-how. The main research activities in the first project phase concentrated on participatory agroforestry design and assessment. Survey and networking was the first step in order to study farmers’ innovations and already available expert knowledge. Interviews in different parts of Switzerland were conducted, yielding an inventory of alternative tree-crop or tree-grass approaches developed by farmers and practitioners. Primarily, traditional fruit tree grassland/pasture combinations were identified. According to the survey, Swiss farmers are less interested in timber production than in fruits. Important steps in establishing improved agroforestry systems such as selecting site-adapted tree species were documented and also used as input factors in the bio-economic modelling. Based on the surveys, literature and expert knowledge, a land-use and resources database was established. The farm management data in addition to soil and climate data were supplied to the biophysical (YieldSAFE) and bio-economic (FarmSAFE) models. With the models we compare conventional and alternative land-use scenarios, and discuss with land users management strategies that achieve best production and profit levels. The final calibration of the models and the baseline/alternative scenarios for all identified systems are in progress. The survey and modelling results shall be presented and discussed in the context of participatory land use improvement.

The encounter between local and professional knowledge regarding tree growing in the southwest Amazon
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Abstract
Plantations of forest products and, particularly, the establishment of agroforestry systems have been intensely promoted by development agencies to improve living conditions in the rural Amazon. Evidence across the region demonstrates that these experiences have had limited success in the face of severe constraints. While research has largely focused on the technical feasibility and more recently on the marketing aspects of the products,
little systematic research into the determinants and consequences of the unequal access to technical knowledge has been carried out. Even where cooperation has the overt intention of transferring technology, it has been found that the transfer of knowledge does not take place as readily as anticipated. This contributes to the failure of tree-growing initiatives. This paper explores how knowledge is exchanged between small-scale farmers and professionals. In particular, the nature of the knowledge exchange process during encounters between professionals and small-scale farmers is analysed. The promotion of plantations and agroforestry systems in the southwest Amazon provides the empirical context for this study. Data were gathered through semi-structured interviews with 25 professionals and 25 small-scale farmers, focusing on three fundamental elements considered by professionals and small-scale farmers when promoting tree growing: 1) species used; 2) purposes and criteria of tree growing; and 3) silvicultural practices employed. The interviews revealed different levels of misunderstanding between small-scale farmers and professionals mainly due to divergence of knowledge. However, some essential factors that facilitate knowledge exchange were identified; by which small farmers learn, test, copy and finally adapt practices to suit local needs and realities. The field of silvicultural practice seems to have the highest potential to achieve understanding; nevertheless, this is the most neglected topic by professionals when promoting tree growing which often leads to poor sustainability of these practices and even to complete abandonment of initiatives.

The gender of trees: local knowledge systems in a forest fringe community in rural Ghana

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Abstract
This study explores gendered local knowledge systems in a Ghanaian forest fringe village, elucidating linkages among environmental degradation, loss of local knowledge and gender. It investigated the content and processes of acquisition and transmission of tree-related knowledge, and how these areas differed among community members. Qualitative data were collected in semi-structured interviews, participant photography and workshops. Research findings confirmed the centrality of biophysical and social environments, local practices, belief systems, gender and informal and non-formal learning experiences in shaping tree-related knowledge and management strategies. First, despite the increasing formalization of knowledge and emphasis on formal schooling, and the deteriorating state of the biophysical environment, most of what community members know about trees was learned through social and experiential learning within the local ecosystem. As such, place and personal experiences in informal and non-formal learning environments continued to play vital roles in shaping local knowledge systems. Second, local knowledge was not uniformly distributed in content and depth, but instead corresponded to engagement in daily subsistence and commercial activities. Opportunities to engage in these activities were influenced by the gender division of labour, gender roles and gendered resource tenure systems. Third, study participants’ commitment to tree management was affected by a variety of factors – engagement with trees, awareness of trees and their uses, ability to mobilize resources, personal need and/or use for the benefits derived from trees – and was balanced with other commitments. Moreover, their commitment to management and conservation efforts was usually limited to familiar species exhibiting desirable characteristics. Fourth, while there was a potential for formal education to supplement the tree component of local knowledge systems, it cannot be a perfect substitute because of the importance of place. These findings underscore the importance of beginning agroforestry projects with an understanding of within-community differences in preferences and needs.
Using strategic entry points to enhance adoption of natural resource management innovations in the humid highlands of East Africa

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26. Local knowledge in agroforestry science

Abstract
A study was conducted in the humid highlands of Uganda, Ethiopia and Tanzania to investigate the effectiveness of using selected incentives as entry points for encouraging farmers to adopt integrated natural resource management technologies. Some 1200 farmers from 10 villages were involved. Participatory techniques were used to identify priority problems in each site, which if tackled could trigger farmers into adopting integrated natural resource management practices. In Lushoto (Tanzania) and Ginchi (Ethiopia) farmers chose the limited availability of water for domestic uses as their problem number one. In Areka (Ethiopia) farmers chose limited water availability and destruction of crops in the fields by porcupine (a vermin) while in Kapchorwa (Uganda), farmers prioritized inefficient soil and water management practices. To address these problems, site teams of the African Highlands Initiative (AHI) involved communities in rehabilitating 54 degraded water sources (in Lushoto (34), Ginchi (12) and Areka (8)) through collective action, encouraged use of indigenous knowledge in controlling porcupine, undertaking capacity building programmes, facilitating establishment of fodder and promoting household income-generation activities. Results indicated that rehabilitation of the water sources cut down water-fetching time from 2 hours to 15 minutes across the sites thus allowing the families more time for other natural resource management (NRM) activities. In Lushoto it was further observed that the rehabilitation of water sources has reduced waterborne infections by 77% around the same periods of the year, while 30% of the families with access to more water were involved in better and more efficient water-use practices such as raising 12 000 water-loving and other tree seedlings, brick making and water supply for their livestock. Across the three countries, over 75% (n=300) of the surveyed farmers and 80% (n = 40) of the political leaders expressed their satisfaction with the use of these entry points as a tool for community mobilization.
Session 27
The role of underutilized crops for agroforestry
Agroforestry with underutilized crops in India

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**Session** 27. *The role of underutilized crops for agroforestry*

**Abstract**

Bringing degraded farmland under productive use is a major challenge under dry tropical conditions of India. Besides land quality, several constraints related to production and post-harvest handling hamper the restoration of these lands to productivity. There have been many successful initiatives over the years to rehabilitate these lands. A majority of them are tree-based farming systems. Research conducted during the past three decades has identified a large number of agroforestry systems. Although those having multi-purpose trees have the potential to outperform others in terms of biomass productivity, the popular preference of farmers is generally for trees producing food. BAIF Development Research Foundation, a non-government organization engaged in implementing rural development projects in India has been introducing tree-based farming in several states of India. Initially, market-oriented species such as mango and cashew were the species preferred by farmers for these systems. Subsequently, however, systems with underutilized species such as Indian gooseberry and custard apple were also introduced. Another underutilized crop component of these systems is the intercrop. Farmers that BAIF works with, mostly tribal communities, grow traditional annual crops or varieties of crops such as rice. Thus, agroforestry systems with underutilized crops have become an established practice in many development projects for small farmers. The ability to survive and produce reasonable yields under adverse environmental conditions and the expanding demand for the produce, make many underutilized crops prime candidates for production systems of smallholders. Highlighting the successful interventions, the paper analyses the importance of backward linkages in the form of planting material and forward linkages through processing and marketing opportunities to promote underutilized crops.

Current situation and future development of processing units of non-timber forest products in Cameroon

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**Session** 27. *The role of underutilized crops for agroforestry*

**Abstract**

Over the years, most non-timber forest products sold in Cameroon markets were fresh or dried/processed through the use of traditional methods such as smoking and solar energy. Some of these products include: eru (*Gnetum africanum*), bush mango (* Irvingia gabonensis*), safou (*Dacryodes edulis*), and some spices such as country onion (*Afrostyrax lepidophyllus*) and groundnut spice (*Monodora myristica*). However, in recent times of the sale of processed byproducts has emerged from some of these non-timber forest products such as the oil produced from safou (*Dacryodes edulis*) and powder produced from bush mango (* Irvingia gabonensis*). This paper is the outcome of a study carried out with some processing units involved in the processing of these non-timber forest products. After presentation of the research methodology, the paper moves on to a technical and commercial diagnosis of the types of processing units identified, the perspectives for further development of these units and the impact of the income generated by the producers of these products.
Ethno-ecological knowledge in the selection of elite cultivars of *Uapaca kirkiana* in southern Africa

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Session: 27. The role of underutilized crops for agroforestry

Abstract: This study integrates ecological knowledge of local communities and scientific principles in selecting superior cultivars of the underutilized miombo fruit tree, *Uapaca kirkiana*, in Malawi, Zimbabwe and Zambia. A rapid ethno-botanical appraisal was carried out in 6 districts in each country during 2002-2003 and superior fruit attributes were identified by communities. Seeds and scions of superior trees identified by local people were collected, raised in a nursery and early growth and survival of seedlings was assessed. The qualitative and quantitative information collected during these exercises was subjected to empirical analysis. Fruit collectors and road-side marketers provided insights into locations of wild phenotypes having superior fruit traits for fresh market and processing ideotypes. Fewer superior phenotypes were found in communal land and cultivated land than in forest reserves. Tree-to-tree variation in fruit attributes was greater than within-tree variation. Early growth and survival of seedlings differs between provenances but were not related to fruit weight. Fruit weight ranged from 10 to 46 g in the 3 countries, while less than 5% of all identified trees had fruits weighting more than 40 g. The phenotypes with the highest fruit weight (46 g) were found in southern Malawi (Nazombe MW80). The depth of ecological knowledge of communities differs between regions and countries. Much of the local knowledge of heavily-loaded, large-sized and sweet fruits resides with fruit collectors, mostly children. In Zambia and Zimbabwe, Maria ZM10 and Mafa ZW40 were respectively the largest. Stewardship of superior phenotypes was less in communal lands than homesteads and forest reserves. It is concluded that combining ecological knowledge of local communities with scientific approaches in a complementary manner could facilitate the selection of superior phenotypes of fruits within a relatively shorter period. The implication of this finding for clonal propagation and domestication of underutilized fruit trees is also discussed.

Indigenous lac production strategies of the monga-stricken people in rural Bangladesh: a study on agroforestry

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Session: 26. Local knowledge in agroforestry science

Abstract: This paper intends to portray the traditional strategies of lac production that the ‘monga’-stricken community people of northern Bangladesh formulate and undertake in order to reduce the ‘monga’ situation that has caused a food crisis and employment crisis that have affected their livelihoods during two lean agricultural seasons. The adverse environmental situation and lean agricultural seasons induce monga for the poor people here in this region of the country, and this fact is addressed in the paper which explores the economic difficulties associated such crises that the community people have to face twice in a calendar year. Empirical data were collected from the monga-stricken people of two Nilphamari villages through observation, case studies and focus group discussions (FGDs). The findings are presented in a qualitative fashion in association with quantitative analysis. The paper explored how many indigenous host plants are planted in homesteads and agricultural land and used by the respondents for raising lac. The traditional methods and techniques of extracting matured lac from the branches of these host plants are also detailed in this paper. The paper aims to explain the contribution made by this non-wood product of
indigenous host plants to the reduction of economic crises and other consequent crises caused by monga in this region. It is evident that the indigenous knowledge of the lac farmers needs to be incorporated into scientific knowledge so that the lac production and its management can be more effective in reducing the monga situation. Finally, the paper suggests some policy interventions based on the findings for alleviating the monga situation for consideration by the government and non-government organizations with an emphasis on the incorporation of indigenous lac production knowledge into scientific knowledge for their future development contents.

Market chain analysis of Telfarea pedata as a potential agroforestry underutilized species in East Usambara Mountains, Tanzania

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Session 27. The role of underutilized crops for agroforestry

Abstract Telfarea pedata (oyster nut or Kweme) is one of the remaining under utilized non-timber forest products in tropical forests which have market potential and which, if managed sustainably, could provide additional incentives for maintaining forest cover and improve livelihoods of local communities in the respective areas. Under the Landscape Mosaics project research initiative of the CIFOR-ICRAF Biodiversity Platform implemented by the Tanzania Forest Conservation Group (TFCG) in collaboration with World Agroforestry Centre (ICRAF) in Tanzania, this study assessed the market chain of commercial biodiversity products. In this paper we present the market chain of T. pedata as an underutilized agroforestry species from smallholder farmers’ homegardens in the East Usambara Mountains. Various uses of T. pedata includea special diet for the lactating mothers, cooking oil and medicinal purposes. Market chain analysis indicated that the main actors are farmers who are the growers, collectors, sellers and consumers of T. pedata. Other buyers rarely take the product to outside markets thus, in most cases the market chain is from producers to buyers direct, and on very few occasions the chain goes from producers to retailers to the final consumers. Consumption of this product is basically local due to the fact that, production of T. pedata is very low, there are no established formal market outlets and the demand of the product is currently low. Although there is no established formal market, T. pedata seems to have potential markets within the country. Whereas the establishment of a sustainable market for this product will help to encourage mass production, which as a result improves communities’ livelihoods, it will provide additional incentives for maintaining forest cover in the landscape.

Keywords: agroforestry, underutilized species, market chain analysis, Landscape Mosaic, Tanzania

Marketing of Adansonia digitata L products in Malawi

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Session 27. The role of underutilized crops for agroforestry

Abstract Adansonia digitata L (Baobab) is among the 10 priority indigenous fruit tree species identified for domestication and commercialization in southern Africa. Trade in baobab products has recently increased both locally, regionally and internationally. A market study was undertaken in four trading areas of Malawi including one in an urban setting in order to determine the availability, market and value chain of baobab products. A targeted sampling method was employed to interview at random people involved in the baobab trade using a structured questionnaire. The study revealed significant differences in most of the factors influencing the market chain including: type of products sold, distance from home to market, selling points, type of buyers, mode of transport, average price, and pricing dynamics. The
fruits were mostly (65%) sold raw, with value addition done in the processing of juice (35%), lolly-pop freezes or ice drinks (11%) and jam (2%). Traders travel varied distances to markets ranging from 1 km to 360 km. The final consumers were the most prominent buyers (65%); while the middlemen (agents) accounted for only 5% of the buyers. The mode of transportation was mostly on foot (26%), bicycles (24%) and public transport (21%). The most important units of trade were sachet of freezes (45%) and 50 kg bag of fruits (21%) with prices ranging from 0.03 USD to 0.07 USD, and 0.08 USD to 3.6 USD, respectively. Revenue accrued per month for an individual ranged from 2.5 USD to 715 USD; while cottage industries made between 1100 USD and 2300 USD; with gross margins of about 595 USD per person and 1535 USD for industry. The study showed that the marketing of Adansonia products was predominantly an informal trade with limited commercialization in the form of ‘supermaketization’ of ‘Mlambe juice’ from baobab that is predominantly in southern Malawi.

**Processing and value addition to tamarind** (*Tamarindus indica*), an important forest tree for sustainable development in Rural India

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**Session**  
27. The role of underutilized crops for agroforestry

**Abstract**  
India is the world’s largest exporter of tamarind (*Tamarindus indica*), exporting 11 145 tonnes of tamarind annually. A fully developed tree can give production of 200 to 250 kg per annum, of which the pulp may constitute 30 to 55%, the shells and fibre 11 to 30%, and the seeds, 33 to 40%. The acidic pulp is a common ingredient in culinary preparations such as curries, chutneys, sauces, ice cream and sherbet, in countries where the tree grows naturally. Tamarind is marketed locally, regionally and internationally. Market value varies depending on location, variety, quality, processing and demand. Products sold in local markets are usually in the form of fresh fruits, pulp, juice, sauce and paste. Products in international markets include pulp, juice, paste and TKP (tamarind kernel powder). Immature fruits are used for chutney and ripe fruit pulp is an important ingredient in South Indian vegetable dishes to induce sourness. It is used for seasoning other food and in curries, preserves, chutneys and sauces. Green tamarind is pickled in brine. In India sweetmeats or the sugared tamarind made by rolling the semi-dried pulp and seed in crystal sugar are very popular products of tamarind fruit. Tamarind fruit is full of acidity which combines well with sugar, chilli and other flavours, hence its pulp is used to prepare a variety of traditional refreshing and highly energetic drinks. TKP is a major industrial product, which is used in the sizing of textile, paper and jute. The seed and its extracts can be used in the food processing industry, as an adhesive in the plywood industry and in the tanning industry due to the high tannin content in the seed testa. The bark is used in tanning, the tender leaves and flowers are also eaten as a vegetable.
Successful species combinations in the Sahelian baobab gardens are threatened by destructive nematodes

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Session 27. The role of underutilized crops for agroforestry

Abstract Baobab leaves form an important part of the local diet in Sahel countries and elsewhere in Africa. In the Sahel, the baobab functions as an agroforestry tree in cultivated fields, where farmers recognize different varieties. It is also planted and managed around villages and in vegetable gardens where the trees are typically maintained in stunted form to maximize leaf yield and accessibility. With the exception of the regularly watered gardens, baobab Adansonia digitata shades its leaves during the dry season, thus reducing the availability of fresh leaves for human consumption. The introduction of other Adansonia species from the centre of diversity in Madagascar and from Australia show potential for enhancing food security as their leaves are very rich in mineral contents and levels of vitamin B1 and B2. However, the local species normally used in the vegetable food banks far out-performed the introduced species in survival, growth and resistance to termites. Results from grafting as a way of harnessing the vigour of well-adapted local baobab varieties to the superior nutritional profiles of introduced baobabs show great success with more than 80% survival 1.5 years after planting. Such cross-species grafting tests in Adansonia are creating new agroforestry possibilities with different scion/rootstock combinations in the baobab nutritional banks. But baobab has been reported as a host for several species of plant parasitic nematodes. Because gardens are frequently watered for fresh leaf production throughout the year, nematodes attacks become a real threat. Various nematodes, including the destructive Pratylenchus species and Helicotylenchus, have been associated with baobab gardens in Mali. As nematodes can be a serious threat to the extension of this successful agroforestry technology, an extensive survey is needed in order to achieve a better knowledge on the threat.
Session 28
Agroforestry-based livelihood strategies for smallholders in the Amazon
Cocoa-based smallholder agroforestry: livelihood enhancing land-use to control fire and reduce deforestation in the Transamazon

<table>
<thead>
<tr>
<th>Authors</th>
<th>Carla Rocha, Ione Vieira and Noemi Miyasaka Porro</th>
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<td>Session</td>
<td>28. Agroforestry-based livelihood strategies for smallholders in the Amazon</td>
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<tr>
<td>Abstract</td>
<td>This paper examines how families in the Brazilian Transamazon combine slash-and-burn shifting cultivation and extraction of forest products, while introducing cocoa-based agroforestry. The study was conducted in the municipality of Anapu, where since the mid-1990s, social movements claimed new forms of land regulation combining agrarian reform and environmental conservation. Specifically, the study was carried out in the Sustainable Development Project (PDS) of Anapu, where in 2002 the federal government granted tenure over 52 480 ha of forested land to 154 families. According to PDS regulations, each family is allowed to slash 3 ha/year for agriculture, up to a total of 20 ha. As local soil and landscape conditions will not sustain extensive slash-and-burn, since 2005, 40 families have been experimenting with agroforestry systems (AFS). Annual crops are integrated with cocoa and other trees, such as mahogany, cedar, copayba and other native species. Also, to protect PDS from illegal occupation by loggers, a community-based forest management project was launched in 2006. The paper thus presents preliminary findings of a study conducted in 2008 by the Transamazon Agroecological Laboratory of Pará’s Federal University Center for Family Agriculture Studies, in partnership with the grassroots organization ASSEEFA and the Amazon Initiative Consortium. The research on livelihoods and environment was based on quarterly interviews with a random sample of 75 households and shows that for most of the participating farmers, cocoa agroforestry in its third and fourth year is an incentive against uncontrolled burning. Considering current trends for cocoa prices and projected income from the on-going Forest Management Project, it is likely that 5 ha of cocoa-agroforestry will prevent deforestation beyond the allowed 20 ha per household.</td>
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Contribution of forest products and agroforestry for livelihoods of indigenous and colonist communities in the Peruvian Amazon: a comparative assessment

<table>
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<tr>
<td>Session</td>
<td>28. Agroforestry-based livelihood strategies for smallholders in the Amazon</td>
</tr>
</tbody>
</table>
| Abstract | This study comparatively examines the importance of forest resources and agroforestry practices across indigenous and colonist communities in the Ucayali region of Peru. The survival strategies of four socio-environmental contexts are compared. Lowland Shipibo communities (settled at the banks of the Ucayali river), and upland Cashibo communities (located in the vicinity of the San Alejandro River) predominantly perform fishing, hunting and gathering of forest products, with incipient agricultural practices. Forest products extracted for subsistence are wildlife (meat and skins), wood and thatch for housing, fruits, medicinal plants, resins, and seeds for crafts. Recent development programmes promote commercial timber extraction and management of secondary forests, especially near Pucallpa, the regional market. Lowland non-indigenous communities comprise colonist families from the Andean and coastal regions in alluvial areas of the Abujao River Basin, who extract timber and thatch, as well as wildlife. Their farming systems are based on annual crops (rice, cassava) and informal gold mining is a major economic activity in the area, with considerable impact on natural resource integrity. Upland colonist families of Andean origin are located at the margins of the Federico Basadre road and use few forest products due to progressive forest degradation in the area. Their main land-use strategies are agriculture (annual crops, cocoa and cotton), livestock, and more recently, oil palm. In
Description of homegardens in Araçá Indigenous Land, in the Lavrado (savannahs) of Roraima, Brazil

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Session 28. Agroforestry-based livelihood strategies for smallholders in the Amazon

Abstract

In Araçá Indigenous Land, Roraima, Brazil, homegardens are planted around dwellings dispersed in the savannah. Sixty homegardens were surveyed in relation to the diversity, origin, and use of plant species. A total of 79 species were found, of which 45 produced edible fruit. The most abundant trees were lime (Citrus aurantifolia), araçá (Psidium guineense) and mango (Mangifera indica), with 13%, 13%, and 11% of the total of individuals, respectively. These species were also the most frequent, present respectively, in 90%, 62% and 93% of the homegardens. The greater part of the fruit is used for domestic consumption, although 40%, 15% and 8% of the homegardens sell, respectively, limes, mangos and oranges. Both species richness and total number of plants is directly related to homegarden age. The species planted are generally acquired through exchanges or gifts in a social network of relatives and friends, and each species may have one or more origins, the principal source being Araçá Indigenous Land (75% of the species) and the state capital, Boa Vista (49%). Of the 79 species found in homegardens, 21 are spontaneous and are maintained because of some useful property, edible fruit being cited in 46% of these cases. Most spontaneous species are native to nearby forests islands in the savannah or riparian forests, and may arise from seeds discarded following fruit consumption. This is generally the case for Acrocomia aculeata, Astrocaryum tucuma, Byrsonima crassifolia, Genipa americana, Hymenaea courbaril, Mauritia flexuosa and Spondias mombin. Other native species may arise from seeds dispersed by wind, fauna and cattle. The homegardens studied represent an interesting mix of species and processes, with initial planting of more drought-tolerant trees such as mango and cashew providing over time conditions for the establishment of less resistant species, via planting or natural regeneration.

Evaluation of biological and economic parameters of agroforestry systems (AFS) being promoted as a strategy of biodiversity use and conservation in the frontier forests of northwest Mato Grosso, Brazil

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Session 28. Agroforestry-based livelihood strategies for smallholders in the Amazon

Abstract

This case study aimed to identify economic and ecological parameters of innovative land-use systems in the context of a UNDP/GEF-supported project in the northwest Mato Grosso. Two categories of agroforestry systems (AFS) (intensive and extensive) were identified. They differ in the following respective values: income in hayear−1 (USD 8000 and USD 1000), units of human labor (UHL) per ha−1 year−1 (≤ 75 UHL ha−1 and ≤ 25 UHL ha−1) and costs as a percentage of gross income (≤ 5% and ≤ 3%). The higher values for economic parameters found for AFS were the following: (a) gross annual income ≥ USD 24 000 year−1; (b) time for
production to become consolidated ≥ 12 years; (c) ≥ 275 m3 ha⁻¹ in total biomass; (d) ≥ 77 m3 ha⁻¹ in total volume of timber; (e) ≥ USD 1600 ha⁻¹ year⁻¹ of timber stocks; (f) ≥ 70% of annual gross income derived from AFS products; and (g) ≥ USD 80 pd⁻¹ (amount of annual average income derived from one person-day of labour invested). This value represents over 570% more than the current payment (USD 14) for one working day (8 hours) in the region, suggesting it to be a very competitive value and a vector for decision making. The analysis of environmental services showed that, in areas managed under AFS for more than 10 years, the values of biomass and carbon stocks reached up to 201.6 m3 ha⁻¹. Tree diversity in AFS reached 54 vascular species, against 87 in forest fragments. Low use of technological inputs and predominant use of manual labour resulted in a positive energy balance (ratio output to input), which reached up to 25.3 units (Mcal). Sightings of wildlife were reduced (≤ 20 sp) for cases where AFS and forest were 1 km or more apart. Even larger areas of forest inside the farm did not affect these values, reinforcing the general assumption that lack of connectivity is critical for wildlife. In general, AFS being promoted in northwest Mato Grosso was demonstrated to play a decisive role in promoting both economic benefits and environmental services, including biodiversity, reduction of deforestation and retention of carbon stocks.

Multistrata agroforestry systems as an alternative for slash-and-burn farming in the Peruvian Amazon

Authors Bohdan Lojka, Rita Riva Ruiz, Abel Meza Lopez, Jana Lojkova, Zbynek Polesny, Jan Banout, Daniel Preininger

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Session 28. Agroforestry-based livelihood strategies for smallholders in the Amazon

Abstract

One of the causes of deforestation of Amazonian forest is small-scale slash-and-burn farming, with the greatest rates occurring around population centres, such as Pucallpa in Peruvian Amazon. Farming systems that in part imitate the structure and processes of natural forest vegetation, such as multistrata agroforestry, have a high potential to increase the productivity and sustainability of small-scale farmers. In 2004 we started a development project with the main objective of implementing these alternative systems among rural households. The system is based on the cultivation of the fast-growing leguminous tree species guaba (Inga edulis) combined with native fruit (e.g. guanabana, Anona muricata; caimito, Pouteria caimito; uvilla, Pouroma cecropiaefolia) and timber species (e.g. shihuahuaco, Dipterix odorata; tropical cedar, Cedrela odorata; bolaina blanca, Guazuma crinita). The key component, acid and soil-tolerant tree guaba, which improves soil fertility through nitrogen fixation, is traditionally used to shade perennial crops, provide fuelwood, control noxious weeds and produce a sweet pulp. In early years, when participating farmers establish their plots, they intercrop the trees with their staple crops such as cassava, maize and rice. In the following years, growing trees prevents farmers from annual cropping, but there is enough space for growing shade-resistant crops such as pineapple (Ananas comosus). The incentives given to farmers are based on providing them with tree seedlings, organic manure, organizing communal work and continuous technical assistance. Over time, this multistrata system proved to be viable alternative for the local conditions. The system is able to restore fertility of heavily degraded land; and on the other hand it can provide farmers with useful marketable products. In the first years they can harvest annual crops, lower the can harvest valuable fruits and pineapples, and it is estimated that after ten years farmers can start to harvest their timber trees. The economic performance of the systems is also promising.
Related forestry, agriculture and agroforestry activities in livelihoods of smallholders in the Amazon region of North Bolivia

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Session
28. Agroforestry-based livelihood strategies for smallholders in the Amazon

Abstract
This paper examines the extent to which forest products, agroforestry and agricultural activities contribute to the well-being of smallholders in the Amazon region of North Bolivia. The paper presents preliminary findings of a socioeconomic survey with 20 communities and 169 households in the domain of the Amazon Network of Studies on Livelihoods and Environment (RAVA). All communities presented a strong diversification of livelihood strategies, including off-farm services, mostly based on forest activities. The communities studied presented a high variation in the proportions of three major smallholder types, which were defined according to their main productive activity: (a) ‘extractivists, mainly dedicated to the extraction of forest products; (b) farm-foresters, combining shifting cultivation, livestock, small-scale commercial agroforestry, and the extraction of forest products’ (both timber and non-timber); and (c) agroforesters, combining commercial agroforestry systems with agriculture and the extraction of forest products. Extractivists, were strongly dependent on forest-based activities (85%) which are mainly channelled towards subsistence. Some products such as Brazil-nut and hardwoods for global markets are traded. Forest activities were also more important (70%) than agriculture and commercial agroforestry (<10%) for the farm-foresters. Finally, in the case of the agroforesters, although the relative importance of agroforestry (>30%) increases considerably, forest activities (54%) still had significant importance. Forest-based, shifting cultivation, and agroforestry activities are thus strongly related to subsistence-oriented livelihood strategies in the area. Most of the production is found to be for consumption and local markets, while few relevant products are oriented to global markets, these being hardwood and Brazil-nut from natural forests and cupuaçu and cocoa from commercial agroforestry systems. Although still incipient, agroforestry produces highly commercial products that allow enhanced livelihood conditions in a region where most communities are below the poverty line.

Sheep or cattle browsing does not endanger fallow vegetation in an innovative agro-silvo-pastoral system for smallholder farmers

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Session
28. Agroforestry-based livelihood strategies for smallholders in the Amazon

Abstract
In the northeast Amazon, the ecological sustainability of smallholder agriculture is based on the nutrient-restoring secondary vegetation, nationally called ‘capoeira’. However, pastures have to be abandoned after 7 10 years. We propose a new production system with an animal component, temporally integrated between the cropping and the fallow phase: a grass-legume-capoeira-pasture. To test this system we planted Brachiaria humidicola-stolons and two multipurpose forage legumes, namely Cratylia argentea and Flemingia macrophylla, together with the last cassava crop, at the end of the rainy season (June 2007). After half a year of pasture establishment, two mixed-bred male cattle (live weight 200 kg) and 20 Santa Inês sheep (live weight 20 kg) were introduced in the beginning of the rainy season (March 2008), and rotated weekly between three replications (stocking rates: 267 kg/ha/yr). To compare the browsing effects of sheep and cattle on the resprouting capoeira fallow, defoliation damage was estimated in percentages, in September 2008. Up to ten individuals of each capoeira species per plot were classified into three damage groups, the last one (0
The role of agroforestry-based practices in shaping policies and programs for licit smallholder livelihoods in the Colombian Amazon

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Session
28. Agroforestry-based livelihood strategies for smallholders in the Amazon

Abstract
This study examines the extent to which agroforestry practices are incorporated into economic strategies of smallholder communities located in the forest margins of the Caquetá Department, Colombian Amazon. It was conducted under the auspices of RAVA, the Amazon Network of Studies in Livelihoods and Environment, through the implementation of quarterly surveys with 100 households, as well as two annual surveys at the community and household level. The region is characterized by the presence of an active agriculture and livestock sector. In addition to annual crops and cattle ranching, relevant activities are: extraction of forest products such as fuelwood, timber and seeds, hunting, fishing, the cultivation of vegetables and fruits in homegardens for subsistence, raising of small livestock, and the cultivation and processing of coca. The latter, despite being outlawed and the object of eradication programmes, continues to be an important source of cash income for local livelihoods. An examination of smallholders' demographics, socioeconomic status, market integration and the natural resource endowments of their landholdings provide an understanding of: 1) the main factors that contribute or hinder the adoption of agroforestry; 2) what types of agroforestry practices are preferably adopted by smallholders in the Colombian forest margins; and 3) the relative contribution of agroforestry to household subsistence in this region. The study concludes with an examination and discussion of local perceptions of well-being, and research, training and policy needs identified by the community as priorities to improve their livelihoods.
Session 29
Cabruca agroforestry systems of Bahia, Brazil
Cabruca its agrobiodiversity potential on small farmers in southern region of Bahia, Brazil

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Session: 29. Cabruca agroforestry system of Bahia, Brazil

Abstract:
The cacao cabruca agroforestry system of production was developed by farmers in Bahia over 200 years ago. This system consists of planting of cacao under the shade of trees of the Atlantic rainforest and has an average of 693 cacao plants and 93 trees per hectare. Even though the local community utilizes the agrobiodiversity of the cabruca in their daily life for food, fuelwood, and timber, etc., the main source of income is mainly from the cocoa beans. Because of the loss of productivity of cacao caused by disease and pests, the sustainability of cabruca agroforestry is being threatened and therefore, its maintenance requires the exploration of other elements of the system to generate income. A study was implemented to understand the point of view of small farmers on the utilization of the agrobiodiversity of the cabruca system of cacao cultivation. The survey was developed with a sample of 160 small-scale farmers in seven agrarian-reform settlements. These farmers have low incomes, and have difficulty in absorbing conventional technologies; however they have high ethnobotanical knowledge. The results demonstrated that in regard to exploitation of cacao the constraints were grouped as follows: loses with diseases and animals; low soil fertility and too much shade; and lack of rural technical assistance, organization and financial resources. In regard to utilization of agrobiodiversity the solutions were grouped as follows: enriching the system with fruit trees and native timber trees; utilization of organic fertilizers; utilization of water present in the farm; production of chocolate in combination with fruits; harvesting of native tree seeds and raising native animals. These results show that for the farmers the cabruca agroforestry has greatest potential income, which is yet to be explored, and that cocoa diseases are the main limitation for production.

Cacao cabruca agroforestry system of production in Bahia, Brazil

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Session: 29. Cabruca agroforestry system of Bahia, Brazil

Abstract:
The cacao cabruca agroforestry system of production was developed by farmers in southern Bahia, probably in the beginning of the 20th Century. To establish such a system in the Atlantic rainforest region, farmers selectively maintained around 75 adult individual trees per hectare, removed other trees and planted cacao under the shade of these selected trees. Currently Bahia has around 400 000 hectares of cabrucas, which has a floristic composition of native and exotic species. The main economic return of these agroforestry systems from selling cocoa beans, but this system also provides other indirect benefits; these benefits are usually not valued. Unfortunately the cabruca system is being threatened because of the low income per hectare, and is rapidly being replaced by pasture and other uses. This study gives an overview of the agronomical, environmental and social benefits of the cabruca. Surveys carried showed that cabruca agroforestry is very much a diversified system that has around 93 trees and 693 cacao plants per hectare and consists of 227 different tree species. Compared to earlier surveys, in the present survey the number of trees per hectare has increased from 73 to 93. At the same time the number of cacao plants has decreased from 723 to 693 per hectare. This amounts to reduction of 12 millions cacao plants in 400 000 hectares of cacao cabruca system. Cabruca enhances nutrient cycling and biological nitrogen fixation, retention of soil moisture and organic matter, control of weeds and reduces soil erosion. In these systems we observed 17 nitrogen-fixing tree species and also
the presence of other tree species that provide a mix of goods such as timber, fuelwood, seeds, natural medicines, and fruits. Cabruca also provides watershed protection, habitat for endemic and threatened animal species and in situ conservation of threatened and valuable timber tree species.

**Carbon stock and available nutrients in soils under cacao cabruca system in the southern region of Bahia, Brazil**

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- **Session**: 29. Cabruca agroforestry system of Bahia, Brazil
- **Abstract**

In agro-ecosystems, efficient nutrient cycling is considered responsible for plant nutrition; however it is important to consider the amount of total available nutrients. An experiment was undertaken to quantify the carbon stock and available nutrients in cacao plantation grown under tree shade of a system called ‘cacao cabruca’, in the southern region of Bahia state, Brazil. Sixteen cacao cabruca systems were selected for this study. Soil samples were collected from 0 to 20 and 20 to 40 cm depth, and were analysed for concentrations of organic carbon, calcium, magnesium, potassium, phosphorus, sulphur, boron, iron, manganese, copper and zinc. From these analyses the organic carbon stock and the total available nutrients in the 0 to 40 cm of soil depth were calculated. The average carbon stock observed in these cacao cabruca systems was 87.3 t/ha. Average total available nutrients, observed /ha were 4164.4 kg Ca; 882.8 kg Mg; 315.7 kg K; 37.6 kg P; 1.7 kg B; 1091.5 kg Fe; 96.8 kg S; 27.6 kg Cu; 307.9 kg Mn; and 49.3 kg Zn. Considering the observed total available nutrients amounts and the carbon stock, it is fair to infer that the cacao cabruca system is quite fertile and requires no additional external nutrient inputs, with the exception of phosphorus and boron. Since all the other nutrients determined were beyond sufficient levels of available nutrients, the mineralization of soil organic matter is an important additional nutrient input to meet plant nutritional demand in this cacao cabruca system.

**Economical viability of silvopastoral system with teca (Tectona grandis L.f.) in the northeast of Pará, Brazil**

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- **Session**: 29. Cabruca agroforestry system of Bahia, Brazil
- **Abstract**

Proposing alternative models for the use of the land, that are both economically and environmentally sustainable, has been a great challenge for agricultural research. The silvopastoral systems (SPS) have been considered as a promising alternative to integrate growing trees in livestock production systems and eventually recovering large areas of degraded pasture in the Amazon. Although such an approach has been used on a small-scale by innovative producers, the SPS lacks a scientific basis to provide technical knowhow to its wider use, and especially to justifying the economic sustainability of these systems. The objective of this study was to analyse the economic viability of SPS used by producers in the northeast region of Pará and compare them to the traditional monoculture (FM). The system was considered temporary, such as ‘grazing in plantations of trees’ composed basically by teca (Tectona grandis L.f.) in kikuyu grass (Brachiaria humidicola (Rendle) Schweick) being grazing by cattle. The analysis of economical viability was assessed by indicators such as net present value (NPV) and internal rate of return (IRR). Interviews were conducted with ten producers who use these systems in the region. The total costs of operation was USD 7689.22/ha and USD 7582.06/ha respectively for FM and SPS. The cost of day work was higher for SPS (USD 674.73) than for FM (USD 659.90). This means that the SPS could
generate more job opportunities. The tree density in SPS was 1100/ha. The price of the wood was USD 54.17/m³ in first and second the looping; USD 250.00/m³ in the final cut. The IRR was 15.68% in SPS and 15.41% in the FM. The NPV was of USD 2026.60 in SPS and USD 1892.11 in the FM the tax of 12% to the year, respectively. Thus, we conclude that the SPS is economically more attractive than the FM.

Phytosociology of the tree component of cacao cabruca agroforestry systems and its relation to shade management practices

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Session 29. Cabruca agroforestry system of Bahia, Brazil

Abstract Cacao cabrucas are agroforestry systems in which cacao is grown under the shade of trees, some of which are remnants of original forest. Cacao cabruca represents an important land-use category in the landscape of the southern Bahia, Brazil, which contributes to the conservation of part of the biodiversity of the Brazilian Atlantic Forest. In order to determine and explain the shade-tree composition in cacao cabruca a phytosociological survey, which consisted of shade management and farmers’ tree preferences, was carried out on an area of one hectare within 16 cabruca farms. A total of 1946 trees belonging to 227 species were found. The tree density and basal area ranged from 44 292 individuals/ha and from 13.0 31.8 m²/ha among farms. The richness varied from 17 59 species/ha while the diversity (Shannon) varied from 2.21 3.68 nats/individual. The majority (94.3%) of the species was native, and some were endemic to the region, with 9.3 percent being pioneer species. However, the most important species were the exotic fruit tree species *Artocarpus heterophyllus* Lam. (jack tree) (IV=7.7%), *Spondias mombin* L. (caja fruit, hog plum tree) (IV=4.0%) and the native timber tree species *Plathymenia foliolosa* Benth. (vinhatico) (IV=3.8%). The cacao cabruca showed high plant diversity in relation to other agricultural systems, but presented a distinct floristic composition from the original mature forest due to the presence of pioneer and exotic species. Farmers’ tree preferences and shade management revealed a strong inclination towards the promotion of exotic fruit trees and native trees species providing valuable timber, explaining some of the results obtained with the phytosociological survey. The results showed that policies oriented toward the maintenance of threatened endemic species in cacao cabruca areas are needed in order to maintain its biodiversity conservation value as well as other environmental functions.
Session 30
Socioeconomics, livelihoods, and island and coastal agroforestry
Agroforestry on the frontline against climate change, biodiversity erosion and global recession: agroforestry as a basis for sustainability in the Pacific Islands

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Session: 30. Socioeconomics, livelihoods, and island and coastal agroforestry

Abstract

The small island developing states of the Pacific Ocean are on the frontline in the battle against climate change, loss of biodiversity and the negative impacts of globalization. Small island countries and communities are among the most vulnerable areas on Earth to the impacts of climate variability, sea-level rise, extreme events, loss of biodiversity and the global recession. Because of their plight, attempts have already been made to resettle ‘climate change refugees’ from Pacific atolls and coastal areas, up-scale island biodiversity conservation initiatives, and to promote more sustainable livelihoods to address the global economic downturn. Because there are few options for urban-industrial and commercial development in most small island developing states, especially in outer islands and rural areas, there is an almost obligate dependence on agroforestry to supply most basic needs, most cash income and much of the foreign exchange. This paper stresses that for most small island states and coastal communities, the protection and enrichment of existing agroforestry systems is perhaps the most practicable, cost-effective and culturally and environmentally appropriate means of simultaneously addressing many of the current and predicted negative impacts of climate change, extreme events, loss of biodiversity, economic and social problems, as well as making the islands more habitable in the long run. The paper discusses rural and urban agroforestry models and strategies and important tree and associated crop species that currently dominate atoll and coastal agroforestry systems in the Pacific Islands, and development initiatives, including coastal reforestation, conservation of arboreal genetic diversity, agroforestry conservation and enrichment initiatives, and commercial development schemes that have been, and can be employed, to protect and enrich these systems as a basis for ecological, economic, nutritional and cultural sustainability. The findings are based on studies conducted over 35 years of the agroforestry systems of Melanesia, Polynesia, Micronesia and an assessment of initiatives to protect and enrich the rich agroforestry traditions of the Pacific Islands.

Constraints and strategies for developing markets for Philippine coconut-based agroforestry farms

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Session: 30. Socioeconomics, livelihoods, and island and coastal agroforestry

Abstract

This paper focuses on initiatives for market development of coconut-based agroforestry farms in Quezon Province, Philippines. It addresses the constraints faced by smallholder farmers and other market participants and analyses the problem of coconut logging (cutting of coconut trees for lumber) due to concerns about the coconut industry’s long-term sustainability and threat to the environment. The market development needs of farmers for enhancing the productivity of coconut-based agroforestry farms are primarily concerned with access to capital, technical and entrepreneurial skills, equipment and tools, and market linkages and information. The recommended initiatives focus on the various possibilities for improving farmers’ incomes through a strategic and comprehensive market development framework that considers the following elements: sustainability of the coconut resource base, enhanced market competitiveness, policy measures, and institutional support services. Specific strategies should include (1) effective implementation of the replanting programme and policy guidelines on cutting of coconut trees and coconut product standards, (2) re-orientation of extension programmes to a holistic package of services on technologies, credit,
information, markets, and entrepreneurial skills, (3) strengthening of farmers’ organizations
to enable them to undertake viable value-addition and various marketing options, and (4)
improvement of farm-to-market roads and immediate use of existing market facilities in the
area.

Keywords: Products, markets, value-addition, policy, support services, infrastructure

Economic analysis of smallholder rubber agroforestry system efficiency in Jambi. Indonesia

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Session 30. Socioeconomics, livelihoods, and island and coastal agroforestry

Abstract
The objectives of this research were: 1) to analyse production efficiency and profitability
of smallholder rubber monoculture and smallholder rubber agroforestry systems; and 2)
to find out the effects of policy distortions towards rubber production under smallholder
monoculture and smallholder agroforestry. Smallholders are not only judged by yield per
hectare; economic efficiency is not only a matter of returns to land and returns to labour – smallholders can adopt a low input strategy, and continue making profits at prices that
would be economically viable. Such flexibility offers the possibility of efficient resource
allocation in response to diversification of economic opportunities. Results from he policy
analysis matrix (PAM) with the domestic resource cost (DRC), indicated that, under the
baseline scenario, the use of domestic resources in production of rubber was efficient and
socially profitable under the two systems but was more desirable under the monoculture
system given the current prices for physical inputs, outputs, technologies and policy transfer. However, even with sensitivity analysis of 10% increase in the price of rubber (holding
other factors constant) does not make the rubber agroforestry system more efficient than
its counterpart, and a 20% fall in the price of rubber, made rubber production under
an agroforestry system less efficient and undesirable. All measures are compared to the
alternative policy indicators currently used. Therefore, recommendations made from this
study relate to the need for diversification into better practices that can sustain efficient
rubber production under the agroforestry system, encouraging private sector participation
and reducing disincentives to rubber production.

Keywords: smallholder rubber agroforestry, economic efficiency, policy analysis matrix

Homegardening – a new dimension for household food security in vulnerable
southern coastal areas of Bangladesh

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Session 30. Socioeconomics, livelihoods, and island and coastal agroforestry

Abstract Coastal areas of the southern part of Bangladesh are rich in natural resources and food security,
but presently most of the resources are vulnerable because of natural and human activities.
A rapid increase in soil and water salinity has been identified as the most important factor
that is severely affecting crop, livestock, fish and forest productivity and diversity. Among the
different causes, fast-expanding shrimp farming and barriers to mixing fresh and sea water
are the major factors for increased salinity. As a result, croplands are becoming unsuitable
for production, and consequently, the majority of the areas are turning from food sufficient
to food deficit. Under these circumstances, households became dependent on homestead
resources for their livelihoods. Consequently, intensive homegardening has appeared as the
alternative source for food security and income generation by growing different types of
vegetables and fruit species along with the rearing of livestock in homesteads. Among the vegetables, *Colocasia* spp., *Solanum melongena*, *Lycopersicon esculentum*, *Basella rubra*, *Cucurbits*, *Lablab niger*, *Amaranthus* sp., *Brassica oleracea*, and *Moringa oleifera* were found to be dominant in the homesteads, which were reported by households to play a vital role in meeting family needs and acting as the main source of income. Diversity of tree species has been reduced as well, but few species were found to grow abundantly. The prominent fruit species were *Manilkara azapotilla*, *Zizyphus auritiana*, *Psidium guajava*, *Cocos nucifera*, *Areca catechu*, *Borassus Flabelliformis* and *Tamarindus indica*, and the dominant timber/fuelwood species were *Acacia nilotica*, *Samanea saman*, *Swietenia macrophylla*, *Leucaena leucocephala*, *Albizzia lebbeck*, *Lannea coromandelica*, *Melia azedarach*, and *Erythrina variegata*. Researchers and policy makers should pay attention to developing a sustainable management system that will save the valuable natural resources of the region.

**Interest in diversification through agroforestry for small-scale farms on Malo Island, Vanuatu.**

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**Session** 30. Socioeconomics, livelihoods, and island and coastal agroforestry

**Abstract** Coconut-based agroforestry systems have a central role in livelihoods on Malo Island, in the South Pacific. This complex pluri-specific plantation provides the family with both food and cash income, thanks to the association in space and time of food crops (mainly root crops) and cash crops (coconut, cacao and vanilla). Since the year 2000, vanilla has been developing on the island as a new cash crop. Farmers try to adapt their production systems to include it. Some of them chose to do so by associating vanilla with their main cash crop, coconut. A survey of these innovative practices and their economic results was conducted in 2005 and this resulted in economic modeling of this new agroforestry system. Based on this study, the process of diversification of production inside small farming units is analysed.

**Poverty and the environment's road to co-independence through agroforestry in Haiti**

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**Session** 30. Socioeconomics, livelihoods, and island and coastal agroforestry

**Abstract** The importance of the socioeconomic matrix surrounding agroforestry is particularly evident in Haiti, the poorest and most deforested country in the western hemisphere. This Caribbean island offers a contrast to the situation in the Pacific featured in this session. Political history, land tenure insecurity, and resource limitations contribute to Haiti’s current condition. This socioeconomic matrix is the biggest challenge to agroforestry, but with proper management the negative aspects of poverty can also be an opportunity. The Haiti Timber Re-Introduction Project (HTRIP) works directly with small-scale landowners and subsidizes the start-up phase of agroforestry plantations. This enables mountain communities to profitably restore their natural capital and transition from eroded slopes to agroforest plots. Moreover, the programme is integrated with community health and development programmes for a holistic, efficient approach. This paper describes the non-irrigated hillside agroforestry promoted by HTRIP using land-use systems analysis, which demonstrates how profitable agroforestry can be, and discusses the socioeconomic reasons why it has not yet become common practice in Haiti. We hope that HTRIP, which will begin sustainable tree harvesting in 2017, will be the start of a new chapter in the island’s history as emerging natural capital is integrated with increasing social capital.
Promoting agroforestry in the Pacific

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Abstract: Agroforestry is an old farming concept known to have been practised for thousands of years in many island countries in the Pacific when their forefathers developed farming systems that combined annual crops, trees, shrubs and perennials on gardens and farms. The traditional system has undergone considerable changes and modifications over the years in response to the local environment and socioeconomic needs. In most Pacific islands, particularly on atoll islands, where there is limited land area, the traditional practice of agroforestry has evolved through ages and has included the protection or planting of trees for the wide variety of products and functions that they can provide. The agroforestry systems and the technologies involved varied according to the ecological and socioeconomic conditions in the community. But the increasing demands for food, fuelwood, timber and other products together with environmental concerns, including climatic change, are putting a lot of pressure on these systems, and these issues need to be adequately addressed to ensure the systems' sustainability. The continued use of tree and plant resources by growing populations and the loss or degradation of woodlands has become a serious concern for the sustainability of valuable forest trees and non-forest products. The Secretariat of the Pacific Community, through its Forests and Trees Programme, is promoting the concept and practice of agroforestry mainly through: training/workshops in order to build the capacity of national and local communities and provide support in setting up demonstration trials and community nurseries; identifying and collecting threatened species and cultivars; collecting information on native tree propagation and diversification; planting trees in crop-land areas and developing intercropping and multi-storey tree gardens; assessing nutrient deficiency, propagation techniques and obtaining a better understanding of how to plan and implement programmes for the protection and enrichment of existing systems and their component trees. Promoting awareness on the importance of protecting and disseminating knowledge of traditional agroforestry systems and component trees and associated plants, including staple food cultivars, and integrating this knowledge with modern scientific technology for disease and pest control, soil improvement, propagation and nursery development are also given emphasis.

Socioeconomic analysis of agroforestry and livelihoods on a small island developing state: a case study of Pohnpei, FSM

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Abstract: The Small Island Developing States (SIDS) face unique challenges to establish sustainable development strategies consistent with their small size, remoteness, and fragile natural resources. Agriculture is considered instrumental in furthering sustainable development of SIDS. Agroforestry dominates many landscapes among SIDS, yet little is known about productivity, value, and use of agroforests or the role agroforestry plays in the livelihoods of SIDS. Such information is important to ensure that decision makers are able to establish sustainable programmes for economic development. Research conducted on Pohnpei, Federated States of Micronesia, documented livelihood systems, quantified agricultural activities, and simulated the impact of potential policy scenarios on both agroforestry and livelihood systems. One-hundred percent of households were engaged in subsistence agriculture, and 88% and 90% of households used crops for cash income and ceremonial purposes, respectively. Homegarden agroforestry practices provided between 24% and
98% of the total value of agricultural products. Agroforests contributed, per household, an average of USD 4242 yr⁻¹ and island-wide contributed 18% to Pohnpei's GDP. Limited market access was found to increase dependence on crops for cash income. In contrast formal employment was found to reduce dependence on crops for cash income. Using ethnographic linear programming, the results suggested that establishing a price policy and/or expanding market opportunities would contribute directly to households most reliant on agriculture for cash income but would have little impact on households reliant on fishing, remittances and formal employment for cash income. Desire for greater material wealth is threatening traditional cultures and limited natural resources on Pohnpei and SIDS worldwide. For those SIDS where agroforestry remains an important component of livelihood systems, development strategies should emphasize using agroforestry as a foundation for agricultural development. To achieve development goals for all members of an island's society, it is critical to tailor development strategies to specific livelihood systems.
Session 31
Rewards for the environmental services of agroforestry
Adopting a holistic approach to determine the financial performance and carbon sequestration potential of silvopastoral systems in Costa Rica and Nicaragua

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Session 31. Rewards for the environmental services of agroforestry

Abstract

Livestock related land-use changes are a significant source of carbon dioxide (CO2) emissions which contribute to climate change. In search of sustainable production systems which meet complex human needs ranging from food to environmental services, silvopastoral practices such as dispersed trees in pasture have been rediscovered which can – if well designed – increase livestock production and reduce atmospheric CO2 emissions. In our study we analysed the environmental and economic outcome of interactions of silvopastoral system components on dual-purpose cattle farms in the central Pacific region of Costa Rica and in northern Nicaragua to calculate the costs of carbon sequestration in these systems. We simulate the change from naturalized to improved pasture with trees which are incorporated through natural regeneration. Meat and milk yields under different canopy coverage are determined as well as the above-ground and below-ground carbon (C) sequestration potential of trees. Improved pasture without trees presents the land-use alternative with the highest net present value followed by pasture with 20 percent of canopy coverage which sequesters 104 tCO2 over a 30-year period. In Costa Rica, the establishment of pasture with lower or higher tree densities than 20 percent requires payments in a range of USD 0.8 to USD 4.5 per tCO2 to compensate farmers for foregone revenues. In Nicaragua, the establishment of improved pasture with up to 40 percent of canopy coverage is profitable without compensation payments. However, opportunity costs which occur when a paddock has to be closed for two years to allow for natural regeneration discourage many farmers from establishing the systems in focus. We suggest different payment schemes which could help to overcome this barrier to adoption of silvopastoral systems.

Agroforest carbon finance schemes in Indonesia

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Session 31. Rewards for the environmental services of agroforestry

Abstract

Deforestation contributes up to 25 percent of all anthropogenic greenhouse gas emissions, and Indonesia is the third largest emitter worldwide. On the island of Sulawesi in the vicinity of the Lore Lindu National Park (LLNP), many smallholders contribute to conversion processes at the forest margin as a result of their agricultural practices. Specifically the area dedicated to cocoa plantations has increased from zero (1979) to nearly 18 000 hectares (2001). Some of these plots have been established inside the LLNP. An intensification process is observed with a consequent reduction of the shade tree density. This study assessed the impact carbon sequestration payments for forest management systems have on the prevailing land-use systems. Additionally, the level of incentives which induce farmers to adopt more sustainable land use practices was determined. The household behaviour and their resource allocation was analysed with a comparative static linear programming model. At the plot level, the compensation payments were the highest for the full-shade cocoa agroforestry system, but with low carbon prices these constitute less than 5 percent of the cocoa gross margin. Focusing on the household level, however, an increase of up to 18 percent of the total gross margin can be realised. Furthermore, for carbon prices up to 32 €/t the majority of the households have an incentive to adopt the more sustainable shade-intensive agroforestry system and the deforestation activities of most households can be stopped.
Are PES-like mechanisms realistic, voluntary, conditional and pro-poor? Exploring opportunities for ‘tipping the balance’ of PES

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Session  
31. Rewards for the environmental services of agroforestry

Abstract  
Continued degradation of wealth-creating assets and sources of income flows for the rural poor in Nyando and Yala basins, is evident in high poverty levels, land degradation, increased frequency of environmental shocks, stronger upstream downstream linkages and the emergence of PES-like initiatives. Legal pluralism and multiple interests in typologies of ecosystem services interact at different scales to shape the nature of PES-like initiatives. Balancing multiple interests, and addressing challenges associated with high levels of poverty, land degradation and shocks will require beneficiaries of ecosystem services to recognize support and provide incentives for the rural poor to pursue land uses that provide the basis for stable productivity. The state of ecosystems and associated services is traceable to the lack of recognition, support and incentives for the rural poor. Payments for environmental services, although externally driven, are increasingly seen as mechanisms that provide a platform for achieving multiple goals, including the Millennium Development Goals. Predicting the success of the would-be PES mechanisms is a daunting task given the lack of context-specific pilots that can provide lessons. There are however, local and community-based PES-like initiatives that provide useful lessons to inform the design, adoption and scaling-up of PES mechanisms in the two critical river basins of Western Kenya. Understanding how context, culture, ecology, economy and governance shape the functioning and potential scaling-up of PES-like mechanism is critical in the design and adoption of transfer schemes for ecosystem services. In this paper we: i) scope, review and synthesize lessons from existing PES-like initiatives in the basin; ii) investigate the role of legal pluralism in shaping their functioning; and iii) review frameworks related to MEAs, MDGs, PRSPs and explore how use of PES could promote the achievement of MEAs, MDGs and poverty reduction goals and objectives.

Key words: assets, flows, PES-like, legal pluralism.

Assessment of potential challenges and opportunities in the implementation of legislation for payment for ecosystem services in Kenya

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Session  
31. Rewards for the environmental services of agroforestry

Abstract  
Payment for ecosystems services is an emerging concept in natural resources management. Just like the purchase of goods and services in a market place, consumers of natural resources should pay for them. Earnings from payment for ecosystems services should then be used for sustainable management of the said resources. Also, local communities surrounding such resources should be paid for hosting and managing the resources. Payment for ecosystem services is seen as an important means of internalising full costs and benefits of natural resources. In addition, local communities fully benefiting from the natural resources that surround them, are likely to be motivated to gainfully participate in the conservation of these resources. Payment for ecosystem services is addressed to a certain extent by recently published legislation, including the Water Act of 2002. However, payment for ecosystems services policy has not yet been fully implemented for various reasons, which may include inadequate understanding of the underlying principles, processes and frameworks. This paper seeks to analyse the Water Act and the associated subsidiary legislation to determine
the extent to which the government has implemented payment for ecosystems services, as well as eliciting existing challenges. The paper will be informed by best practices from other parts of the world.

**Can fiscal policies be designed to compensate for biodiversity conservation and strengthen small forest enterprise?**

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**Abstract**  
Compensation mechanisms for biodiversity conservation are yet unconsidered in Cameroon and the public remains largely unaware of conservation costs. Equally, direct taxation to raise money for conservation is likely to meet with resistance, unless perhaps, the conditions are better understood. Still, biodiversity conservation in community forests incurs opportunity costs, even though ecosystem services they produce remain public goods with non-excludable benefits. In general terms, the utilitarian perception of biodiversity conservation is hypothesized to be strong amongst forest resources management and conservation constituencies in Cameroon. Therefore, investigating the conditions under which this niche can support biodiversity conservation through fiscal instruments, the characteristics of such a taxation system and modalities for managing such a fund, are components of the hypothesis tested and reported in this paper. Few full methodologies have been developed for testing ‘willingness to pay hypotheses’. We used the payment card contingent valuation method (CVM), with the exception that our sample was targeted, not random. Being first of such known studies in Cameroon targeting was considered a safer way to maximize response rates. The study targeted 47 government services, non-governmental and international organizations. In total 400 responses were achieved with rates varying according to the question categories. Independent variables were: characteristics of the respondents; salary range; positions in organizations; expatriates/non expatriates; and gender amongst others. Dependent variables were discrete payment amounts or percentages of current prices, surplus to market prices for selected products and services; linked to forests, to disposable income, or habits weighing on public funds. In addition to ‘willingness to pay’ responses, the study generated: very wide interest; suggestions on how to improve usefulness of results; how funds raised should be managed; and above all, conditions under which people will be most willing to finance conservation via taxation.

**Carbon trading potential of babassu agroforestry systems in land reform settlements, eastern Amazon, Maranhão, Brazil**

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**Abstract**  
The babassu palm tree is a native multiple-use species of essential importance to the livelihoods of an estimated 300 000 peasant families in the eastern Amazon. Continuous expansion of cattle ranching in this region is causing the removal of babassu forests and the reduction of land available for the traditional slash-and-burn system locally known as ‘Roça do Toco’. This process has two clear consequences: shortening of the fallow periods to unsustainable levels and a decrease in the landscape carbon stock. One possible way of tackling these two problems at once is the establishment of ecologically sound land use with fire-free land preparation associated with the payment of environmental services for carbon sequestration, which would demand the implementation of a project with the involvement of hundreds of families. A scenario with small holders of land reform settlements located in
the state of Maranhão shows that if half of each farm with 30 ha is used for fire-free cropping systems and the other half for babassu forest regeneration, each farm can potentially capture 52 t year⁻¹ of carbon. This amount of carbon is additional, since without an intervention the new land-use system will not take place. Financial analysis revealed that the viability of the envisaged project is reached if one ton of carbon is traded between € 13 and € 17. The trading of the carbon guarantees annual cash earnings for the families and increases the household income in the long run, besides creating helpful technical and institutional frameworks. The time necessary to offset the opportunity costs reduces only 2 years, from 12 to 10 years, which would demand other short-term incentives. Despite the benefits, even the conversion of 2000 farms is not sufficient to invert the observed decrease in the regional carbon stock, making other additional initiatives necessary.

**Delivering on eco-certification’s promise for conservation and development**

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**Session** 31. Rewards for the environmental services of agroforestry

**Abstract**

Using jungle rubber – a traditional Indonesian agroforestry practice – as an illustration, this paper shows that eco-certification has promise for delivering conservation and development to the tropics. However, much fine print must be observed for this to happen. The conceptual framework behind eco-certification is that eco-motivated consumers will pay extra to purchase environmental services when they come with agricultural commodities. This extra amount can become a funding pool to maintain environmental services if used to compensate farmers for producing these services, thereby signaling demand for them. However, significant gaps exist between the concept and the practice of eco-certification. With wood, for example, large companies with power in retail sectors such as do-it-yourself construction, stock eco-certified products but do not promote them as such. As a result, awareness of eco-certification remains low and price premiums have not developed. Also, producers such as the Indonesian jungle rubber farmers have limited capacity for marketing to commercial buyers who export to the US and the EU, which have high demand for eco-certified products. One solution includes increasing capacity of smallholders to strategically position themselves in the environmental services value chain and to form partnerships that can bring in needed expertise and services. Research institutes must develop expertise in assisting the smallholder communities to gain this capacity. Another solution is using direct contracts between producers and marketing entities to separate the environmental services value chain from the value chain for the physical commodity. Doing so can facilitate an ‘accounting’ chain of custody that: lowers transaction costs over current chain of custody practices; allows eco-certification payments based on indicators of environmental performance rather than on quantity of commodity produced, which potentially creates perverse incentives; and conserves environmental services without requiring intermediaries to change purchasing practices.

**Emeralds on the Equator: an avoided-deforestation carbon markets strategy manual**

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**Session** 31. Rewards for the environmental services of agroforestry

**Abstract**

This strategy for producing and marketing avoided-deforestation carbon credits applies Thoumi’s Rational Convergence Model for effective communication, Thoumi’s Emeralds on the Equator ‘Zamrud Khatulistiwa’ Model for environmental services, Afuah’s New Game business model, and Nordhielm’s Big Picture model. Using the value stream of
raw materials, manufacturing, and marketing and sales, the avoided-deforestation project developer can successfully create value through carbon credits manufacturing and sales for the project owner. The 4 criteria a developer must use to successfully bring about an avoided deforestation project are the following: the land dictates the rules; rural communities are the gatekeepers for a project; governments dispense rights; and businesses structure risks.

**Estimating payments necessary to secure carbon services through smallholder agroforestry contracts in Tanzania**

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**Session** 31. Rewards for the environmental services of agroforestry

**Abstract** This paper estimates the payment necessary to secure carbon sequestration through agroforestry in the Uluguru Mountains in Tanzania. It informs the international debate on effectiveness of payments for ecosystem services (PES) in conserving environmental services. Under PES, land stewards receive direct economic incentives conditional on their efforts to secure specific ecosystem services. However, in absence of a competitive market, it is difficult to ascertain the payment necessary to compensate land stewards for their opportunity cost of adopting new land-use practices. Offering ad hoc payments results in under-performance of the programme and sometimes even in rejection of the conservation contracts by farmers if they are not adequately compensated. Similarly, potential poverty alleviation benefits may remain unfulfilled if poor people are unable to participate due to poorly structured PES contracts. This paper addresses these issues by exploring farmers’ willingness to adopt agroforestry in Uluguru Mountains. Ulugurus, part of the Eastern Arc belt, possess rich biodiversity and are a source of water for the cities of Dar and Morogoro. However, due to large-scale deforestation in the area, several of these services are under threat. Tree woodlots on marginal lands can arrest this deforestation and provide carbon services to the global community. Therefore, local farmers were asked to choose from several different kinds of PES contracts (varying by life of the contract, payment type and farm size) to take up tree woodlots. These choice experiments were followed by reverse auctions where conservation contracts were allocated as per the second lowest bid (Vickrey rule). Analysis of these field experiments answers the following questions: 1) what kind of PES contracts are acceptable to smallholders, especially the poor; 2) what is the equilibrium price at which farmers are willing to provide carbon services in the region; and 3) what is the supply curve for scaling up conservation at a landscape level in the Ulugurus?

**Payments for forest environmental services: an empirical experiment in Viet Nam**

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**Session** 31. Rewards for the environmental services of agroforestry

**Abstract** This paper assesses the potential for the ‘payments for environmental services’ (PES) conservation approach in Viet Nam. The study was undertaken by conducting an experimental PES scheme involving sustainable forest management in an upland area of central Viet Nam. The work was constrained by the fact that all land in Viet Nam is state-owned and that there has been limited PES market development in the country. However, the results of the experiment (in forest areas where the fundamental conditions for PES were met) were quite promising. Participation in the trial scheme was good, despite the fact that it was an experiment of limited duration. Moreover, institutional support was already available and effective. Expected environmental impacts were also observed: the sustainable forest
management regime that was tied to the PES scheme resulted in a reduction in both soil erosion and in destructive natural forest extraction activities. Income effect/livelihood impact and transaction costs of the PES scheme were also estimated. In light of these findings, it is suggested that more practical policy and programme trials should be implemented. These will allow Vietnamese policy makers to gain more experience and knowledge before the large-scale implementation of PES is tried in the country.

Payments for watershed services: implications and considerations for upland indigenous groups in Sibuyan Island, Philippines

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Session: 31. Rewards for the environmental services of agroforestry

Abstract: Payment for watershed services has gained worldwide popularity. Cases involving indigenous subsistence societies are sparsely documented. We examine the payment system implemented with upland indigenous groups residing on the slopes of Mt. Guiting-Guiting Natural Park in Sibuyan Island, The Philippines. An existing contract pays USD 105 per year each to 60 indigenous households to stop illegal logging, perform patrols and for agroforestry activities. We estimated the opportunity costs of the indigenous community for foregoing illegal logging by examining income and expenditure data. We found existing payments insufficient, covering only 50% of opportunity costs. Future payments can be augmented from downstream water users based on an estimation of their opportunity costs from future loss of watershed services. Using the replacement cost approach and rice production function, we estimated the value of water to domestic water users and rice farmers respectively. A referendum with 200 sampled respondents estimated people’s willingness to pay for two alternative 25-year land use scenarios with moderate and high levels of conservation practices in place. Results from the referendum show a preference for the high conservation scenario. The high conservation scenario will entail monthly transfers of USD 2.50 from 866 lowland water users to 60 upland farmers. This amount will not only cover opportunity costs from destructive activities but it will pay for scholarships of upland school children and transaction costs of the programme. Due to cultural, power and capacity limitations of subsistence societies to participate in market-based mechanisms, we found that NGOs or the state plays an important role as a social planner in facilitating payments and watershed agreements.

Potential of agroforestry to meet food security and environmental quality: moral persuasion, wielding stick or dangling carrot?

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Session: 31. Rewards for the environmental services of agroforestry

Abstract: One of the greatest challenges in many sub-Saharan African countries, many of which face seasonal food deficits, is how best to integrate the concerns for environmental quality into food security initiatives. Few land-use practices offer opportunities to attain the two seemingly divergent goals. Drawing from the lessons learnt from research and development on agroforestry for two decades in southern Africa, in this paper, we focus on fertilizer trees to highlight opportunities for agroforestry land-use practices to achieve food security and promote environmental quality. We noted that the dissemination of agroforestry among farmers has been based primarily on moral persuasion (sensitization and training). While some success stories have been recorded in some locations, farmer adoption of fertilizer trees has lagged behind relative to biophysical and technological advances already attained,
thereby reducing their potential impacts. We then used natural resource economics to provide economic logic for conditional incentive mechanisms (‘dangling carrots’) as an additional policy option to promote the adoption of smallholder agroforestry land-use practices in southern Africa. We then highlighted different strategies and policies on how the mechanism could reward smallholder farmers for agroforestry ecosystems goods and services that are generated by their investments in agroforestry land-use practices. These policies are required at both national and regional levels to align smallholder farmers’ incentives with those of the society, and ensure that farmers are mindful of environmental quality when making decisions on agricultural land use, and unlock the potential of agroforestry to meet both food production and global environmental quality. We concluded that beyond having the ‘right’ agroforestry land-use practices that can simultaneously support food security and respond to climate change, there should be complementary politics, market and policies that are conducive to the scaling-up of these practices.

Potential for PES to support smallholder agricultural development in East Africa

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Session 31. Rewards for the environmental services of agroforestry
Abstract Markets for greenhouse gas mitigation, if structured properly, have significant potential in East Africa to improve smallholder farmers’ incomes. These markets can also provide incentives for farmers to develop higher productivity, sustainable agriculture, agroforestry and community forestry systems. This paper describes the existing scale of the agricultural carbon markets in East Africa, the current and potential buyers and the extent of smallholder farmer participation. After setting this foundation, the paper explores the policy and institutional conditions that will be necessary for these markets to reach their potential for small-scale farmers in East Africa. In carbon markets, a post-2012 international agreement must support a trading regime that strengthens the global role of land-based carbon sequestration, and specifically includes agricultural offsets. National governance systems must guarantee the rights of farmers and farming communities to manage and sell the ecosystem services they provide. Innovative business and partnership models are required to reduce the transaction costs of engagement with large numbers of smallholder farmers in carbon deals. These conditions are especially important if carbon markets are to create incentives for landscape planning. Smallholder farmers and their organizations also need to access the technical capacity and financing opportunities necessary to benefit from these markets. The paper concludes by highlighting promising models for successful smallholder PES schemes and suggests specific investment strategies that could bring them closer to reality.

Private and social values of the cork oak agroforestry system in Tunisia

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Session 31. Rewards for the environmental services of agroforestry
Abstract Tunisia’s cork oak agroforestry system provides several goods and services, mainly from livestock grazing and fuelwood for local inhabitants, and cork for the government, and plays a considerable role in preventing soil erosion and sequestering carbon for the whole society. Private and environmental costs are usually incurred by local users’ overuse of public forests, resulting in forest degradation and soil erosion. This paper presents a comprehensive analysis and assessment of all components of the social economic value (SEV) associated with these forests. Private benefits (PB) exist on all returns which the government or the local population receives for the forests. By contrast, external benefits
(EB), represented by environmental services, are beyond the producers’ and consumers’ actions. Social benefits (SB) are totally for the whole society in general. Similarly, social costs (SC) include, in addition to Private costs (PC), the external costs (EC) caused by the producers and consumers to society. Results showed that SEV attained 66.8 €/ha in 2005, with nearly 71% of this value corresponding to private economic value, shared between the local users (62%) and the government (38%). The important value of the environmental benefits, 29 €/ha, confirms that their omission underestimates the economic value of the cork-oak agroforestry system and underlines the need for developing an environmental accounting system. Also, the important costs due to forest overuse and mismanagement (28.5 €/ha) show the losses induced by the current multiple uses. These results call for identifying policy tools such as payment of environmental services and compensation in order to attain a greater sustainable management and rationalized local usage.

Using markets to drive agroforestry: the case of eco-palms

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Session
31. Rewards for the environmental services of agroforestry

Abstract
The gathering and sale of NTFPs from important biosphere reserves can provide an important motivation for forest communities to protect and maintain those forests which generate important environmental services for society. A market for Eco-Palms has developed over the last 4 5 years through a partnership between: forest communities in Chiapas, Mexico, the Peten region of northern Guatemala, the Rainforest Alliance, PRONATURA, a large environmental NGO in Mexico, government agencies in Mexico and Guatemala, a large importer of floral goods in Texas, a floral wholesaler in Minnesota,. ‘Eco-Palms’ are marketed as socially just and environmentally sustainable products to Christian congregations for Palm Sunday celebrations with a premium payment going to the harvesting communities. Sales have grown from 5000 fronds in 2005 to over 580 000 fronds in 2008. This presentation will present the development of this project and the importance of the partnerships along with recent research results from a survey that was sent out to all congregations that participated in the project in 2008. The survey explored the reasons congregations purchased Eco-Palms and reasons for continuing to purchase palms in the future. Results demonstrate the importance of training communities to function as businesses and to maintain the quality of products sold in markets which emphasize environmental and social benefits.

Voluntary standards in coffee sector and payments for environmental services mechanisms, incentives to ES provision by agroforestry systems: the Costa Rican experience

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Session
31. Rewards for the environmental services of agroforestry

Abstract
With almost half of the national coffee production under voluntary private standards, coffee certification schemes have become an important incentive to maintain or change, as well as value, practices in coffee-based agroforestry systems (AFS) in Costa Rica. Based on a literature review, field data on the coffee sector and experiences of payments for environmental services (PES) in Costa Rica, this study compares the limitations and opportunities between certification schemes and PES as instruments to provide incentives for environmental services (ES) by coffee AFS taking into account their effects in term of ES provision and
socioeconomic impact, their efficiency and their financial and institutional sustainability. It also analyses the unique situation of Costa Rica where a wide range of private voluntary standards are already in practice and proposes a typology of existing certification schemes according to market characteristics and their potential role in ES provision. The study shows that PES is a territorial instrument relying on a strong institutional support together with good public private governance whereas private voluntary schemes are a commodity chain-based instrument relying solely on market governance. Thus, the first instrument is more directly linked to ES provision and its efficiency depends on local adaptation of the governance; the later is strongly affected by other factors such as quantity and quality of coffee production. The review also highlights the common limits of both instruments. Both are mainly oriented towards the promotion of ‘best agricultural practices’ rather than the effective provision of ES and thus, neither one makes a differentiation in remuneration according to effective ES provision level. In conclusion, operational recommendations are proposed to enhance the complementary benefits of the 2 instruments in order to increase ES provision of AFS.
Poster Abstracts
Forage potential of trees and shrubs for agroforestry in the West African humid tropics

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Preferred session: A2. Agroforests in humid tropical Africa

Abstract: Several trees and shrubs have been evaluated in the past 15 years in the search for trees and shrubs with potential for development of agroforestry technologies on the acid soils of the West African humid tropics. However, quantitative data on their fodder yield and quality are scanty. The paper summarizes research on fodder yield and quality of trees and shrubs with potential for development of agroforestry technologies in the humid tropics of West Africa.

Keywords: edible fodder, chemical composition, digestibility, tannins, gas production, palatability, in sacco rumen degradation.

Opportunities for judicious use of saline water for agroforestry in water scarcity areas of India

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Preferred session: B2. AF for salinity control and land rehabilitation in Central Asia

Abstract: Agroforestry is a most desired land use, especially for reclaiming and rehabilitating the degraded includes salty lands (6.7 million hectares in India), it has been estimated that poor quality water constitutes a major portion (30 84%) of ground water development, especially in dry regions of Rajasthan (84%), Haryana (62%), Punjab (41%), Karnataka (38%) and Gujarat (30%). The combination of judicious irrigation, suitable salt-tolerant plant species and ideal management options using proper techniques, can help increase sustained productivity of degraded lands through agroforestry in dry regions using saline waters. In one field experiment 31 tree species were evaluated for their establishment and wood production with saline water, and most suitable species for wood production were identified. Nine grass species were grown successfully with saline water particularly during the fodder scarcity period when people lead nomadic lives in search of fodder for their livestock. Many medicinal and aromatic, oil and spice-yielding, non-conventional and petro-crops suited to biosaline agriculture have been evaluated, and suitable species identified. Agronomic practices have been developed for potential and high-remunerative species such as medicinal psyllium (Plantago ovata) irrigated with saline water. The performance of agroforestry systems involving fruit tree species such as kaith (Feronia limonia), ber (Zizyphus mauritiana), karonda (Carissa carandus), anwla (Emblica officinalis) and bael (Aegle marmelos), and rain-fed or low water requiring crops such as cluster bean and barley, irrigated with saline water, have been evaluated. Results of a series of experiments conducted on calcareous sandy loam soil irrigated with saline water in water scarcity regions of northwest Haryana have also been reported in this paper.

Agroforestry systems and their contribution to the maintenance of biodiversity in arid areas: the case of Tehuacán Valley, Mexico

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We examined the ability of the main agroforestry systems of the dry Tehuacán Valley, Central Mexico, to maintain species richness and diversity of native vegetation and genetic variation of some key species. We identified the agroforestry system called ‘chichipera’ which maintains on average 72% of the plant species richness, and the system called ‘jiotillal’ which maintains 58%; no significant differences in species diversity were found between the wild vegetation and agroforestry systems (t=3.3471’ p=0.0886 in chichipera; and t=0.9659’ p=0.2453 in jiotillal). On average the agroforestry systems retain 54% of native perennial plant species, 94% of the genetic variation of species of columnar cacti existing in wild populations, and the population growth rate of one species studied is >1. The traditional agroforestry systems therefore are able to maintain biological diversity and processes of recovery of populations of key species that are impacted by land clearing practices. However, their ability to preserve rare and endemic species is limited. Processes influencing the maintenance of perennial species in agricultural parcels include: i) collective rules; ii) training and dissemination of information by the staff of the local Biosphere Reserve; and iii) the exchange of information for researchers between different institutions. However the agroforestry systems are under a process of loss, mainly influenced by: i) government programs aimed at removing patches of vegetation within agricultural land; ii) inequity in the amount of land managed by households; and iii) introduction of technologies to intensify agriculture. Policies to stop the negative processes and enhance the positive ones are discussed.

Synergy between green charcoal and agroforestry development

Soil fertilisation by charcoal (biochar) is an ancestral practice initiated thousands years ago by pre-Columbian Indians who applied fields with a mixture of carbonized matter and organic waste. This led to the formation of ‘Terra Preta’, a deep-colour soil with remarkable fertility, recently rediscovered by scientists. They observed that these qualities result principally from the presence of numerous carbonized particles that act as a ‘nest’ and facilitate the fixation of water and nutrients and the development of a rich and beneficial population of microorganisms. Not only agricultural crops but also trees such as acacia (Ogawa, 2004) or meranti (Forda, 2005) have been growing better with biochar amendment. However, a lot more research on the effectiveness of biochar in agroforestry systems has still to be done. Pro-Natura, with a long agroforestry experience, is encouraging research on biochar that particularly suits the production and promotion of its green charcoal. The Pro-Natura International green charcoal technology is well suited because the process can use agricultural residues in place of wood and does not emit methane. While initially only used as domestic fuel, green charcoal can perfectly serve as biochar. Pilot projects have therefore been established on sites where the substitution of wood charcoal for green charcoal already brings benefits to the environment by avoiding deforestation. Terra Preta assesses a very long duration of carbon sequestration in the soil and can thus be considered as ‘carbon sink’. Therefore, besides potentially fighting against poverty and hunger by improving the soil, biochar also offers an effective and sustainable solution to mitigate climate change. The generation of substantial carbon credits can help fund the development of agroforestry around the green charcoal machines.
Agroforestry model of biodrainage for combating waterlogging in northwest India

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Preferred session B5. Biodrainage for Prosperity

Abstract Waterlogging has become a serious problem in canal command areas located in arid and semi-arid regions of the world. To combat the problem, four parallel strip plantations of clonal *Eucalyptus tereticornis* (Mysore gum) were raised in December 2002 on ridges constructed in a north-south direction in 4.8 ha waterlogged area of Haryana state (northwest India) in which 10% of the area (0.44 million ha) has already become waterlogged resulting in reduced crop yields and abandonment of agriculture lands. The strip plantations were spaced at 66 m and each strip plantation contained 2 rows of plants at a spacing of 1 m x 1 m resulting in a density of 300 plants ha-1. Levels of ground water table were measured over 4 years in 22 observation wells installed in 2 transects across the strip plantations. The groundwater table underneath the strip plantations remained lower than the groundwater table in the adjacent fields without plantation. Rate of transpiration of strip plantations, measured with a sap-flow meter, was 50 litres day-1 plant-1 which was equal to 438 mm year-1 against the mean annual rainfall of 212 mm. Benefit-cost ratio of first rotation of strip plantations was 3:1 against 1.3:1 of agricultural crops in Haryana and it would be >100:1 for next 3 to 4 rotations, each of 5 years, due to negligible cost of maintenance of coppiced *Eucalyptus*. Wheat yield in the inter-space of strip plantations was 3.34 times the yield in adjacent waterlogged areas without plantation. This agroforestry model proved an ideal option for higher returns, in situ utilization of excess groundwater and reclamation of waterlogged areas.

Opportunities and plausible benefits of biodrainage over conventional drainage in combating waterlogging and salinity

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Preferred session B5. Biodrainage for Prosperity

Abstract Waterlogging and salinity have become a serious threat for more than 1/3 of the irrigated area of the world. The conventional engineering based sub-surface drainage systems are so costly that they cannot be installed on a large scale in developing countries such as India. Results of these systems already installed on a pilot basis at few sites in India are also not encouraging, due to their short life, environmental problems, very high cost of operation and maintenance, and a lack of farmers’ participation. Contrary to this, the biodrainage system in the form of agroforestry is relatively low cost, long life, environmentally friendly, highly remunerative and acceptable to farmers, as is evident from the studies conducted in 22 waterlogged villages of 7 districts of Haryana state (northwest India), in which 10% of the area is already waterlogged. The investigations carried out at a couple of sites have shown that the groundwater table beneath 20 year-old *Eucalyptus tereticornis* plantations on sandy loam soil remained lower than the adjacent fields; the area of influence was more than 730 m from the edge of plantation, the water table was maintained below 5 m depth, sinker roots reached the zone of capillary fringe above the groundwater table, and the soil and ground water salinity underneath the plantations was lower than in the adjacent fields. At some waterlogged sites the water table, which was within 1m at the time of strip plantation, has fallen down below 2.5 m after 5 years and farmers have harvested 39 t ha-1 wood biomass in addition to enhanced yields from arable crops. The plantation sequestered 18 t ha-1 of carbon in the above-ground biomass and 7 t ha-1 in the below-ground biomass. It could be concluded that biodrainage has a great potential for: increasing the production of crops and wood in waterlogged areas; and sequestering carbon.
Alley cropping – an option to combine crop and woody biomass production at degraded post-mining sites in Germany

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Preferred session  B4. Agroforestry in Europe: Land Reclamation
Abstract
The post-mining landscape of the Lusatian lignite mining district in northeast Germany is characterized by low precipitation and marginal soils at the initial stage of soil development (low water-retention capacities, low humus and nutrient contents). Due to these conditions crop yield stability is relatively low. Establishing an economically feasible land use on such sites is a challenge for farmers and foresters. Alley cropping systems (ACS) for biomass production offer a promising land-use alternative to enhance the economic value of such sites. The integration of hedgerows can improve the microclimate by shading and the reduction of the wind speed. As a consequence soil moisture and soil temperature will be more balanced and hence crop yield stability could be increased. Furthermore, the additional utilization of the hedgerows as energy wood can be a profitable source of income. In order to assess the overall impact of hedgerows in ACS on crop yields at poor sandy soils, an ACS was established in 2007 in the Lusatian lignite mining district. Hedgerows consist of four double rows of black locust and have a width of 12 m. Alfalfa was established in the alleys with a width of 24 m. Weather and soil data will be determined in different distances from the hedgerows in order to characterize their effects on microclimate and soil properties such as nutrient availability or C sequestration. In addition, crop yield and woody biomass data will be collected. Based on these investigations we expected a precise characterization of effects of hedgerows in ACS on microclimate, crop yield and soil properties. The results will be the basis for recommendations for an optimization of the tree-crop interaction in order to increase the reliability of plant production as compared to mono-cropping systems.

Evaluating ecosystem function and conservation potential for birds in cacao agroforests of Cameroon

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Preferred session  C1. AF, climate change, biodiversity conservation
Abstract
The cocoa agroforests of southern Cameroon are known for their tree diversity and are seen as a potential model for sustainable cocoa production systems across West Africa. There is an interest in identifying the ecosystem services these agroforests provide at a larger landscape level. Baseline data are needed to understand which birds are ecologically important in cacao agro-ecosystems. In addition, documenting management practices and resource availability for birds is an important first step to evaluating the conservation potential from cacao agro-ecosystems. To assess the conservation value of Cameroon cacao agroforests, we used mist-netting and area searches at the farm level (~1 ha) to survey birds found in 7 cacao-producing villages (4 farms per village, 28 in total). We found that Cameroon cacao agroforests support a high diversity of birds (150 observed species with 56 species in the cacao layer). This is not surprising considering the high diversity of trees observed in these farms (112 species). A high proportion of the birds found in the cacao vegetative layer were insectivorous and could help reduce pest outbreaks for farmers, providing an incentive for farmers to have an interest in their birds. In addition, many of the shade trees found in these cacao agroforests were also observed being used by hornbills in previous research in the nearby Dja Reserve. Many of these trees also provide economic value for farmers creating the possibility of a ‘win-win’ scenario where farmers’ economic interests are in line with conservation. This research demonstrates the potential value of cacao agroforests for biodiversity conservation.
Using cocoa-agroforests for biodiversity conservation around protected areas: the case of the East Nimba Nature Reserve (Liberia)

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Preferred session: C1. AF, climate change, biodiversity conservation

Abstract:
Cocoa agroforests constitute a land-use system, which mimics the forest and can buffer protected areas and help avoid edge effects. It can also create corridors between fragmented forest stands and allows cocoa farmers to earn diverse incomes through the sale and use of multiple produce while conserving nature. This also lays the basis for any payments for environmental services produced by the systems. The East Nimba Nature Reserve (ENNR) in northeast Liberia is part of the Upper Guinean Forests of West Africa and it is considered a biodiversity hotspot. The ENNR faces complex environmental and developmental challenges due to a marked trend of deforestation and land degradation. Population growth, increasing deterioration in existing agricultural lands, coupled with poverty of the local peoples, have resulted in severe pressure on resources in the reserve. To reverse this trend, the Sustainable Tree Crops Program (STCP) with support from the World Bank and USAID initiated a biodiversity conservation project in 2007 that seeks to use cocoa agroforestry to reduce the intensity of encroachment on the reserve. One of the main objectives is to improve cocoa farmers’ awareness of the importance of biodiversity conservation since cocoa is one of the main cash crops in the landscape surrounding the reserve. This presentation discusses biodiversity conservation models that hinge on the local values of the area while relating them to universal issues. It also describes a participatory learning and demonstration approach proposed by STCP to encourage mutual learning between farmers and experts to create and share knowledge on the different (traditional and scientific) concepts of biodiversity conservation. It goes on to discuss processes used to train farmers and forestry authorities as community conservationists for the reserve. Finally, it ends with a recommendation on the idea of payment for environmental services to farmers in conservation.

Wildlife diversity and farmer livelihood in rural landscape mosaic at the forest margins of southern Cameroon

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Preferred session: C1. AF, climate change, biodiversity conservation

Abstract:
One of the challenges faced by landscape managers in the Congo Basin fringe is the difficulty in separating land for biodiversity conservation from land useful for farmer livelihoods. Smallholder multi-strata agroforestry practices such as cocoa agroforestry have been cited as potential land use that can integrate both biodiversity and farmer livelihood considerations at the landscape scale. In order to assess the potential of the rural landscape mosaic for the conservation of wildlife as well as farmer livelihoods, this preliminary study consists of (1) wildlife transects (n=35Km), (2) hunter-follow surveys (n=14), and (3) socio-economic interviews (n=42) in four villages across a gradient of human population density (from peri-urban to remote), in a rural land-use mosaic consisting of (a) cocoa agroforest, (b) food crops, (c) fallow fields, (d) secondary forest and (e) primary forest. We observe, among other results, that (i) mammalian diversity increases with village remoteness, (ii) secondary forest has the largest proportion of animals signs of all land uses, (iii) cocoa and cassava are the most important sources of income, (iv) cocoa and hunting are increasingly important parts of the household annual revenue (as a percentage of total contribution) in more remote locations (that is, if cocoa income were to decline due to decreasing prices/demand, income would need to be substituted from other sources, with the possible effect of increasing pressure on wildlife). The study ends with a discussion on the potential role of smallholder cocoa agroforestry for biodiversity conservation and support of rural livelihood in the forest fringe.

Key words: rural landscape mosaic, wildlife diversity, livelihoods, southern Cameroon
Smallholder agroforestry models of biodrainage for reclamation of waterlogged areas in semi-arid regions of northwest India

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Preferred session: B5. Biodrainage for prosperity

Abstract: A farmer’s model of biodrainage was developed in waterlogged area at Hisar, in northwest India. Twelve bunds 150 m long, 2.6 m broad and with 45 cm height, were raised in a north-south direction in a 10 ha waterlogged field on the university campus. The distance between the two bunds was 60 cm and this size of plot represents the actual plots of the farmers. Eleven tree species i.e. Melia azedarach, Eucalyptus tereticornis clone-10, Terminalia arjuna, Pongamia pinnata, Casuarina equisetifolia, Tamarix aphylla, Callistemon viminalis, Eucalyptus tereticornis clone-130, Eucalyptus tereticornis clone-3, Eucalyptus hybrid and Prosopis juliflora, were raised on bunds with two rows of plants. At the age of 3 years, Eucalyptus tereticornis clone-10 showed the best growth followed by E.tereticornis clone-130, E.tereticornis clone-3 and Eucalyptus hybrid (E. tereticornis x E. camaldulensis). Tamarix aphylla, Melia azedirech and Pongamia pinnata also showed excellent growth on bunds, however, the growth was much lower compared to the eucalypts. The canopy of young eucalypts (leaf area index 3 to 4) was more effective in lowering the water table up to 30 50 cm than other broad leaf species. The comparative potential of biodrainage of these broad-leaved species was also studied more accurately through the lysimeter technique. The rates of transpiration in Prosopis juliflora and Casuarina equisetifolia, were significantly higher than eucalypts although the later group has higher rates of photosynthesis. The model of biodrainage described above has also been developed at farmers’ fields, and was found cheaper in establishment, environment friendly and economically viable. The effectiveness of the farmers’ model of agroforestry to ameliorate the waterlogged or shallow water able soils is discussed in detail. The strategies to promote such models are also discussed.

Does tree management affect aboveground and soil carbon sequestration in Acacia mangium Willd in the humid tropics of India?

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Preferred session: C2. Carbon sequestration in agroforestry

Abstract: Initial spacing and tree pruning are customary stand management strategies in silviculture to meet particular management objectives. A field experiment was conducted at Thiruvazhamkunnu, Kerala, India to evaluate the changes in above-ground and soil (0 15 cm) carbon pools of 6.5-year-old Acacia mangium trees; it was influenced by stand-management practices such as planting, density regulation and tree pruning. The experimental variables included four planting densities (625, 1250, 2500, and 5000 stems ha-1) with and without 50% crown pruning arranged in a factorial RBD design with three replications. The carbon- sequestration potential of A. mangium trees was significantly (p<0.01) altered by the planting density and pruning treatments. The low-density stands (625 trees ha-1) had higher mean tree C-accumulation (46.87 kg tree-1) which declined with increasing density (21.68 kg tree-1 for the 5000 stems ha-1 stand). However, the stand-level trend followed a contrasting pattern. The above-ground C-sequestration on a per hectare basis was significantly higher for the 5000 trees ha-1 (108.42 Mg ha-1) compared to 29.3 Mg ha-1 for the 625 trees ha-1. Tree pruning in general reduced the rate of C-sequestration. Pruned trees had lower biomass C (57.18 Mg ha-1) than unpruned stems (73.57 Mg ha-1). Soil C stocks in the Acacia mangium stands also indicated considerable variations with planting densities. Treeless control plots registered the lowest soil C stock (24.7 Mg ha-1 for the 0 15 cm layer) while the stand with 2500 stems ha-1 showed the highest soil C content, implying some negative effects of very high stand densities (for example, 5000 stems ha-1) on the soil C pools. Nevertheless the Acacia mangium trees in general had considerable potential to enrich the C status of the top soil layer.

Keywords: Acacia mangium- C-sequestration- stand density-pruning- soil C
Rehabilitation of degraded riparian forests and watersheds based on useful trees: issues and lessons from Benin

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Preferred session: B3. Riparian system effects on soil and water quality

Abstract:
Riparian forests (RFs) and their watersheds are of extreme ecological and economic value for local people. Their rich biological resources are now disappearing before they can be inventoried and assessed. The forest law in Benin recognizes the uniqueness of RFs, and clearance of wood and shrubs is not allowed within 25 m on both sides of any water course and stretch of smooth water. Meanwhile the implementation of the protection rules in these particular ecosystems, especially in non-protected areas, leaves a lot to be desired. It is planned in Participatory Management Plans (PMP) for forest reserves that RFs will be left uncut. Unfortunately for biodiversity conservation this measure in RFs is not implemented. Most recent PMPs include RFs as “priority zones for protection” with a 500 m wide buffer at each side of major waterways, and strict conservation rules are intended to be applied. Apart from sacred stands of RFs and water sources where indigenous rules are respected, nothing is done for RF and watershed rehabilitation in rural lands. Most municipalities do not implement zoning plans that protect marginal vegetation and hot spot biodiversity ecosystems, such as RFs and their watersheds. They are more interested in selling all their land including floodplains, marshes, and waterways with their forested banks. Therefore, simply protecting RFs in a buffer zone may not be adequate to ensure their existence in the long term. Instead, the integrated management of RFs must be a component of good landscape management plans that take into account agroforestry systems with the conflicting needs of all stakeholders. Trees, such as Pterocarpus santalinoides, Cola laurifolia, Syzygium guineense, Berlinia grandiflora, Elaeis guineensis, Manilkara multinervis, Xylopia parviflora, Dialium guineense, Diospyros mespiliformis, etc. can be used for the rehabilitation of degraded RFs and watersheds.

Keywords: Riparian Forest, Biodiversity, agroforestry systems, useful trees, rehabilitation.

Can golden-headed lion tamarins survive in cabruca agroforest? Management implications for an endangered species and habitat

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract:
Cabruca is a type of agroforest with planted cocoa trees and a native forest overstorey. It has been considered an important habitat for conservation of Atlantic Forest biodiversity in southern Bahia State, Brazil. Cabruca is the predominant forest habitat throughout the range of golden-headed lion tamarins (GHLT), Leontopithecus chrysomelas, an endangered primate endemic to this region. Cabruca and the biodiversity it contains are now under threat in Brazil due to economic crisis in the cocoa industry. Understanding how GHLTs use this agroforest and how the species is affected by cabruca management emerges as an important conservation objective for both species and habitat. We evaluated demographic and ecological parameters for GHLTs in different areas of cabruca agroforest. We captured and monitored four groups of GHLTs in four privately owned farms. Two of the areas were covered only by cabruca forest and were smaller than those groups living in areas with different habitat types (92.5 and 136.5 respectively). These preliminary results suggest that GHLTs can live and reproduce in cabruca agroforests, with demographic and ecological
aspects apparently similar to groups that live in primary forest. Thus conservation of cabruca agroforests directly contributes to conservation of this endangered primate.

Institutional innovations in rehabilitating degraded public lands through agroforestry in the Terai of Nepal

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Preferred session D3. Policy formulation and stakeholder engagement in NRM
Abstract The Terai is composed of alluvial and fertile plains in the southern part of Nepal covering about 17% of the total land area and about 8% of the total forest area of Nepal. However, the forests are located towards the northern part resulting in a situation in which traditional people have limited access to forest resources. In addition, the restrictions imposed by community forests have further toughened the situation for receiving the forest products. Further, the location and distance has limited the contribution to and benefit sharing from the community forests. The situation has demanded novel approaches to creating forests and forests products in the Terai. It was discovered that there are thousands of hectares of unmanaged public and institutional lands in the region. These lands are degrading both in quality and quantity. Recently, a new institutional innovation in rehabilitating such lands through agroforestry has emerged, in which the management responsibility for these lands is transferred to the poor and marginalized community. This paper is based on the case studies of nine Terai districts. Latest statistics show that there are 400 groups managing 600 ha of lands involving 13 000 households in 80 village development committees. The paper presents the process and approaches of institutional mobilization, investment, and effects of management at household, community, and local government levels. The study found that the approach is encouraging with regard to generating income, rehabilitating degraded lands, increasing supply of crop and forest products, health improvements and planting motivation on private lands. The paper argues that the innovation is instrumental not only for greening the region but also in developing an inclusive approach to resource management and reducing vulnerability of the poor. Recommendations have been made for improving the scaling up of the program.

Agroforestry as a way forward to mitigate climate change and loss of biodiversity in the development of tropical peatland

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Preferred session C1. AF, climate change, biodiversity conserv
Abstract The conventional way of peatland tropical development has resulted in a loss of biodiversity and an increase in emission of carbon dioxide. An agroforestry approach is considered one of the best development practices for meeting economic and ecological objectives. This study, carried out at Sessang MARDI Research Station in Sarawak, aimed to quantify the impact of human activities on biodiversity and climate change. The pattern of biodiversity (microbial, plant, and insect) and CO2 flux was monitored over three types of peatland ecosystem: natural, conventionally developed and agroforestry-developed areas. In conventionally developed areas, natural peatland was cleared by felling and burning. In the agroforestry areas, natural peatland was selectively cleared and big trees were left standing. Our preliminary results indicated that clearing of peatland resulted in reduction of biodiversity and emitted more carbon. However, minimal disturbance activities through selective clearing reduced these negative impacts. The results imply that an agroforestry approach may be adopted to develop peatland ecosystems in a more sustainable manner. Current and future research activities are investigating the selection of the potential short-term crops to be planted within this new ecosystem.
Sustainable biofuel production systems on marginal lands: fiction or fact?

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Preferred session | B7. The role of degraded lands in biofuel production in SE Asia

Abstract
The objective of this paper is to critically address sustainable biomass production for future bioenergy and the role of agroforestry by using marginal lands. Whereas a promising future has been sketched for the role of biofuels in development, serving a dual role in the Millennium Development Goals on poverty reduction and climate-change mitigation, there is also increasing skepticism. Critics speak of the ‘biofuels myths’, referring to the lack of evidence of biofuels benefits and pointing at biofuels and their inefficiency in reducing greenhouse gas emissions and reducing climate change. Likewise there are reports on production of biofuels leading to competition with land used for food crops, rising food prices, dependency on subsidies, conflicts with land-use rights, conversion of natural forests and impacts on biodiversity and ecosystem services. The use of unproductive marginal lands may provide an outcome for the issue of land competition, particularly in Southeast Asia where idle grasslands cover 34 (4% of total land area) to 54 million ha. Moreover, the generation of land-use avoiding co-products may put first-generation biofuel crops, that also serve as food crops, again in a different perspective particularly where planted in an agroforestry setting. Yet, also with biofuel crops on marginal land, the debate on perspectives of sustainable biomass production continues, with theoretical considerations stressing large-scale, high-production potentials being confronted with questions about smallholder production potentials and ecological, social, economic and technological limitations. In order to cope with these criticisms, integrated research on the sustainability of the biofuel value chain and its driving forces is needed to be able to grasp a complete picture and distinguish fiction from facts.

Pongamia pinata – propagation through vegetative means

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Preferred session | B7. The role of degraded lands in biofuel production in SE Asia

Abstract
Pongamia pinnata a medium-sized evergreen tree with a spreading crown and a short bole, which belongs to the family (Papilionaceae). It is one of the few nitrogen-fixing trees producing seeds containing 30 40% oil. It thrives in areas having an annual rainfall ranging from 500 to 2500 mm, in its natural habitat, the maximum temperature ranges from 27 to 38 °C and the minimum from1 to 16 °C This species grows to an elevation up to 1200 m. It can grow on most soil types ranging from stony to sandy to clayey. It is among the few species in India, which can yield oil as a source of energy in the form of biodiesel. The present paper deals with the standardization of vegetative propagation techniques for P. pinnata through stem cuttings and through air layering. By treating with different concentrations of IBA, NAA and combination of IBA and NAA, including a control. Among the 4 seasons, Spring (February cuttings) was the best for achieving maximum sprouting and rooting success. IBA was found to be the best auxin for the treatment of cuttings in reference to all the parameters, followed by the combination of IBA+NAA and NAA alone, respectively. Among the different concentrations of growth hormone, the concentration of 400 ppm was found to be the best. For air layering studies different concentrations of IBA were used. The data were recorded for sprouting, rooting percentage and rooting-related parameters. The biochemical changes occurring during rooting, and effect on rooting success were studied. The results showed that P. pinnata can be successfully propagated vegetatively through stem cuttings as well as through air layering.
Improve Farmer Livelihoods by Increasing Agrobiodiversity: A Case Study in the State of Veracruz, Mexico

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Preferred session: A4. AF in Mesoamerica: perspectives and challenges

Abstract
This research was conducted during 2007 with the aim of contributing to livelihood improvement of citrus producers through increased agrobiodiversity in the state of Veracruz, located on the Atlantic coast of southeast Mexico. Citrus-based agriculture is the principal economic activity in the agricultural sector of the state of Veracruz. It is practised in mono-crop plantations by the majority of farmers, who are rendered vulnerable to price depreciation resulting from simultaneous harvest and over-supply of a single commodity. Some innovative farmers have therefore associated multiple crops in citrus farms (agroforestry techniques) as a strategy to improve their livelihoods. The results indicate that farmers who increased agrobiodiversity in their farms have significantly improved their livelihoods compared to mono-crop plantation owners. Further, the associated benefits can be classified in three ways, which correspond to the tripartite goal of sustainable development: (i) ecological sustainability (through increased ecosystem resilience); (ii) economic stability (through diversified, less risk-prone sources of income); and (iii) social well-being (through lower unemployment and increased reliance on indigenous knowledge). Conclusively, it is argued that increased agrobiodiversity can serve as an important strategy to improve the livelihoods of citrus producers in the state of Veracruz. However, further research is required to recommend appropriate plantation crop combinations suitable for different biophysical conditions and easy adoption by different categories of farmers.

Keywords: agrobiodiversity, rural livelihoods, citrus plantations, citiculture, agroforestry, multiple cropping, Veracruz, Mexico.

Genetic improvement of Jatropha curcas

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Preferred session: B7. The role of degraded lands in biofuel production in SE Asia

Abstract
Developing countries such as India are experiencing an energy security crunch mainly because of the fast depletion of fossil fuels. Out of many non-edible tree-borne oil-seed species Jatropha curcas is recognized as having the greatest potential for biodiesel production in India. There is lot of variability for growth and seed characteristics in this species. Hence, exploration trips were carried out in during 2003 to 2006 to collect the germplasm from various parts of the country. The collection of 284 accessions from Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Chhattisgarh, Uttar Pradesh and Uttrakhand was conducted. A wide range of variability was recorded for fruit and seed characters among all accessions. The range of oil content in seeds was 22.79 to 47.12%. Eighty-seven accessions were recorded for oil content of more than 35% in seeds. All accessions have been planted in the field in form of progeny and provenance trials to assess growth and seed yield. The accessions with high seed and oil yield at the National Research Centre for Agroforestry were sent for a multilocation evaluation trial in varied agroclimatic conditions. Ninety intraspecific crosses have been developed and are being evaluated in experimental fields for seed and oil yield. A study on reproductive biology reveal that the ratio of male to female flowers was from 14:27 male:1 female, in case of accessions, whereas in the case of crosses the ratio was 8:10:1. A number of crops in rabi and kharif were raised under agri-silvicultural trials with Jatropha plantation. Accessions were analysed for biochemical activity and are being characterized at molecular level.
Holistic analysis of coffee-based agroforestry and management priority setting in the northeast Atlantic Rainforest of Brazil

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
A case study, funded by the Brazilian Ministry of the Environment in the Atlantic Rainforest, was conducted in the Baturité Highlands, Ceará State, to identify innovative farmers’ solutions with agroforestry system (AFS) practices. The site is an island of rainforest emerging from the semi-arid lowlands, and harbours 5000 hectares of shaded coffee dating from the end of the 18th Century. With 13% of forest cover remaining and harbouring a Critically Endangered 2008 IUCN Red List Category endemic parakeet (Pyrrhura griseipectus), this is a high-priority case for conservation.

The performance of farm and AFS economic and ecologic indicators was explored by principal components analysis, aiming to identify variables to support policies. These shaded coffee farms contain 1 60% more native forest cover than is demanded by Brazilian law. Coffee produces an average of US$ 15 gross income (GI) per unit of human labour (UHL) invested, a value 1.8 times that of a competing subsystem cattle ranching. Farms with a higher density of shade trees (340 versus 120 trees/ha) produce 15% less GI, but equaled GI per UHL invested in the system; and fruits in the AFS increase farm incomes. Projections considering improvements in coffee processing quality, shade and timber management indicate a 3.7-fold increase in the current GI (US$ 627 ha-1 year-1). With larger forest remnants to take care of, coffee productivity under 100 kg ha-1, an aging rural population, and real estate speculation as a negative outside vectors, farms over 50 ha are specially prone to conversion to banana farming, cattle ranching or real estate for tourism.

Investments of US$ 173 to US$ 557 ha-1 year-1, financed over a period of up to 15 years, could competitively promote the recovery of these shaded coffee farms and their role in conservation-through-use of this Brazilian Atlantic Rainforest hot spot.

Mitigation efficacy of vegetated buffers in reducing non-point source pollution: a critical review and meta-analysis

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Preferred session B3. Riparian system effects on soil and water quality

Abstract
Vegetated buffers are one of the most studied and widely used agricultural management practices for reducing non-point source pollution. A wealth of existing literature provides experimental data on their mitigation efficacy. This paper aggregated many of these results and performed a meta-analysis on them to quantify the relationships between pollutant removal efficacy and buffer width and buffer slope. Theoretical models for removal efficacy (Y) versus buffer width (w) were derived and tested against data from the surveyed literature using statistical analyses. A model of the form, ( ) is shown to successfully capture the relationship between buffer width and pollutant removal, where K reflects the removal capacity of the buffer and b reflects its probability of removing any single particle of pollutant in a unit distance. The estimates of K are 90.9, 93.2, 92.0, and 89.5 for sediment, pesticides, nitrogen (N) and phosphorus (P), respectively. Buffer width alone explains 37, 60, 44 and 35% of the total variance in removal efficacy for sediment, pesticides, N and P. Buffer slope is linearly associated with sediment removal efficacy either positively (when slope < 9%) or negatively (when slope > 9%). Buffers composed of trees have higher N and P removal efficacy. Soil type did not show statistically significant effects on pollutant removal efficacy. Models for all the studied pollutants are statistically significant with P-values < 0.001. Based on our analysis, a 30 m buffer under favorable slope conditions removes over 85% of all the studied pollutants. These models predicting optimal buffer width and slope could be instrumental in the implementation and design of vegetated buffers for treating agricultural runoff to meet specific water quality objectives. The quantitative relationship established, also provides valuable information for modeling buffer efficacy at the watershed scale.
Climate change mitigation through agroforestry in South Sorong District, Papua

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract

Agroforestry practices could be used in developing adaptation and mitigation strategies for climate change. In Papua, agroforestry has been developed for social and community forest purposes, to increase income of local communities, ensure environment sustainability and maximize opportunities to get international funding. However, very little research has been conducted regarding agroforestry practices particularly endemic species choice for climate change mitigation (carbon sequestration) and for income generation for local people. The objective of this study was to develop a mitigation effort in the forestry sector through the establishment of agroforestry-based community forest management. The evaluation of the mitigation potential of selected endemic species, and community income were also examined in South Sorong District. A comprehensive mitigation analysis process (COMAP) model was used for data analysis. Three categories of community forestry were evaluated: simple agroforestry systems (patterns 1-4), complex agroforestry system type 1 (pattern 5) and complex agroforestry system type 2 (patterns 6 and 7) respectively. The result show that the simple agroforestry system gave mitigation potential value of ~500 tC/ha, the complex agroforestry type1 system was ~550 tC/ha), and the complex agroforestry type2 system was~700 tC/ha. Both simple style agroforestry system and complex agroforestry systems produced positive financial impacts, with a range from USD 16 752 to USD 62 775 per ha/rotation. The benefit from agroforestry systems is double that of a monoculture system (forest plantation). The total area available for agroforestry system implementation is approximately 226 259 ha in South Sorong District alone.

Large mammals in traditional cacao plantations and forest remnants in the Una-Lontras Corridor, southern Bahia, Brazil

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

Traditional cacao plantations (cabrucas) are a common habitat in southern Bahia and the mainland used in the corridor between two of the largest forest blocks in the region: Una Biological Reserve and remnants at Serra das Lontras. Given the high forest loss and fragmentation, cacao agroforests are considered critical environments for the native flora and fauna. Although large mammals have been previously recorded in cabrucas, little is known about which species are able to use these habitats and which landscape factors influence their use. We recorded large mammals in 31 cabrucas and in forest remnants adjacent to nine of these plantations using camera-traps to: 1) compare large-mammal frequency of occurrence between environments, and 2) investigate the influence of the amount of forest cover in the surrounding landscape on large mammal frequency in cabrucas. Eighteen native mammals were recorded in cabrucas, including four threatened species; six of these mammals (two of which were threatened) were seldom recorded, and five had sufficient records to allow comparisons. Two primates (Leontopithecus chrysomelas and Callithrix kuhlii) and the opossum (Didelphis aurita), a generalist species locally threatened by hunting, were widespread, being more frequently recorded in forest than in cabrucas, and/or more frequently recorded in cabrucas if these were surrounded by larger amounts of forest. Contrary to this observation, the frequency of occurrence of two common generalist carnivores (Cerdocyon thous and Procyon cancrivorus) in cabrucas was negatively influenced by the amount of forest, probably benefiting from the scarcity of specialist carnivores. Our results indicate that although cabrucas are a relatively permeable habitat for large mammals, including some threatened species, their frequency of occurrence in cabrucas depends on the amount of forest in the landscape. This suggests that the role of traditional cacao plantations in corridor conservation strategies will depend on the maintenance of forest patches at the landscape scale.
Agroforestry and biochar potential for carbon sequestration

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Preferred session  C2. Carbon sequestration in agroforestry

Abstract

The biosphere faces imminent, irreversible and potentially catastrophic climate destabilization. Anthropogenic greenhouse gases have been unequivocally confirmed as the driver of these changes. Recently, a growing number of climatologists have revised estimates for the safe upper-limit of atmospheric CO2 levels downward to between 300 and 350 parts per million (ppm), whereas the current levels are around 378 ppm. It is becoming increasingly clear that we will not only need to reduce present emission levels (6.7 Pg C year-1) radically, but that we will also have to sequester large amounts of carbon dioxide out of the atmosphere. Biochar has been proposed as a unique approach to establishing sustainable, verifiable and long-term carbon sinks with the ancillary benefits of renewable energy production and soil fertility enhancement. The scale and rate at which biochar production will need to be ramped up in order to sequester large amounts of carbon dioxide, however, is a significant challenge that will depend on a wide range of complex social, political, technological and economic factors. Therefore, a sustainable and comprehensive ‘systems approach’ to mitigating and adapting to climate change is being proposed, of which biochar plays a central, but non-exclusive, role. Sustainable agroforestry methods are essential to informing the overall biochar soil sequestration strategy. The initial findings of this paper suggest that a draw down of 5 Pg C year-1 (roughly 74% of annual global fossil fuel emissions) is possible using sustainable agroforestry methods in combination with biochar production.

Analysis of nitrate, ammonium and E. coli NAR in tile drain effluent from two adjacent maize agricultural systems: a mixed tree

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Preferred session  C3. Agroforestry, water quality and env amelioration

Abstract

Contamination of groundwater in agricultural areas by nitrate and E. coli can potentially lead to several harmful health effects for those who consume or are exposed to it. The objective of this study was to determine if trees can reduce loadings of these contaminants to the groundwater. Tile drain effluent from two adjacent agricultural systems (a mixed tree intercrop and a monocrop) was collected from April to November during 2005 and 2006 from a mini watershed area of 17 200 m2. An area of 1100 m2 (6.4%) in each system was subject to application of a mixture of water and a biotracer E. coli NAR, a naturally occurring strain that is resistant to naladixic acid and has been shown to be safe for introduction into the environment. The effluent was analysed for concentrations of the biotracer and NO3-N. The premise of this study was to determine if the safety net hypothesis is valid in a temperate intercropping system. The quantities of NO3-N in the leachate were similar in 2005: 57.37 and 54.74 kg ha-1 leached from the monocrop and intercrop sites, respectively. However in 2006, NO3-N levels were significantly higher (P<0.05) in the monocrop effluent: 164.67 kg ha-1 compared to that of the intercrop, 88.59 kg ha-1. Few significant differences were found in E. coli NAR outputs during both years: for the same number of samples collected, the total colony forming units (CFU's) found in the monocrop and intercrop effluents, respectively were 4040 and 3558 in 2005 and 34 025 and 28 401 in 2006. This indicates that intercropping systems and perhaps trees in general have a potential mitigating effect on E. coli movement to the groundwater.
Spatial decision support for coffee pests and diseases risk management in Costa Rican agroforestry systems

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract: The occurrence and intensity of an epidemic are determined by the interactions of the host with the pathogen or the pest, the environment and the agronomic management (as shade management in coffee agroforestry systems). As a consequence of the spatial heterogeneity of these factors, patchiness is the rule in the distribution of plant pests and diseases. Environmental information is now readily available in high resolution and can be combined with spatial analyses to determine potential pest and disease distribution due to environmental factors, and subsequently lead to better decisions and improved risk management. The objective of this paper is to show how better decisions and disease risk-adapted agroforestry practices, for entire coffee growing regions, can be derived based on spatial decision support tools and a minimum of ground data evidence. We used ground data, on coffee pests and diseases, collected in previous surveys conducted in Costa Rican coffee plots within a range of shade density. The diseases retained for our analyses were coffee rust (Hemileia vastatrix), American leaf spot disease (Mycena citricolor), and coffee blight (Phoma costarricensis). We first used the environmental data for the coffee plots with less shade density, and generated for the different diseases the decisive environmental driving factors by means of Geographical Information System (GIS). The climatic data such as radiation, precipitation and temperature are derived on a 1 km resolution. We used algorithms based on maximum entropy, Bayesian statistics, and spatial analysis to delimit areas with distinct risk potential. The results appraise the disease risk of coffee growing areas associated with their physical characteristics. For the areas where the results were significant, the decisive factors for each disease are identified and shade-management strategies are suggested according to their known effect on these factors.

The influence of shade trees on coffee quality in small holder AF systems in southern Colombia

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract: Production of coffee, especially by small holders, is often associated with various forms of shade management. To analyse the effects of shade on physical coffee quality and on sensory cup quality of Coffea arabica L. cv. Caturra KMC, a study was carried out with 94 plots on 16 farms in 2 municipalities, Timaná and Oporapa, located at elevations from 1272 to 1730 m above sea level in Huila, Colombia. The study was designed with emphasis on shade cover variation within each of the 2 study areas, while minimizing the variability of environment, agronomic management other than shade, and post-harvest processing. Forty-six samples of shade coffee and 46 samples of sun coffee were evaluated for physical and sensory attributes using 3 professional coffee cuppers (assessors). A principal component analysis including all quality and environmental variables showed that sensory attributes were influenced negatively by shade, and that physical attributes were influenced positively by altitude. A mixed linear model, with coffee cupper and farm as random variables, revealed different shade effects on coffee quality in the 2 areas. In Oporapa, situated at high altitudes, shade had a negative effect on fragrance, acidity, body, sweetness and preference of the beverage, while no effect was found on the physical quality. In Timaná, situated at lower altitudes, shade did not have a significant effect on sensorial attributes, but significantly reduced the number of small beans. At high altitudes with low temperatures and no nutrient or water deficits, shade trees may thus have a partly adverse effect on C. arabica cv. Caturra resulting...
in reduced sensory quality. The occurrence of berry borer (Hypothenemus hampei) was lower at high altitudes and higher under shade. Further shade effects were assessed, such as influence on coffee plant health, though not quantitatively. The results led to immediate benefits to some farmers through improved marketing.

Tree crop portfolios, life cycles and commodity markets in West Africa

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Preferred session A2. Agroforests in Humid Tropical Africa

Abstract
In the humid tropics, a ready-market environment for export-oriented tree crops may lead to farming systems generating one overwhelming source of monetary revenues. This has been the case for cocoa for decades in West Africa. Whatever the complementary role of food crops and the use of shade trees, cocoa provides more than 90% of the monetary revenues to migrant cocoa farms in Côte d'Ivoire and Ghana. The first aim of this study was to update the information available about forms of intercropping or monocropping of the ‘big five’ tree crops in the humid tropics, cocoa, coffee, oil palm, coconut and rubber. They are considered here as ‘shares’ at the only ‘stock exchange’ available to smallholders in the humid zone: tree crops. How do smallholders combine the advantages and disadvantages of these shares to build a portfolio? The second objective was to identify the market factors interacting with other determinants that lead farmers to intercrop these trees in the same farm plot or a different plot. Surveys were conducted with some 500 farmers in the forest zones of Ghana and Côte d'Ivoire. Farm structure data were first recorded, followed by farmers’ opinions about advantages and disadvantages of various tree crops, and about the choice of intercropping. Farmers logically tended to opt for ‘shares’ that bring returns as early as possible. Monthly revenues, adapted to a modern life, was also very much searched for. Food security was not neglected. Some food crops were maintained in mature cocoa farms and still play the local role of ‘grocery’. Mainstream markets for the ‘big five’ do not seem to encourage smallholders to associate tree crops in the same plot, as if farmers were more confident in one share than in a trust fund. However, this leads to a kind of mosaic landscape which is not that far from agroforestry land use.

Environmental services by agroforestry systems: how to operationalize them?

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
Agriculture is among the main sources of income in developing countries, as well as being an important driver of environmental disturbance. Agroforestry, by combining agricultural and forestry components, with specific management strategies at plot, community and landscape scales, can satisfy multiple demands, among which is the provision of environmental services. Environmental services are proposed as compensation mechanisms to revert negative ecological impacts; these incentives must be based on an adequate understanding and evaluation of the services provided. For this purpose, based on multicriteria and multivariate analyses, we have devised a protocol that addresses the assessment of environmental services provision, through an integrative insight on influential components, but without neglecting the farmers’ productive priorities. The approach combines productive, ecological and operational indicators, and aims to identify the management decisions that encourage overall system performance. The protocol was focused on biodiversity as a case study and it was carried out in northern Brazil. The sample considered 3 groups of farmers, based on the time of settlement, property size, technological know-how, organization and access to market, that is, ‘CAMTA partners’, ‘immigrated’ and ‘newcomers’. The study revealed the following factors as the most relevant in encouraging biodiversity: (a) the farmers’ technical qualification and their preference for low-impact techniques; (b) their capacity to adapt to environmental, social and political changes; (c) the diversification of species composition at plot level and the increase in the use of perennial ones; and (e) the financial profitability of the system. Concerning the assessed groups, the ‘CAMTA partners’ perform significantly better than the other two, due mainly
Carbon sequestration of smallholder tree farms and agroforestry farms in The Philippines

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Preferred session C2. Carbon sequestration in agroforestry

Abstract
Carbon budgets of terrestrial ecosystems and agro-ecosystems play an important part in the global carbon cycle. Recently, much interest has been focused on the role of such systems in mitigating climate change through carbon sequestration. Our aim in this paper is to synthesize ten years of research on the potential of smallholder tree farms and agroforestry systems in The Philippines to sequester carbon. Aside from published information, we included new research results and unpublished data. The first part of the paper presents and analyses carbon sequestration rates from various smallholder farms and agroforestry systems in The Philippines. In general, these systems have high carbon sequestration of up to 9.9 tC/ha/yr with a mean of 4.0 tC/ha/yr. However, there is wide variation depending on site quality. The second part of the paper explores the potential of smallholder tree farms and agroforestry systems in accessing the emerging carbon markets. Case studies of projects under preparation in The Philippines are presented. Barriers that could hinder successful project implementation are analysed and lessons are drawn.

Incorporating agroforestry approaches into commodity value chains

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
The productivity of tropical agricultural commodities is affected by the health of the ecosystem. Shade tolerant crops such as coffee and cocoa benefit from environmental services provided by forested landscapes, enabling landscape design that meets biodiversity conservation and economic needs. What can motivate and sustain adoption of such landscape approaches? Rather than a proliferation of externally funded projects there are major new opportunities through the international market that buys these commodities. Companies are promoting agroforestry approaches through their supply chain, requiring producers and traders to demonstrate that the source of their commodities complies with a set of principles that conserves forested landscapes and improves local livelihoods. This paper will present examples of international companies that are moving in this direction, analyse why and how they are doing it and discuss the impact that has been measured in coffee and cocoa communities in Latin America and Africa. It will particularly consider the role of standards and certification systems as a tool for promoting profitable production, environmental conservation and social responsibility, and for enabling the international market to communicate its commitment to its customers as the most responsible way to source goods from fragile tropical ecosystems. It will further argue that such approaches are already being taken to scale and are not operating only in small niches of the market.
Smallholder farmer survival strategies in Arabica coffee agroforestry farming systems of East Africa

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract:
Smallholder coffee farmers in producing countries face many uncertainties given the nature of their product. In East Africa specifically, the domestic consumption is under 2%, ensuring that the farmers are subjected to the volatility of global markets. This also means that currency fluctuations affect smallholder farmers. Given information asymmetry, farmers are at the receiving end of the transaction costs of a constantly changing global market. At the farm level, the yields are not consistent either, based on access to inputs, labour and externalities like weather, pests and plant diseases. And when other factors like population and social pressures are added, the farmer is in a regime of very limited choice. Based on a farmer’s survey in the Arabica growing areas of Mt Kenya (Kenya), Lake Kivu (Rwanda) and Mt Elgon (Uganda), this paper attempts to assess farmer responses to externalities and limited choice in order to survive and better their lives. The paper briefly characterizes the pressures on farmers and evaluates in depth how farmers respond differently at different times to these pressures. It also compares and discusses the difference in the agroforestry farming systems and farmer survival strategies across the 3 countries. The results suggest that the farmers are finding it increasingly difficult to cope with the coffee markets and are trying to shift to other crops. But for many smallholders coffee is the only means to access cash because, along with having an assured market, the crop allows farmers to access credit from the coffee value chains or as an advance on the next coffee crop. Also, given the inconsistencies of local labour markets and limited access to off-farm sources of income, coffee is a significant part of the annual income of the farmer, hence maintaining its importance within the agroforestry systems in the region.

Trees establishment constraints and role in rehabilitating degraded dryland in Sudan

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Preferred session: B6. Agroforestry as a tool for landscape restoration

Abstract:
A crop production land-use system is problematic in semi-arid areas where drifting sand is a prevailing condition. Creating obstacles or decreasing soil surface roughness enhances sand settlement, which changes the soil level critical for gravity irrigation systems. Therefore where protection is questionable, sustainability of crop production is at risk. This study was carried out at Umjawasir, north Sudan, on irrigated, 1000 Fadden, with wheat as the main crop. The study consisted of three phases: phase zero (unprotected), I and II (protected). The research aimed to assess the risk to sustainability presented by drifting sand, and to investigate the efficiency of earth embankments (used as a protection measure) compared to the role of selected trees species.,. The results indicated that the cultivated areas that had been abandoned due to sand invasion were 100%, 35% and 25% of the total cultivated areas of phase zero, phase I and phase II respectively. It showed that the earth embankments gave effective protection, but over 13 years sand developed into dunes in the vicinity of the farm and these served as secondary source of sand and a potential major hazard. The effectiveness of Leptadenia pyrotechnica, Prosopis juliflora, and Panicum turgidum in trapping drifting sand was studied (by the author elsewhere). Leptadenia and Prosopis species have the capability to capture moving sand providing good protection, while Panicum was very efficient given its small size. The establishment, survival and growth of Leptadenia pyrotechnica, Prosopis juliflora and Panicum turgidum were investigated with and without protection from sand blasting and deposition. Unprotected soil had rain water run-off, while protection was not very effective, but irrigation was effective. Establishing trees without irrigation appeared impossible. This suggests that irrigated shelterbelts could be the solution in the study area and other similar areas in Sudan.
Taungya system in the Blue Nile Riverine Forest Reserves, Sudan

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Preferred session: B3. Riparian system effects on soil and water quality

Abstract

The study deals with the taungya system in the blue Nile Riverine Forests with special reference to Gazair Forest, Sennar State, Sudan. The first objective of the study was to test the effect of intercropping on growth of Acacia nilotica (Sunt). The second objective was to test soil moisture during the cropping period since flooding was the only means of irrigation. Theta probe devices were used for this purpose. Pit sowing was applied to Sunt at a distance of 2x2 m using complete randomized block design. The crops involved were chickpea, haricot bean and watermelon. Results show no significant difference in Sunt growth (using parameters of height and diameter) between the control and under the different crops after 2 cropping seasons. The yield of crops was fairly considerable during the first season when compared to similar conditions of dry tropical zones, except for haricotbean. There was a reduction in yield of all crops during the second season of intercropping due to influence of trees. Results of moisture content show that it was very ample and adequate for all crops and Sunt seedlings during the study period. Throughout the Taungya experiments results show a reduction and saving in the initial cost of the plantation for the forests department of up to 114 person-days/ha/yr.

Coffee and cocoa base agroforests in the southern Côte d’Ivoire: evaluation of their diversity.

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Preferred session: A2. Agroforests in humid tropical Africa

Abstract

The first producer of cocoa in the world, Côte d’Ivoire has developed huge plantations through national and foreign industry and multinationals. Alongside these huge plantations, the peasants produce some cocoa on a smaller scale. This occurs on farms belonging to individual farmers and their families. These plantations of smallholder producers are located on land around villages. Through their vertical and horizontal structures, these farms can be said to be agroforests. Most of them contain a significant number of trees, shrubs, palms, bananas and other fruit trees. This study attempted to describe and analyse these coffee and cocoa-based agroforests. It showed that agroforests of Cote d’Ivoire come from either the conversion of a natural forest or the conversion of secondary vegetation and fallows. They involve food crops and perennial crops such as coffee and cocoa. Botanical inventories achieved in 12 coffee and cocoa-based agroforests show that they are composed of 87 plant species and 10 species of birds, small mammals and insects. Among the plants, 5 species are identified as vulnerable on the IUCN’s Red List of endangered and rare species. The plant species recorded are used in medicinal, food, construction and for other mystical purposes. Finally, the study concluded that the sample of agroforests studied have a conservation value for biodiversity.

Keywords: agroforest, biodiversity, coffee, cocoa, Côte d’Ivoire
Forest carbon, land tenure, and carbon revenue distribution

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Preferred session: C2. Carbon sequestration in agroforestry

Abstract

This paper analyses the iterative relationship between land tenure, the design and success of community-based forestry carbon finance projects (reforestation activities) and the carbon revenue distribution mechanisms. The paper is a comparative case study of 4 forestry carbon-sequestration projects in sub-Saharan Africa currently being implemented under the Clean Development Mechanism (CDM). Following a brief presentation of the 4 projects in Kenya, Ethiopia, Niger, and Madagascar, the paper discusses: changes in the land tenure situation among those involved in the projects during project design and implementation; how the land tenure situation impacts project design; and the carbon revenue distribution mechanism at the project level. As part of this analysis, the paper looks at how the land tenure situation in the different projects affects its institutional set-up, including the functions of a carbon aggregator, contractual arrangements for the purchase and selling of carbon credits, and flow of carbon revenues to individual project participants at the community level. The paper also analyses the extent to which a change in the land tenure situation, if one occurred, can be attributed to the implementation of the project itself or whether it was rather a necessary pre-condition for implementing the project. Based on the analysis of the 4 case studies, the authors provide some general observations on the links between land tenure, the design of forest carbon projects and the carbon revenue distribution mechanism adopted by the country.

Efficacy of teak (Tectona grandis) and dahoma (Piptadeniastrum africanum) heartwood water extracts on the durability of five LUS

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Preferred session: C3. Agroforestry, water quality and environmental amelioration

Abstract

Although conventional wood preservatives such as CCA, Pyrinex 48EC and creosote are found to be very effective against wood-destroying organisms, they are known to cause environmental pollution, carcinogenicity, liver damage and teratogenicity and ultimately climate change. A few of them are lethal to animals and human beings at certain doses. Even chromated copper arsenate (CCA), the most widely used preservative in Ghana, which was thought to be non-toxic to humans and animals because of its permanence and stability in wood, has now been revealed by research to leach into the environment over time. In an effort to find new preservatives which do not pose these problems, efficacy of teak and dahoma (highly and moderately durable timber species respectively) heartwood water extracts (0.60 g/ml), was tested on selected lesser-utilized timber species (LUS), Sterculia oblonga, Antiaris toxicaria, Canarium schweinfurthii, Celtis zenkeri and Cola gigantea of varying natural durability, by non-pressure impregnation and buried in a termite prone field for 8 months following EN 252. The effect of teak and dahoma heartwood water extracts were tested based on visual durability ratings, percentage hardness and mass losses of impregnated selected LUS after burial. Regardless of retention levels, teak heartwood water extract improved the natural durability of selected LUS to a greater extent than dahoma heartwood water extract. Improved durability of LUS was ranked as follows: Sterculia oblonga = Cola gigantea > Celtis zenkeri > Antiaris Toxicaria > Canarium schweinfurthii. Though extracts showed reduced efficacy over time, indications were that extracts from the heartwood of tropical timber species such as teak could be employed to preserve their low-durability counterparts eluding such problems that come with conventional wood preservatives.
Diversity of coffee shade trees and traditional management practices in coffee-based agroforestry systems of South Ethiopia

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Preferred session A1. Multistrata agroforestry systems with perennial crops
Abstract The coffee-based agroforestry systems of Dale district which evolved from wild coffee forests, possess diversity of tree species maintained as shade for coffee, boundary and front yards plantings. This research was undertaken to understand the traditional coffee-based agroforestry and tree-shade management practices and species diversity in the system. The major data collection techniques used in this study were a semi-structured questionnaire-based survey, point transect-based sampling of shade tree diversity and percent canopy cover, a group interview, observation and review of secondary data. The collected data were analysed descriptively and logically. The result shows that 5 tree species are most frequently used as shade and a similar number of other tree species was entirely excluded from the farm because of inferior qualities with respect to several parameters. The main criteria for selecting and using a tree in farm practices are soil-improving quality, moisture discharging capacity, availability of seed, wood quality, shade level, moisture retention, cash generation, cultural value and non-negative effects on livestock and people. On the basis of a transect-based tree inventory, 71 perennial species were registered. Trees that were severely threatened and scarce in the natural forest also grew more abundantly in a domesticated landscape. Farmers manage shade trees to maximize benefits and reduce their adverse impact on component crops. Major tending practices used are: pruning of branches; pollarding of the entire crown; removing the stump of dead and felled trees; and removing less vigorous trees. The shade trees are either planted, deliberately retained or wildlings. In order to avoid competition and enhance complementarity of species, farmers manipulate their trees and crops by segregating them in time and space. It can be concluded that traditional coffee shade management is contributing to the preservation of species diversity in the region.

Keywords: shade trees diversity, agroforestry, south Ethiopia, coffee-shade management

Agro-silvipastoral model for improving productivity of marginal salt-affected lands in the Aral Sea Basin

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Preferred session B2. AF for salinity control and land rehabilitation in Central Asia
Abstract An agro-silvicultural model of trees intercropped with complementary crops was evaluated on marginal lands in an arid climate in Central Asia. Herbaceous fodder crops planted within the inter-spaces of salt-tolerant tree or shrub plantations improved productivity of saline-prone soils, solved the animal feed gaps in the lands degraded both by overgrazing and salinity and increased the profits for farmers. Wild halophytes planted in widely spaced patterns allows for easy mechanical cultivation and harvesting of forage grass and legumes. Our findings from the screening of 16 multipurpose tree species (MTS) showed a high survival rate, quick relative growth rate, high adaptive features and utility value of fuelwood and/or foliage. The most promising species were Haloxylon aphyllum, Populus euphratica, P.pruinosus, P.nigra var.pyramidalis, Elaeagnus angustifolia, Robinia pseudoacacia, Tamarix hispida, T. androsowii, Salix babylonica, Cynodon oblonga, Armeniaca vulgar, Malus silvestris, Acacia ampliceps, and shrubs Atriplex canescens, A. nitens, and A. undulata, Hippophae rhamnoides and Ribes niger including native rangelands halophytes, either on their own or mixed with various traditional salt-tolerant fodder crops. Tree or shrubs plantation requires limited irrigation during the initial stage of growth before sole reliance on available drain water (Ec ≤ 4.0, 3 dS m⁻¹) resources become possible. Species of Tamarix, Elaeagnus and Salix having an exceptional ion-salt translocation/bioremediation mechanism are
often referred to as aggressive colonizers since they tend to invade natural habitats and push out less salt-tolerant species. *E. angustifolia*, *Morus alba*, *M. nigra*, *Acacia ampliceps* and *Atriplex* species are possible alternative supplementary feed to low-quality roughages throughout the off-season. The expansion and commercialization of non-timber forest products has the potential to increase the cash income of rural households.

**Change legislation to rebuild agroforests. Rebuild agroforests to change legislation**

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops

**Abstract**

In recent years, research has emphasized the benefits of agroforestry in enhancing positive externality and environmental services of biodiversity in cocoa cultivation. However, in practice, in the two major producing countries, complex agroforestry cocoa production systems are shrinking both in terms of surface area and number of species. The timber legislation in Africa and what farmers perceive of this legislation, having been excluded from the legal timber market for decades, is one of the main factors behind this trend. One of the reasons farmers cut or burn their trees is to avoid disturbance by logging companies that come to extract trees from their cocoa farms, without any reasonable compensation. The main objective of this paper is to show that this trend will not be reversed by legislation change coming from the top, with the hope that fewer trees will be spoiled, but rather by a move from below, from farmers themselves. The question is now less one of preserving existing or surviving ‘chocolate agroforests’, but rather one of having smallholders favouring tree regeneration from the stumps and planting trees, mostly indigenous trees, and organising themselves for that purpose. The only method is to review a few initiatives taken by a few institutions and by farmers themselves with the aim of re-inserting timber trees in their farming systems, mostly by planting. Among these initiatives, one undertaken in Ghana in the early 2000s by an Italian NGO seems to have been successful since some farmers continued to maintain their trees and even kept planting after the project closed. Some farmers also started to informally organize themselves to get coverage in papers in the capital of the country and defend their property rights. The paper evaluates the main factors and lessons that can be drawn from of this experience.

**The role of cardamom agroforests for biodiversity conservation in Tanzania**

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

Is shade-grown agriculture an ecologically viable answer to tropical forest restoration and connectivity? The East Usambara Mountains of Tanzania contain what may be the most biologically rich forests in Africa. Within the current era of promoting conservation incentives for expansion of forest cover, encouraging shade-grown cardamom is proposed as a method to utilize private land to expand forest cover in order to increase ecosystem services and habitat for biodiversity. Most of the ecological research in this area has occurred within protected government forests. This study fills a critical data gap by providing empirical floristic evidence of the role of cardamom farms in biodiversity conservation and the ecological functionality of cardamom forests as corridors and habitat for forest species. Floristic data from protected areas, mature secondary growth, and active and recently inactive cardamom farms are analysed to determine the ecology and conservation value of cardamom forests. The results are discussed in the context of current economic and development realities in the East Usambaras, and related to relevant literature from other tropical agroforestry systems. Although, cardamom farms on average are only slightly poorer than natural forest in some biological aspects including species richness and endemism, they differ in attributes of canopy structure and size-class composition, and are dominated by an invasive exotic tree. Agroforestry may not be the best method to increase connectivity of a biodiversity and endemic species hotspot. However, compared to the sun-grown crops that are replacing the cardamom forests due a number of converging factors, agroforestry is seen as having a role in the East Usambara landscape.
Charismatic carbon Inpang Community Agroforestry Carbon Bank, northeast Thailand

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Preferred session C2. Carbon sequestration in agroforestry

Abstract

Tropical forests play an important role in climate change – as a source of greenhouse gas emissions from deforestation and in terms of their mitigation potential. Pressures on tropical forests by local people may, however, be alleviated through the adoption of agroforestry. Certain complex agroforestry landscapes actually mimic tropical forests in ecological form and ecosystem function. One advantage of agroforestry systems is the potential to provide farmers with a number of possible income streams from non-timber and timber products as well as resources for their own subsistence. Agroforestry landscapes that increase the long-term storage of biomass by replacing annually cropped areas with diverse production systems that incorporate perennials, especially trees, have an additional marketable commodity in carbon. The conversion of low-biomass landscapes, such as annually cropped land or grassland, to agroforestry systems with high-biomass landscapes, mitigates climate through the sequestration of atmospheric CO2 and its storage in biomass. Agroforestry, therefore, has the potential to mitigate climate change and also provide an additional income stream to farmers. Members of the Inpang Community Network in northeast Thailand have initiated an ‘Agroforestry Carbon Bank’ in line with the tenants of the ‘Sufficiency Economy’ promoted by His Majesty King Bhumibol Adulyadej of Thailand. The project is developing measuring and monitoring protocols, and a web-GIS carbon registry management application for small-holder agroforestry carbon offsets. The ‘Carbon Bank’ aims to link sequestered carbon in agroforestry landscapes to carbon buyers on the Chicago Climate Exchange or other credible, voluntary markets. This paper highlights the lessons learned in developing the Inpang Community Agroforestry Carbon Bank and the accomplishments to date. Arguably, agroforestry carbon is a more socially and environmentally valuable form of carbon offset than a single-species reforestation plantation, which also sequesters atmospheric CO2. It is feasible, that sequestered carbon in different landscapes, might seek differential pricing from markets.

Use of CAF2007, a process-based model of coffee agroforestry systems, to represent and understand the evolution of coffee productivity in two long term trials in Mesoamerica

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract

Coffee is frequently cultivated under shade in Mesoamerica. The effects of shade trees on coffee productivity depend on the environmental conditions: mainly temperature, humidity, solar radiation and rainfall patterns. Crop models may be useful to assess current systems and modify their shade management, to improve productivity and provision of environmental services. The CAF2007 model was recently developed to simulate coffee growth and yield elaboration under shade at plot scale, under Mesoamerican environmental and technical conditions. The model was first compared with the scientific and local knowledge on coffee productivity under shade. Our results show that coffee phenology is correctly accounted for in the model, although the module that simulates the effects of light and water stress on flowering needs adjustment. The water module, carbon accumulation module and N balance module were then tested in coffee plantations, using 2 experimental data sets. When adequately parameterized, the modules did simulate correctly the variables measured, with a few exceptions. Proposals were formulated to develop or modify modules, to improve the simulations. The model was then parameterized to reproduce 2 data sets from two 7-year-old experiments of CATIE, with coffee cultivated under diverse shade trees.
and N management: one in Turrialba, Costa Rica, under humid conditions, with no definite dry season, and one in Masatepe, Nicaragua, with a very pronounced dry season. The model was able to reproduce the evolution of coffee bean production and the accumulation of biomass in the experiments. Functional explanations for observed evolutions, related to excessive shade and to insufficient N inputs, were proposed from the model. The implications of these results for future model improvement and applicability are discussed.

Using agroforestry to mitigate crop damage by grasshoppers, invasive weeds and other plant pests

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Grasshoppers are seasonal insect pests which reurface at the start of rainy season, the farming season and sprouting of new vegetation, feeding on almost all green plant material, damaging food crops, economic plant species and destabilizing ecological systems. Their actions are rapid, devastating and difficult to control. About 58 chemical control methods have been found to successfully eliminate grasshoppers, but chemical actions are extensive and will kill many other useful plant and animal species. An agroforestry approach using Cassia semen was adopted as a process that is cheap, environmentally safe, increases benefits, maintains ecology and biodiversity, eliminates other invasive weeds and pests such as Centrosema pubescens etc. Three trial plots of 1hectare each, hedged around with Cassia semen were set up. Plot I was an abandoned fallow, spot planted with Cassia semen; Plot II was cultivated, monocropped with maize and furrow line planted with Cassia semen; Plot III was cultivated and planted with assorted crops, maintaining existing economic trees in a mixed-cropping fashion with Cassia semen. Physical observation during 5 year periods on Plot I, indicated grasshoppers isolated Cassia semen and fed on the other plants. In Plot II, damage was high during the first 2 years and diminished as Cassia semen sprouted and developed, while stock borers appeared to increase over time. Plot III, had no damage or significant disease effects, instead productivity increased. Cassia semen was observed to have a toxic and repellent effect on grasshoppers as those that fed on it died. Mixed-cropping with trees prevented the spread of disease and pest epidemics in plant communities, ameliorated microenvironment and production. Non-determination of the chemical components or elements in Cassia semen, noted to be toxic or repellent to grasshoppers is a gap to be filled.

Keywords: agroforestry, biodiversity, cassia semen, ecosystems, pest control, plant pests.

Selecting framework tree species for restoring degraded montane tropical forests in Kenya based on natural regeneration

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Preferred session B1. Quantifying the role of AF in modifying watershed functions

Abstract Framework tree species are indigenous tree species, planted to complement and accelerate natural regeneration and biodiversity recovery of degraded natural forests. In Kenya, past restoration attempts have failed due to inadequate knowledge of the ecology and silviculture of most indigenous tree species. Two theories have been used by ecologists to explain recovery dynamics of degraded forests: 1) recovery starts with pioneer species which later facilitate establishment of true forest tree species; and 2) there is no facilitation, and that pioneer and true forest species grow together. In this paper we evaluated the potential of 16 indigenous tree species which naturally regenerated in a degraded forest that has undergone recovery for 11 years. Species were enumerated in zones which had just started to recover, in advanced naturally restored zones and in the natural forest.
We used multivariate analyses to examine the relationship between species composition of tree seedlings, saplings and mature trees, and environmental variables—zones, grazing, and human disturbances—to explore how much these variables explained the variation in natural regeneration and species composition. We found that the sapling stage is the best indicator of the success of a tree species in germinating and establishing in any site. Saplings of 9 tree species were strongly related to the recovery zones but had low abundance in the natural forest. Seven tree species had saplings that had low association with any of the 4 zones. We tested the extent to which these 16 species influenced the regeneration and establishment of other tree species, in order to rank their potential suitability as restoration species. Five species were ranked as ‘excellent’ framework species. Eight species qualified as ‘acceptable’ framework species. The remaining species were ranked as ‘marginal’. Two species performed poorly in most respects and should probably be rejected as framework species.

Phytoremediation of a metal-contaminated industrial soil of Porto Marghera

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**Preferred session**
B4. Agroforestry in Europe: Land Reclamation

**Abstract**
A field test to evaluate the phyto-remediation technology used to mitigate As, Cd, Pb and Zn contamination in an industrial area located in Porto Marghera (Venice Lagoon, Italy) was studied. The polluted area is an artificial island, 41 ha wide, built using different materials, including industrial by-products. Two clones of *Populus deltoids* (Dvina, Lena) one of *P.x Canadensis* (Neva) two of *Salix matsudana* (S76-005 and S76-008) and one of *Salix alba* (SI64-017) were planted in an experimental area of 1600 m² in a randomized block design with four replications at a density of Short Rotation Coppice (6000 plants/ha). The different clones were evaluated for growth, photosynthesis, transpiration rates and re-growth capacity after cutting in order to select the best suited to the specific environment. For each clone, metal accumulation capacity was measured in roots, stems and leaves. The hydrological balance of the tree stand was also calculated, to evaluate the reduced risk of metals leaching into the water table. Poplars proved to endure soil contamination better than willows, having a higher photosynthesis, transpiration rates and metal extraction capacity, with some variability within clones. Considering all clones together, poplar trees on average accumulated per plant: around 5 mg Pb, 12 mg Cd, 825 mg Zn and 1 mg As in leaves; 824 mg Pb, 62 mg Cd, 2343 mg Zn and 16 mg As in stems; and 365 mg Pb, 8 mg Cd, 439 mg Zn and 6 mg As in roots. The plantation was efficient in removing the rainfall available in the soil, in excess of the field capacity, during the vegetative season. Metal accumulation was also assessed in indigenous weeds and some species have been taken into consideration for a co-cultivation within the rows of the *Salicaceae* stand, to accelerate the reclamation of the polluted site.

Bringing the trees back: farmers adapting to climate change in the Offin River Basin, Ghana.

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**Preferred session**
C4. Mitigation and adaptation to climate change

**Abstract**
The Offin River basin is in the moist semi-deciduous forest region of Ghana. Communities in the basin are mainly rural and predominantly rain-fed crop farmers. Farmers in the Offin River basin are experiencing crop loss, damages and low yield and they attribute this to recent observed changes in climate. The rainfall pattern has changed drastically: it is either too little or too much and highly unpredictable. Mean annual rainfall has generally decreased by over 20%. Sunshine duration and intensity has increased and mean temperatures in the Offin River basin have increased by over 1%. These changes coupled with intense deforestation have resulted in crops failing due to: little or no rainfall or storms destroying farms; lack of moisture in the soil for root uptake; hard, cracked and
degraded lands with low fertility; and wilting of crops from high incidence of sunshine. Adaptation to the effects of climate change has not been very successful for many farmers, but a few who are now either incorporating trees in their farms, had left trees on their farms, or re-planting trees they once removed form their farms, have a success story to tell. The trees are playing important roles such as: providing shade for tree crops such as cocoa; improving soil fertility through nutrient cycling; enhancing rainwater infiltration; and improving the microclimate. In this era of climate change, agroforestry systems will not only help to mitigate climate change through carbon sequestration but they also offer a relatively cheap means of adaptation to climate change by the poor farmers in the Offin River basin. A successful replication of the success in other areas requires more research into the best tree species to plant and which agroforestry system to adopt - improved fallows or simultaneous tree crop systems, which best suits the agro-climatic zone and meet the farmers’ needs.

Comparative analysis of spatio-temporal dynamics in agroforestry systems in African peri-forestrial zones: the case of Guinea and Cameroon

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Preferred session A2. Agroforests in humid tropical Africa

Abstract In recent decades rural areas in the forest regions of West and Central Africa have been subject to rapid changes in their physical, social and economical environment. In some cases, local exploitation strategies have evolved towards agroforestry-based cropping systems like coffee and cocoa. The spatio-temporal dynamics of these systems are still poorly understood, however. To better understand these dynamics in the rural zones of two countries, in 2008 a comparative analysis was conducted of two situations in West Africa (Guinea) and Central Africa (Cameroon), both of which are located on the peri-forestrial Guineo-Soudanian savanna. A geo-agronomical approach was adopted, combining aspects of territorial geography and agronomy of farmers’ practices. In both cases the evolutionary spatio-temporal dynamics of agroforestry systems was described and quantified. The results of this study confirm that over the last 3 decades the spatial footprint of agroforestry systems has heavily increased. In particular, coffee-based agroforestry systems have developed at the expense of annual crops in Guinea, while in Cameroon cocoa-based agroforestry systems have spread widely over the savanna. A better understanding of the dynamics of agricultural practices and their impact on peri-forestial land in Africa is indispensable for a more thorough evaluation of the contribution of agriculture to the evolution of rural areas and their sustainable management. These changes urge a rethinking of analytical tools and intervention evaluations in the face of the challenge of sustainable development.

Keywords: agro-forestry systems, satio-temporal dynamics, coffee, cocoa, Guinea, Cameroon

Riparian zone health identification utilizing remotely sensed imagery and object orientated analysis

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Preferred session C3. Agroforestry, water quality and environmental amelioration

Abstract The ability to identify riparian areas and assess their characteristics addresses some long-standing information requirements regarding riparian health. We recognize the positive impacts that healthy riparian zones have on water quality of rivers, lakes and other major receiving basins. We also recognize the potential of operational earth observation-based ecosystem monitoring as a means to develop this type of information and do so at a low cost alternative to on-ground field assessments. The geomatics-based riparian health assessment pilot project in the Upper Assiniboine Conservation District of Manitoba, Canada, will provide sound, science-based information on the feasibility of
classifying riparian areas using remote sensing technologies abroad. The project aims to establish an object-orientated methodology to identify riparian zone attribute values to classify riparian areas across the landscape using spectral, spatial and relational riparian zone characteristics. Attributes are derived from synthetic aperture radar (SAR) imagery and orthophotos for moisture, vegetative type and health identification of riparian zones. The new quad-polarization and ultra-fine beam modes provided by RADARSAT-2 imagery will be examined to identify moisture levels of riparian zones and provide a measure of vegetation volume structure, biomass and canopy structure. High resolution orthophotos will provide vegetative type and health criteria statistical information. Findings will be further supported by supplemental ground assessments. Once the riparian health identification information gap can be addressed effective agroforestry and water-quality management practices can be implemented on a watershed scale.

The influence of a tree-based intercropping system on nitrous oxide emissions compared to a conventional monoculture in southern Canada

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Preferred session
C4. Mitigation and adaptation to climate change

Abstract
Agricultural practices to limit N2O emissions are sought as a result of the current climate change crisis. One method that has the potential to limit N2O emissions from agriculture is tree-based Intercropping (TBI). The objective of this study was to determine N2O flux in both a TBI system and a conventional monoculture located at the Guelph Agroforestry Research Station (GARS) in Guelph, Ontario, Canada. The study was a stratified random design, with three pseudo replicates and partially blocked to take into account time series effects on emissions. Gas samples were taken from June 2007 to August 2008 in both a monoculture and TBI system using the chamber method and divided into seasons according to planting and harvesting times. N2O flux was 1.07 kg ha-1 day-1 and 0.75 kg ha-1 day-1 in the monoculture and TBI system, respectively, with no significant difference in emissions between the two systems over all seasons (SE=0.3327, p=0.5281). A correlation between water-filled pore space and residual soil inorganic N with N2O flux did occur in both the monoculture and TBI system from summer 2007 to spring 2008 but not in the summer of 2008. Soil temperature did not correlate with flux across all field seasons in both fields. Although these results indicate that emissions are not statistically significant between the two fields, N2O flux was numerically lower from the TBI system by 0.32 kg ha-1 day-1. This indicates that with further research, a higher number of replicates and number of samples could show TBI systems as a potential practice for limiting N2O emissions from agriculture.

Effect of voluntary private standards on coffee commodity chain in Costa Rica

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Preferred session
A1. Multistrata agroforestry systems with perennial crops

Abstract
During the last 20 years, private voluntary standards for coffee have been developed around the world. In Costa Rica, they were strongly developed after the coffee crisis in the early 2000s. Nowadays, half of Costa Rican production is certified. This paper proposes an analysis of the effect of the increase of voluntary private standards (organic, fair trade, UTZ certified, Rain Forest alliance, Starbucks, Nespresso) in the coffee sector on the commodity chain in Costa Rica. Based on a literature review and direct interviews of actors in the coffee sector in Costa Rica, the paper presents the main evolution of the structure and functioning of the Costa Rican coffee commodity chain during the last decade. It shows that early certification channelled through local organizations, especially in organic and fair trade, helped the coffee growers of the marginal coffee production areas to cope with coffee market crises in the early 2000s. Later, after the coffee crises, the multiplication and development of environmentally friendly voluntary standards appears as
one of the elements of the strategies of producers and producers’ organizations to cope with increasing production costs and market competition. Nevertheless, the impact on final producers’ income has been limited. Finally, private standards in the coffee sector increase the resilience of coffee producers to market shocks and have contributed to the consolidation of producers’ organizations and the maintaining of coffee-based agroforestry systems.

Predicting the effects of land use on runoff and sediment yield in selected subwatersheds of the Manupali River using the ArcSWAT

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Preferred session 
B6. Agroforestry as a tool for landscape restoration

Abstract 
The quantitative prediction of environmental impacts of land-use changes in watersheds could serve as basis for developing sound watershed management schemes, especially for Philippine watersheds with agroforestry systems. ArcSWAT, a river basin-scale model developed to quantify the impact of land-management practices on water, sediment, and agricultural chemical yields, was parameterized and calibrated in selected Manupali River sub-watersheds with an aggregate area of 200 ha to simulate the effects of land use on runoff volumes, sediment yield and stream flows. Calibration results showed that ArcSWAT can adequately predict peaks and temporal variation of runoff volumes and sediment yields with a Nash and Sutcliffe coefficient (NSE) ranging from 0.77 to 0.83 and 0.55 to 0.80, respectively. When the calibrated model was run to simulate land-use change scenarios, it indicated an increase of runoff volumes and sediment yields by 3% to 14% and 200% to 273%, respectively, when 50% of the pasture area was converted to agricultural lands. Consequently, these results decrease stream flows by 2.8% to 3.3%. The upper limit indicates condition of the watershed without soil conservation intervention. More seriously, an increase of 15% to 32% in runoff volume is likely to occur when whole sub-watersheds are converted to agricultural lands. This accounts for 39% to 45% of the annual rainfall to be lost as surface runoff. The simulated effects of forest conversion to agricultural crops clearly indicate an alarming phenomenon of watershed degradation. In our test watershed, we recommend an intensive information and education campaign be conducted on the consequences of forest conversion and ways of rehabilitating the watershed. Finally, this study recommends that alternative livelihood opportunities be considered in policy implementation.

Agroforestry in the Western Ghats of peninsular India and Satoyama in Japan: a comparison of two sustainable agricultural systems

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Preferred session 
C2. Carbon sequestration in agroforestry

Abstract 
Western Ghats in peninsular India and the Satoyama landscapes of Japan are geographically diverse regions. Yet there are remarkable similarities in the physiographic features as well as the traditional land-use systems followed in these territories. A series of rolling hills and plateaus intersected by deep valleys characterize both. The hill and valley farming system of Western Ghats (HVC) and the Satoyama system of Japan also have major similarities. Rice forms the predominant crop in the lowlands and on the often-terraced plateaus, bordered by homesteads and various forms of managed woodlands. Traditionally, the farmers in southern Western Ghats owned land parcels at different altitudinal zones within a micro watershed: paddy fields (providing a significant part of the food and feed requirements), ‘garden land homesteads’ close to the paddy lands sustaining a mixed plant/tree crop system (producing tubers, nuts, fruits, vegetables, timber, fuel, etc.), and upland plots with mixed-tree cover, including forest trees (meeting the grazing and organic manure needs). The multistrata ‘garden land homesteads’ and the upland plots are thought to be ‘relics’ of forests left behind during the process of land clearing, but evolved subsequently under variable planting and/or extraction regimes. The woody perennial-based systems in both...
HVC and Satoyama also serve as sinks of atmospheric CO2 and conserve biodiversity. Both HVC and Satoyama are seemingly sustainable production systems. Commercialization and urbanization are, however, major banes of both, which have resulted in considerable loss of tree cover and cultivatable areas. While significant efforts to conserve the Japanese Satoyama lands are being made, little or no such efforts are visible in the HVC context. An attempt is made to compare the species richness and carbon sequestration potential of these two noteworthy traditional land-use systems.

Balance between soil N2O emissions and above-ground CO2 uptake in coffee monocultures and agroforestry plantations in Costa Rica

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Preferred session C2. Carbon sequestration in agroforestry

Abstract

Soil N2O emissions and C storage were measured in coffee monocultures and coffee agroforestry systems (AFS) with N2-fixing shade trees, under two agricultural managements. Two of the coffee plantations (monoculture and AFS with Inga densiflora) were conventionally managed (250 kg mineral N ha-1 y-1); the two others (monoculture and AFS with Erthrina poeppigiana) were organically managed (150 kg organic N ha-1 y-1). Measurements of soil N2O emissions, litterfall, litter and biomass were achieved when the plantations were 7-8 years old (conventional management) and 6 years old (organic management). Soil N2O emissions over the life time of the plantations (32 years) were simulated as a function of N inputs through fertilization and litterfall. Over the same period, CO2 uptake by aboveground biomass was calculated by simulating the growth of the coffee plants and shade trees. The annual rate of the litterfall was assumed to be proportional to the above-ground biomass and the standing stock of litter was calculated as a function of litter inputs and decay rate. For both types of agricultural management, measured annual N2O emissions were higher in the AFS (5.8±0.3 and 3.7±0.5 kg N2O -N ha-1 year-1, in the conventional and organic managements, respectively) than in the monocultures (4.3±0.1 and 1.8±0.3 kg N2O -N ha-1 year-1, in the respective managements), coinciding with higher N input through litterfall. The balance between cumulated N2O emissions and CO2 uptake over the life time of the plantations was negative in the monocultures (-25.5 and -8.2 Mg CO2-eq ha-1 32 year-1 in the conventional and organic managements, respectively) but positive in the AFS with a greater contribution to climate change mitigation of the organic management (37.3 Mg CO2-eq ha-1 32 year-1) than of the conventional one (14.9 Mg CO2-eq ha-1 32 year-1).

Examining the nexus between depletion of wetlands, forests and the deepening water crisis in Uganda

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Preferred session B3. Riparian system effects on soil and water quality

Abstract

Uganda, like the rest of the world is grappling with the problem of environmental degradation and its attendant negative adjuncts. Yet the state of the environment in Uganda’s pre-independence period was the most ideal in the whole of Africa. Once described as the ‘Pearl of Africa’ and a fairly tale by Sir Winston Churchill, the former Prime Minister of the United Kingdom and Second World War hero, Uganda now lies at the brink of environmental catastrophe. The paper has the following aims: to document evidence about the decrease in water availability and its linkage with the environment; to evaluate the effectiveness of government policies on restoration and conservation of water catchments systems; to provide policy actions that need to be included in the new Land Policy to address the situation; and to document the role of farmers in conservation and restoration of water catchments systems. With every wetland encroached on, every swamp drained, every parcel of top soil eroded, with river drying up and lakes shrinking, desertification becomes more of a reality in Uganda. The culprits and victims for this environmental catastrophe
are largely the farmers who interact with the environment on a daily basis. Yet if educated and given capacity, farmers can be the best protectors and custodians of the environment, especially through robust agroforestry practices. The study notes that despite the fact that the Government owns over 80% of the land occupying water catchment, these areas continue to be encroached upon due to weaknesses in law enforcement, corruption, political interference and impunity. The study contends that instead of drafting more laws and policies to protect and conserve the environment, the Government should focus on implementing and monitoring the enforcement of the already existing laws. The need to mainstream restoration efforts in all existing and upcoming environment policy-related regimes is also emphasized.

Characterization of cocoa agroforestry cropping systems and evaluation of their sustainability: the case of Central Cameroon

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Preferred session  A2. Agroforests in Humid Tropical Africa

Abstract  The oldest cocoa production region of Cameroon is the Centre-South basin. Here, cocoa cultivation appeared at the beginning of the Twentieth Century before it greatly expanded until the 1960s. Therefore, a large part of the cocoa orchards contain very old, yet still active, cocoa plots, contrary to what is commonly thought. With regard to the questions that the existence of these aged and still exploited cocoa plots pose, 742 surveys were conducted to characterize and to evaluate their level of sustainability. Two old cocoa production zones, Nyong and So'o and Lékié, which differ with regard to their pedo-climatic and socioeconomic characteristics, were surveyed. Four criteria: stability, viability, technical level, and complexity, each including several indicators, were defined to characterize the sustainability of these cocoa cropping systems. The results confirm that these old cocoa plots, handed over from generation to generation of farmers, remain the economic and social basis of the farm. On the one hand, their sustainability is based on their agroforestry characteristic. This characteristic is expressed by a plot layout with many forest and fruit tree species associated with the cocoa trees. On the other hand, their sustainability is based on the progressive renewal of the cocoa trees which causes a high diversity within the cocoa tree populations. These cocoa-agroforestry systems, which require few inputs and little work, allow a cocoa production level which is stable for the very long term, combined with a high level of agro-biodiversity.

Indigenous agroforestry systems: conservation and stewardship of biodiversity in an era of rapid economic growth and climate change

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Preferred session  D4. Incorporating local knowledge in agroforestry science

Abstract  Indigenous Agroforestry Systems (IAS) and their biodiversity evolved in ancient times. They are the result of long years of human environment interaction resulting in resilient and outstanding landscapes. In recent years, intrusive rapid economic growth and climate change are now putting IAS in transition where farmers have no choice but either to continue or abandon their traditional farming practices. The focus of this paper is an analysis of the current drivers of change affecting IAS and the threats and barriers to their long-term conservation and proper stewardship. Toward the end of the paper, a general framework for the conservation and stewardship of IAS is proposed. The major drivers of change are industrialization, market forces, education and Christianity. The threats are degradation and loss of biodiversity, loss of interest in culture that underpins the management of IAS, and a shift from subsistence to commercial agriculture as an offshoot of changing priorities and needs. The barriers to the long-term conservation and stewardship of IAS are: national governments do not have the tools and methodologies for shared management of
IAS; IAS farmers lack the capacity to respond to external pressures; and most IAS in the tropics are not captured by both domestic and external markets. The proposed general framework for the conservation and stewardship of IAS comprises: the development of innovative funding mechanisms for IAS conservation; developing niche market for IAS products and services including eco-labeling standards; in situ management of IAS biodiversity and resources; and a program for restoring the cultural foundation of IAS.

The current agroforestry strategies indigenous knowledge nexus in the Philippines: an annotated review of the literature

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract
In many parts of the world, agroforestry evolved as a mechanism to protect upland ecosystems from the threats of soil erosion and degradation. These threats to the ecosystem were brought about by cultivation of sloping lands by people from the lowlands who were driven up the slopes by population pressure and poverty. Yet, the Philippine uplands is also home to many indigenous peoples with knowledge systems that enabled them to inhabit these areas sustainably for centuries. This paper will present the different agroforestry strategies, programs and initiatives that are being implemented by the government. It will also present an evaluation of these strategies from the point of view of implementers and beneficiaries. The different indigenous knowledge systems related to agroforestry of the various indigenous peoples that had been documented and reported in the literature will also be presented and discussed. The possible areas of complementarity between current government initiatives in agroforestry, social forestry and community-based forest management programs and the indigenous knowledge systems will be discussed with the view of influencing policy and institutional innovations in the development and implementation of agroforestry programs.

Agroforesterie à base de l’anacardier et occupation du sol dans le secteur Agbassa-Idadjo, région des Mont Kouffè

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
Les données utilisées sont issues de la recherche documentaire et des enquêtes en milieu réel. La statistique descriptive et les travaux cartographiques, ont aidé au traitement et analyse des informations et données. L’agroforesterie tend à stabiliser le paysan sur la même superficie culturelle pendant plusieurs années. Les plantations d’anacardiers ont participé à la restauration des jachère.

The case of agroforestry in Togo

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Preferred session A2. Agroforests in humid tropical Africa

Abstract
The case of agroforestry in Togo: the situation as seen by Simon Todzro of CFAPE-TOGO. Although
the term 'Agroforestry' has never been known in the vocabulary of the people of Togo, one would certainly assert that the practice of agroforestry has nonetheless been the mainstay of traditional systems of farming.

Analysis of small-scale forestry as a multifunctional agriculture option in Uruguay

Authors Bennadji, Z, Trujillo, I. and Rocanova, M.

Abstract

The Uruguayan economy was traditionally based on livestock production. In 1987, the government launched loans for fast-growing, large-scale eucalypt and pine plantations; this had a high economic impact but raised huge environmental concerns. In 2005, governmental policies promoted an alternative forestry model based on small-scale plantations, involving non-traditional native and exotic species, in the belief this would give direct benefits to both forest and livestock growers, and have a positive effect on society. In this framework, the Forestry Program of the National Agriculture Research Institute (INIA-Uruguay) initiated a project on domestication of multipurpose trees. Its first activity was the study of landholders' attitudes, motivations and expectations with respect to small-scale forestry and multipurpose trees. A survey was developed and launched by email and the Internet. It assesses the following aspects: (i) size of operation, (ii) ownership, (iii) main agriculture activity, (iv) previous forested area, (v) species choice, (vi) forestry objectives, (vii) interest in small-scale forestry, (viii) priority multipurpose trees, and (ix) research and technology transfer needs. The data obtained were processed in a qualitative and quantitative matrix. The purpose of this paper is to present the survey’s main results. First, it revealed that 74% of landholders traditionally plant eucalypt and pine woodlots for animal welfare. Second, 81% was interested in small-scale forestry with non-traditional species as a means of production diversification, and a listing of priority multipurpose trees was obtained. Third, a growing awareness of the range of social and environmental benefits of small-scale forestry was detected. Research could be oriented to multipurpose tree domestication strategies for adapting the expertise developed previously by INIA in tree improvement of fast growing species. The government still has a significant role to play in consolidating these trends and removing social and economic impediments.

Key words: Small-scale forestry, multipurpose trees, domestications, Uruguay.

Contributions of agroforestry for small-scale farming systems in Sri Lanka: productivity growth, environmental services and livelihoods

Authors Mangala De Zoysa

Abstract

Agroforestry is considered not only a cost-effective production system but also a farming system that makes environmental and livelihood contributions to small-scale farmers. Agroforestry practices are found in Sri Lanka as age-old traditions playing a vital role in productive landscapes. The traditional small-scale farmers planted and protected trees as a part of multi-species and multipurpose land use systems. Presently, agroforestry systems in Sri Lanka are broadly classified as farm-based agroforestry and forest-based agroforestry systems. Agroforestry has a crucial role in supplying food, timber, biomass energy, and non-wood forest products while protecting the farming environment. The forest policy emphasizes developing agroforestry systems also as a main strategy for meeting the increasing subsistence and industrial demands for wood. This paper reviews the literature and critically discusses the contribution of agroforestry to small-scale farmers in Sri Lanka in terms of productivity growth in farming systems, improvement of environmental services and enhancement of livelihoods. Improvement of land productivity, production of diverse agricultural and forest products and supply of alternative farm inputs are recognized as the
main contribution of agroforestry to the productivity growth of small-scale farming systems. The important environmental services of agroforestry for small-scale farmers are revealed as: protection of biodiversity; conservation of soil, and improvement of soil fertility and soil stability; and control of soil, water and food pollution. Their livelihood enhancement includes: improved food security, poverty alleviation and enhanced status of women; a sustainable supply of renewable rural energy; diversified and increased farm incomes; and better promotion of rural enterprises. Although the agroforestry practices make a vital contribution to productivity growth, environmental services and livelihood enhancement, favorable policies, interdisciplinary technology and commercially viable agroforestry systems are required to address the impediments of existing small-scale farming systems.

Forest farmlands: indigenous forest management by agroforestry symbiosis in South and Southeast Asia

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Preferred session E4. Socioeconomics and agroforestry in the Pacific

Abstract

Forests provide multiple benefits as a safety net to the poor and also help to increase the overall ecological balance. Of particular importance in this respect, this research has been conducted in six typical villages in South and Southeast Asia, located in northern Bangladesh, southern Myanmar and northwest Thailand. Data collection methods used were observation, FGD, interviews, and a structured survey of farm households. Data were analysed through qualitative methods largely following heuristics of causality, and through quantitative economic methods and models such as the cost-benefit analysis of the actors concerned. Forest culture as practised by smallholder farmers in this region is not an exclusive professional activity, but one component of farmers’ livelihood strategies. Forest culture on farmlands usually starts from the swidden. Seedlings of selected forest species are planted together with rice, and the young trees develop along with the fallow vegetation. Forest culture through swidden cultivation thus is profitable even on small plots. Foresters usually assert that forest culture cannot be conceived on a small scale. But small-scale forest culture is possible without increased costs or with acceptable economic returns if, and only if, it respects a close integration with swidden and other existing agricultural practices. Swidden agriculture may disappear when the silvicultural system has sufficiently matured, and in return, the substitution of a productive forest stand that allows a quick intensification of swidden agriculture without drastic changes in practices or dynamics. This intensification can be achieved through a smooth adaptation of practices, avoiding painful revolution of the whole farming system. This adaptation has obviously important social consequences, as it avoids the marginalisation and impoverishment of a whole class of farmers. In this respect, the association of ‘agro’ and ‘forest’ components occurs at the level of the farming system itself.

Management of forest environments and sustaining forest-dependent communities: options for dryland Africa based on experiences from Sudan

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract

The United Nations Conference on Environment and Development (UNCED) Earth Summit in Rio de Janeiro in 1992 brought the need for greater community participation in natural resource management into sharp public focus. This is reflected in the Forest Principles, in Agenda 21, UN Convention on Biological Diversity (CBD) and UN Convention to Combat Desertification (UNCCD). In fulfillment of national forest-related obligations derived from global environmental conventions and forest agreements and processes, experience in partnerships is recognized for various types of natural resources in central Sudan; and their management involved local
communities. Since the early 1980s, international assistance has introduced management practices inside natural forest reserves based on project concepts and local people’s participation with the objective of forest rehabilitation and sustainable management. Various organizations have been involved including, Food and Agriculture Organization, United Nations Sahelian Office (UNSO), as well as many other non-governmental organizations. A cross-sectional survey was conducted among two community categories of farmers, namely the taungya system and collaborative reserve farmers, using questionnaire-based interviews, focus group discussions and participatory learning and action (PLA) methodology. Results from descriptive statistics suggest partnership-based, land-use practices in central Sudan conserve biological diversity in the drylands while contributing to poverty reduction among local people. The study also proposes options for policies and land-use arrangements that enable the rural population to manage their farm and forest resources in an integrated and socially, economically and ecologically sustainable way, and to add value to their products, thus improving their livelihoods. The study combines the experiences gained from implementing different partnerships, and formulates suggestions for future development of partnerships.

Keywords: Agroforestry, conservation, drylands, forest law, rehabilitation, Sudan, sustainable forest management, taungya.

Energy value as a factor influencing wood selection for agroforestry in some rural communities of Oyo state, southwest, Nigeria

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Preferred session D4. Incorporating local knowledge in agroforestry science
Abstract
Biomass energy is still central to survival and sustenance of livelihoods in many parts of sub-Saharan Africa. For instance, the demand for firewood and charcoal is increasing in this region, therefore feasible sustainable production methods are necessary, bearing in mind the influence of indigenous knowledge and users’ perspectives on their success. In line with this, a survey was carried out by questionnaires to 240 respondents in 8 rural communities of Akinyele and Ido Local Government Areas (LGAs) of Oyo State, Nigeria (where the predominant type of agroforestry system is scattered trees in croplands), to elicit information on preferred fuelwood species for incorporation into, or retention in, agroforestry plots. Of the surveys, 179 (74.58%) were successfully retrieved. Twelve wood species, Annona senegalensis, Anogeissus leiocarpus, Bridelia ferruginea, Daniellia oliveri, Detarium microcarpum, Gardenia ternifolia, Hymenocardia acida, Lophira lanceolata, Parkia biglobosa, Terminalia avicennioides, Triplochiton scleroxylon and Vitellaria paradoxa, were prioritized on the basis of respondents’ preferences. The mean net calorific values (NCV) of the species were found to range between 3.50 and 5.18 kcal g⁻¹. Friedman chi-square analysis showed that there was no significant difference (p<0.05) in the ranking pattern of the respondents in the two LGAs while two-way analysis of variance indicated a significant variation (p<0.05) in NCV among the species but not within species except for D. oliveri with a follow up test using Fisher's Least Significant Difference. The correlation analysis gave a high value (r=0.88, p<0.05) between the preference for the species in the two LGAs and their NCV. Based on the outcome of the study it was recommended that users’ perspective and/or native intelligence or indigenous knowledge should be part of the criteria for selecting potential fuelwood species for incorporation into, or retention in, agroforestry schemes in this study area and others with similar characteristics.

Determination of minimum sale price of teak thinning products in a multi-specific agroforestry system at Danac Foundation, Venezuela

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**Preferred session**  
A1. Multistrata agroforestry systems with perennial crops

**Abstract**  
The minimum sale price determination of wood products is important for forest plantation managers as a reference price at the time of negotiation. With this aim, a case study was carried out, which consisted of the analysis of empirical data production of the first thinning of a coetaneous commercial batch of 3.3 hectare of a seven-year-old Tectona grandis plantation intercropped with *Cajanus cajan* during the first three years of establishment at the Danac Foundation Multispecific Agroforestry Project, in Yaracuy, Venezuela. The study considered the costs of establishment, maintenance, thinning, administration and land, according to institutional records. Timber production was measured in cubic metres and in number of products obtained from the trees thinned. The use of financial indicators, such as the interest rate (12%) and the producers minimum acceptance rate of return (TRMA = 10%) was determined. We calculated the cash flow updated to 2006, when the thinning (30%) was completed. The gross price (based on cost) and liquid price (considering TRMA) were estimated. A total of 985 trees were thinned, which produced, with a 3.5% discard, 1908 units of products (1002 madrinas, 519 varas, 252 horcones and 145 madrinas) and 153.7 m³ of timber. Maintenance costs (34%) and thinning costs (32%), followed by the opportunity cost of land (21%), were the most important of the total production cost structure. These results do not include, due the lack of data, the cost of irrigation in the first two years of planting. The liquid price was estimated at 2.93 BsF per product and 36.38 BsF m⁻³. In conclusion, to avoid economic losses producers should not sell the timber at a price lower than cost, in this case at 2.66 BsF perproduct and 36.08 BsF m⁻³.

**Keywords:** Financial analysis, Production cost, Woods products, Agroforestry systems, Venezuela.

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**Sustainable agroforestry system for reclaiming degraded environment in Abuja, Nigeria.**

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**Preferred session**  
A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**  
This study was carried out at the Federal Capital Territory (FCT) Abuja, the capital city of Nigeria. The essence of the research was to evaluate the impact of development and farming activities on the FCT environment, and identify the causes and extent of the degraded environment. The research was aimed at proffering laudable and lasting solutions for the improvement of the environment through: arresting and resolving environmental problems that are likely to threaten the quality of both fauna and flora, or biotic organisms and abiotic components; and, identifying and reversing adverse environmental degradation trends, and maintaining environmental stability and sanctity. The research provides comprehensive and qualitative data, and the collated data were in turn analysed to give real graphic environmental status of the FCT. An effective and elaborate research methodology was used. The 6 area councils served as a research population frame to ensure a comprehensive and thorough coverage of Abuja. Areas/communities in each of the 6 area councils were stratified and randomly selected; photographic interpretation of the randomly selected areas, and rapid appraisal techniques were used. Results were discussed, research recommendations drawn and conclusions made.

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**The role of agroforestry in managing snow distribution on the Canadian prairies**

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**Preferred session**  
A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**  
Agroforestry effects on snow distribution, particularly the effects of shelterbelts, were studied in the central great plains of North America. In this geographic context, the potential of agroforestry for snow management will be discussed. This region has a continental climate which is characterized
by cold winters and hot, dry summers. Snow is an important source of water, representing between 20 and 40% of annual precipitation on the Canadian prairies, but there is much annual variability in the amount, timing and fate of snowfall. On the prairie landscape, a large percentage of the snow is transported by wind and up to 40% of the annual snowfall may be lost to sublimation of drifting snow. Woody vegetation, as well as topographic changes and other obstacles that affect wind flow have a major effect on snow fate and distribution. Trees and shrub plantings that are well designed and placed in the right locations can be used to manage snow. In this paper, research into the effects of agroforestry practices will be used to show the significant role and potential of agroforestry for snow management at local and regional scales. This paper will rely on snow distribution studies that have been conducted over a 20-year period and relate their results to the outputs of the Cold Regions Hydrological Model (CRHM). The importance and potential for snow distribution management by agroforestry to help drought-proof the prairies, especially in view of the climate impacts which models have predicted, is discussed.

Growth performance and ameliorative effect of eucalyptus species on salinity and waterlogging

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Preferred session B5. Biodrainage for prosperity
Abstract Waterlogging and salinization are major obstacles for sustainability of irrigated lands and profitability of the farmers in affected areas of Pakistan. Several efforts have been made; however, in spite of huge investments, the results have in general been disappointing and the problems of waterlogging and salinity persist. A lysimeter study was conducted to evaluate the variation in salt and waterlogging tolerance of 13 eucalyptus species. The treatments applied were control, salinity (ECe 10, 20, 30, 40 dS m⁻¹), waterlogging, and combined salt and waterlogging in factorial combinations with five replications. The salinity was developed by mixing of NaCl and CaCl₂ salts in 20:1 and waterlogging was seasonal (four months) with a one month interval. Salinity reduced the growth of plant species, however, significant growth reduction variations were found among species. Reduction in plant height, stem diameter and shoot fresh/dry weights were more aggravated by combined salt and waterlogging than by either treatment alone. Eucaluptus camaldulensis performed well with good growth and minimum reduction in observed parameters. Production of adventitious roots and indications of aerenchyma development was observed on E. camaldulensis, which confirms its better tolerance to combined salinity and waterlogging stress. A field study was also conducted at two saline and waterlogged soils on a 3-year-old plantation to evaluate the performance of E. camaldulensis and its ameliorative effects on salinity and waterlogging. The reduction in soil ECe, SAR and the improvement in hydraulic conductivity was observed along with a significant reduction in water table depth. It was noted that groundwater table depth reduced from 120 cm to 180 cm in 3 years.

Keywords: eucalyptus, waterlogging, salinity, growth, amelioration

Pulpwood based industrial agroforestry in Tamil Nadu

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract The forests in India were degraded at an alarming rate owing to the expansion of industrialization, urbanization, population explosion and over-exploitation of forests and forest resources. These forces have taken a heavy toll of Indian forests leaving an actual forest cover of 20.55% where the mandated requirement is 33%. The low forest cover, coupled with low productivity of Indian forests in comparison to global statistics, has created a mismatch between the demand and supply of timber, non-timber and industrial wood resources. To meet the growing wood requirement
both for domestic and industrial uses and also to protect and conserve natural forests, a massive afforestation programme outside the forest lands is needed to utilize the available wastelands. Of India’s 328 million hectares (ha) of geographical area, nearly 158 million ha is degraded, under-utilized or unutilized, and poses serious environmental problems. These areas are to be rehabilitated not only for greening but also to meet the demands from all levels of stakeholders. The demand for industrial wood raw material is also rising. Wood-based industries have been mandated to acquire their own raw material without depending on Forest Department supplies. Almost all industries in the country are in the process of establishing captive as well as farm and agroforestry-based industrial wood plantations in order to generate their own raw materials. Against this backdrop, the pulp and paper industries in the state of Tamil Nadu have promoted agro and farm forestry-based industrial wood plantations through technological support from Forest College and Research Institute. This paper indicates the successful establishment of eucalyptus and casuarina-based pulp wood plantations in the state; and that during the last three years 19 349 acres have been covered, in which 91% of the plantations were established in farm lands through local people’s participation.

Rehabilitation of active gold mine tailings dumps: growth performance of indigenous and exotic tree species.

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Preferred session  B9. Collective action for tree-based rehabilitation of degraded lands
Abstract  Forests form an integral part of livelihoods systems in Africa as they support current consumption, provide an economic buffer and are an important source of cash income to poor households. In areas where mining is a major economic activity, mining tailing dumps have negative impacts on the forest ecosystem. The mine dumps destroy wildlife habitats and leach out toxic chemicals that pollute the soil, streams and rivers, and underground water sources. If the mining industry is to contribute effectively to sustainable development, it must develop and consistently apply sound environmental management practices such as revegetation of dumps to minimize on and off-site environmental impacts. The objective of the study was to compare the growth performance of indigenous (Acacia polyacantha and Bauhinia thonningii) and exotic (Eucalyptus grandis and Acacia saligna) tree species in rehabilitating active gold mine tailings dumps. The seedlings were produced in a nursery and transplanted onto the tailing dumps during the rainy seasons in the years 2000, 2001 and 2002. The growth performance of the saplings was assessed by measuring survival, root collar diameter and height. The tree species did not differ significantly in their survival. The two exotic species had similar root collar diameter. A. polyacantha had a significantly higher mean root collar diameter than the exotic species and B. thonningii, which consistently had the lowest value compared to the other species. Of the indigenous species, A. polyacantha had a greater mean height than B. thonningii. The exotic tree species (E. grandis and A. saligna) had similar mean heights which were greater than those of the indigenous species. It can be concluded that the indigenous tree species are comparable to the exotic tree species in both survival and growth performance and can therefore be used successfully in revegetation of gold mine tailing dumps.

Industrial agroforestry a successful tree business model in Tamil Nadu, India

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Preferred session  D3. Policy formulation and stakeholder engagement in NRM
Abstract  The forests in India were degraded at an alarming rate owing to the expansion of industrialization, urbanization, population explosion and over exploitation of forests and forest resources. These forces have taken a heavy toll of Indian forests leaving an actual forest cover of 23%, where the
mandated requirement is 33%. The low forest cover coupled with low productivity of Indian forests compared to global statistics has created a mismatch between the demand and supply of industrial wood. The Forest Policy (1988) has advised wood-based industries to produce their own raw material to become self reliant in raw material requirements. Against this backdrop Forest College and Research Institute, Tamil Nadu, India have designed farm and agroforestry models to promote industrial wood plantations across the state in association with two paper industries (Tamil Nadu Newsprints and Papers Limited, and Seshasayee Paper Boards Limited). Through this system, three models - captive plantations, farm forestry and agroforestry - have been promoted using the superior and elite clones of eucalyptus and casuarinas. Precession silvicultural technologies have been adapted and productivity improvement was achieved to the tune of 15-20 m³ ha⁻¹ yr⁻¹ compared to the traditional yield of 5-7 m³ ha⁻¹ yr⁻¹. Additionally, the rotation of the species has been drastically reduced to 3 years (casuarinas) and 5 years (eucalyptus), which gained momentum among the farmers. Through this industrial agroforestry model, a tripartite contract farming system has been introduced involving financial institutions, growers and industries. This model facilitated an assured price to the growers and sustained raw materials to the industries. During the last 4 years more than 16,000 ha of industrial wood plantation have been established involving 6500 farmers. This paper describes the methodologies adapted for plantation establishment coupled with the contract farming models practised.

Three decades of agroforestry education at Tamil Nadu Agricultural University

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Preferred session B7. The role of degraded lands in biofuel production in SE Asia

Abstract Realizing the pivotal role that forests play in the economic prosperity and ecological stability of a country, Tamil Nadu Agricultural University started, as early as 1973, a fully fledged department of forestry with the mandate of carrying out research mainly in the areas of agro and plantation forestry. Due to sustained development in the agriculture, forestry and industrial sectors, the University had the responsibility of offering a separate course on Agroforestry to the students of Agriculture and Horticulture degree programmes, and inculcating agroforestry practices. With advancement of time and concomitant mushrooming of problems encountered by farmers and wood-based industries, the academic ambit of the university was enlarged to encompass other areas of forestry. Hence the university introduced BSc (1985) MSc (1989) and PhD (1990) programmes in forestry to meet the professional forestry workforce requirements. The course curricula and syllabi are designed to suit the needs of agroforestry to promote forestry outside the natural forests. The course curriculum comprised fundamental, management, technological and application-oriented courses in addition to entrepreneurship development. The curriculum also included agroforestry work experience to learn the state of the art agroforestry technologies and the problems encountered by growers. The curriculum is revised once in every four years and recently forestry education was updated with an e-learning system in which the examinations are conducted on-line. Through e-learning the graduates get access to all information sources, thereby helping to update forestry education. The curriculum is designed in such a way that the graduates can choose elective courses in the areas of industrial agroforestry, tree breeding, wood technology and value addition to develop skills and expertise on the subject. This paper discusses the changes taken in agroforestry education during the last three decades.

Potential of smallholder cocoa agroforests of Ondo State, Nigeria, as carbon sink

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Preferred session C2. Carbon sequestration in agroforestry

Abstract The status of Ondo State as a major producer of cocoa and a leading producer of timber in Nigeria has continued to place conflicting demands on its land resources. Gazetted forest reserves have
continued to shrink in area under the pressures of a rapidly growing population and the consequent increasing rate of conversion of forest into agricultural lands, especially cocoa farms. The cocoa agroforests of Ondo State, Nigeria are complex agroforestry systems which resemble the natural forest ecosystem in appearance and function. Even though there may be some negative local effect from losing natural forests to cocoa agroforests, its effect on the global climate deserves a closer look. This paper examines the extent to which some of the natural forests in the state have been converted and the structure of the resultant cocoa agroforests. The potential contribution of these agroforests to carbon sequestration and climate change mitigation is highlighted.

Forest trees composition, fisheries and wildlife status of Omo Biosphere Forest Reserve, Ogun State, Nigeria

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Preferred session A2. Agroforests in humid tropical Africa

Abstract

The vulnerability of most Commonwealth countries to climate change was identified almost 20 years ago. Large areas of the world’s forests have been lost or degraded and landscapes everywhere are being simplified by current land-use practices and these actions are contributing to the havoc of climate change phenomenon in developing countries. This study was carried out in the Omo Strict Natural Reserve (SNR), the oldest and largest SNR in Nigeria, established in 1949 and internationally recognized in 1977 as a Biosphere Reserve. The status of the economic forest trees, fisheries and wildlife resources of Omo Biosphere Reserve was assessed with a view towards highlighting the state of the diversity of these resources. In situ sampling of trees, fishes and wildlife resources was conducted. The data obtained were compared to existing data obtained in the last 15 years. Eight of the most economically valuable tree species were observed to be highly depleted: their population reduced by over 45% compared to data obtained 15 years ago. These include *Triplochyon scleroxylon*, *Nauclea diderichii*, *Entadrophagma cylindricum*, *Lophira alata* and *Celtis zenkeri*. Twenty-five fish families and 66 fish species were observed, out of which 91% were freshwater species and 9% shellfish. There was a marked reduction (28%) compared to the data obtained 10 years ago. Over 31 mammalian fauna species, 8 reptiles and numerous avian species were enumerated. Among these were primates, bush bucks, duikers, squirrels, grass-cutter, and rodents. Reduction in animal population, especially primates, was high compared to the figure of 15 years ago. Occasional or accidental bush burning, illegal felling and intrusion into the reserve by crop farmers and cattle herders were the major sources of anthropogenic impact in the reserve. The paper recommends a monitoring programme that will reduce human activities that trigger off climate change within and around the reserve.

Effects of land-use decree and traditional land-title deeds on sustainable capture fisheries among poor fisherfolk in Nigeria

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Preferred session B1. Quantifying the role of AF in modifying watershed functions

Abstract

Fisheries provide vital livelihoods for coastal dwelling communities in Africa. West coast African countries rely on fisheries to provide significant contributions to their gross domestic product. More than 70% of the artisanal fisherfolk lives in rural coastal areas of Nigeria. Artisanal fisheries include some of the poorest and most neglected communities within society for, without land, such communities find themselves outside mainstream economic and political life. To the Nigerian Government, the development of agriculture, rural economy and farmers’ prosperity is a subject of major interest and continuing concern. Artisanal fish production accounts for over 91% of domestic total fish supply in Nigeria, hence the need to focus attention on the rural communities. However fisherfolk activities extend far beyond fishing. They rely heavily on the flora resources of
the areas for food, clothing and fuel (heating). The pursuit of their livelihoods has led to communal clashes and most evidently forest depletion and loss of biodiversity. Large economic trees like *Mitragyna ciliata* and *Lophira alata* and smaller trees *Berlinia auricular* and *Carapa procera* are fast disappearing from the study area. This paper presents the result of a pilot Fishnet Land-use Initiative (FLI) of the Ilaje local government area of Ondo State. The effects of the National land-use decree of 1977 and the traditional land-title deeds on the use and availability of forest and fishing grounds (floodplains, wetlands and water bodies) were examined. Issues relating to land ownership, land acquisition and land lease for fisheries and fishing activities were assessed and the effects of their practices on the social driving forces were identified and analysed. A model land-use initiative that provided data on fishing grounds, the allocation of forest lands and their utilization by poor fisherfolk was established with the aim of improving the sustainable use of coastal resources of the study area.

**Watershed and tropical rainforest management options in sub-Saharan Africa: an anecdote of climate change mitigation**

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**Preferred session** C4. Mitigation and adaptation to climate change  
**Abstract**  
Empirical and modeled data suggest that the tropical humid rainforest is at risk of climate change effects. The tropical rainforests of the world contain a staggering proportion of the world’s biodiversity, which supports thousands of people through agriculture, silviculture, and commodity and non-commodity products. The climate of sub-Saharan Africa has changed over the last century. Recent studies have shown the link between deforestation and precipitation, and other changes in climatological rainfall patterns, warmer temperatures and decreased biodiversity. This paper looks at the protection, sustainable management and restoration options for watersheds and rainforests in sub-Saharan Africa. The effects of fire-assisted conversion of forest and poverty-induced forest-use patterns were employed to analyse the cumulative net sink of atmospheric CO2. The paper shows that forest fire releases a substantial amount of smoke into the atmosphere which can reduce rainfall and thus promote more drought. The paper suggests ways to manage forest fires in tropical rainforests.

**Nodulation characteristics of multi-purpose (MPT) legumes in soils under different management systems in Zambia and Zimbabwe**

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**Preferred session** A6. Ecophysiological bases of agroforestry-system design  
**Abstract**  
Although rhizobia occur in large numbers in soils across the globe, those compatible with different MPTs may be difficult to detect. Previous work has shown that differences in detection limits of indigenous rhizobia by different MPT legumes normally causes large variations in inoculation response. This study evaluated nodulation characteristics of different multi-purpose tress in soils with no history of rhizobial inoculation. The results showed that rhizobia that nodulate MPTs were present in most soils sampled with nodule numbers ranging from 0 to 98, but distribution and effectiveness varied widely. Australian acacia (*A. auriculiformis*) either nodulated poorly or did not nodulate at all in field soils. However, *A. crassicarpa* nodulated heavily in soils collected from natural fallows under miombo woodland. Zambian natural miombo woodland fallows from Chadiza, Kalichero and Msika had the greatest diversity of rhizobia because all 11 legumes tested nodulated in those soils. In the remainder of the soils, less than 50% of the legumes tested nodulated. Crotalaria and *S. sesban* were most prolific (they nodulated in 100% of the soils), followed by Siratro at 94%. Crotalaria and *S. sesban* also had the highest count of nodules per plant per soil.
Any program to promote Australian acacias needs to include compatible inoculant strains as part of the package. However, because *A. auriculiformis* and *A. crassicarpa* nodulated heavily in soils collected from natural fallows under miombo woodland, the current nursery procedures may continue to be selectively applied. Isolation of rhizobia for MPTs for any further work must target Zambian soils as the source.

### Techniques and technology for carbon microfinance

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**Preferred session** E5. Rewards for the environmental services of agroforestry  
**Abstract**  
In this paper, techniques and technologies are explored that could contribute to an overall scheme – called carbon microfinance – compensating local communities and families directly for environmental benefits generated by the trees either planted by them or whose care has been assigned to them. A first technique discussed is the linking of GIS and election systems to provide an as-fair-as-possible zoning of the areas to be allocated to local communities: GIS systems have been chosen because of their ability to treat geographical data, election systems because of their objective to engage as systematically as possible the whole population. Specific voting techniques like budget voting could allow individuals or representatives to express the preferences about the parcels to be allocated; where after, the system, taking into account the findings of previous zoning experiences, would strive to optimize parcel allocation, taking into account those preferences. A second link being explored is with microfinance. Taking as an example the common platform, currently being built by Care and IBM, that will allow large financial institutions to invest smoothly and directly in microfinance products, this paper will explore ways to plug the carbon market directly into the microfinance market, where the carbon sponsors would share part of the infrastructure of the microfinance institutions to pay local communities directly for environmental benefits of the trees on the parcels assigned to them. Finally, techniques originating from complex IT projects, like object orientation, the use of existing information exchange standards and automation of workflow processes will be explored and the possible impact on the above techniques assessed.

### Building resilience in coffee agroforestry systems to environmental and economic changes

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops  
**Abstract**  
Coffee agroforestry producers have to contend with constantly changing external conditions of production. During the last 10 years coffee prices have varied from USD 0.45 to USD 1.40 per pound, labour costs have risen between 30–50%, fertilizer prices have doubled, and pests continue to expand their ranges with coffee berry borer arriving in Costa Rica in 2004. Climate has fluctuated reinforcing the biannual productivity cycles in Nicaragua varying from around 2 million sacks in the rainy La Nina years of 2005 and 2007 to around 1.2 million sacks in dry El Nino years of 2004 and 2006, reflected in small-farm income oscillating between USD 650 and USD2300 per year. The diversification of products from coffee agroforestry systems provides supplementary income equivalent to about 15–20% of coffee income in low-price or low-productivity years (compared to 1–2% in high-price years), but more importantly it meets family needs in fuelwood and cooking bananas. Improved cultural management of coffee has enabled farmers in Honduras to increase net income from USD 150 to USD 700 between 2004 and 2007. Farmers receiving training in farm management and micro-credit assistance in Segovias, Nicaragua aim to increase the productivity of their coffee in low productivity years. Complementary to this is building the capacity of producer organizations to participate in coffee markets that recognize social and environmental responsibility. Between 2005 and 2007 coffee cooperatives improved the price of
coffee sold by USD 0.04 per pound with a 24% increase in the volume of sales. The combined effects of the price increase and improved productivity led to an increase in income of some 2000 families by USD 800, or USD2.4 million of income to the cooperatives. Strategies are needed at the level of the production system, the family, and the producer business organization to adapt to economic and environmental change.

**Restoration of degraded Sal forest in Bangladesh through participatory agroforestry: a glimpse into farmers’ acceptability**

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**Preferred session** B9. Collective action for tree-based rehabilitation of degraded lands

**Abstract**  
Agroforestry has been increasingly viewed as an alternative means of combating deforestation and restoring degraded forest land in the changing socio-economic and climatic scenarios in Bangladesh. Despite increasing pressures on its dwindling forest resources, it has, so far, restored 7198 hectares of encroached and degraded Sal forest land since 1985 through agroforestry practices using participatory approaches, where forestland encroachers were deliberately involved as participant farmers. A study was done at the alley-cropping agroforestry farms in the degraded plainland Sal (Shorea robusta) forest land of Kadighar Beat, Mymensingh, Bangladesh, to: determine the progressive yield of Saccharum officinarum, Curcuma longa and Vigna unguiculata, when grown principally with Acacia auriculiformis, using a conventional yield assessment method; and also to assess the farmer’s acceptability of the current agroforestry practices by randomly conducting a farmer’s opinion survey. The yield study showed progressive reduction in crop yield with increase in tree age from the third year. Additionally, farmers identified some problems and constraints such as reduced crop yields in the older alleys due mainly to increased shade and root competition of trees over crops, inadequate tree-management practices, lack of credit and marketing facilities, inadequate input support, scarcity of irrigation water etc. relating to the agroforestry practices. However, the study showed farmers’ acceptance of the current agroforestry system with some suggested modifications of design and management practices. Acacia mangium and A. Hybrid were found to be incompatible species, whereas, farmers showed interest in Acacia auriculiformis because of its reasonable fast growth and wood value. Rational and integrated management of components, selection of compatible crops and redesign of the model were deemed necessary to minimize the negative effects of trees over crops for increased total productivity, sustainability and social acceptability of the system and eventually, to accelerate the restoration process.

**Potential and suitability of medicinal and aromatic herbs for agroforestry conditions**

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**Preferred session** A5. Ecological sustainability: panacea or Pandora’s box?

**Abstract**  
The theme of this study was to look for successful cultivation of medicinal and aromatic herbs under agroforestry conditions. Sustainable production under any agroforestry system is the main goal to be achieved through short and long-term strategies. Diversification of the existing conventional cropping sequences, coupled with development of suitable technology packages is the need of the hour to cope with the ever increasing demand for diversified products. The hypothesis is, intercropping of annuals, biennials and perennial medicinal plants in association with fuel, fodder, timber, pulp, fruit trees including tree species with medicinal values on the farmland, and an alternate land use system; can provide an economically viable option for sustainable systems. This paper describes the potential and benefits of medicinal plants-based agroforestry. Our experience is that planting timber, fuel and fodder or fruit tree species in combination with
medicinal crops paves the way for diversified products and better economic returns to the farmers. Multipurpose tree species outside the forest have played a very important role in catering to the day-to-day requirements of the rural population. Different farming systems consisting of crops plus trees have yielded encouraging results and have not only helped diversification but have enhanced the productivity of land per unit area. Intercropping medicinal and aromatic herb species further makes agroforestry more remunerative. A rough estimate is that 95% of the medicinal and aromatic plants is collected and harvested from natural habitats, which has not only reduced the availability of medicinal plants but severely affected their regeneration and even put some of them at risk. The demand by pharmaceutical firms at national and international levels has further led to over exploitation of these precious herbs. The shift from exploitation to commercial cultivation with multipurpose tree species and conservation seems to be a promising strategy.

Climate change and phenology of tree species an appraisal

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Preferred session C4. Mitigation and adaptation to climate change
Abstract
If climate change (global warming) is any indication, this has substantially influenced growth behavior of tree species by enhancing phonological phases of several tree species. The purpose of this investigation, which was undertaken for eight consecutive years, was to find out the impact of climate change, if any, on the phenophases of eleven multipurpose tree species, growing as a block plantation at one site. Close monitoring of important fuel, fodder and timber tree species, namely Grewia optiva, Morus alba, Bauhinia variegata, Robinia pseudoacacia, Melia azedarach, Dalbergia sissoo, Toona ciliata, Celtis australis, Gmelina arborea, Sapindus mukurosi, and Albizia stipulata has indicated a significant shift (advancement) in the phenophases. The increase in monthly temperature above than the normal has advanced leaf emergence and flower initiation phases. The variation in inter-annual climate change at regional level has prolonged the growth period of 10 out of 11 multipurpose tree species ranging between 31 and 46 days within 8 years. The increase in monthly temperature above than normal has advanced the leaf emergence and flower initiation phases. Climate change at the regional level has prolonged the growth period of tree species. The variation in minimum and maximum average annual temperature and total precipitation during the study period seems to have exerted a strong influence on the phenology of tree species.

Evaluation of the productivity of crops under Prosopis cineraria (Khejri)-based traditional agroforestry in Rajasthan, India

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Preferred Session A10. Dryland agroforestry R&D
Abstract
Prosopis cineraria (Linn.)-based agroforestry is one of the best examples of a successful farming system witnessed in Rajasthan, India. It meets the multifarious requirements of the people in addition to improving soil quality and maintaining the ecological balance in the arid tracts. To evaluate the performance of the six annual crops (Brassica campestris L., Brassica nigra Koch, Cuminum cyminum L., Cicer arietinum L., Plantago ovata Forsk. and Hordium vulgare L.) under khejri trees, an investigation was carried out at farmers’ field in Nagaur and Sikar districts of Rajasthan. When compared to an open field the percent light reduction was greater (53%) nearer to the base, and less (16%) at 5.6 m from the tree base. To assess the growth and yield of annual crops, 1 m2 quadrats were placed in all the 4 directions at 3 distances: 1.2, 3.4 and 5.6 m from the tree base in addition to the open field. Four trees having and average girth were selected for each crop combination. No definite trend was found among the directions for the various crop yields; while an increasing trend occurred as the distances increased from the tree base. Compared to
the open field, increased grain production was obtained in *C. arietinum* (7.3 %) and *B. nigra* (4.9 %) whereas the grain yield decreased in *Brassica campestris* (9.0 %), *C. cyminum* (11.4 %), *P. ovata* (14.6 %) and *H. vulgare* (5.9 %). The proper tree management like cent per cent lopping of the branches during the winter season (before the sowing of the crop), and optimum tree density and its arrangement facilitates maximum production. Interaction with farmers suggests that there is little or no effect of the khejri on the yield of under-storey crops, and that tree density was decreasing owing to mechanisation and recent insect infestation.

Avoided deforestation and reforestation of lands under shifting cultivation in northeast India: opportunities for building climate-resilient society

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Preferred session C3. Agroforestry, water quality and environmental amelioration

Abstract The northeast region of India has been experiencing a sharp decline in forest cover over the last three decades. Beginning in the nineteen eighties the losses reached 635 km² between 1991 and 1993 and peaked at 783 km² between 1993 and 1995 before registering a decline. The basic reasons for this forest decline are shifting cultivation practice and forest degradation and destruction. The cumulative area under shifting cultivation in northeast India is estimated to be 1.73 million ha. Considering the trend of deforestation in northeast India, it is visualized that by adopting the good practice of avoided deforestation, a significant leverage could be provided to poverty alleviation in the northeast tribal society. It is observed that carbon credit incentives could be an important driver to lock up the forest land, and that adopting forest restoration practice in the region will reduce GHG emissions. There appear to be good possibilities of forestry activities over these lands under shifting cultivation through the willing participation of the traditional and current tribal users of these lands, provided that the economic returns are quick, steady and substantial. This approach will eliminate the drawbacks in tree growing being viewed as an unattractive economic activity, and can address the ‘long gestation’ issue of forest, since incomes start accruing from the beginning as carbon is sequestered. In this paper the authors believe that restoration of forest and avoiding forest destruction and degradation can reverse the trend of deforestation in the region, restore ecological balance while bringing significant economic rewards, which will stimulate the building of a climate-resilient society.

Resources generation and use: implications for an inter-disciplinary approach towards sustainability through agroforestry education

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract Agroforestry systems, although age-old worldwide traditional practices, are fast receiving global attention and scientific recognition owing to comparatively recent approaches in systems modifications and development in many parts of the world, making them one of the solutions to the problems associated with the availability of productive land for agricultural and renewable natural resources (RNR) production activities including their relevance to many strategies aimed at environmental management. The capability of these systems to incorporate various agricultural and RNR production technologies into the same land management unit either simultaneously or sequentially in a deliberate manner has made them to be so adjudged, thus, there is need for consistent increased effort by stakeholders to sustainably enhance this capability. One of such efforts that are imperative in this regard is the need for a paradigm shift in terms of curricula development and training in land use practices, agriculture, RNR, environmental management, and other disciplines. The current system whereby most of the curricula for the different disciplines are developed and operated in many of our research and academic institutions in ways that do
not encourage interdisciplinary collaborations and exchanges should not be expected to aid contemporary research, educational, and national developmental priorities particularly in this part of the world when compared with global best practices. There is therefore, an obvious need to dovetail disciplines related to land use practices, agriculture, RNR, environmental management, and others, applying experiences acquired from agroforestry research, systems practices, and education. The concept behind this article is to reiterate the fact that agroforestry systems are veritable technologies combining different production systems on the same land management unit for the production of goods and services, the necessity for integrating different relevant disciplines through inter-multidisciplinary approaches aimed at confronting a series of challenges, and suggested means of achieving this, using agroforestry education as a platform.

Soil carbon dynamics in a goat-loblolly pine silvopasture system in the southeast U.S.

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Preferred session  C2. Carbon sequestration in agroforestry

Abstract  Agroforestry presents an opportunity to increase land productivity and to improve cash flow by combining income from agriculture, forestry, and animal production on the same piece of land. In addition, agroforestry offers environmental benefits such as increasing the diversity of plants and animals, nutrient recycling, erosion control, and mitigating adverse effects of climate change through carbon sequestration. This paper presents data on soil carbon dynamics in a goat-loblolly pine silvopasture system in the southeast U.S. The study is being done at the Federation of Southern Cooperatives, Epes, Alabama on a Kipling silt loam soil (fine, smectitic, thermic, Typic Paleudalfs). A 7 year-old loblolly pine plantation was thinned from 600 to 150 trees per acre in 2006. Paddocks were fenced out and treatments consisting of 0, 4, and 8 goats per acre stocking rates and an enhanced soil management treatment were studied in 2007 and 2008. Baseline soil analyses indicated that the soil at the project site was characterized by low pH (<5) and deficient in soil carbon (C). Preliminary results show that after 1 year of grazing and soil management, low soil pH and soil C content are still a problem in the silvopasture system. However, total soil N (TSN) in the 0 15 cm soil profile for the enhanced soil management treatment was significantly higher in 2008 compared to 2007. Soil management through lime and inorganic fertilizer application significantly increased soil nitrate (N) in the 45 60 cm soil profile. The above results were attributed to N supply and nutrient cycling in the form of plant biomass and animal manure. We hypothesize that animal grazing with and without additional soil management practices can improve soil C in the long term, making silvopasture both environmentally and economic sustainable.

Casuarinas an eco-friendly, economically viable agroforestry species  a boon to farmers of India.

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Preferred session  B6. Agroforestry as a tool for landscape restoration

Abstract  *Casuarina equisetifolia* was introduced in India in the 1960s to protect the coasts and for use in farmers’ fields owing to its sterling multipurpose qualities; it even replaced the staple food crop paddy. The utility of *Casuarina* is manifold. The incredible qualities such as nitrogen fixing Frankia, shelterbelt protection against tsunamis and cyclones, use in paper and pulp, rayon, construction props, timber, fuel wood, charcoal, brick kiln etc. are farmer friendly. Of late *Casuarina junghuhniana* also became popular due to its fast growth, high yield potency, and drought and blister bark disease resistance. In the initial year of plantation, many agriculture crops, like cow pea, ground nut, gingili, brinjal, gourds, chillies and okra, are grown as intercrops for
one year which provide additional revenue to the farmers, and also improve the nutrient status of the soil by fixing atmospheric nitrogen in their root nodules and also by adding remarkable quantum of leaf moulds during their life cycles. The twigs and leaves obtained while trimming the plantations in the early stage of growth provide fuelwood to the local people. India is basically an agricultural country, and farm husbandry is the main profession for the rural masses. Many small and marginal farmers are involved in casuarina seedling production as a profession and it provides year-round income, however the availability of quality planting materials are scarce. There is a wide gap between the demand and supply of the casuarina-based sectors. Efforts are being made to produce and provide quality seeds and planting materials by the State Forest Department, research institutes, industries and private organizations to bridge the gap. This paper discusses the influence on the socioeconomics of farmers and the future strategies for improvement of the species and farming communities.

Management of Santalum album L. (sandalwood) bioresource in India: an analysis of policy, legal and institutional issues

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract Santalum album L., (sandalwood), a small evergreen hemi-parasitic tree indigenous to India. It is recognized worldwide to be one of the most valuable commercial timber species with an estimated market volume of more than USD 1 billion. Despite its value and its status as India’s brand ambassador in international markets, recent data on production of sandalwood in India have shown an alarming declining trend, whereas demand has been progressively increasing. Sandalwood bioresource governance in India provides a classic example of how a once abundant valuable bioresource with great agroforestry potential could actually be systematically depleted to reach a ‘threatened status’ through state monopolistic protectionist policies and unimaginative governance. Analysis of sandal-related legal provisions promulgated in the major natural sandal occurring states of peninsular India reveals that monopolistic policies for sandal conservation in India have only exacerbated the deterioration of sandal bioresources. Amendments in 2001 and 2002 on rules governing sandal cultivation were aimed at encouraging domestication, but major sandal-producing states appear unwilling to loosen the tight reins over trade and continue to retain policies which ensure monopoly over the resource. Though sandalwood is an ideal candidate for integration in some existing agroforestry practices, especially in semi-arid areas due to its many favourable attributes, this has not been exploited sufficiently due to prevailing unfavourable policies, legal quagmires and lack of institutional support. Analysis of limited data available in sandal-based agroforestry models using appropriate financial indicators have justified the interest shown by private stakeholders. Sandal domestication initiatives may have potential for ex situ conservation of this species, but the study also highlighted lacunae in institutional research on key aspects of cultivation. Analysis of past failures and drawbacks in current in situ conservation measures also point to the lack of institutional mechanisms for enabling benefit sharing to local communities.

Relationship between research, scaling up and uptake of agroforestry research findings in Zimbabwe

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract Research and development programmes and projects on natural resources management (NRM) have been done to try and address problems of a declining natural resource base. Improvement
in research design is envisaged to improve the impact of research on the livelihoods of the poor at the same time as promoting sustainable resource use. The nature of most of the interventions has often taken a long time for significant and appreciable change to happen. This has led to prolonged realization of the impacts of such projects on community livelihoods. Although these innovations and improved technologies are essential to support increased productivity of both agriculture and natural resources management, few of the recommendations from research have been effectively put into use by the targeted end users. Lack of an enabling policy environment is one of the major contributors for non-adoption especially of agroforestry interventions. This is attributed to inadequacy in communicating research findings by researchers to stakeholders other than farmers. Other contributors include climate change and land degradation. A study was conducted to better understand research and communication processes and barriers to the various communication media used for various stakeholders across a range of levels in development sectors. The study also aimed at understanding the policy, institutions and processes guiding research design and implementation of agroforestry and other forms of NRM. Results showed that most research projects do not have communication plans for ensuring uptake of findings by other stakeholders such as various extension agents, policy makers, and industry with most of them prioritizing resources for conducting field-work rather than dissemination of knowledge-sharing products. The study proposes that in order influence decision making and resource allocation for utilization of new or improved technologies/research findings, research projects should include communication strategies for all their research findings to the relevant stakeholders. These should also be area specific.

Land planning, trees, livelihoods and tsunamis: where are the priorities?

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract Trees fulfill diverse roles such as supporting intricate biological webs, regulating microclimates and providing direct and indirect products and services for millions of species, including human beings. Tree crops as part of livelihoods in Aceh-Sumatra, Indonesia, offer a constant source of income and benefits for local communities. After the devastating tsunami of December 2004 that took away the lives of over 150,000 people and left half a million homeless in Indonesia alone, trees and tree crops suffered tremendous impact. Nevertheless, in this process, according to some studies, mostly done in Sri Lanka and India, some tree species were capable of mitigating the storm and partially shielding communities. These studies prompted massive afforestation of coastal sites, including Aceh, Indonesia. Our study developed on the west coast of the Aceh province presents a scenario where trees, as multifunctional entities, have yet to be fully evaluated in order to state their functions, including tsunami buffering. Our research established a statistical regression model stating that where vegetation (land cover – tree crops) is present in front of coastal communities, it provides protection against a tsunami. Nevertheless, if this land cover is located behind a community it endangers people by creating a blockade, preventing escape from the advancing wave. Possible mitigation strategies should consider this double function of trees on a more long-term land-planning program. Moreover, given the current assessments for a long-term tsunami recurrence period, a tsunami mitigation approach that considers trees as essential for local livelihoods, and social, environmental and economic conditions, that is, not only their function as wave barriers, is highly appropriate and needed.

Wood industries development for sustainable forest in Lao PDR

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Preferred session B1. Quantifying the role of AF in modifying watershed functions
Abstract

According to the government statistics for 2002, 41.7% of the total land area down from 47% in 1999, with the industrial plantation in 2005 is about 224,000 hectares (Urgewald, EV. 2007). Therefore, it is significant to intend on the forest management by wood industrials development. Lao Wood Industries currently are common being continuous their business base on their basically capability as only few of the products were exported, but almost are decking tile, floorboard and lumber and also handicraft production. Therefore, Lao government stamped the regulation to stop the export of lumber, semi-Products. All wood production must be finished as the furniture products would be allowed for export, (PM Ordered No. 30/PM, 2007). The wood industries in Lao PDR need to improve their industry structure, constructions and workers capacity. Within to develop the industries, the government should offers the technical supply for those industries such the standardization of the companies as strictly, the capacity to input the raw materials base on the size of the resources supply for the factory. In this case the factories must grow their own tree. Ensure the safety operation for the workers on the processing. And the machineries should be recommended to arrange as the approximately with the main production flows. Other wide the government should offers technical advisors to conduct the activity to supply for the standardization. In particularly, the plantation management should be monitoring the plantation of the industries to ensure the effective harvesting to be able to supply for the furniture productivity, it would be better to estimate the options for solar kiln base on the climate ambient condition to avoid the carbon emission. The manager must be understand and experience on the machine setting up and installation as suitable to the production flows.

Applications of GIS and remote sensing technologies in agroforestry: an Indian perspective

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract

Agroforestry is a traditional and ancient land-use practice, having the deliberate integration of trees in crop and livestock operations to get the combined production from a system. In India its origin is believed to be in the Vedic period. However, organized agroforestry research in India began in 1983 with the initiation of an All India Co-ordinated Research Project on Agroforestry. The last 25 years have made a significant contribution in agroforestry research in India covering different aspects of this land-use system. However, spatial technologies like geographical information system (GIS), remote sensing (RS) and geographical positioning system (GPS) have yet to be implemented extensively in this field in India. The diagnostic survey and appraisal revealed that there are enumerable agroforestry practices prevalent in different agro-ecological zones of India occupying sizeable areas. The spatial technologies have the potential for the utilization of aggregate agroforestry information for a variety of research and application purposes. At the National Research Centre for Agroforestry (NRCAF), Jhansi, a project entitled ‘Spatial and Temporal analysis of agroforestry interventions in North-western India using GIS and Remote Sensing’ has been initiated. In northwest India the agroforestry systems are very prominent land use systems and about 70 million trees of Populus producing 10.40 million m3 of industrial wood are standing in this region. Through this study the area under agroforestry systems in general and Populus and Eucalyptus-based systems in particular using GIS and RS technologies will be estimated and mapped in two selected districts, Yamunanagar (Haryana) and Saharanpur (Uttar Pradesh). Besides this, any changes occurring in the area under agroforestry over a period of 10 years as a result of declining wood prices will also be assessed. Further, the methodology developed as an outcome of this study may be replicated for agroforestry systems existing in other parts of India.
Extension approaches, methods and strategies for agroforestry development

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Preferred session  D3. Policy formulation and stakeholder engagement in NRM

Abstract  Extension has the greater responsibility to facilitate community awareness and participation to promote agroforestry development. Major factors influencing the rate of adoption of agroforestry are: complexity of innovation; divisibility of innovation; effects on farmers’ flexibility; likely economic benefits; implementation cost; capital outlay; and social infrastructure. There are many approaches and methods of extension that can broadly be categorized as ‘top-down’ versus ‘bottom-up’. Overall, the extension approach in India is a ‘top-down’ model. But in many cases, there have been some changes in extension methodologies. The approach to poor villagers is by indirect and continuous educational process of developing, motivating and by creating new incentives and building up social pressure to induce the people to change. Research studies show that several methods are better than any single method. The extension in the agroforestry implementation has five main strategies: (i) raise the awareness of the stakeholders, that is, farmers, industries, cooperatives, NGOs, etc. on the significance of the Agroforestry; (ii) increase the understanding and participation willingness of farmers and stakeholders; (iii) establish cooperation with those who influence the participation of farmers, for example. WIMCO, ITC, IFFCO, etc; (iv) include the farmers in the implementation process of the agroforestry; and (v) technology transfer through R&D institutions, KVKs, state departments, NGOs and VOs. The restriction on the movement of wood without permit has led to a lot of hardship for poor people who are forced to sell their wood to contractors. Tree growers’ cooperatives which are already functional in some states may be followed in others. This will assist farmers to market their products remuneratively and safeguard their interests from middlemen and price fluctuation. Once the needs of the people in respect of forest products are satisfied, dependence of the people on forests will be reduced, which will be of great help to ecological restoration.

Agroforestry redefined: research and policy implications

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Preferred session  A5. Ecological sustainability: panacea or Pandora’s Box?

Abstract  Agroforestry has been traditionally in vogue since time immemorial in one form or other all over the globe. In the recent past this traditional knowledge has gained scientific impetus. Authors in this review discuss many aspects of agroforestry in view of published research data and emphasize the need for some sort of quantitative dimension to the subject to achieve a more pragmatic approach to realizing the local needs of the farm. To support this view, various issues in agroforestry, that is, crop yields versus crop yields in agroforestry, tree density in agroforestry versus forestry, agroforestry versus orchards, tree management practices in agroforestry, and research project duration in agroforestry, are analysed and discussed. A quantitative discussion is presented on extent of yield reduction in understorey crops in agroforestry that is socially, economically and nutritionally acceptable, and the future implications of this level for food security. What should be the dividing line between the number of trees in agroforestry, forest and orchard? What should be the level and the main tree management practices, especially pruning and application of nutrients in agroforestry? What should be the dividing line between research project duration in agroforestry so as to give complete recommendations about the system, as in seasonal cropping research? Results published in research experiments are also discussed with traditionally evolved wisdom in agroforest farms. Over and above, a few policy issues in dissemination of agroforestry practices are also discussed and recommended for achieving ecological balance at the micro level.

Key words: agroforestry, crop yields, tree density, forest, traditional, policy
Analysis of land use and estimation of runoff from Nagini watershed of the Himalayan region using GIS and remote sensing

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Preferred session: B1. Quantifying the role of AF in modifying watershed functions

Abstract: Land use and surface runoff estimation is of immense importance as it directly affects hydrological and watershed management planning. The study area is located between 78°22' to 78°25' east and 30°19' to 30°21' north with an elevation of 1084-1921 m above mean sea level in Tehri Garhwal district of Uttarakhand, India. The watershed drains into Nagini river, a tributary of The Ganges, and is spread over in an area of 12.41 km². Land uses were digitized by visual interpretation using digital satellite data of 1:25,000 scale for the year 2002, procured from NRSA, Hyderabad. Satellite data (PAN IRS-1D + LISS IRS-1D) were classified into 7 categories. Almost 33 percent was observed under agriculture followed by dense forest (26.28%), moderate dense forest (14.04%), agroforestry (13.51%), dense scrubland (11.8%), barren/rocky outcrop (0.33%) and roads (1.23%). The area under agriculture was mostly rainfed and irrigation was limited to valley areas only. The main crops grown by the farmers were wheat, paddy, finger millet, peas, tomato, chilli, beans, etc. The curve number method was used to estimate runoff from the study area. Land use and soil maps were overlaid using the GIS utility of Geomatica. The weighted curve numbers for AMC-I, II and III conditions were found to be 46.0, 64.3 and 79.8, respectively, for the entire watershed. In the period of 21 years (1985-2005), rainfall varied from 719.1-1840.2 mm. During the study period, average annual runoff was found to be 123.23 mm, however, maximum annual runoff was found to be 386.4 mm in the year 1998 and the minimum was 1.3 mm in the year 2001. The outcome of the study may be used in planning and management of land and water resources of Himalayan eco-region.

Harmonizing disciplines and resources towards institutionalization of agroforestry science in the Philippines

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Preferred session: E4. Socioeconomics and agroforestry in the Pacific

Abstract: This paper highlights the experiences of the Institute of Agroforestry and the Philippine Agroforestry Education and Research Network (PAFERN) in working towards the promotion of agroforestry science in the Philippines. Specifically, this paper puts emphasis on how PAFERN harmonized the various disciplines to develop the new and most needed policy standards and guidelines for the Bachelor of Science in Agroforestry (BSAF), a policy that was absent for about 3 decades after the first program implementation in the mid-1970s. PAFERN has been an effective vehicle in addressing the institutional issues and development needs of state colleges and universities engaged in agroforestry education, as it helped built institutional capacities of its members for a more effective implementation of agroforestry education programs. These are in the form of staff and institutional capability building programs, improvement of learning resources, development of teaching materials, provision of better access to agroforestry information, creation of venues for policy advocacy, and intensification of institutional linkages. This paper also stresses the initiative of PAFERN and other institutions in recognizing agroforestry education in the Philippines through the Proposed Bill for the Creation of Agroforestry Board that was seen as a mechanism for safeguarding the quality of agroforestry education, and providing better employment opportunities for the graduates.

Agroforestry: reconciling natural resources management conflict in Thailand

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Preferred session: D3. Policy formulation and stakeholder engagement in NRM

Abstract
Conflict of interest in Thailand forest management has become more severe in the last 2 decades. On the one hand, dwindling forest area and increasing land degradation, has led the government to strictly control forest land from encroachment and occupation. Land with elevation above 35% has been categorized as class A watershed, legally an accessible area for farming. On the other hand, land shortage due to population growth and growing demand for agricultural products has put more pressure on forest land conversion by people for mono-cropping of annual crops. These two opposite land-use systems caused disquiet in the land of the King. Several efforts to reconcile these two opposing objectives have been tried with little success; forest area continues to decline. The failures seem to be set in the provided land-use options, which were either forest or mono crop. The same is also true for a reforestation project, which is mainly mono crop of eucalyptus that was not in the interest of local people. In addition, a logging ban policy implemented in 1989 has caused rampant illegal logging. The same is also true for the creation of park and protected areas. These types of forest land use always put the government and local people into continuous conflict. An alternative land use that reconciles these various objectives is needed. Based on ongoing field work in Thailand, this paper aims at reconciling natural resources management conflict in Thailand by proposing an agroforestry land-use system. Specifically, it has three objectives: i) to assess recent policies and programmes related to reforestation and tree planting programmes; ii) to explore the possibility of developing agroforest system land use in Thailand from socioeconomic aspects, that is, land and forest tenure; and iii) to propose an agroforest type that is suitable for Thailand’s upland.

Aligning western science with Aboriginal knowledge in agroforestry in the wet tropics, Australia.

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Preferred session: D3. Policy formulation and stakeholder engagement in NRM

Abstract
In Australia there has been evidence from indigenous Aboriginal communities that livelihoods derived from natural resources give both social and landscape benefits (fire, health and biodiversity). However research is needed to understand the broader factors that still impede novel NRM-based enterprise success. In the wet tropics of Queensland, in the past, researchers have attempted to work on agroforestry projects with local indigenous Aboriginal groups that promote the production of domesticated wild fruits for local consumption and commercialization, but have failed. This paper will attempt to identify ways to integrate indigenous knowledge with western Agroforestry systems that will help to improve indigenous livelihoods and the transformation to sustainability.

Livestock production in agroforestry practices

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Preferred session: A.11. on silvopastoral systems

Abstract
Growth in the agricultural sector where most of the workforce is located is a must for poverty reduction. Poverty remains rural and is strongly tied to changes in agriculture and the rural economies. Of the 1 billion people living on less than USD 1 a day, 485 million are living on between 75 cents and USD 1 a day, 323 million are living on between 50 and 75 cents a day, and 162 million, the ultra poor, are living on less than 50 cents a day. Three quarters of the ultra poor live in sub-Saharan Africa, in the midst of huge agricultural potential. Agriculture
Cocoa agroforest types and carbon stock in southern Cameroon

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Preferred session: C2. Carbon sequestration in agroforestry

Abstract
The socioeconomic and ecological values of agroforestry depend on its composition. Cocoa plantations in West and Central Africa contain multitudes of plants. From the perspective of using cocoa farms for climate change mitigation, biodiversity conservation and to improve the livelihood of forest farmers, carbon stock was evaluated in different types of cocoa plantations in southern Cameroon. Four types of cocoa plantations were used, 3 shaded and 1 un-shaded. The 3 shaded cocoa plantations vary according to the cocoa and associated plants’ density: Type A has more banana plants and palm trees, type B has a cocoa tree density 70% higher than the others, and type C has relatively high density of high-economic value industrial timber together with non-timber forest products (NTFP). Inside each cocoa plantation, carbon stock was evaluated in above ground location, litter, roots and soil. The carbon stored in type C (201 mg ha-1) is 2 to 3 times the amount stored in other cocoa management methods. The aboveground parts of plants associated with cocoa stored 49, 39 and 147 mg ha-1 of carbon in type A, B and C respectively. Carbon stored in the aboveground parts of associated plants accounted for 50-75% of the carbon stock under different shade conditions. In the absence of shade, the carbon stored in aboveground parts of the cocoa tree (20 mg ha-1) is 2 to 3 times the amount under shade conditions. The system with relative important forest components (high value timber trees and NTFP) thus stores more carbon. Since this system demonstrates a relatively better forest structure and provides products for household consumption and for the market, it offers a good opportunity to bind climate change mitigation, biodiversity conservation and livelihood provision. The study ends with a discussion on using cocoa plantation to meet the above services.

Rehabilitation of tsunami-affected coasts with casuarinas in Puducherry, India

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Preferred session: B2. AF for salinity control and land rehabilitation in central Asia

Abstract
‘Tsunami’, the word was murmured by a million lips in Sumatra, India and Sri Lanka with fear on 26 December 2004. The tsunami took a toll of millions and made many orphans. The assessments have shown that many people have escaped by holding trees, and houses situated behind thickets of trees or mangroves have either escaped the wrath of the tsunami or suffered lesser damage. Hence a project has been formulated to rehabilitate the tsunami-affected coasts and to protect it
from future natural calamities. The project concerns a 100 m wide coastal shelter belt plantation predominantly of casuarinas, coconut, thespesia, calophyllum, and pongamis. The project is designed to have long term twin – ecological and economic – benefits. The casuarinas will act as the first line of defence, the cut branches as fuel, and the needles will enrich the soil with moulds. The coconut is second line of defence, but it also offers usufructs to the villagers in the form of tender coconut, palm cola, oil nut, fibre for rope making, waste coir for compost, leaf shingles for decoration, thatch for hut roofs, etc. The pongamia and clophyllum seeds can be used for biodiesel; thespesia and clophyllum flowers can be used for Pooja. The shelterbelt protect the coasts from drifting sands and sand dunes, it reduces evapotranspiration, promotes soil moisture conservation and soil micro fauna. The plantation offers a good cover for smaller mammals and birds, hence there is scope for improving eco-tourism potential. The paper analyses and evaluates the overall ecological and economic perspectives and suggests monitoring strategies for improvement and corrective modification mechanism in the project.

The contribution of integrated soil fertility replenishment technologies to smallholder household food security in Kasungu and Machinga districts of Malawi

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Preferred session C3. Agroforestry, water quality and environmental amelioration

Abstract Integrated soil fertility replenishment (ISFR) technologies are promoted as a sustainable, low input method that may be used solely, or in conjunction with, inorganic fertilizers. However there has been little research into the long-term effects of ISFR adoption on household security and poverty reduction. Through the use of household interviews, this study sought to examine the contribution of ISFR adoption to household food security and livelihoods in smallholder farming households in Kasungu and Machinga Districts of Malawi. The results showed that following the adoption of ISFR technologies, household maize production in Kasungu and Machinga had increased by 382 kg year-1 and 242 kg year-1, representing approximately 35% and 22% of the annual household maize requirements, respectively. There was also a significant increase in the acquisition of assets and disposable income that was attributed to the use of agroforestry technologies. While hunger was present in all households, the length of annual hunger periods had significantly decreased by an average of 0.6 months year-1- at both sites. Selling assets was the most common response to shocks. In this regard, training and ‘starter pack’ germplasm were identified as crucial to the success of any agroforestry program. Considering the substantial increase in maize yields and seemingly small reduction in hunger months, it is postulated that farmers underreported the actual reduction in hunger months. However, the reduction in hunger periods revealed that ISFR technologies are fulfilling their primary role as a means to food security, but the persistent poverty shows that integrated approaches are needed to achieve significant impacts on livelihoods. In addition to addressing food production, such integrated approaches should be holistic in addressing market access and resource constraints, and improving educational opportunities, as these are critical to the success of livelihood improvement programs.

Keywords: agroforestry, food security, livelihoods, Malawi, soil fertility replenishment

Dry matter production and crude protein level of tropical legumes under shading

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract This research was carried out at Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro State, Brazil. The cultivation of four tropical legumes (Calopogonium mucunoides (calopo), Pueraria phaseoloides (puero), Macrotyloma axillare (archer) and Neonotonia wightii (perennial soybean)) was assessed under increasing shade levels (0, 30, 50 and 70%) during rainy
and dry seasons. Randomized block experimental design with four replications and 4x4 factorial arrangement was performed. The qualitative variable (species) was evaluated by a SNK test at 5% probability, and the quantitative variable (shade) was evaluated by regression statistical analysis.

The estimated parameters were: dry matter production (DMP), crude protein level (CP) and crude protein production (CPP). Legumes DMP increases, due to larger shade levels during both evaluation periods, were observed. In the rainy season, calopo showed the highest DMP (3.1 t DM ha-1 cut-1) at 30% shade differing from pueraria and archer which presented the highest DMP (5.1 and 3.9 t DM ha-1 cut-1, respectively) under 50% shade. Under the most intense shade treatment perennial soybean presented the highest DMP (4.2 t DM ha-1 cut-1). In the dry season, DMP the highest increase for the legumes pueraria, archer and perennial soybean at 50% shade (4.4, 4.5 and 3.5 t DM ha-1 cut-1, respectively) were obtained. Calopo did not present any re-grow in the dry season. At 70% shade level DMP legumes presented a decreasing rate compared to that obtained at 50%. In relation to CP levels, shade effects in the dry season were observed. Shade levels of 30% and 50% presented the highest increase at CP levels (17.6% and 18.4%, respectively). The responses to extreme treatments (0% and 70% shade) were similar (15.1% and 15.3% CP, respectively). For CPP, pueraria presented the highest output during the rainy season, showing an increase until the level of 50% shade (883.5 kg CP ha-1 cut-1). In the dry season, the highest CPP output by archer was obtained. Shade treatment of 50% presented the best performance for all variables studied.

### Shading effects on fibre fraction of tropical legumes

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**Preferred session** A6. Ecophysiological bases of agroforestry system design

**Abstract**

This research was carried out at Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro State, Brazil. The cultivation of four tropical legumes (*Calopogonium mucunoides* (calopo), *Pueraria phaseoloides* (puero), *Macrotyloma axillare* (archer) and *Neonotonia wightii* (perennial soybean)) was assessed under increasing shade levels (0, 30, 50 and 70%) during rainy and dry seasons. Randomized block experimental design with four replications and a 4x4 factorial arrangement was performed. The qualitative variable (species) was evaluated by a SNK test at 5% probability, and the quantitative variable (shade) was evaluated by regression statistical analysis.

Different shade effects on the legumes fiber fractions were estimated according to the parameters: neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose (CEL), lignin (LIG) and acid detergent insoluble ash (ADIA). During the rainy season, calopo presented lowest levels for NDF, ADF, CEL and ADIA (47.7, 32.5, 23.4 and 0.34%, respectively), pueraria presented the highest levels for NDF, ADF and ADIA (47.7, 32.5 and 23.4 and 0.34%, respectively). Cellulose’s (26.0%) highest level was in perennial soybean. During this period NDF, ADF and ADIA (47.57, 32.91 and 23.68% respectively) lowest levels for no shade treatment were obtained, as was the highest one at 70% shade level. For ADIA levels, the highest increase (0.56%) was demonstrated by the 50% shade level. No effect of shade level for the LIG in any period was observed. Calopo did not re-grow after the first cut. During the dry season, perennial soybean showed the lowest levels of NDF, ADF and CEL (48.78, 33.29 and 23.74%, respectively), pueraria presented the highest levels of NDF, ADF, CEL and ADIA (52.7, 35.3 and 0.63%, respectively). Cellulose’s (26.0%) highest level was in perennial soybean. During this period NDF, ADF and ADIA (47.57, 32.91 and 23.68% respectively) lowest levels for no shade treatment were obtained, as was the highest one at 70% shade level. For ADIA levels, the highest increase (0.56%) was demonstrated by the 50% shade level. No effect of shade level for the LIG in any period was observed. Calopo did not re-grow after the first cut. During the dry season, perennial soybean showed the lowest levels of NDF, ADF and CEL (48.78, 33.29 and 23.74%, respectively), and pueraria presented the highest levels of NDF, ADF, CEL and ADIA (53.4, 35.8, 23.74 and 0.61%, respectively). For archer the lowest level ADIA (0.38%) was obtained. Increased levels of NDF, ADF, CEL and ADIA due to the different shade levels were observed.

### Mineral composition of tropical legumes under shading


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**Preferred session** C5. Soil organic matter and nutrient cycling in multi-strata AF systems
This research was carried out at Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro State, Brazil. The cultivation of four tropical legumes (*Calopogonium mucunoides* (calopo), *Pueraria phaseoloides* (puero), *Macrotyloma axillare* (archer) and *Neonotonia wightii* (perennial soybean)) was assessed under increasing shade levels (0, 30, 50 and 70%) during rainy and dry seasons. Randomized block experimental design with four replications and a 4x4 factorial arrangement was performed. The qualitative variable (species) was evaluated by a SNK test at 5% probability, and the quantitative variable (shade) was evaluated by regression statistical analysis. Different shade effects on the legumes’ mineral composition were studied, according to the parameters: mineral matter (MM), calcium (Ca), phosphorus (P) and potassium (K). During the rainy season differences were observed among species for Ca levels, with calopo presenting the highest level (0.26%) and archer the lowest (0.22%). Levels of Ca and P increased with enlargement of shade levels (Ca: 0.20 to 0.26%; and P: 0.12 to 0.17%), increased K levels were also demonstrated up to the 50% shade level. Calopo did not re-grow after the first cut. During the dry season, effects among species for MM and Ca levels were reported. Perennial soybean presented the highest MM (8.85%) levels, and puero showed the highest Ca level (0.36%). The lowest levels for MM and Ca (6.72 and 0.23%, respectively) were observed. With respect to the influence of shade levels, Ca and P had the highest increases in levels at 70% shade treatment (0.33 and 0.19%, respectively). Under no shade treatment, Ca and P levels showed the lowest results (0.25 and 0.11%). An influence of shade on K levels during dry season was not demonstrated.

**The socio-economic Impact of home gardens on refugees communities in eastern Sudan**

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**Preferred session** A5. Ecological sustainability: panacea or Pandora’s Box?

**Abstract** In the past 4 decades Sudan has received across its boarders massive waves of refugees. They were settled in eastern Sudan where the environment is devastated by the clearance of forest. Their settlement in this fragile environment has exerted a pressure on the limited natural resources. The strategy of UNHCR was to assist refugees to practice agroforestry as a rational means of promoting self-reliance. Agroforestry has been traditionally practised in the study area without any scientific basis. During 1999 2005, the Agricultural Research Corporation (ARC) carried out home garden agroforestry interventions based on dissemination of mature research technologies. The objective of this study was to analyse the potential of home gardens, in terms of nature, structure, biodiversity, management, and component interactions. During 2005 2006, biophysical and socio-economic data were collected using different methodologies, via measurement of tree-crop interactions, semi-structured interview and distribution of questionnaires. The results obtained indicated that the management of home garden agroforestry practices in the study area has fulfilled the diversified needs of the rural households through production of a wide variety of firewood, fodder and vegetables. It meets the subsistence and cash needs of households and enhanced agricultural long-term sustainability (that is control of erosion, improved microclimate, and water use-efficiency). Analysis of the questionnaires showed that there is a tendency towards planting exotic fodder tree species. Livestock and poultry are important sources of income aside from supplying meat, milk and eggs. In addition, animal waste was recycled during dead season when animals make use of tree shade and feed on crop residues, leaf letter and tree fruits.

**Producing timber efficiently, economically and abundantly in northwest India**

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**Preferred session** C6. Agroforestry and reconciliation ecology

**Abstract** Forest benefits are indispensable to human existence, ecological balance, biodiversity, climate,
erosion, flood and pollution control, environmental improvement, tourism and carbon sequestration, etc. The original importance of wood is being ignored with devastating consequences. Exploitation of world forests far exceeds regeneration capacity, often because of low timber yields and poor economic returns on the fertile land where they stand. Poor countries cut more forests for export. Japan, China, Europe and USA are the largest importers of wood (Japan’s forest cover is 65% and Europe’s 46%). Rich countries keep these inefficient timber producing forests for the other benefits; poor countries cannot afford this luxury. India’s over-exploitation soon depleted abundant forests: timber prices skyrocketed, and India couldn’t afford to import timber. A large wood processing company employed scientists to produce genetically superior clones of fast-growing poplars that would respond to irrigation, manuring, etc. plus accumulate wood in the main trunk and not form fat branches. “Ideal miracle plants” were produced by 1978 then offered to farmers with a buy-back that gave better economic returns. Hara Farms, in 1980 took the challenge to produce timber more efficiently, economically and abundantly. Optimum tree density per hectare, irrigation, plant nutrition, pruning, plant protection and sunlight were identified. Timber yields of 500 t ha⁻¹ over a 10-year cycle are normal. Agronomically compatible crops give continual cash flow. Hara Farms practices are emulated by myriads of farmers that now produce 10 000 tons of timber daily to feed 800 processing factories established since 1990. This billion-dollar-a-year economy has changed the entire landscape and financial strength of this small area. Our Agroforestry can be replicated anywhere with different species and end uses, because the future of global land use is Agroforestry.

Scope for silvopasture for improving dairy feed rations in the non-tropical, irrigated drylands of Central Asia

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Preferred session B2. AF for salinity control and land rehabilitation in Central Asia

Abstract Animal rearing has become vital for sustaining livelihoods in the Central Asian countries (CAC), yet it is foiled by a deficiency of quality feed. Outcomes of long-term afforestation experiments underlined the scope of various species to revegetate degraded agricultural land and produce quality feed with high leaf crude protein (CP) contents. But the best moment for harvesting remained inconclusive. Given the CP dynamics of tree leaves over the growing season, a long-term forestry experiment was conducted on marginal land with Elaeagnus angustifolia L., Robinia pseudoacacia L., and Gleditsia triacanthos L. to assess a) their contribution to improving soil health, b) the suitability of leaves as feed, and c) their optimum harvesting moment. This allowed determination of their potential to complement dairy rations. Following the calibration of the chlorophyll meter SPAD-502, the leaf CP content was monitored throughout the season. The average CP content followed the order: E. angustifolia (226 g CP kg⁻¹), > R. pseudoacacia (211 g CP kg⁻¹), > G. triacanthos (177 g CP kg⁻¹); it peaked at the season onset for all species and was superior to that of commonly used feed (straw, cotton cake, etc.). The optimization of a feed mix consisting of common feeds and examined tree leaves, was estimated with a least-cost ration model driven by an optimal CP:ME (metabolizable energy) balance of 13 g MJ⁻¹, a digestible organic matter value > 70% and at lowest expenses for small-holders. The nutritive value and prices from the common feed were derived from secondary sources. Scenario results indicated substantially lower shares of common feed when introducing tree leaves and increased farmers' profits by 53% at the onset, 38% at mid-season and 34% at the end of the season. Converting marginal lands into silvopastural areas has substantial prospects for improving nutrition and health of livestock, protecting the environment and generating household income in CAC.

Constructing an agroforestry policy and institutional environment for sustainable agricultural development in Africa

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A wide range of agroforestry technologies and practices exist that can make African agriculture become more productive and competitive. These technologies and practices have, however, not been widely put to use due to a broad range of economic, socio-cultural, political and environmental factors. This paper addresses the issue of optimizing the benefits of agroforestry research for sustainable agricultural development in Africa. It looks at policy and institutional considerations and posits that the absence of an enabling policy and institutional environment constitutes a critical missing link between agroforestry research and sustainable agricultural development. Constructing an enabling policy and institutional environment therefore provides the link to optimize the benefits of agroforestry research. A policy and institutional framework encompassing economic, socio-cultural, political and environmental considerations in the conception, development, dissemination and adoption of agroforestry technologies and practices, and operationalized through aggressive, targeted advocacy and resource mobilization, partnerships and strategic alliances, and capacity strengthening provides a proper recipe for sustainable agricultural development in Africa. The Forum for Agricultural Research in Africa (FARA) aims to achieve sustainable improvements in broad-based agricultural productivity, competitiveness and markets in Africa through appropriate knowledge and technologies; enabling regional policies, institutions and markets; capacity strengthening; and supportive partnerships and strategic alliances. These provide the essential building blocks for constructing an agroforestry policy and institutional environment for sustainable agricultural development in Africa.

Production potential of subabul and intercrops under irrigated agro-ecosystems

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Abstract
The scarcity of fodder in quantity and quality is a major reason for low productivity of dairy animals. Fodder-based agroforestry systems designed to improve forage production are expected to make a significant contribution to farm productivity. Subabul (Leucaena)-based hedgerow intercropping is a low input high production system, though it can be equally suitable under a high level of technological inputs. A study was carried out to quantify the fodder production potential of subabul-based silvipasture systems. Intercropping of subabul with annual (maize plus cowpea/berseem plus rye grass) and perennial (napier bajra hybrid) grasses had a positive interaction. The production of perennial and annual crops was 140.2 and 110.3 t ha⁻¹ (respectively) in alleys, compared to the 128.7 and 98.7 t ha⁻¹ in the open. The Leucaena-based silvipastoral model was found highly productive, yielding fuelwood (35.25 q ha⁻¹ on a dry weight basis) in addition to fodder from intercultivated crops and Leucaena. The Leucaena mimosine content was diluted to a greater extent by mixing the intercultivated fodder in hedgerows in the ratio of 1:3, the Leucaena K-743A had the minimum anti-quality characters, though is was the least productive of the three sources under investigation. The subabul-based silvipastoral system had high levels of fodder and fuel output. One hectare of subabul intercropped with annual as well as perennial grass produced a dry biomass (edible and non-edible) equivalent to 1.5 and 1.45 ha respectively, of sole fodder crops. Subabul-based agroforestry systems produced 55.03% and 33.03% higher protein with perennial and annual fodder crops, respectively, than the fodder crop. The increase in frequency of subabul lopping increased the leaf:shoot ratio, though the overall biomass was reduced. The Leucaena–fodder crop intervention (K-8 at 1:2 ratio) is an excellent option for small farmers to optimize the synergy between production (fodder and fuelwood) and conservation of natural resources.
Mangrove-friendly agroforestry systems as a sustainable development option in brackish coastal wetlands

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
A productivity study of a mangrove swamp located in Puerto Galera, Oriental Mindoro, was made. The area was covered with tall grasses and a nipa plantation was established following the aqua-silviculture concept, and agricultural crops were planted on the dikes and surroundings. The existing mangrove stand at the seaward fringe was protected and mangrove organic matter was used as soil conditioner and organic fertilizer. Results showed that the intervention enhanced the ecosystem and provided greater income for the farmer. Comparison of milkfish production in artificial stocking versus natural recruitment in an agri-nipa-aquaculture system indicates comparable yields (1.62 versus. 1.43 t ha-1 crop-1). The advantage of the natural system is that the farmer doesn’t have to buy expensive milkfish fingerlings for stocking. In terms of small ruminant production, goats’ feed with 100% mangrove forage showed the highest growth rate of 1.28 kg month-1. Honey bee farming using the native honeybee (Apis cerana) is an additional benefit to the farmer with very little capital. Keeping honey bees will not only improve pollination of the mangroves and surrounding vegetation but will give good income for the farmers with very little capital and maintenance. The first nipa harvest was made when the stand was 3 years old. On the third year of farm operation, the farmer’s income increased from a mere PHP 500 a year before the project implementation to more than PHP 5000 per month at the 3rd year of operation. Wildlife diversity was also enhanced as a result of the protection of the mangrove ecosystem in the area. It is now one of the tourist destinations in Puerto Galera.

Rehabilitation of degraded forest landscape in Ologbo Forest Reserve, Edo State, Nigeria

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
A study was conducted in the degraded catchments of Agbaa stream located at 60 31 111 north and 50 37 1141 east. The study aimed to rehabilitate the entire catchment of Agbaa stream and build the capacity of local peasants to adopt improved farming practices to local ecological, economic, social and cultural conditions. The plot (1.2 ha) was devoid of the herbal and grass vegetation with all relic trees and shrubs retained. Four nursery-raised indigenous timber species Nauclea diderrichii, Khaya grandifoliola, Entandrophragma angolense, Triplochyon scleroxylon and Petersianthus macrocarpus were later planted at 3 m x 3 m intervals and nurtured for 30 months. Cuttings of 3 cassava varieties Tropical Manihot Series 30572, 30555 and 4(2) 1425 were introduced and inter-planted as single variety or in mixed proportions in the 8 sub-plots and maintained on two successive rotations of 12 months each. There were marginal increases in the number and diversity of trees, shrubs, and herbs, as well as grasses. Twenty-one families represented by 33 species and 1312 individuals were recorded. Among the introduced taxa, 1160 seedlings representing 6 species and 5 families survived. Among introduced taxa, 258 individuals attained height of 201 cm to 250 cm, while 14 of the individuals recorded grew >400 cm in height in 30 months. Mortality among the introduced seedlings K. grandifoliola, E. angolense and N. diderrichii – (recorded at 12 months after planting) was 23%, and was significant for all sub-plots (P<0.05). Degraded agricultural landscapes can recover from deflected succession occasioned by repeated cropping and fire stress, when appropriate eco-friendly cropping mixtures and agroforestry practices are adopted.
Land-use change and carbon stocks in the babassu palm region, eastern Amazon, Brazil

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Preferred session: C2. Carbon sequestration in agroforestry
Abstract
On the eastern border of the Amazon region are situated the babassu forests, which cover an area of approximately 200 000 km2 in Brazil, half of which is in the state of Maranhão. The babassu palm (Orbignya phalerata) is a native multiple-use tree of essential importance to the livelihoods of an estimated 300 000 peasant families, providing several marketable and subsistence products. The association of babassu with intercropped rice, beans, maize and manioc is a traditional slash-and-burn system locally known as ‘Roça do Toco’. The expansion of cattle ranching since the 1970s has caused land-use changes and substituted babassu forests and crop land for pastures, creating resource-use conflicts. Biomass measurements in a case study area located in central Maranhão showed that the fallow babassu forests aged 1 to 30 years have an above-ground carbon stock of 12 110 t ha-1 and an average carbon accumulation rate of 3 t ha-1 year-1. Comparison of remote sensing images of a sample area of 70 km x 70 km in the same region indicated that the area used for cattle ranching has expanded 13% between 1988 and 2006. This expansion has caused land-use intensification and the fallow periods have fallen to unsustainable levels, threatening the food security of the communities in the long run. Data integration using GIS techniques indicated that the observed cattle expansion has reduced the regional carbon stock in the landscape from 17.65 Mt in 1988 to 14.78 Mt in 2006. The difference has been emitted to the atmosphere, contributing to the global greenhouse effect.

Adapting agroforestry for climate change in arid West Africa: challenges and opportunities

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Preferred session: C4. Mitigation and adaptation to climate change
Abstract
Perhaps, no other region of the world is more vulnerable to the impact of climate change than Africa. While Africa’s contribution to the greenhouse effect is small, accounting for only 7% of global emissions in 1990, projections indicate the region is set to be impacted disproportionately by the emergent climate change phenomenon. There are projected increases of 30 40 degrees centigrade in average annual temperature in northern and southwest Africa and simultaneous reduction of 10 20% in annual precipitation. The Sahelian agro-ecological zone is particularly vulnerable to climate change. The arid region stretches from the Gambia and Mauritania, through Mali, Niger, Chad and the northern fringes of Nigeria. The zone is characterized by a fragile agro-ecological system, featuring high average temperatures, low rainfall, and periodic droughts. Total cultivable land in the zone is less than 20% of the surface area, largely due to increasing desertification. Also, forest land, mostly woody savanna, accounts for less than 10% of its total surface area and decreasing at an annual rate of 0.8%. This trend has fuelled conflicts and hunger, as well as famine, particularly in conflict-prone areas. Therefore, the objective of this paper is to provide a comprehensive policy framework, adapting agroforestry as the mechanism to revive the agro-ecological system of the arid zone and provide mitigation strategies against the onslaught of global climate change. The framework aims to counter the pressure of deforestation, allowing planned harvests of both food and fuel from the same field. It also recommends agroforestry species for the arid zone, particularly multi-use trees, providing timber for construction, medicines, livestock feeds, wind brakes and other uses, apart from food and fuel. This provides the opportunity to reverse the long-standing degradation of the region’s environment and to revive the livelihoods of millions living in absolute poverty.
The dynamics of cacao agroforestry in the margins of protected forest areas

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Preferred session  E4. Socioeconomics and agroforestry in the Pacific

Abstract  The Lore Lindu National Park in central Sulawesi, Indonesia, hosts a unique collection of endemic species which are very important for biodiversity and natural conservation. Rural communities which inhabit the forest margins certainly play a significant role in maintaining the stability of the rainforest. For more than 2 decades, land use in this region has continuously changed in substantial ways, driven by both the expansion and the intensity of cacao cultivation. Although cacao is an important factor in improving the economy of rural communities, such intensive cultivation practices might be dangerous for the environment. In this study, the reasons underlying the rise in unfavourable cacao cultivation practices are analysed, in order to identify sustainable alternatives and viable policy options. This paper presents the dynamics of cacao agroforestry over the past 26 years with respect to one particular forest using panel and recall data from 2001 and 2007. The research is part of a collaborative interdisciplinary research project, STORMA (Stability of Rainforest Margins), funded by the DFG (Deutschen Forschungsgemeinschaft). The data were obtained from surveys of 80 villages on the periphery of the national park by random sampling. Descriptive and econometric analyses were used to analyse the socioeconomic and spatial data. The GIS data are presented to explain physical changes in land use. Based on these empirical facts, cacao cultivation area in the last 26 years has expanded from 685 to 20,590 ha. The cultivation pattern has become more intensive; many shade trees have been cut down, contributing to the degradation of the rainforest. There is, nevertheless, still a future for cacao agroforestry in this region. To maintain the sustainability of the environment and thus to ensure rural welfare, it is imperative that the suggested policy options and institutional innovations be implemented.

Tithonia diversifolia (Hemsl.) A. Gray, a potential forage shrub in Yucatán: effect of age of regrowth and planting density

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Preferred session  A6. Ecophysiological bases of agroforestry-system design

Abstract  The objective of this study was to determine the yield and forage quality of Tithonia diversifolia under three distances (0.5x1.0 m, 0.75x1.0, 1.0x1.0 m) and two ages of regrowth (30 and 45 days), planted with stem cuttings on two types of soils (red and rocky soils). The experiment was carried out at the Instituto Tecnológico de Conkal (20° 59’ N, 89° 39’ W), in Yucatán, México. The climate of the area is dry tropic (Aw) with a mean annual rainfall of 850 mm and mean temperature of 26.5 °C. Soils are predominantly Lithosols (FAO indicators) with a pH 7.8. A randomized design with 3 x 2 x 2 factorial arrangement and six repetitions was used. The yield was measured when the plantation was 12 months old at 50 cm of height. The variables were: yield (kg DM ha-1), percentage of forage components (leaf, green stem and mature stem) and crude protein. The total yield was greater for distances of 0.75x1.0 m with 4950.5 kg DM ha-1, than for distances of 1.0x1.0 with 3795.2 kg DM ha-1. No differences were found between ages of regrowth. The yield was higher in red soil than rocky soil, with 5285.9 and 3487.6 kg DM ha-1, respectively. The percentage of leaf plus green stem was higher for distances of 0.5x1.0 m in rocky soil with 30 days of regrowth with 93.0%. The study found higher values of crude protein of leaf, green stem and mature stem (of 25.0, 10.5, and 6.8%) at 30 days of regrowth. The use of T. diversifolia plantation allows acceptable forage production defoliated at a minimum of 30 days in red soil with higher crude protein.
Traditional ecological knowledge on tree management and forest restoration.

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Preferred session: E4. Socioeconomics and agroforestry in the Pacific

Abstract: There has been escalating rates of tropical forest conversion and degradation worldwide. Concerted efforts to reverse this situation need to combine traditional forest management with actions that aim at halting and ultimately reversing forest loss and degradation. In order to design appropriate forest restoration measures, a study aimed at establishing traditional ecological forest restoration and management practices was conducted in Mabira Central Forest Reserve from 2007 to 2008. The objectives were to (i) assess levels of local economic and subsistence dependence on the forest and (ii) investigate traditional ecological knowledge on forest/tree management and restoration practices. Data were collected through 83 household interviews, 6 key informants, 6 focus group discussions and participatory field visits. Fifty percent of the respondents were highly dependent (75% dependence) on the forest for subsistence products such as firewood, water, medicine, poles and craft materials; while 31% of the respondents were highly dependent 75% dependence) on the forest for economic needs. Local subsistence forest dependence was associated with age, ethnicity, access to forest and the presence of products in the forest. Local economic forest dependence was associated with time required to get to the forest, access to forest and the presence of products in the forest. Fifty-seven percent of the respondents planted/retained trees on-farm, women being more involved than men. The target age group of people involved in restoration was 35 50 years. On-farm tree management practices comprised thinning, controlling parasitic plants, pruning, selective killing of undesired trees, weeding, pollarding and slashing. Subsistence dependence is of more importance to the local community than economic dependence. Traditional ecological knowledge is indirectly used to foster forest restoration through on-farm tree planting/retaining and management practices. On-farm tree planting of locally prioritized tree species and forest enrichment planting should be promoted.

Yield, components and forage quality of *Tithonia diversifolia* associated with *Cynodon nlemfuensis* and *Gliricidia sepium*

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Preferred session: A.11. on silvopastoral systems

Abstract: The objective of this study was to evaluate *C. nlemfuensis*, *T. diversifolia* and *G. sepium* in monoculture and agroforestry systems (AS). The experiment was carried at the Instituto Tecnológico of Conkal (20° 59’ N, 89° 39’ W), in Yucatán, México. The climate of the area is dry tropic (AwO) with a mean annual rainfall of 850 mm and mean temperature of 26.5 °C. Soils are predominantly Lithosols (FAO indicators) with pH 7.8. A randomized design was used; the treatments were in monocultures: T1) *C. nlemfuensis* (Cn); T2) *T. diversifolia* (Td); T3) *G. sepium* (Gs); and T4) AS with the three species; there were six repetitions for each monoculture and five for the AS; the variables were: yield (t DM ha-1), percentage of forage components, crude protein (CP), and neutral detergent fibre (NDF). The production was higher in the AS (P <0.05) with 11.8 t MS ha-1 compared to the monoculture of Cn, Td and Gs, with values of 8.4, 2.7 and 2.1 t MS ha-1, respectively. The components were not affect by the crop system (P >0.05), with values for leaf of 38.4%, 65.5% and 64.4% in Cn, Td and Gs in the monoculture respectively; and 35.9%, 65.8% and 69.5% in Cn, Td and Gs for the AS, respectively. The study found similar values for CP between crop systems: 10.8% for Cn was, 16.5% for Td and 16.9% for Gs; and a tendency in the AS of reduced content of NDF with 74.0%, 47.3%, and 47.3% for Cn, Td and Gs, respectively. The AS increased the yield without affecting the percentage of forage components and the quality of the star grass; however, Td and Gs presented a high production of edible material in both crop systems.
Tree-based land utilization in the periphery of Ujung Kulon National Park, Indonesia

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Preferred session: C6. Agroforestry and reconciliation ecology

Abstract
Many parts of the Ujung Kulon National Park (UKNP), especially in Honje Mountain area, have been changed from jungle into gardens and rice fields, and even illegal settlements. The UKNP is one of the oldest national parks in Indonesia and has been classified as a world heritage area by the IUCN. To support the sustainability of the UKNP, the welfare of the people living on the periphery of the UKNP should be improved. An alternative program that could be implemented is the optimum utilization of their lands. A study on tree-based land utilization on the periphery of the UKNP was conducted in 2 villages: Cibadak and Cimanggu. The objective of this study was to explore the potential of involvement of local people in a tree-based farming system. Forty two respondents (21 in each village) were interviewed with a semi-structured method. Data were analysed descriptively and quantitatively using frequency tabulation. The results showed that 69.1% and 40.5% of the respondents could potentially be involved in developing tree-based farming in their gardens and home yards, of each town respectively. The ranges of their land plots that could be developed were 0.25 3.75 ha and 210 2,500 m² for gardens and home yards respectively. In Cibadak Village, 28.6% of respondents cultivated gardens inside the UKNP area with a range of 0.25 2.00 ha. Data of the tree species preference and the existing tree species mentioned by respondents indicated that they had a solid interest in planting trees. This could be a good start for stakeholders with an interest in tree-based farming programs.

Effect of poplar (Populus deltoides) boundary plantation on yield of rice wheat and carbon assimilation in agri-silvicultural systems

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Preferred session: C2. Carbon sequestration in agroforestry

Abstract
Rice wheat cropping systems are of immense importance for food security in South Asian countries in general and the most dominant system of irrigated agro-ecosystem in northwest states of India. The potential of poplar (boundary) was studied to assess the productivity and carbon sequestration in this dominant rotation under an agri-silvicultural system. Wheat and paddy yield decreased in comparison to sole-crop cultivation and data was generated to quantify the effect on the crop with respect to aspect as well as distance from the base of poplar tree lines. Maximum heat and paddy yield was found in the southern aspect (16.44 q acre-1 and 20.22 q acre-1, respectively), whereas, the minimum was found in the northern aspect (10.00 q acre-1 and 16.52 q acre-1, respectively). Distance from tree base also played a significant role on the yield of grain crops. Wheat and paddy yield increased with increases in distance from 2 m to 10 m from the poplar trees (11.40 q acre-1 to 14.51 q acre-1 and 12.86 q acre-1 to 22.65 q acre-1, respectively). However, in control conditions wheat yield was 17.87 q acre-1 and paddy yield 27.86 q acre-1. Organic carbon and nitrogen content were also assessed to quantify the effect of this system on nutrients. The effects on all the studied parameters were quantified in the light of growth parameters of boundary plantation of poplar in all the four directions. The yield of wheat as well as paddy increased with increases in distance from the boundary tree lines. The decrease of 33.75% and 36.15% in paddy and 26.68% and 25.69% in wheat with the 5th and 6th year old boundary plantation than the control was observed. Total productivity of the system was used to quantify the carbon sequestration potential of the system.
Economie d’énergie du bois de chauffe pour la lutte contre la déforestation au Togo

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Preferred session  B6. Agroforestry as a tool for landscape restoration

Abstract
Sustainable development requires energy management. In rural areas of countries in Africa south of the Sahara, domestic energy represents more than 90% of energy used. The main source of this energy is the dry wood used in households for cooking. Women, the largest users of energy, collect dead wood from forests but also cut it from living trees. Worse, they waste a lot of energy out of ignorance: in homes, at the end of food preparations, the final embers left turn into ashes to be discarded. In order to provide reliable solutions to this unnecessary deforestation, a project was initiated in Togo aimed at energy efficient production of “white” coal (CB). The project’s steps are: i) identify households from 31 villages in southern Togo for the production of CB; ii) strengthen the capacities of women in the economy of domestic energy from wood and organize them to recover the embers of their fires for transformation into CB; iii) assess in terms of trees saved in Togo, the quantity of CB recovered. The work will involve organizing women to identify equipment and technical recovery and transformation of the embers in CB, tools storage, use and sale. After production, 30% of CB will go to local reuse, 20% to purchase of seed fields and 50% to the supply of generic pharmaceutical products most commonly used. At the end of a strategic plan for 5 years, the project will lead to: 18 322 households and women identified and organized into groups producing CB; 833.28 tons of CB products; 41 664 trees preserved in an estimated 26 ha of forest. Collaboration and bilateral or multilateral partnerships will be sought for for this work.

Importance of carob (Ceratonia siliqua) fruits as animal feed

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Preferred session  A.11. on silvopastoral systems

Abstract
Considering the cost and availability of concentrates for livestock feeding, it would be wise to replace them with locally available and cheap feed ingredients such as tree fodders and by-products. Carob (Ceratonia siliqua L.) is a multipurpose tree common in Mediterranean areas. The fruit pods provide two important products: seeds from which Locust Bean Gum is extracted, and pulp obtained after the removal of the seeds. This pulp could be a valuable supplementary feedstuff for ruminant livestock due to its high energy content. To assess the effect of replacing conventional concentrate (CC: 75% barley; 22.5% soybean meal, 22.5% mineral mixture and 0.5% salt) with 25% (C25) and 50% (C50) carob pulp on feed intake and digestibility, six Barbarine sheep (21±3 kg live weight) were used in a replicated 3×3 Latin-square design. Carob pulp had high sugar (47%), neutral detergent fibre (31.44%), calcium (0.63%), magnesium (0.10%) and potassium (1.10%), but low crude protein (5.7%) content. The extent of fermentation, as measured by 96 h cumulative gas production, and organic matter digestibility were higher in carob pulp than in the conventional concentrate. The total dry matter intake and dry matter apparent digestibility of diets were not influenced (P>0.05) by the carob levels in the concentrates. However, diets supplemented with C25 and C50 resulted in low digestibility of crude protein (<60%) and neutral detergent fibre (<50%), which can lower animal performance. Evaluation of growth performance and feed efficiency using 42 lambs is now in progress.

Keywords: Carob pulp; Digestibility; growth; sheep.
Adaptation strategies to climate change in arid and semi-arid regions: the case of Laikipia District, Kenya

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract:
Environmental challenges in land management, in combating drought and desertification and in promoting sustainable agriculture remain considerable in Africa. Hence adaptation to, and coping with climate change will involve a range of social and economic factors including education, literacy, financial and technological solutions that are cost effective. Most communities are able to adapt to climate change by devising their own coping strategies as is the case with communities that CETRAD (Centre for Training and Integrated Research for ASALS Development) is working with. Any developmental agency passionate about promoting communities in their endeavours need to amplify these coping strategies by enhancing communities’ efforts to counter climate change effects. Promoting what communities have already started makes it more relevant, participatory, and community ownership is ensured. CETRAD undertook an exploratory survey of tree nursery groups within Laikipia, Isiolo and Meru areas. The objective was to identify: established tree nursery groups; their activities that mitigate climate change impacts; and management challenges faced by the groups. The criteria for qualification for interview were: i) the group must have a tree nursery, ii) have 7 or more members, and iii) be established and registered under the Department of Social Services Ministry of Sports and Youth Affairs. A total of 44 established and registered tree nursery groups were purposively sampled and interviews conducted on the groups’ representatives. An evaluation of tree nurseries on site and needs assessment of each group was also carried out. Results indicate that communities are not aware that their tree nursery and tree planting efforts contribute to combating climate change impacts. However, they identify with seasonal variability, unreliable rainfall and prolonged droughts among other things. CETRAD seeks to assist such groups because their efforts contribute to environmental sustainability and combating climate change by increasing vegetation cover, and positively contribute to adaptation to and mitigation of climate change.

Ecological implications of climate change on the genetic diversity and distribution of African locust bean *Parkia biglobossa* in north Central Nigeria

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract:
The African locust bean *Parkia biglobossa* is a very important tree crop in the African savannas where the natives use it as food, medicine, glaze for ceramic pots, fodder, fuelwood and charcoal production. However, its wide range of wild species, which is quite restricted, is seriously under threat of genetic erosion, although the need to develop improved seedlings or varieties of this tree with lesser growth cycles and other socioeconomic characteristics is under consideration. So many factors might be responsible for this threat even though the consequence of climate is suspected as one of the most important causes. This study was therefore carried out to determine the ecological implication of possible impact of climate change on the genetic distribution and diversity of this valuable source of biodiversity in selected locations in North Central Nigeria. Different agro-climatic factors such as rainfall distribution, temperatures and relative humidity in 10 locations in the north central region, or Northern Guinea savanna agro-ecological zones, as is popularly known in Nigeria, were undertaken. The suitability of these locations to Parkia biglobossa prevalence or otherwise with regards to the climatic factors was observed in the 2006 and 2007 cropping seasons and statistically analysed. Also the fruit yield over the two cropping seasons with respect to climatic factors was analysed using correlation coefficients. Crop prevalence across locations significantly varied with rainfall distribution, temperature and relative humidity, and these results are discussed; and limitations and suggestions are presented for a postulation of the probable effect of shifts in the main agro-climatic factors on the yield productivity and genetic diversity of this important germplasm in sub-Saharan Africa.
Seeding and natural regeneration in unmanaged and silvopastoral-managed Nothofagus antarctica forests in South Patagonia

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Preferred session A.11. on silvopastoral systems

Abstract
Cattle raising is one of the major economic activities in South Patagonia, and silvopastoral systems were proposed to manage Nothofagus antarctica (ñire) forests. Actually, silvopastoral systems were applied in old-growth forests, but in the near future the managed forests will include secondary forest structures too. Beside this, the proposed thinnings of the silvopastoral systems significantly affect seeding and natural regeneration cycles. To design sustainable agroforest management in South Patagonia requires knowledge of key aspects of seed production. The aim of the study was to determine the changes of seeding and natural regeneration in unmanaged and silvopastoral managed Nothofagus antarctica forests. Ten traps per stand (n=8) were collected monthly to analyse seed quality and quantity in old-growth (OG), secondary forests (SF), recent silvopastoral plots (RSS) and long-term silvopastoral use plots (LTS) stands. Natural regeneration was studied in 5 plots (1 m2) per stand. Data were compared using simple ANOVAs and multivariate analysis. Seeding processes and natural regeneration were significantly affected by stand age and silvopastoral management. Seeds decreased in number (F=33.10, p<0.001), weight (F=4.05, p=0.010) and viability (F=4.05, p=0.005), but the percentage of empty seeds increased (F=8.06, p<0.001). Seedling number (F=3.88, p=0.016), mean age (F=4.34, p=0.0104) and height (F=2.86, p=0.050) were also affected. Multivariate analysis related OG and LTS compared to SF and RSS groups. Seeding and natural regeneration changed along the natural forest cycles (SF compared to OG), and were significantly impacted by the silvopastoral management (RSS), but values were recovered over time (LTS). The proposed silvopastoral management impact over the reproductive cycles in the short term, are necessary to develop silviculture strategies to assure the regeneration of the stands in the long term.

Indian Farmers and Agroforestry

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Preferred session A5. Ecological sustainability: panacea or Pandora’s box?

Abstract
Indian farmers traditionally integrated crops, trees and livestock in agriculture. Agriculture in its broadest sense includes horticulture, fishery, grass, tree-leaf fodders and NTFP. It was in the late 1970s that the term ‘agroforestry’ was coined and attracted attention of scientists and development agencies. India immediately recognized the potential of agroforestry (AF) and embarked on a nation-wide research programme on AF in 1983. Now there are 36 research centres of many Indian Council of Agricultural Research (ICAR) Institutes, and State Agricultural Universities (SAU). While initially the research was concerned with biophysical aspects of AF, over a period of time new issues about the social, livelihood, economic, environmental and carbon sequestration (SLEEC) impacts of AF have also come to the fore and are being articulated. It is generally assumed that the tree component of AF, even if scattered or in line or in woodlot, will have the same SLEEC impact as a forest. If this assumption is accepted, then it leads to the question how many trees are in AF outside the state forest, so that the impact of AF as practised by Indian farmers can at least be conceptualized. The paper attempts the first approximation of the number of trees on various lands and in uses outside the state forest, and then articulates in qualitative terms the SLEEC impact of AF. Some interesting conclusions are derived from this study. These lead to policy issues also.
Role of coffee-based agroforestry in conservation of biodiversity and livelihood support: a case study from South India

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Preferred session  A3. Role of agroforestry in landscape-scale conservation strategies
Abstract  India is a leading coffee-producing country in the world and South India accounts for 88.90% of the total area under coffee cultivation in the country. Within South India, the Karnataka State is the largest coffee-producing state and Kodagu district (30%), Chikmangalore and Hasan are the main coffee-growing areas. Coffee agroforests are one of the dominant land uses of the district and are located in the central part of Western Ghats, a mega-center for hotspots of biodiversity. In this context the present investigation was carried out to throw light on the conservation significance of the agroforests and their support for livelihoods. Findings of the present investigation indicates the presence of 118 tree species in coffee agroforests of moist deciduous vegetation types, and 105 tree species in the coffee agroforests of evergreen vegetation types. The richness of trees was close to the natural forests of the district (134 tree species). Coffee agroforests under evergreen vegetation had a higher proportion of endemic (11.11%) and threatened (7.94%) tree species compared to moist deciduous vegetation types (4.26% and 4.26% of endemic and threatened trees, respectively). The diversity values were also very close to the natural forest landscapes. The multifunctional and diverse agroforestry systems are not only a refuge for biological diversity, they also support livelihoods by providing a large number of timber (worth of an average Rs 5.96 lakhs ha-1) and non-timber forest products, supporting sustainable and quality coffee production, which helps get the premium price for the coffee. It is very important to note that, if these coffee agroforestry systems are to be converted to monoculture annual crops the entire landscape would become a biological desert and may not produce the services that are essential for sustainable livelihoods.

Social work and agroforestry: towards an integral practice model for sustainable futures

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Preferred session  D2. Integrating disciplines through agroforestry education
Abstract  The professional realms of social work and agroforestry have much in common. Both are oriented to, indeed committed to, the integrity of international social, economic and ecological systems. Both are intimately engaged with people and their communities around the world who endeavour to enjoy urban and rural livelihoods honouring social welfare and justice expectations. Moreover, both realms represent vast repositories of progressive education and practice experiences which, in turn, frame and support respective commitments. Essentially, professional social workers and agroforesters share many common goals and objectives and so have much to learn from each other. Nonetheless, social work and agroforestry professional collaborations are largely uncommon despite common scenarios involving critical interactions between human communities and living conditions and increasingly sensitive thresholds of natural resource systems. Such conditions are complicated and exacerbated by impacts of climate change, energy transitions beyond peak and post-petroleum and related economic uncertainties across local-through-global settings. In face of these and other serious global issues, and in the interest of timely interventions, interdisciplinary and robust collaborations among social workers and agroforestry professionals are needed, and represent an exciting and innovative new domain for 21st Century practices. Combining social and natural science perspectives, sustainable community and economic development, intercultural relations and psycho-social support services, these and other interdisciplinary practice dimensions afford opportunities for advancing best-integrative practices. This paper will explore how and in what ways such professional collaboration could emerge in service of respective and shared professional interests. Subsequent recommendations and resources for education, research and field practice are presented and discussed.
Interactive restoration: environmental development alternatives for a sustainable Madagascar; project ‘ho avy’

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Preferred session E4. Socioeconomics and agroforestry in the Pacific

Abstract
‘Ho avy’ means ‘future’ in Malagasy, and the future is the focus of a novel community-based, long-term program, endorsing the sustainable use of natural and life resources, and safeguarding Madagascar’s biodiversity for the future. Through synergistic relations with rural communities, ho avy actively links restoration of the endemic spiny forest in southwest Madagascar to conservation of the nearby marine resources. These interconnected biomes are among the planet’s most unique, yet most highly impacted ecosystems; largely due to a lack of education and viable livelihood alternatives, leading to deforestation, over-fishing, and climate change. Overcoming the degradation of the world’s most diverse ecosystems may prove impossible without offering genuine opportunities to sustainably mitigate poverty amongst rural communities. Ho avy’s integrated platform, ‘restoring future’ combines capacity building with creative environmental education, clever livelihood alternatives and basic and applied research, to maximize natural resource protection and use. Ho avy aspires to conserve resources through sustainable regional development, to initiate economically compelling community programs, as well as hands-on opportunities to research and restore the rich biodiversity of Madagascar.

Agroforestry impacts in soil fertility in the Rema’a Valley, Yemen

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract
Yemen is a developing country that suffers from problems of scarcity of natural agricultural resources, as well as soil erosion and degradation. Agroforestry systems (AFS) are being promoted as a more appropriate land-use system than monocropping systems (MCS) for smallholders worldwide. Unfortunately, long-term studies on the sustainability of different land-use systems (LUS) do not exist and the AFS in this region have started to deteriorate and many farmers have turned to traditional agriculture MCS. This study was conducted in the Rema’a Valley, near Alsharq town, Dhamar Governorate, Yemen. The study evaluated the soil nutrients, organic matter and other soil properties such as pH, bulk density, and porosity, and compared them with soil under MCS. Standard procedures for soil sampling and analysis were used to collect and analyse 36 composite soil samples from the higher area (site 1), and 36 composite soil samples from the lower area (site 2). The results showed that there were significant variations in relation to land-use system. AF practices, mixed trees with coffee (S1), and Cordia africana Lam. with coffee (S2) – have a higher nitrogen concentration (0.17–0.26%) than the Ziziphus spina-christi L. with maize (S3) and the MCS (<0.16% in both site 1 and site 2). Similar results were also seen on the effect of the different LUS on the soil P, K and SOM contents at the two sites (p<0.01). While soil N, P and K were higher under agroforestry systems S1 and S2 in both areas, it was the lowest in S5 in both areas. Other physical soil properties were more favorable under AFS than S5 and S3 that showed the highest bulk density and lowest porosity in both sites.
Agroforestry practices in the Rima’a Valley, Yemen, and the factors influencing adoption decisions by farmers

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract
Agroforestry as a sustainable agricultural system is being widely promoted all over the world especially in arid and semi-arid regions such as Yemen. This paper aimed to describe the agroforestry practices in the Rima’a Valley, Yemen, and to study the adoption process and the factors influencing the adoption decision by farmers. Direct interviews and a questionnaire were used to collect data from 162 agroforestry farmers and 83 non-agroforestry farmers. Results from logistic analysis suggest that education level, efficiency of water irrigation, non-farm income, farming experience and awareness of farmers towards agroforestry are significant variables in determining the adoption of agroforestry (P < 0.01). It was observed that farmers modified technologies to suit their situation which is characterized by scarcity of farming inputs like irrigation water and soil erosion and degradation. This suggests that local knowledge and availability of such production inputs are important factors in agroforestry technology development.

Key words: Agroforestry; Adoption; Yemen; Logistic model

Empowering women self-help groups: an innovative approach towards forest conservation and poverty alleviation

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract
Utilizing a self-help groups (SHG) model to increase literacy, small business acumen and develop skills for capacity building is increasingly been seen as an alternate approach for improving living conditions of rural tribal women and building social capital. A study was initiated under a DFID (UK)-funded project in the four tribal-dominated villages of Jabalpur district (Madhya Pradesh), in traditional knowledge skills, Lac culture (from Laccifera lacca insect) Mahua (Madhuca indica) flower processing. The SHGs were exposed to innovative systems of lac culture as compared to traditional methods, and exposed to techniques for hygienic dust-free collection, which enhanced shelf life and longevity qualities of Mahua flowers and fetched better prices particularly during the lean season. The traditional Lac culture was improved to enhance the production of lac. Knowledge skills, especially relating to the best season for lac cultivation, the recommended seed rate, the method for broodlac inoculation and the time of lac harvesting were upgraded, and SHG’s were motivated to adopt such practices to enhance their income generation. SHG’s were able to successfully cultivate lac on host trees, that is, Butea monosperma, Zizyphus mauritiana and Cajanus cajan. An additional income of USD 54.88 65.86 per crop had been generated by utilizing this technique. The results were very encouraging especially when an assured buy-back system for lac was initiated; initially tribes sold lac at USD 0.329–0.439 kg⁻¹ and now they are getting USD 1.09–1.20 kg⁻¹ at weekly markets. The adoption of this innovative technology helped tribal women to become economically empowered and to build social capital.
Nitrate and *E. coli* NAR analysis in tile drain effluent from a mixed-tree intercrop and monocrop systems

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Preferred session C3. Agroforestry, water quality and environmental amelioration

Abstract

Contamination of groundwater in agricultural areas by nitrate and *E. coli* can potentially lead to several harmful health effects for those who consume or are exposed to it. The objective of this study was to determine if trees can reduce loadings of these contaminants to the groundwater. Tile drain effluent from two adjacent agricultural systems (a mixed-tree intercrop and a monocrop) was collected from April to November during 2005 and 2006 from a mini-watershed area of 17 200 m². An area of 1100 m² (6.4%) in each system was subject to application of a mixture of water and a biotracer *E. coli* NAR, a naturally occurring strain that is resistant to naladixic acid and has been shown to be safe for introduction into the environment. The effluent was analysed for concentrations of the biotracer and NO₃-N. The premise of this study is to determine if the safety-net hypothesis is valid in a temperate intercropping system. The quantities of NO₃-N in the leachate were similar in 2005: 57.37 and 54.74 kg ha⁻¹ leached from the monocrop and intercrop sites, respectively. However in 2006, NO₃-N levels were significantly higher (P<0.05) in the monocrop effluent: 164.67 kg ha⁻¹ compared to that of the intercrop, 88.59 kg ha⁻¹. Few significant differences were found in *E. coli* NAR outputs during both years: for the same number of samples collected, the total colony forming units (CFU’s) found in the monocrop and intercrop effluents, respectively were 4040 and 3558 in 2005, and 34 025 and 28 401 in 2006. This indicates that intercropping systems and perhaps trees in general have a potential mitigating effect on *E. coli* movement to the groundwater.

Growing short-rotation woody crops in a tree-based intercropping system in southern Ontario, Canada

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract

Recently, there has been interest in shifting to carbon-neutral sources of energy, including bioenergy from short-rotation woody crops (SRWCs). In southern Ontario, there are large amounts of degraded farmland which could grow SRWCs such as shrub willow and hybrid poplar to supply feedstock to the greenhouse industry located here. To investigate the potential for short-rotation willow on marginal land, three willow varieties from SUNY-ESF (*Salix dasyclados* SV1, *S. miyabeana* SX67 and *S. purpurea* 9882-41) were established in 2 fields at the University of Guelph's Agroforestry Research Station in May 2006. One field was set up in conventional single variety plots and the other was in an agroforestry intercropping system where willow plots were located between 15 m wide rows of 20-year mixed tree species, leaving a 2 m buffer between the tree rows and willows to avoid direct below-ground competition and intense shading. In both fields, 10 m x 50 m plots of each clone were grown in a randomized design with four replications. Microclimatic differences and their effects on willow growth and yields were compared between the two fields over the 2006 and 2007 growing seasons. Daily average photosynthetically active radiation (PAR) was 16% lower in the agroforestry system. PAR was correlated with differences in soil temperature of 0.4–2.7°C between fields during the two years (R²=0.68–0.87). Soil temperatures were negatively correlated with soil moisture levels (R²=0.17–0.30), and soil moisture was correlated with biomass yields in both years (R²=0.24–0.52). Yields in the agroforestry and control fields at the end of 2007 were 3.0 and 1.1 odt ha⁻¹ respectively. It is believed that incorporating older trees into the landscape in specific tree-intercropping arrangements contributes to the sustainability of intensive agricultural practices, including SRWCs, especially when using marginal land.
La recolte du pollen par abeille, un nuveau moyen d’exploitation et de bio monitoring de l’ environnement: Cas de l’ arboretum de Ruhande

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
Le pollen est un produit de la forêt oublié au Rwanda malgré ses qualités tant nutritionnelles que thérapeutique. Bien plus il est un échantillon le plus parlant qui démontrent toutes les changements tant chimiques et biologiques. On peut lire facilement les disparitions des certaines espèces florales surtout les melisso-pollinifères, ainsi que toute menace de pollution chimique ( métaux lourds, pesticides, les bactéries etc car chaque espèce vegetal a son pollen caracteristique,son emplinte dans la nature. Cependant le principe de la recolte du pollen est facile, la main d’oeuvre est gratuite: l’abeille visite une affaire de 300 milles fleurs par jour et y recolte du pollen minucieusement qu’on collecte juste à l’entrée de la ruche avec les trappes à pollen localement fabriquées. L’analyse du butin au laboratoire donne des informations de tout genre dont on a besoin, Cette analyse est communément appelé analyse palynologique. Les résultats de cette analyse peuvent aider dans la prise des decisions sur les espèces agroforestières à caractère mellifère et pollinifère à diffuser et ainsi aider dans le processus de la tracabilité du bon miel au Rwanda (quel fleur, quel région), en plus on saurait prendre les precautions sur certaines espèces florales en voie de disparution au Rwanda et aux menaces des pollutions chimiques qui incidentes à l’environnements dues aux pesticides et autres produits chimiques degagés par les moteurs dans la nature.

The role of Boswellia and Commiphora species in rural livelihood security and climate change adaptation in the Horn of Africa: a case study in northeast Kenya

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Preferred session A10. Dryland agroforestry R&D

Abstract
This paper focuses on local people’s knowledge and attitudes towards vulnerability to climate change and impacts on their lives. It investigates the adaptation measures of local people to changes in climate. It also examines the important role of Boswellia and Commiphora species in alleviating poverty, providing fodder and a large variety of products for household consumption and direct sale, and generally protecting the environment. A survey was conducted in Wajir district in northeast Kenya, among 4 community livelihood categories, nomadic pastoralist, agropastoralist, villagers and Internally Displaced Peoples (IDPs), by questionnaire-based interviews. From the target population, a representation sample of 31% nomadic pastoralist, 3% Villagers 22% Internally Displaced Persons (IDPs) and 16% agropastoralist, were randomly selected for the study. The data collection focused on the socioeconomic and ecological benefits derived from Boswellia and Commiphora species. Results from descriptive statistics suggest that management of Boswellia and Commiphora for goods and services is a definite added economic advantage both at community (provides employment) and national (import substitution of foreign exchange) levels, and provides an incentive to combating land degradation based on the principle of multiple use. This study demonstrates that Kenya adopts an integrated approach addressing the physical, biological and socioeconomic aspects of the impacts of climate change, and integrates strategies for poverty eradication into efforts to adapt to climate change. The study emphasizes the importance of sustainable harvesting of aromatic resin in the conservation of vegetation resources and protection of the vast degraded dryland environment, that help to achieve policy impact at the government level, in the private sector and in civil society on this subject of climate change and adaptation.
Management of forest environments and sustaining forest-dependent communities: options for dryland Africa based on experiences from Sudan

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Preferred session
B9. Collective action for tree-based rehabilitation of degraded lands

Abstract
The United Nations Conference on Environment and Development (UNCED) Earth Summit in Rio de Janeiro in 1992 brought the need for greater community participation in natural resource management into sharp public focus. This is reflected in the Forest Principles, in Agenda 21, UN Convention on Biological Diversity (CBD) and UN Convention to Combat Desertification (UNCCD). In fulfillment of national forest-related obligations derived from global environmental conventions and forest agreements and processes, experience in partnerships is recognized for various types of natural resources in central Sudan, and their management involved local communities. Since the early 1980s, international assistance has introduced management practices inside natural forest reserves based on project concepts and local people’s participation with the objective of forest rehabilitation and sustainable management. Various organizations have been involved including, Food and Agriculture Organization, United Nations Sahelian Office (UNSO), as well as many other non-governmental organizations. A cross-sectional survey was conducted among two community categories of farmers, namely the taungya system and collaborative reserve farmers, using questionnaire-based interviews, focus group discussions and participatory learning and action (PLA) methodology. Results from descriptive statistics suggest partnership-based, land-use practices in central Sudan conserve biological diversity in the drylands while contributing to poverty reduction among local people. The study also proposes options for policies and land-use arrangements that enable the rural population to manage their farm and forest resources in an integrated and socially, economically and ecologically sustainable way, and to add value to their products, thus improving their livelihoods. The study combines the experiences gained from implementing different partnerships, and formulates suggestions for future development of partnerships.

Keywords: Agroforestry, conservation, drylands, forest law, rehabilitation, Sudan, sustainable forest management, taungya.

Agroforestry potential with multipurpose native trees of the semi-arid Mexican Plateau

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Preferred session
A10. Dryland agroforestry R&D

Abstract
The present degree of desertification caused by the exploitation of natural resources in the Mexican Plateau requires information that allows the decision makers to plan the productive conversion of the land. In this study cartography was generated to delimit the agroforestry potential of multipurpose native trees and shrubs under the criterion of environmental restoration and sustainable management of natural resources. The majority of selected species belong to the dry tropical forest and the thorny shrubs vegetation of semi-arid zones. The species were grouped using multivariate methods to analyse data of availability of climatic and soil variables; these were correlated with derived biological registries from tree species in the field; later by means of geographical information system (GIS), the classification of groups was made using variables of physical characteristics that marked the environmental needs of species from similar botanical families. The results delimited areas from 1’844,610 ha to 265.070 ha with very good to good agroforestry potential for the species studied; the greatest area registered was for the fabaceae family, with shrubs that are essential for the ground restoration in semi-arid zones and for production of non-wood products. The resulting maps contribute to the planning of plantations with different species of native multipurpose trees and shrubs by botanical families at degraded zones as well.
Agroforestry working manual: practical guide to farmers and woodland owners in southern US

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Preferred session: D2. Integrating disciplines through agroforestry education

Abstract: Agroforestry intentionally combines agriculture and forestry to create integrated and sustainable land-use systems. Agroforestry takes advantage of the interactive benefits from combining trees and shrubs with crops and/or livestock. Many small farms and woodland owners are reluctant to produce tree-based products using traditional forestry practices because the time between planting and income generation is so long. Agroforestry offers advantages over forestry in producing agricultural products throughout the life of the tree so that income flow is not interrupted. Agroforestry systems such as riparian buffers, alley cropping, windbreaks, silvopasture and forest farming provide significant economical and environmental protection opportunities. Currently there is no single practical handbook to guide small farmers and woodland owners in designing, establishing, managing and marketing agroforestry projects that are sustainable. The Agroforestry Consortium Team is developing an agroforestry working manual that aims at educating small farmers and private woodland owners about productivity and sustainability. The manual will seek to achieve these goals by improving the capacity of natural resource educators and landowners to develop woodland management practices that are adequately diverse, integrated, profitable, healthy and sustainable. Our targeted audience includes farmers and forest land owners with special emphasis on the minority and limited-resource landowner. The audience will also include educators, scientists and anyone in the general public interested in designing, implementing and assessing the performance of promising agroforestry practices. Each chapter of the manual will contain the following themes: 1) introduction economic potential/outlook and feasibility (marketing); 2) production methods establishment of costs (accessibility and availability of materials) and site selection; 3) marketing research and time schedule; 4) value-added processing; 5) regulations; and 6) local resources. The funding for this project is provided by the USDA-Natural Resources and Conservation Services and the Agroforestry Center.

Cocoa agroforestry Cameroon

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract: Cocoa remains the main cash crop for more than 75% of the peasant population in Cameroon. Its production is mainly by peasant farmers who, even though they are the main producers of the high-demand crop, do not earn sufficient income to meet their needs and maintain a moderate standard of living. They are left to suffer, which endangers the cocoa sector, the environment and their entire livelihood. Some factors account for this include: i) neglect of the sector by the government since this sector was privatized without necessarily letting the peasant farmers know what privatization was all about, as occurred initially under the National Produce Marketing Board (NPMB); ii) poor knowledge on the exact period in which to apply fungicides and pesticides on the cocoa fields, and insects resistant to particular chemicals on; iii) lack of inputs available for the farmers such as fungicides, pesticides, as well as lack of transportation and production resources such as trucks to convey cocoa from farms to homes, and homes to market, diggers,
vessels, tarpaulins, and ovens; iv) lack of warehouses to store dried cocoa; v) lack of sound market knowledge to avoid prices being dictated to farmers by buyers; vi) poor farm-to-market roads; vii) lack of cocoa drying facilities; viii) poor and falling prices, for example, Local prices fell from 450 to 150 FRS cfa in 1997 and from 1200 to 400 FRS cfa in 2004. This contributes to increased poverty, poor health conditions, prevalence of diseases, especially HIV/AIDS, malaria and hunger within villages, increasing child labour, and no child education. These problems need to be arrested. Cocoa production offers significant opportunities for poverty alleviation and sustainable development if the necessary infrastructure and support is facilitated.

**Keywords:** Agroforestry, climate change, diseases, farm to market roads, poverty and privatization

### Agroforestry/farm forestry in Karnataka, India

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**Preferred session** B9. Collective action for tree based rehabilitation of degraded lands

**Abstract** Indian National Forest Policy emphasizes that at least 33.33% of total geographical area should be under forests. But India’s designated forest land constitutes over 22.8% of total land area of the country. Karnataka State in India with an area of 3.86 million hectares constitutes 20% of the total geographical area. The Government of India has realized that even if intensive and systematic efforts are made to improve the traditional forests, they would not be sufficient to meet the needs of the growing number of people and livestock; hence it started extending forest activity outside the forest areas. This situation necessitated a massive afforestation outside the forest through Agroforestry/farm forestry. The Karnataka Government implemented several programmes using a Joint Forest Planning and Management (JFPM) strategy in 1993 to promote Agroforestry/farm forestry as one of the important components to enhance the green cover in order to reach 33% of the total geographical area. The JFPM strategy was implemented by village-level farming institutions. Therefore, a scientific in-depth research study was undertaken to analyse attitude, adoption behavior and the socioeconomic and ecological impact of agroforestry in Karnataka State. The study revealed that the majority of the farmers is following agri-horti system, agri-horti-silvi system and agri-pasture models. Among the 7 different agroforestry models, the agri-horti-silvi-pasture model fetched the highest net return per hectare. Further, farmers held the conviction that practising agroforestry: inculcated the culture of growing trees along with food crafts; improved livelihoods; and generated higher income and employment person-days per year than monocropping. Also, farmers have agreed that agroforestry can supply raw materials to start subsidiary enterprises. Further, the great majority of the farmers have agreed that agroforestry facilitated the recharge of the groundwater table and improved soil fertility.

### Alleviating the food security of upland farming households through homegarden agroforestry system in Claveria, Misamis Oriental

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**Preferred session** E4. Socioeconomics and agroforestry in the Pacific

**Abstract** Home gardens are sound, efficient and sustainable agroforestry land-use systems consisting of perennial trees, annual crops, vegetables and often livestock. The trees provide products and services such as food, fuelwood, fodder, timber, medicines, organic matter and nutrient replenishment and help in soil and water conservation. Homegardens help improve household food security through the ava

*Abstract/Title incomplete at time of going to press;*
**Aquaforestry as an agroforestry practice in the southwest coastal area of Ondo State Nigeria**

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*Preferred session* A2. Agroforests in humid tropical Africa

**Abstract**

Aquaforestry (silvo-aquaculture) is a practice that links trees with aquaculture. Attempts have been made to show how agroforestry could help reduce the environmental risks attached to techniques for increasing animal production. However, little is known or has been carried out in the integration of aquaculture/fisheries into silvopastoral production systems in both arid and humid moist areas of Africa. This paper highlights the possibilities and potential of cultivating some brackish-water fish species (prawns, crabs and tilapia) in three different types of mangrove tree species, *Rhizophora spp.* (red mangrove); *Avicennia spp.* (white mangrove) and *Nypa spp.*, in the southwest coastal area of Ondo State, Nigeria. The paper presents the economic and environmental benefits of this practice.

**Carbon stock in the Dukuh traditional agroforestry system: a case study at Banjar District South Kalimantan Province, Indonesia**

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*Preferred session* C2. Carbon sequestration in agroforestry

**Abstract**

Recent changes of global climate are caused by an altered energy balance between the earth and atmosphere. This balance is influenced by levels of carbon dioxide, methane and nitrous oxide, also known as greenhouse gases. Forest conversion to intensive agricultural systems leads to a reduction of ecosystem carbon stocks. The ‘dukuh’ traditional agroforestry system is one of type land use employed by a community in forests in South Kalimantan Province, Indonesia. Intensive measurements were taken at dukuh Durian, dukuh Langsat and dukuh Cempedak, which have specific conditions. The results of measurements indicate that tree biomass in dukuh Cempedak contributes carbon reserves of 187 347 ton ha-1, higher than dukuh Durian and dukuh Langsat, of 100 872 ton ha-1, and 89 286 ton ha-1 respectively. Plant biomass of the dukuh Langsat make a carbon contribution of 2282 ton ha-1 higher than dukuh Cempedak and dukuh durian, which contribute 1194 ton ha-1 and 1001 ton ha-1, respectively. Whereas litter at dukuh Durian contributes a carbon reserve of 29 054 ton ha-1 higher than dukuh Langsat and dukuh Cempedak which contribute 12 774 ton ha-1 and 2492 ton ha-1, respectively. File carbon content in organic material in dukuh agroforestry systems varies between 2–7.5 %. The level of reserve C above ground at dukuh Cempedak was around 196.61 ton ha-1 higher than dukuh Durian and dukuh Langsat, which were around 134.11 ton ha-1 and 109.08 ton ha-1, respectively.

*Keywords*: carbon stock, dukuh traditional agroforestry system

**The legal injection into climate change mitigation and adaptation**

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*Preferred session* C4. Mitigation and adaptation to climate change
Abstract
This paper will relate adaptation and mitigation efforts to the law. It is fitting that we should discuss greenhouse gas emission issues regarding climate change adaptation and mitigation post-Kyoto Protocol in line with the target emission goals of 2012. The Inter-governmental Panel on Climate Change in 2001 stated that adaptation is a necessary strategy at all scales to complement climate change mitigation efforts. Among the collaboration efforts is climate change and food security, which notably touches into tenure patterns, among other things. This paper shall, however, focus on the law, particularly the Kenyan Environmental Framework Law EMCA and relate it to the means in which community-driven projects can help transform and conserve Kenya’s precious resources.

The on-site costs of soil erosion and choice of land-use systems by upland farmers in central Viet Nam

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Preferred session
B6. Agroforestry as a tool for landscape restoration

Abstract
Soil erosion is a significant problem in the uplands of the central coast of Viet Nam. It affects the livelihoods of farmers and could hinder long-term economic development efforts in the uplands. Yet, trapped in poverty, upland farmers, especially the ethnic minority, are still mining the soil using erosive land-use systems to meet their urgent needs. This study demonstrates that the level of soil erosion varies across typical land-use systems. The fruit tree-based agroforestry system is the least erosive and most financially profitable. Measured by the annualized income loss, the on-site costs of soil erosion under upland rice-based and eucalyptus-based systems are 1022 and 1019 thousand VND ha⁻¹ year⁻¹, respectively. Meanwhile, the costs under the sugarcane system is 635 thousand VND ha⁻¹ year⁻¹, as compared (in all cases) to the fruit tree-based agroforestry system. The choice of land-use system is influenced by farmers’ attributes, land plot characteristics, and policy-related variables. Promoting a switch to the agroforestry system and the adoption of soil conservation is of great importance in reducing soil erosion and sustaining development in the uplands. However, it is a very challenging task.

Agroforestry and Native American Agroforestry Agents Of Acre

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Preferred session
D4. Incorporating local knowledge in agroforestry science

Abstract
Native American Agroforestry Agents (AAFs) are youth and adults of all Acrean tribes, chosen by their villages to work on agroforestry systems and territorial and envionmental management of the reservations after training at the Comissão Pró-Índio of Acre (CPI/AC). The AAF are a new category of skilled worker that emphasizes Indigenous food security autonomy. This thesis describes the agroforestry systems and swidden agriculture of the Kaxinawá Reservation of the Humaitá River (TIRH), the role of agroforestry agents and their effect on the development of these systems. The methodology included open-ended interviews and participatory observation. Data were collected directly in the field, and from reports written for CPI/AC. The agroforestry systems of the TIRH were planted in homegardens, bush fallow and year-old swidden fields. Fruit tree species were surveyed in each system and classified as native or introduced. Overall there were more trees of native species (65%) than introduced species. Homegardens have a higher percentage of non-native trees, primarily citrus species, an important component of the local diet. The most common species overall were: açai (Euterpe oleracea), soursop (Annona muricata), orange (Citrus aurantium), pineapple (Ananas comosus), patoá (Oenocarpus bataua), peach palm (Bactris gasipaes), upland açai (Euterpe precatoria), passion flower (Passiflora sp.), buriti (Mauritia flexuosa) and cupuaçu (Theobroma grandiflorum). Villages were eager to raise turtle, penned and fed with tree fruits. The Agroforestry Agents are considered to be messengers by the traditional leaders, of traditional knowledge compared to scientific or ‘foreign’ knowledge, and transformed into a state of hybrid knowledge. Present agroforestry systems can be identified as a result of traditional patterns and recently added knowledge.
Wood biomass from coffee plantations as an alternate energy source in central Western Ghats

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Preferred session C2. Carbon sequestration in agroforestry

Abstract Use of biomass as a substitute for fossil fuel and high-energy intensive products such as cement, steel, etc., makes a significant contribution to overcoming global climate change. This not only ensures the reduction of CO2 emission to the atmosphere but also encourages the absorption of CO2 from the atmosphere by the trees replaced after harvest. In the present study, we estimated the quantity of wood removed from private plantations of Kodagu district dominated by coffee plants (Coffeea canefora and Coffeea arabica) for a period of 12 years (1992 to 2003). From the study we found that, 135 794 Mt of wood was harvested including fuelwood and other forms of wood. Out of this 57,474 Mt was used for manufacturing various utility products which will sequester 105 379 Mt of CO2 for a period ranging from 60 to 200 years. A total of 78 321 Mt of the harvested wood was used for fuel which, in energy density terms, is equivalent to 25 580 Mt of LPG and 27 285 X 103 litres of kerosene.

International course on climate change and forestry

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract Land-management activities such as forestry and agriculture are likely to be among the first to feel the effects of a changing climate. The challenge for forestry is to adapt to new threats and new opportunities while still maintaining sustainable forests and woodlands. Forest managers have to consider whether their woodlands will survive in the new climate. We are not able to shift cultivation and crop type as easily as farmers but we are dealing with long-lived habitats that have their own natural adaptation mechanisms. All ecosystems have the capacity to react to change and, in response, to adjust. The extent to which a system is able to generate such adjustments is known as its adaptive capacity. The main objective of this interactive international course is to equip participants with a comprehensive understanding of what climate change may mean for low-income populations that are affected by these changes. This will lead to an understanding of prospects for adaptation to environmental changes related to a development context. The target audience will be staff from some of Africa’s leading research institutes on environment and social development. Participants will gain a state-of-the-art knowledge and have the opportunity to develop their analytical skills in the field of climate change adaptation through project work focusing on their own country context or professional sector.

An integrated model for analysing land-based carbon sequestration dynamics: model description and application

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Preferred session C2. Carbon sequestration in agroforestry

Abstract This paper describes a dynamic bioeconomic model capable of analysing the effects of land-
use changes, forest degradation/regeneration and soil degradation on carbon sequestration and emission processes following a systems approach at watershed level in Nepal. The main focus is on capturing interactions between agriculture and forestry activities taken as closely linked production consumption systems. The model includes: biomass growth (both above and below ground); harvest and loss due to fire events; soil erosion; end uses of the products; and C fluxes under nine distinct land-use categories as affected by production and consumption activities in the watershed: for a planning horizon of 25 years. First, we present a conceptual framework for developing and using the model and describe the watershed characteristics and input data to the model. Then the model is described in detail, and, finally, results for one application are shown. It is argued that if done appropriately, this type of modeling can provide valuable results for land-use planning and policy making.

Local knowledge on lesser-known indigenous plants in the Cordilleras, Northern Philippines: perspectives and role in Agroforestry

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Preferred session: D4. Incorporating local knowledge in agroforestry science

Abstract
Indigenous plants are widely distributed and used in the Cordilleras for different purposes such as sustainable farming system, agroforestry, food source, community health care and livelihood activities. However, proper organization and management of information on local knowledge on the use of indigenous plants are very limited and most often fragmented. The study aims to elicit the role of local knowledge on lesser-known indigenous plants in agroforestry science. A literature survey, key informant interviews, field visits and the compilation of local knowledge on lesser-known indigenous plants were conducted in Cordilleras, Northern Luzon, Philippines. To manage the local knowledge, an information system was developed with open source development tools. About 30.90% or 93 species of documented indigenous plant was used as food and food supplements and only 3.32% was used for sustainable farming systems such as agroforestry in the Cordilleras. Indigenous plants, particularly trees, are used by the local people in afforestation (Albizia procera), agroforestry (Erythraea orientalis, Trema orientalis, Areca catechu), watershed rehabilitation (Ficus nota, Wrightia pubescens) and stabilization of slopes in steep environments (Bambusa blumeana). Two species were identified as potential agroforestry tree species: a) E. orientalis L. Meril (‘dapdap’) and b) T. orientalis (‘anabiong’) belonging to the family Fabaceae and Celtidaceae, respectively. Both species are claimed to serve as shade plants for coffee, cacao and other plantation crops in an agroforestry system. Both species can also be used in afforestation activities. Other species such as A. catechu L. (‘betel’), locally known ‘galiagiwon’, ‘bakkuwog’ and ‘gali-on’ are part of an Ifugao version of a woodlot called muyong or pinugo. It is an indigenous forest-management system commonly practised by Ifugao. Local knowledge on indigenous plants provides an essential role in agroforestry science. The use of information systems is an important tool in the management of local knowledge on indigenous plant species.

Effets de la densité et de l’âge de la régénération naturelle assistée des ligneux sur la culture du mil et du niébé en associa

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Preferred session: B6. Agroforestry as a tool for landscape restoration

Abstract
La régénération naturelle assistée (RNA) des ligneux est une pratique agro forestière largement adoptée par les populations d’Aguié (Niger) pour entretenir la fertilité des terres agricoles. Cette étude vise à apprécier l’effet de ces deux facteurs (densité et âge) sur la culture du mil et du niébé en association sur des terres dunaires. Pour cela, différentes situations culturelles ont été identifiées dans les champs des paysans où seuls la densité et l’âge des ligneux varient. Ces champs sont
semés à la même date avec les mêmes variétés et sans aucun apport de fumure minérale et organique depuis plus de 5 ans. Un dispositif split-plot à deux facteurs et à trois répétitions a donc été mis en place. Le facteur densité comporte cinq niveaux (0, 50, 100, 150 et 200 arbres/ha) tandis que le facteur âge en a trois (0-3 ans ; 3-6 ans et plus de 6ans). Les observations ont porté sur la hauteur des plants, les stades phénologiques et les rendements en grain et en paille. Chez le niébé qui est une léguimineuse, les effets de l’âge et de la densité, ainsi que leur interaction ne sont pas significatifs pour tous les caractères étudiés. En revanche chez le mil, les effets densités sont significatifs mais seulement pour le rendement grain et en paille. Le meilleur rendement grain (334 kg/ha) est obtenu avec la densité 200 arbres/ha contre 135 kg/ha pour les parcelles sans arbres. En outre, le seuil de 200 arbres/ha n’est préjudiciable aux cultures, même avec des sujets âgés qui ont un grand houppier, en raison des coupes et élagages effectuées par les paysans à l’approche de la saison des cultures. Mots clés : Régénération naturelle assistée (RNA), mil, niébé, Aguié, Niger

Root growth potential as affected by planting distance and provenance on the growth and survival of *Gmelina arborea*

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**Preferred session**
B8. Participatory tree domestication (PTD) for land rehabilitation

**Abstract**
The study was conducted in Arakan Matalam, Cotabato Mindanao, Philippines, to test the effect of root classes, provenance and distance of planting on early field survival and growth of *Gmelina*. The experimental design used in the study was a strip-split plot design with three replications. Analysis of variance revealed significant differences in the growth of *Gmelina* after one year. Strong genetic control over height, basal area, and biomass were found. This result was supported by the positive and significant relationship of provenance with the same traits. Seeds from Quezon were significantly different in terms of merchantable and total height compared to seeds from Cotabato and Davao del Sur. While in terms of basal area and biomass, Quezon and Cotabato did not differ significantly. On the other hand, the three provenances did not vary significantly in terms of DBH, tree volume and survival. Distance of planting also insignificantly affects height, diameter growth and survival of the tree. However, basal area, tree volume and biomass varied significantly. Root classes significantly affected tree diameter, total height, percentage survival, and volume. All factors did not show variation on basal area, and merchantable height. Root classes were found to be positively and significantly correlated with DBH, basal area, root and total tree biomass.

Growth performance and yield of *Zea mays* planted on RGP trials of *Gmelina arborea*

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**Preferred session**
B8. Participatory tree domestication (PTD) for land rehabilitation

**Abstract**
*Zea mays* was intercropped with 6-month-old *Gmelina* RGP trials in Arakan, Matalam, Cotabato Mindanao, Philippines, arranged in a strip-plot design with three replications. Analysis of data revealed significant differences in all agronomic and morphological characters as affected by tree spacing but not to RGP classes. Mono-corn crops dominated significantly in all morphological and agronomic characters compared to the corn planted in between rows of the trees. Tree spacing was correlated significantly with corn yield, weight of 500 seeds and biomass, while RGP class was negatively correlated with yield, weight of 500 seeds, biomass, leaf area and leaf area index.

**Keywords**: RGP class, tree spacing, mono-corn
Agroforests for improved livelihoods and food security in rural communities in the Adamawa highlands.

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Sustainable farm management schemes are fundamental to poverty reduction, food security, natural heritage conservation and climate change. Multistrata are among the most performant agroforestry systems in the tropics. Homegardens have been used in the Adamawa highlands for centuries. To access the impacts of these gardens on the well-being of the farmers, on the maintenance of food security and on the adaptation to climate change, record books were handed over to farmers to document information concerning food production and income generation on a monthly basis. Eleven types of homegardens existing in the region were also monitored during a one-year period. For each type, 10 farmers were involved. The households were visited twice a month. A total crop yield of 112.43 t/annum for all the farmers was recorded. This was made up of 27.01 t of cereals, 35.07 t of tubers, 3.89 t of legumes, 29.06 t of fruits and 18.4 t of other crops. Respectively, 35.2 t, 30.12, 16.3 t of the total production were consumed, commercialized and offered to others. The remaining crops were stored. Only 1.6 t of food were bought from the market. The gifts received from relatives were 13.2 t/annum. The most consumed and purchased crop type by the farmers were cereals, whereas fruits were the most commercialized. Although food products were harvested year long, the period from March to April was perceived as the famine period in the majority of households. However, homegardens occupy an important place in a farmer’s life by improving the daily diet, consolidating and creating relationships, generating income and providing products for the treatment of various diseases. Information in the farmers’ record books could be used to predict periods of hunger within the year.

Keywords: homegardens, production, income, well-being, sustainability, adamawa.

Use and socio-economic importance of wild edible plants in rural communities of Chad.

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Preferred session E1. Hot or cold: the role of underutilized crops for AF

Abstract The livelihoods of the majority of rural people in developing countries relies on natural ecosystems as important sources of agricultural land, wood, food, medicine and income. In the Chad Republic, the food security situation in vulnerable groups like refugees, women and children, is precarious because of frequent armed conflicts. The aim of this study is to identify the major wild edible plants (WEP) and describe the commercialization channels. Participatory interviews were carried out in Pandee, Nya, Pala and Gagal Divisions. The study monitored 156 farmers distributed in Ngambaye, Mango, Nang Ta, Gor and Zime ethnolinguistic groups. A total of 46 plant species were recorded, among which, 34 were cited by the Ngambaye, 38 by the Gor, 36 by the Mango, and 35 by the Nang Ta and the Zime groups combined. Thirty species were recognized by all the groups. Some WEP are used locally to make drinks or medicines to cure various diseases. The present study has highlighted the socioeconomic importance of indigenous edible plants in the region. A hierarchical list of the species will be elaborated to set priorities for further research.

Keywords: WEP, food security, income, vulnerable group, domestication, sustainability.
Potential incomes from non-timber forest products for rural communities in the West African Sahel: an incentive to improve livelihoods

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract This paper presents results of a study that examined the role of non-timber forest products on livelihood improvement in the West African Sahel. Surveys were conducted in 45 villages located in five regions in Niger, Burkina Faso, Mali and Senegal. The principal agroforestry system in this region is the parkland, which includes trees and shrubs together with agricultural crops. Agroforestry was the primary source of income in more than 40% of the sampled households, and this was particularly important for women. The most important products harvested from trees and shrubs for sale or for family consumption were fruits, leaves, roots and bark. The annual revenue gained from selling such products varied from USD 310 to USD 3560 per household. Trees and shrubs were also important sources of food: this was particularly important during the ‘hunger period’ when grain stores are low on farms and agricultural crops are not yet mature. The study also showed that the main factors accounting for agroforestry activities and parkland management were market access and income that households expected to realize. Since producers lose a large part of their potential income due to middlemen involved in the commercialization; improving direct market access for the villages to sell non-timber forest products should strengthen parkland management and improve rural livelihoods in the region.

Nursery management of Acacia senegal (L. Wild) for on-farm early seedling growth and survival in semi-arid environment in Nigeria

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Preferred session C5. Soil organic matter and nutrient cycling in multistrata AF systems

Abstract A study to investigate the residual effects of watering regime, mycorrhiza inoculation and NPK fertilizer application in the nursery on early seedling growth and survival of Acacia senegal in the field was conducted in Sokoto, Nigeria. The seedlings which were inoculated with ecto- and endo-mycorrhizae, received varying dose rates of NPK fertilizer (0; 10 g/pot; 20 g/pot) and were subjected to three watering regimes (daily; biweekly; weekly). After 16 weeks of growth in the nursery, the seedlings of the respective treatments were transplanted into the field. The design of experiment in the nursery was factorial experiments in completely randomized design (CRD) while factorial experiments in randomized complete block design (RCBD) was used for the field experiment. At 16 WAP (weeks after planting) of growth in the nursery, the seedling batch subjected to the weekly watering regime, wilted irrespective of whether inoculated with mycorrhizae and treated with fertilizer or not. The biweekly watering regime is most adequate for tending the seedlings of Acacia senegal in the nursery to enhance its early survival in the field. Also mycorrhizae inoculation (particularly endomycorrhiza) enhanced early growth performance and seedling survival of the tree species in the field. Application of NPK fertilizer at the 10 g/pot dose rate to the seedlings of A. senegal in the nursery have a residual effect which enhanced its growth and survival in the field at the early stage. The 20 g/pot dose rate of NPK fertilizer appeared to be a lethal dose for the seedlings of A. senegal.
Rehabilitation of degraded land through agroforestry in community forests of midhills of Nepal

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Preferred session B9. Collective action for tree based rehabilitation of degraded lands

Abstract
Forest lands are important support lands for the large rural population in Nepal as they play an important role in agriculture, in providing timber for construction and fuelwood, and a host of other non-timber products. However, large tracts of degraded forest exist and forest degradation is still a major problem in Nepal. About 4% of forests in Nepal are degraded, and the proportion of degraded forest in the uplands of Nepal show that the middle mountains have the highest proportion of degraded forests at 3.6% of the total forests in that region. The objectives of the study were: 1) to rehabilitate the degraded sites by cultivation of NTFP and MAP; 2) to ameliorate the site condition of the studied sites; and 3) to raise the socioeconomic condition of the community. A team of researchers had conducted a reconnaissance survey in the selected sites in the mid-hills of Nepal. Then the participatory rural appraisal method was used to assess the socioeconomic condition of the people in the study site. Information on preferred NTFPs, medicinal aromatic plants (MAPs), grasses and tree species by the community people was identified for use in rehabilitating the sites. One nursery was established to grow seedlings of the most-preferred NTFPs, MAPs, grasses and tree species. Similarly, water-harvesting techniques were used to supply the water for their cultivation. The information on the soil characteristics was assessed and documented by soil testing in the soil laboratory. Continuous monitoring of the sites was done and the records of amelioration of the sites were assessed and documented. The findings of the study show: rehabilitation of the studied sites; enrichment of soil nutrient condition; development and dissemination of rehabilitation technology for the degraded sites, by people’s participation; and an improvement in the socioeconomic condition of the community involved.

Role of agroforestry in climate change adaptation

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Preferred session C4. Mitigation and adaptation to climate change

Abstract
Agroforestry is emerging as a promising tool to boost agricultural productivity, improve food security and enhance rural income in Africa. The role of agroforestry in sequestering carbon and contributing to climate change mitigation is relatively well documented. What is less understood is its potential for mitigating the negative effects of climate change. Agroforestry comprises a wide range of practices and promising technologies that can biophysically and economically buffer against current climate variability and food and income risks. Growing multipurpose tree and shrub species with crops and/or animals provides benefits, which the farmers may not obtain with any of these three components alone. Products and services provided by agroforestry include: the improvement of soil fertility; the provision of animal fodder; the creation of a favourable microclimate for crops and animals; reduction of temperature stress; and fruits, wood and other tree products for local consumption and income. All these benefits have the potential to contribute to climate change adaptation. Whereas the potential of agroforestry systems as a biophysical and economic buffer against current climate variability and food and income risks is real, little is known on the possible impacts of higher temperatures, increased atmospheric carbon dioxide and shifts in rainfall patterns on the agroforestry tree species on the one hand, and on their interactions with food crops on the other hand. In a drier or warmer climate tree–crop competition for water could intensify. What will be the trade-offs between these types of effects and positive impacts such as microclimate effects and soil protection? Unlike in row crops, information on pests and diseases in agroforestry systems is limited. Understanding how climate change will alter the susceptibility of trees to pests and diseases and the effects this will have on their interactions with crops, represents one area in which research would be needed.
Diversified ecological-perennial-based agriculture: enhancing the poor subsistence farmers’ capacity to cope with climate change

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Preferred session C4. Mitigation and adaptation to climate change
Abstract
The diversification of the farming system with many crops is a risk-avoidance strategy of many traditional farmers, which may place them in a better position to cope with climate change. In whichever setting it is practised, agriculture will always cause disturbances and change the ecosystem, and one species (the crop) will nearly always dominate other plants. These disturbances need to be as small as possible. Mimicking nature by redesigning a farm so that it resembles a complex ecosystem, results in a successful pest-management strategy while maintaining soil productivity. Integration of perennial species and reducing tillage – thus achieving minimal soil disturbance contributes to the system’s overall resilience. Because of their deep-rooting system, perennial tree species can better withstand the extremes of weather. In this way they act as buffers or ‘insurance’ crops at times when seasonal crops are destroyed by unfavourable climatic conditions. When farmers in the tropics move towards year-round production through perennial-based and diversified agriculture, farming is not only limited to the rainy season, thereby improving on food security and adaptability to climate change. The most important impact of climate change at the grassroots level is expressed in terms of deficiencies in food production, that is: escalating levels of food insecurity characterized by extreme hunger and malnutrition as a result of reduction in soil productivity; unpredictable-irregular seasons characterized by extremes of both dryness and precipitation that result in destructive floods; escalating incidence of pest attacks resulting from an increase in temperature; and, decreased livestock productivity directly (through higher temperatures) and indirectly (through changes in the availability of feed and fodder, etc.). Diversified-perennial-based systems enhance resilience against the effects of adverse weather conditions, poor soils and pests, thereby improving the poor farmers’ capacity to cope with climate change.

Farm wastes act as growth-enhancing mulch for pine and oak seedlings in an alley-cropping system

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Preferred session A6. Ecophysiological bases of agroforestry-system design
Abstract
Alley cropping may prove useful in the southeast U.S., providing multiple products and income streams, as well as affordable sustainable land-use alternatives to conventional farming and forest planting. Such systems in this region are of particular interest because they can help in soil conservation and nutrient retention and aid in sustaining and improving valued but degraded farmland. In the current study, triple row single-species strips of loblolly pine (Pinus taeda), longleaf pine (Pinus palustris) and cherrybark oak (Quercus pagoda) were planted as 1-year-old seedlings separated by 12 or 24 m wide areas of soybean in spring 2007. Select individual tree seedlings of each species were treated with on-farm wastes, used as mulch in a circular area around each stem. These waste/mulches were hog bedding (corn stover plus hog waste removed from swine houses), old hay (year-old rolled or slightly spoiled Bermuda-grass hay, Cynodon dactylon) and black plastic bedding film. After the first season of growth with the applied mulches, tree seedling growth rates were higher for cherrybark oak and longleaf pine seedlings mulched with old hay applied at 7.5 cm deep in a 30 cm radius around each seedling. Other mulches had varying effects on soil conditions, but no significant impact on tree growth as compared to the untreated control seedlings. These first-year findings suggest that mulching with specific on-farm wastes may be a valuable management tool in temperate alley-cropping systems. Longer-term tree growth in this system, and with regard to these initial mulching treatments, will be studied.
Water, agroforestry and food security in Africa: the role of women

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Preferred session: E5. Rewards for the Environmental Services of Agroforestry
Abstract: Shall be submitted later

Assessment of carbon sequestration in citrus-based agroforestry systems in the humid tropics of Mexico

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Preferred session: C2. Carbon sequestration in agroforestry
Abstract: The present research was conducted from 2001 through to 2003, with the aim of contributing to the understanding of the agroforestry potential for carbon sequestration, in the municipality of Martinez de la Torre, in the state of Veracruz, Mexico. The objectives of the study were to: 1) assess the carbon sequestered by the widely practised citrus-based agroforestry systems and grazing land in the state of Veracruz, Mexico; 2) determine the relative proportion of carbon in different components of production; and 3) to simulate changes in the carbon content in selected agroforestry systems, using models. The experimental design consisted of completely randomized blocks, with three replicates in each of the following treatments: citrus coffee (Ci+Cf), citrus banana (Ci+Pl), citrus coffee banana (Ci+Cf+Pl), citrus ovine-cover crop (Ci+Co), citrus pelibuey (Ci+Pe) and bovine pasture (P). The sampling technique was similar to the one used by the International Centre for Research in Agroforestry (ICRAF). The carbon content was calculated as 45% of the estimated amount of biomass. The results indicate that the minimum and the maximum amount of total carbon stored in the aboveground vegetation of 40.64 and 75.09 tons per hectare, were obtained for Ci+Co and Ci+Pe treatments, respectively, more than 95% of which were recorded for tree species. The maximum (0.57 t C. ha-1) and minimum (nil) values of carbon in herbaceous vegetation were recorded for P and Ci+Pl treatments, respectively. The maximum (2.16 t C. ha-1) and minimum (0.74 t C. ha-1) values of carbon in litter were registered for Ci+Pl and Ci+Co treatments, respectively. Research focus to identify the ideal design of complex agroforestry systems to sequester the maximum amount of carbon and payment of environmental services to farmers, could promote widespread adoption of these systems.
Key words: carbon sequestration, agroforestry systems, citrus, banana, coffee, simulation models.

Agroforestry technology to meet the challenges of livelihood support and natural resource conservation

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies
Abstract: Agroforestry is being viewed as an important option for generating employment and bringing sustainability to agriculture through crop diversification and vertical increase in production. Although agroforestry is an age-old practice in India, organized R&D, its popularization as a systematic farming system and as a development tool was initiated during the 1980s. Three decade’s efforts have resulted in the development of agroforestry models based on compatible tree
crop associations, and genetic improvement of agroforestry species and soil amelioration, which has paved the way for considerable adoption of agroforestry practices. Some of the indicators are: rehabilitation of salt-affected wastelands; adoption of eucalyptus and poplar plantations by the corporate sector, which provided more than 35 million person days of employment; poplar and eucalyptus-based agroforestry systems with short rotations by farmers; and demand for more than 15 million ETPs/year are. Agroforestry options for biofuels through Jatropha and Pongamia, and bioenergy through Prosopis and Leucaena to meet the growing demand for energy alternatives, particularly from wastelands, assume top priority now. It has also been realized that agroforestry is the only alternative to meet the target of Greening India. In addition, the agroforestry potential for environmental amelioration and mitigation of climate change is already drawing considerable attention. Therefore, the experience gained so far calls for appropriate research interventions, adequate investment, suitable extension strategies, harvest process technology, value addition and development of new products. With these inputs, the area under agroforestry in India is likely to be increased by 2025 to more than three-fold its current 7.45 million ha.

Species composition and species utilization patterns in homegardens of Kerala, India

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract In Kerala, mixed-species homegardens are transforming into single species dominant homegardens. However, the impact of such a transformation of homegardens on the farmers’ knowledge-base on species diversity and species usage patterns are not documented. The objectives of this study were to analyse old mixed-species homegardens (OMSHG), old single-species-dominant homegardens (OSSHG), new mixed-species homegardens (NMSHG) and new single-species homegardens (NSSHG), for species diversity, farmers’ knowledge on the uses of different species and changing patterns in usage of species wealth. In the present study 185 species were recorded from 32 homegardens. The density-based index of diversity for trees and palm components, herbs and shrubs are significantly higher values in OMSHG, followed by NMSHG, OSSHG and NSSHG. The number of planted and managed species did not vary much in OMSHG, OSSHG and NMSHG, while they were comparatively less in NSSHGs. However, naturally growing species were significantly greater in number than in OMSHG followed by NMSHG, OSSHG and NSSHG. About 65% to 83% of the total number of naturally growing species in mixed-species homegardens and only 20% to 30% in single-species-dominant homegardens are managed. It was also observed that only about 44% to 77% of the total number of naturally growing species is put under some use. The ratio between actual usage of species and the potential uses of species in each homegarden was calculated. The value obtained for naturally growing species was significantly more in the old homegardens than in new homegardens. Since the mixed-species homegardens are ecologically sustainable and the traditional knowledge on species diversity, cultivation, management and utilization of components of homegardens in the study area are still prevailing, it is concluded that attempts may be made for developing economically viable and ecologically sustainable mixed-species homegarden models.

A NTFP-based agroforestry in the mountain region of Nepal: a viable option for livelihoods

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Preferred session D1. Forest farming of non-timber forest products in N America

Abstract Mountain people of Nepal are poorer than the mid-hills and terai people since livelihood opportunities are much more diverse in the terai and mid-hills. Mountain dwellers largely depend
on subsistence farming and income derived from wild collection of high-value non-timber forest products (NTFPs) for their living. Haphazard and immature collection practices have decreased the availability of these NTFPs and resulted in food insecurity in the mountain areas. The impact of climate change is more pronounced in the region, too. Land productivity has decreased gradually because of climate change. In this context, the Nepal Agroforestry Foundation (NAF) introduced domestication practice of high-value NTFPs, that is, *Rheum australe*, *Veleniana jatamasi* and *Swertia Chirata* in the cultivated land as NTFP-based agroforestry (AF). Ten farmers were selected for cultivating these NTFPs. Each farmer was provided with technical and material support. Economic data were collected at the beginning of the project to see the change in the economy after the NTFPs were traded. The income of participating households was increased by 25% in 2 years. Farmers realized this practice was more cost-effective since it required less tillage, less watering, and less weeding as compared to the cereal crops. They perceived that NTFPs would enhance land productivity in the long run, because this practice controlled soil and water loss. However, the impact was not as extensive as expected because the farmers see risks associated with domestication. Farmers identified “fluctuating market price” as the first, “double taxation rules of the government” as the second, “government’s ever changing policy on NTFPs” as the third, and “NTFPs perceived as illegal trade” as the fourth reasons for farmers’ reluctance towards extensive promotion of NTFP-based AF in the region. In order to have better livelihoods in the mountain areas through this practice, policy needs to be reformed and it should focus on enterprise development to secure markets and avoid the risk of unpredicted price falls.

Reinforcing tertiary agricultural education through the innovation system approach of the agroforestry project Piip (projet d’ap)

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Preferred session D2. Integrating disciplines through agroforestry education

Potential of leaves of planted fodder trees as a source of nutrition for livestock

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Preferred session A.11. on silvopastoral systems

Abstract

In semi-arid Botswana livestock production can be improved through on-farm tree planting to provide shade and much needed protein. Four browse species, *Acacia galpinii*, *Faidherbia albida* (indigenous) and *Leucaena diversifolia* and *L. leucocephala* (two exotics), were planted to assess their potential for shade and fodder in a trial in Malotwana, Botswana. The trial was a 4 x 3 species spacing in a randomized complete block design, replicated 5 times. The study involved determination of acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), in vitro dry matter digestibility (IVDMD), ash, organic matter (OM), crude protein (CP) and condensed tannin (CT). Mineral analysis included calcium (Ca), magnesium (Mg), potassium (K), sodium (Na) and phosphorus (P) concentrations, according to the procedures of AOAC (1996).

ADF, ADL, IVDMD, NDF, OM and ash were significantly different among leaves of the four species (p<0.0001). Condensed tannin was significantly different among species (p=0.0033). Spacing did not influence nutritional concentration (p>0.05) except for ADF (p = 0.0231). All four species had more than twice the amount of crude protein needed for livestock production (8 g / 100 g of dry matter). The differences between the mineral contents of the leaves of the four species were highly significant (p<0.0001). Spacing significantly influenced mineral content of the leaves of both indigenous and exotic species suggests that browse species can be explored as a source of scarce proteinous feed. It is of particular importance that the leaves of indigenous trees had significantly greater protein contents than those of the exotic trees. This suggests great potential for these less-researched species in Botswana, especially for *A. galpinii* which had 98% survival without watering, apart from in the first year of planting.

Growth attributes and modelling of *Eucalyptus tereticornis* Sm. clones under agroforestry systems in central India

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Preferred session A6. Ecophysiologic bases of agroforestry-system design

Abstract

This article reports the analysis, modeling and comparison of yield and growth attributes (dbh, height) of *Eucalyptus tereticornis* under different agroforestry systems agrisilviculture (AS), compact block (CB), boundary plantation (BP) with four clones (C-3, C-6, C-7, C-10) and under different tree spacing: 5x4, 10x2, 8x4, 10x5m in AS; 3x3 and 2.5x2.5m in CB; and 2.5m in BP, planted at NRCAF, Jhansi (India) in 2003. The growth attributes, were recorded quarterly in first year and twice a year in the subsequent period up to 4.5 years. Significantly higher tree growth was recorded under wider spacing in all the three systems, that is, 8x4 in AS, 3x3 in CB and 2.5 in boundary plantation. In terms of dbh and height, the performance of C-3 and C-7, was the optimum, followed by C-10; performance was least in C-6. The growth performance was statistically at par in all 3 systems during the initial period, however significant and distinctly higher growth was recorded under the two agroforestry systems (AS, BP) as compared to monocropping system (CB) from the 3rd year onwards. At the age of 4.5 years, the MAI (mean annual increment) of height was 3.62 m in BP; 3.27 m in AS and 3.14 m in CB, respectively; whereas the MAI of dbh was 3.88 cm in BP, 3.41 cm in AS and 3.22 cm in CB. Various functions usually employed to model the height dbh relationship were attempted and R2 values were almost comparable with respect to allometric (0.95-0.97), Schumacher (0.94-0.96) and Richards (0.94-0.96) functions under the 3 systems. The Richards and Schumacher functions lead to almost constant predicted values of height outside the observed range, whereas allometric function resulted in reasonably accepted predicted values of height outside observed range. Allometric models, therefore, have been developed for prediction of height separately in the 3 systems and thoroughly validated for their prediction capabilities through residual diagnostics using data-splitting techniques.
Role of agro-ecosystems in conservation of tree species in the Lake Victoria catchments

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Preferred session: B6. Agroforestry as a tool for landscape restoration

Abstract:
The extent to which smallholder farms have impacted on tree species composition was documented in the Lake Victoria catchments. The ecological status of tree species among smallholder farms in the Lake Victoria catchments was also investigated. The study also investigated the relationship between socioeconomics and farm conservation of tree species composition. Thirty smallholder farms were randomly selected in the Mayuge catchments and on-farm tree inventories taken. Fifty-six tree species in an area of 51 hectares (30 farms) were recorded. The average farm size was 1.7 hectares and the average number of species per farm was 11 (Shannon-Weaver diversity index of 2.7). Species on farm were evenly distributed, with a mean evenness of 0.18. On average, 40 trees per farm were recorded. Most of these species are indigenous to Uganda. Moraceae and Markhamia lutea dominate other families and species respectively. Exotic trees were ecologically more important than indigenous species. Homesteads were more diverse (Shannon-Weaver diversity index of 2.57) than gardens (Shannon-Weaver diversity index of 2.25), with fruit and multipurpose trees dominating in both cases. The curve for the diameter at breast height shows a general reverse-J shaped distribution, characteristic of species with good rejuvenation and continuous self replacement. The results in the survey indicate that socioeconomic factors have various implications on agrodiversity and local community livelihoods. Factors such as farm size per household, age, education level, gender, family size, livestock, duration under the current head of the farm, farm labour, farm spatial distribution of household, play a leading role in agrodiversity conservation. The most significant explanatory social factor for tree conservation was age of the head. Farms headed by ageing respondents were significantly more diverse than those headed by young ones. There was a strong correlation between farm size and abundance of trees, which was also correlated with tree species diversity.

Farmers’ management of multiple species and their ecological rationalities: a case study of the homegardens in Barak Valley, Assa

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Preferred session: D4. Incorporating local knowledge in agroforestry science

Abstract:
Homegardens are an important component of the agrobiodiversity management by rural people in Barak Valley. The homegarden is an important agroforestry system, in which the multiple benefits of the mixed-species composition and the local knowledge of the farmers regarding plant associations and interactions with soil, plays a central role in the management and sustenance of the system. The study of agroforestry systems such as homegardens, in order to understand their role in the conservation of biodiversity and their contribution to the livelihoods of the poor farmers, can be a means towards achieving the Millennium Development Goals. In the present study an attempt was made to inventory the homegarden species and to examine the product benefits, plant uses, their management strategies in different zones, and the ecological rationale behind such management, and their relation to the local knowledge of the farmers in a village Dargakona in Barak Valley, northeast India. The farmers in the area are basically smallholders and a total of 8 plant-use categories from 171 woody species were identified in the homegardens. Farmers manage plant species in different micro zones, with different strategies and intensity of labour input, which is based on the knowledge of differences in physical soil properties and fertility factors, and the soil plant interrelationships. Although farmers’ knowledge does not include the complexities of modern science, their knowledge was found to have an indirect effect on the ecology of the system through the process of plantation aimed at reducing surface runoff through soil erosion, restoring degraded lands and improving the microenvironment. Such knowledge at all levels has its own
Silvopastoral systems as an agroforestry alternative to achieve tree-based rehabilitation of degraded lands: the Cuban experience.

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Abstract The objective of this paper is to share on-farm research findings from a study in which silvopastoral systems with different tree densities were assessed as an alternative means to rehabilitate degraded lands that are devoted to livestock production, under Cuban conditions. The research was carried out in 6 degraded livestock agro-ecosystems (state-owned and managed farms), 4 of them devoted to milk production and the remaining 2 dedicated to beef production. Three dairy farms and one fattening farm were reforested with *Leucaena leucocephala* over their whole grazing areas by planting 3440, 5480, 6350 and 14,298 trees ha⁻¹. The remaining 2 agro-ecosystems, without trees, were used as a control. In all farms Holstein x Zebu crossbreds were used. Lactating cows were milked twice a day, whereas fattening cattle were subjected to a growth-fattening period of 110 and 154 days during rainy and dry seasons respectively. The rehabilitation indicators measured were: (i) botanical composition of grassland, (ii) quality and yield of biomass, (iii) milk yield, (iv) reproduction performance, and (v) body weight gain. All these indicators were significantly higher in silvopastoral systems, mainly in those with a tree density ranging 5000-6500 trees ha⁻¹ and a botanical composition dominated by improved grasses. However, when the tree density was above 14,000 trees ha⁻¹ the biomass yield was affected, and when it was lower than 3500 trees ha⁻¹ there were no signs of rehabilitation. It is concluded that in Cuba living fences and silvopastoral systems are the agroforestry options more widely promoted but the level of implementation is still low. The use of legume trees, such as *L. leucocephala*, is a feasible alternative to rehabilitate degraded agro-ecosystems, particularly in semi-arid areas of Cuba. For this purpose 5000-6500 trees ha⁻¹ is recommended.

Light transmission under 7-year-old bagra (*Eucalyptus deglupta* Blume) planted with maize (*Zea mays* L.) at Claveria Misamis, Orien

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Abstract The objectives of this research were to determine the amount of light transmitted under 7-year-old bagras hedgerow, and to evaluate the agronomic characteristics of maize planted in the alley (such as height, LAI and grain yield). RCBD was the experimental designed used, replicated twice; the treatment included sole maize as intercrops under 1x3 m and 1x9 m hedgerow spacing. The light transmitted in the system was computed via gap light analysis (GLA) software. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmitted (PAR) was significantly lower under the hedgerow treatments compared to the control. The light transmit...
Effects of *Calliandra calothyrsus* and *Alnus acuminata* green manure on maize production in the highland volcanic soils of Rwanda

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Preferred session
C6. Agroforestry and reconciliation ecology

Abstract
The volcanic soils of Rwanda have high phosphorus (P) absorption and are increasingly being depleted due to overcultivation. The effects of *Calliandra calothyrsus* and *Alnus acuminata* green manures as sources of N and P for maize production, soil N, P and organic matter (OM), and pH were evaluated in northwest Rwanda. A 23-factorial experiment in a randomized complete block design with three replications was carried out at the Institut Supérieur d’Agriculture et d’Elevage (ISAE) and the Institut des Sciences Agronomiques du Rwanda (ISAR) farms located in Busogo and Kinigi sectors of Musanze district. Green manures at 0, 5 and 10 t ha⁻¹ dry matter were incorporated in split application at planting and at 4 weeks after planting. Maize (*Zea mays*, pool 8A variety) was used as the test crop. Analysis of variance was done using the GENSTAT package. The effects of green manure on soil N, available P, OM contents and pH were not significant. Similarly, the applied manures did not influence maize yields. Based on these results, application of both manures is likely to benefit the subsequent crop rather than the first one. It is therefore advisable to incorporate green manures some weeks before sowing or compost them before application.

Climate change mitigation through agroforestry systems in Chiapas, Mexico

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Preferred session
C2. Carbon sequestration in agroforestry

Abstract
Climate change due to the atmospheric carbon concentration has attracted attention worldwide. The objective of this work was to compare carbon reservoirs between two control systems (maize and traditional fallows) and three intervened agroforestry systems AFS (coffee plantation, improved fallow, and taungya system). This study was carried out in Chiapas, where maize cultivated through slash and burn is frequently practised.

Agroforestry extension in Pakistan: present status, problems and prospects

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Preferred session
D2. Integrating disciplines through agroforestry education

Abstract
The forests of Pakistan are thin, sparse and patchy. They are under severe stress as the country faces the highest rates of deforestation ever experienced. On the other hand, as agriculture continues to be the single largest geographic and economic sector, the country suffers acute shortage of food and grains. Pakistan struggles to devise effective production systems which can enhance productivity and at the same time happen be economically viable, ecologically sound and socially acceptable. In this situation, agroforestry has emerged as a very promising farming system and seems to carry a great potential to boost agriculture and overcome wood shortage. Concerted efforts have been made to introduce and promote innovative agroforestry concepts among the farming community through extension education by the foresters. However, extension education efforts have met little or no success as foresters are not experts in teaching farmers. There is a dire need to focus on the
basic framework for an efficient capacity building programme. The skills of the foresters need to be upgraded by improving college and university curricula and by providing in-service training on community and social forestry. Such efforts should be compulsory for all extension foresters planning to work with farmers. In this paper numerous constraints associated with the promotion of agroforestry have been identified. Many remedial measures to streamline the existing system and develop future sustainable extension strategies and approaches are suggested for promoting agroforestry in the country.

A viable multicomponent agroforestry system for high rainfall areas of Karnataka, India

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Preferred session A6. Ecophysiological bases of agroforestry-system design
Abstract
An agroforestry system with multicomponents will be most economically sustainable for a given agroclimatic situation. To this end, a system was developed with sapota (Achrus zapota) as base crop at 10x10 m spacing, silvicultural components (Tectona grandis, Dalbergia sissoo, Casuarina equisetifolia, Eucalyptus tereticornis, Albizia molucan /Lagerstroemia lanceolata) in the sapota line, grass along the tree line and agricultural crops in the interspace. Silvicultural components (2 seedlings of the same species) were planted at 3 2 2 3 m intervals between two sapota. Maize, paddy and sunhemp were grown in the initial 3, 5 and 4 years respectively. Later (after 12 years) with the closure of the canopy, cropping was difficult. Grass along the tree line was harvested regularly at 4-month intervals. During the year 1993 94, the 2 of the three trees adjoining sapota were harvested and the central one was retained for timber (in the case of long-rotation species (T. grandis and D. sissoo). In the case of short-rotation species (E. tereticornis and C. equisetifolia), all three trees were extracted and the central one was allowed to coppice. C. equisetifolia was replanted. A. molucana was extracted fully and replaced by L. lanceolata. With the extraction of the tree species in 1993 94, the tree crop interaction developed was reduced and the resource availability to sapota and the retained tree was enhanced. Economic analysis of the system revealed that net monetary returns at the end of 28 years with the sapota teak grass field crop was Rs. 38 977 as compared to Rs. 16 726 per year per hectare for the sapota field crop. Hence, this system with sapota and teak is sustainable during adverse agroclimatic conditions. The fertility status (OC, P&K) increased considerably with the addition of leaf litter and the values of soil pH and EC were also enhanced due to root activity.

Tree-assisted natural regeneration in the Sahelian parklands for an enhanced plant diversity and an increased agricultural production

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract
Parklands are a mixture of trees and shrubs that farmers select for certain functions, and cultivate together with staple food crops. They provide many functions for the rural poor. Unfortunately, the richness and abundance of indigenous trees and shrubs is being eroded in the parklands and other forested landscapes in the region, especially since the ecological crisis of the 1970s coupled with an alarming overexploitation of natural resources in response to increasing needs of agricultural and pastoral production and domestic energy. Many tree species of great importance for local communities have disappeared and other species are threatened. Thus, different institutional and political changes, as well as social and cultural considerations that have contributed to the establishment of management tools, are being discussed. This paper discusses aspects of plant diversity loss, the assisted natural regeneration for the restoration of the Sahel, various techniques...
for a successful regeneration, and approaches for agricultural diversification. Moreover, we deal
with the impacts of institutional, political and cultural changes on natural resources management
in general and particularly on the tree regeneration. Taking into account the high population
increase in most of the Sahelian countries and the complex socioeconomic conditions of local
communities, assisted natural regeneration practice could be a solution and an adaptation strategy
to ensure food security, preserve plant biodiversity and mitigate climate changes. With respect
to plant biodiversity in the study areas, it is clear that farmer-managed natural regeneration has
favoured crop diversification and intensification and increased crop yields in most of the Sahelian
countries. The scope for possible interventions and key areas in which research is required are
highlighted.

Key words: plant biodiversity, farmer managed natural regeneration, sahel, policy, land and tree tenure

**Populus deltoids** G3 Marsh systems in eastern India: biomass, production, energetics
and nutrient cycling.

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems
Abstract Poplar (*Populus deltoides*)-based agroforestry systems are becoming popular in eastern and
northern parts of India, and make a valuable contribution to improved productivity and nutrient
cycling within the systems. This paper elucidates dry matter, energy and nutrient dynamics in
poplar (P. deltoides, clone G-3 Marsh)-based agroforestry systems at the ages of 4 and 8 years
established at Rajendra Agricultural University Farm, Pusa, Bihar. Total vegetation biomass (32.2
85.9 mg ha⁻¹) was distributed as 25.0 70.9 mg ha⁻¹ in trees and 7.2 15.0 mg ha⁻¹ in crops. Net
primary production (NPP) of total vegetation ranged between 24.2 and 37.7 mg ha⁻¹ y⁻¹, of which
the contribution of trees and crops was 60 70% and 30 40%, respectively. Energy fixation, storage,
net allocation in agronomic yield and the energy accumulation ratio (EAR) were 1.08, 2.44, 0.77
and 2.21 times higher in the 8-year-old system compared to 4-year-old system, respectively. The
energy conservation efficiency (ECE) in the 8-year-old system was higher (1.64%) as compared
to 4-year-old system. Soil, litter and vegetation accounted for 96.6 98.2, 0.5 0.9 and 1.3 2.5%
of the total nutrients in the system, respectively. Annual transfer of litter nutrients to the soil by
vegetation was 58.4 115.3 N, 7.7 14.0 P and 32.8 61.1 K kg ha⁻¹ y⁻¹. The turnover rate for litter
varied between 0.84 and 0.90 year⁻¹ and for various nutrients it ranged between 0.87 and 0.98
year⁻¹. The nutrient return in litterfall and fine roots almost balanced the removal of nutrients in
crop harvest. Thus, the efficient use of nutrients from the soil pool and rapid intra-system cycling
maintained a high biological productivity of the agroforestry system.

How local government drives landscape dynamics, conducting to agroforest
conversion into rubber and oil palm plantations.

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Preferred session D3. Policy formulation and stakeholder engagement in NRM
Abstract In Bungo district (Jambi province) agroforests are quickly disappearing from the landscape, with
the approval or even the support of the local government. Several programmes aiming at regional
economic development are being conducted in the district. One involves opening new access
to cultivated or forested lands by building new roads; another involves distributing seedlings of
clonal rubber; a third involves attracting oil palm companies to the district. These programmes
directly impact on the landscape. Indeed the presence of a road, even non-asphalted, is a sine qua
non condition for oil palm development, and the lack of availability of seedlings of clonal rubber
or oil palm is a main hindrance to the expansion of monospecific plantations. Last but not least,
the proximity of agro-industrial companies has a determining impact on infrastructure, availability
of seedlings and inputs, tenant contracts, technical assistance, credit schemes and processing plants. We conducted surveys at local government agencies and collected statistics, maps and land use plans in order to understand the official reasons behind the location of one or another programme and to learn more about infrastructure planning. In a second stage we conducted field surveys in the very locations where roads had been recently opened in order to determine underlying influences on the process of site selection. A historical map was drawn (based on the analysis of a series of Landsat images from 1973 to 2005, a Spot image of 2006 and on GPS data collection) linking land-use evolution to market facilities, transport infrastructure, trade and production networks and large agro-industrial project development.

Mechanization in sloping areas
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Preferred session B4. Agroforestry in Europe: Land Reclamation
Abstract Several causes have brought about a rapid and progressive reduction in woodlands, thus endangering the delicate biological balance of very complex living systems. The safeguard of forestry resources is therefore necessary: this should be carried out by means of prudent interventions and with respect for the existing equilibrium. Reforestation is certainly an interesting opportunity for achieving this aim and could be performed especially in ‘marginal areas’, that is, in those areas that are unproductive for several reasons (extremely steep slopes, poor pedologic features etc.) and are therefore abandoned. Cultivating these areas is of great importance with regard to both environmental and economic aspects, and social effects. This paper deals with a mechanized reforestation intervention in hilly, hard to reach and steeply sloping areas, in Calabria, Southern Italy. The intervention consisted of the following phases: first, forming terraces, soil tilling in the few flat areas and creating an internal road network; secondly, the soil of the terraces was scarified in order to improve soil texture and prepare the soil for transplanting; the last phase, reforesting, comprised planting of young forest trees according to two different methods, assisted hand transplanting and mechanized transplanting. Tests were performed, and they demonstrated the advantages, from the technical and operational points of view, provided by completely mechanized working chains both for terrace preparation and tree transplantation. Finally an economic analysis showed that, by this kind of intervention, we can perfectly join the economy, work quality and environment safeguards.

Keywords: reforestation, terracing, transplanting.

Recreational values of arid zone agroforestry systems a case study in Karkas, Iran
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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract Traditional agroforestry systems and agricultural systems have been developed in Karkas oasis in the arid region of Central Iran. Population increase, socio-economic problems and unsustainable management have forced the area toward desertification, while its recreational potential provides valuable opportunities. Agroforestry systems have special features which attract eco-tourists. The goals of this study were to determine effective recreational factors from the standpoint of eco-tourists, and to developing a local method for evaluating recreational qualities in order to investigate agroforestry potential in this respect. A questionnaire addressing recreational factors was completed by the visitors to several recreational activities. The priority of these recreational factors was detected by the multiple criteria decision making method followed by the use of the Leopold matrix; a model was developed to quantify recreational values from the view point of the visitors. This model was used in the Karkas area. Various practices were characterized and then evaluated by the model. The results show the following order in recreational values of different
land-use systems in similar conditions: agrosilvopastoral, plantation, agrisilviculture, silvopastoral, rangeland and farms. The income from eco-tourists has reduced the pressure on the land and created a motive to plant trees in farmlands.

Tree structure and diversity of coffee-based agroforests and natural forest in Guinée Forestière (Guinea, West Africa)

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Preferred session A2. Agroforests in humid tropical Africa

Abstract In the current deforestation context, agroforestry is increasingly considered in the tropical zone for its potential contribution to biodiversity conservation. In Guinée Forestière (Guinea, West Africa), coffee-based agroforests are currently expanding on agricultural land around most villages. To assess the biodiversity potential of these agroforests, we compared their tree structure and diversity with those of a neighbouring natural forest. Eighty plots were sampled with a variable-area transect method (60 agroforests plots distributed into 3 village territories, and 20 natural forest plots). The structure of coffee-based agroforests showed obvious signs of farmers’ management: for example, the density of mature trees was significantly lower than in natural forest and most juvenile trees were eliminated and replaced by coffee trees. However, sapling density was not significantly different than in the natural forest. Tree species richness and diversity in the agroforests were also lower than in natural forest but much higher than in any other agricultural or agroforestry land-use system. These results are close to those obtained in the coffee-based agroforests from Central America, confirming that agroforests retain many forest species that could play a key role in the conservation of regional forest-tree diversity.

Key words: agroforest, coffee, forest, Guinea, biodiversity

Reviving the Philippine coffee industry through corporate social responsibility: a viable market strategy for agroforestry expansion

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Preferred session E4. Socioeconomics and Agroforestry in the Pacific

Abstract As the notion of alternative consumption increasingly influences the global markets, a growing movement is brewing among private corporations in the Philippines to revive the Philippine coffee industry through self-regulation, international certification, and organic production. Thus, this paper examines the possibility of translating the many strategies adopted by these businesses to expanding the markets for small-scale agroforestry-based coffee growers in the Philippines. As this paper is exploratory, it uses a grounded theory approach in analysing the websites of major Philippine companies and organizations to generate common themes and concepts on how these innovators promote, utilize, and market their coffee products and how they see the impacts of their market strategies on the small-scale producers in the larger Philippine society. Using the results of such analysis, this paper further explores the opportunities and vulnerabilities for sustaining small-scale agroforestry-based coffee production given these capitalistic endeavors. How are these innovations translated at the community and household levels given the corporate ideology prevalent among these corporations? What are the necessary governance structures and corporate social responsibility mechanisms to buffer the social and environmental conditions of small-scale agroforestry-based producers? Finally, this paper maintains a critical stance on this topic by linking it to the larger literature on corporate social responsibility, green consumerism, and global markets for coffee.
Analysis of the diametric structure and natural regeneration of *Adansonia digitata*, *Khaya senegalensis*, *Parkia biglobosa* and *Vitellaria paradoxa*

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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands

Abstract

This survey intended to make a diagnosis of four medicinal gases used widely for the treatment of the breast illnesses and discomfort: *Adansonia digitata*, *Khaya senegalensis*, *Parkia biglobosa* and *Vitellaria paradoxa*. The survey was based on the analysis of the diametric structure and natural regeneration of these four species. It was achieved on the basis of dendrométric picks and inventories in ‘placeaux’ installed in the riverside soils of the ‘Cynégétique’ areas of the Pendjari Biosphere Reserve. The results showed that *Vitellaria paradoxa* is on average the most abundant species with a density of 186 tiges/ha on the Tanguiéta-Batia axis and 88 tiges/ha on the Tanguiéta-Porga axis. This species displays a typical structure, assuring their renewal within the populations. *Parkia biglobosa* presents the densities raised respectively fairly of 42 tiges/ha and 35 tiges/ha on Tanguiéta-Batia axis and Tanguiéta-Porga axis and a typical structure of the species that are dying within the populations. *Adansonia digitata* and *Khaya senegalensis* present weak enough densities (9 tiges/ha and 19 tiges/ha on average) and of the obvious difficulties to regenerate. The sowers of these two species doesn’t present juvenile in their neighborhood. As far as their distribution in vegetation is concerned, the species don’t present a uniform distribution in the considered area. The extreme values for the relative frequency are gotten at *Vitellaria paradoxa* (70%) and *Khaya senegalensis* (21%). The four studied species show a demographic declension characterized by an ageing of the populations doubled as well of the regeneration difficulties to the level of the establishment that of the development of the young plants. The species answer several criteria on the whole of vulnerability.

Groundcover management affects soil fertility, tree physiology and foliar chemistry in a Fraser fir-cover crop cropping system

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Preferred session A6. Ecophysiological bases of agroforestry-system design

Abstract

Several intercropping systems involving the use of legumes (Dutch white clover and Alfalfa) and a non-legume (perennial rye grass) cover crop in combination with Fraser fir (*Abies fraseri*) were established at the Tree Research Center on the Campus of MSU. We investigated the effects of these cropping systems on soil fertility, tree survival, photosynthetic ability, stem water potential, foliar nutrient content, and growth. Changes in soil fertility were evaluated by quantifying the cover crops’ above ground dry matter production, soil total C and N content as well as net N mineralization rates. Results indicated that Dutch white clover, alfalfa and perennial rye, when mowed every 3 weeks, can produce as much as 19.5, 16.2 and 12.1 tons matter ha−1 year−1 of dry respectively. Nitrogen inputs from Dutch white clover and alfalfa residues were 95.96% and 56.55% higher than the N inputs from perennial rye grass, thus leading to higher level of organic matter in the soil N net mineralization rate in the legume cover crop plots. Groundcover management had a significant effect on tree survival rates, photosynthetic activity (Fm/Fv), stem water potential as well as tree growth. Higher foliar nitrogen and phosphorus concentration were recorded in plots with legume cover crops compared to conventional control and non-legume cover crops. In addition, control plot had higher soil moisture content and foliar Cu, Fe, Ca and Mn concentration than the cover crop plots, thus suggesting strong competition between the cover crops and Fraser fir for water and these nutrients. These results indicate that intercropping cover crops improved nitrogen fertility of the soil; however, there was strong competition for other nutrients and moisture in such intercropping systems. Consequently, identifying management options that minimize competition is vital to the success of tree-cover crop systems.
The role of fruit trees in developing an integrated sustainable agricultural production system in rural villages

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Preferred session E1. Hot or cold: the role of underutilized crops for AF

Abstract This initiative aims to assist in the transformation of poverty into wealth in some of the worst afflicted areas of South Africa and to develop economically viable, self-sustaining homesteads by building upon and supplementing those resources (material, traditional and spiritual) that already exist in these stricken communities. The key to eradicating current suffering is to focus on the creation of dynamic rural communities founded on prosperous farming. Poverty and hunger are crises that face many millions of people in South Africa. Agricultural production is the cornerstone on which the development of the village economy is built. In increasing agricultural productivity it is imperative that this is done in a sustainable and responsible manner. Integrated farming based on conservation agriculture principles will be at the core of the initiative. In today’s challenging environment of climate change and depletion and degradation of our natural resources, all activities must take cognizance of the need to ensure sustainable practices are utilized and to minimize adverse effects on natural resources, environment quality, food quality and safety. In order to achieve these objectives high-value fruit tree gardens were introduced in the rural villages. As a result of the limited land available for utilization, high-density tree plantings are utilized and intercropping with vegetables and herbs is practised. A total of 2500 homestead in 52 villages have planted 54 000 trees in mini-orchards utilizing conventional and traditional tree crops, vegetables and herbs. The development of these integrated, sustainable farming systems based on high value production clusters can now play a leading role in the development of the rural village.

Farm-level tree planting in Pakistan: the moderating role of past behaviour in predicting intentions

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract In this research, an attempt has been made to investigate the role of past behaviour in influencing the components of Theory of Planned Behaviour (TPB) in explaining farm-level tree planting in Pakistan. Results of a regression analysis showed that farmers’ willingness to grow trees on their farms is a function of variables attitude, subjective norm and perceived behavioural control included in TPB. The recent study has provided empirical evidence that suggests the frequency of past behaviour has moderated the relationship between TPB variables and farmers’ intention to opt for farm-level tree planting in Pakistan. The paper also presented implications for extension professionals and policy makers relating to successful farm forestry programmes in the country.

Perceived profitability and adoption of farm forestry in Pakistan: predictions from a logistic regression model in explaining intentions to opt for farm-level tree planting

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Preferred session C6. Agroforestry and reconciliation ecology
Abstract
The perception of high economic returns from trees, in addition to social and ecological benefits, is an important determinant in the adoption of farm forestry. A logistic regression model was developed and tested to understand perceived profitability as a determining factor in forming intentions to opt for farm-level tree planting in Pakistan. Classifications of logit model predictions and assessment of log estimates of farm forestry adoption tended to explain perceptions that growing trees on farmland is a function of weighing the profitability in terms of long-term utilization of land, cost comparisons, influences such as tree crop interface, and concerns about change in soil processes; and these may portray farm forestry as a profitable venture, and influence farmers’ intentions to opt for farm forestry in this country.

Carbon dynamics in nitrogen-fixing Himalayan alder and cardamom agroforestry systems in eastern Himalayas

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Preferred session C2. Carbon sequestration in agroforestry

Abstract
Globally, changes in land use are transforming land cover at an accelerating rate. In mountain ecosystems, such changes are closely linked to the issue of sustainable socioeconomic development. One of the adapted land-use systems in the eastern Himalayas is nitrogen-fixing alder (Alnus-cardamom)-based cardamom agroforestry system. Large cardamom (Amomum subulatum) is the most important perennial cash crop in the region and is cultivated predominantly under Alnus trees. The carbon dynamics and sequestration were studied in cardamom agroforestry with nitrogen-fixing alder and non-nitrogen-fixing mixed-tree species as tree associates. The carbon budget and flux were also estimated in an age series (5, 10, 15, 30 and 40 years) of Alnus-cardamom agroforestry systems. The cardamom storage in Alnus-cardamom was marginally higher, amounting to 21.67 t/ha compared to 18.63 t/ha in the mixed-tree cardamom system. It was 2.8 times higher in the Alnus-cardamom system compared to a mandarin-crop agroforestry system. The carbon storage in the Alnus-cardamom system increased from 18.96 t/ha in the 5-year stand, and it consistently increased with stand age to the highest value of 60.40 t/ha at the 40-year stand. The contribution of cardamom increased from the 5-year stand to the 15-year (15.94 t/ha) stand and then decreased to a lowest value of 1.34 t/ha at the 40-year stand. The carbon flux of the stands increased from 7.64 t/ha at the 5-year stand to a highest value of 10.22 t/ha at the 15-year stand, following which the carbon fixation decreased to a minimum value of 3.35 t/ha at the 40-year stand. The Alnus-cardamom system substantially fixed carbon, assisting the green-sector mitigation of global climate change.

Key words: Alnus nepalensis, Amomum Subulatum (large cardamom), carbon storage, carbon fixation, agroforestry age.

Effect of canopy pruning of Albizia procera on biomass and carbon sequestration in agrisilviculture under an irrigated ecosystem

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Preferred session C2. Carbon sequestration in agroforestry

Abstract
In agroforestry, tree components fix and store carbon from the atmosphere via photosynthesis. Trees, being a perennial component in the system, function as active carbon for many years and continue to store it until they are harvested or die. Shoot pruning is a necessary management practice in agroforestry for reducing both above-ground and below-ground competition with associated crops. A field experiment was conducted in well-established trees (planted in 2000) during 2005 08 with: three pruning regimes (70% canopy pruning, 50% canopy pruning and control (unpruned tree); two crop rotations (blackgram (Vigna mungo Roxb.) and mustard (Brassica juncia L.); and greengram (Vigna radiata Roxb.) and wheat (Triticum aestivum L.)), and sole tree and sole crop. The experiment was conducted in split plot design with three replications. The
allocation of biomass in different tree components was in the order of branch>root>main bole>foliage. Tree biomass was 70.2 t ha-1 and 67.5 t ha-1 in blackgram–mustard and greengram–wheat crop rotations respectively at 8 years of age. Unpruned trees had significantly (P < 0.05) higher biomass and C (85.7 and 40.7 tha-1, respectively) than 50% and 70% canopy pruned trees. The crops grown with 70% canopy pruning had highest biomass and C (7.25 and 1.7 t ha-1, respectively) and lowest (2.1 and 0.9 t ha-1, respectively) was with control (unpruned trees). Carbon concentration in tree components was in the order of branch>main bole>root>foliage whereas accumulation followed the order of branch>root>main bole>foliage. In the sole crop, carbon accumulation was comparatively higher than that of agrisilviculture. Trees without pruning had sequestered 28.0 t C ha-1, and trees with 70% and 50% canopy pruning sequestered 23.0 and 21.3 t C ha-1, respectively.

CO2 sequestration potential of Albizia procera in plantation and agrisilviculture systems under semi-arid conditions of India

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Preferred session
C2. Carbon sequestration in agroforestry

Abstract
Trees fixe and store carbon from the atmosphere via photosynthesis and, being perennial, can function as an active carbon pool for many years. Trees continue to store carbon until they are harvested or die. The rate of carbon sequestration depends on the growth characteristics of the tree species and the conditions for growth where the tree is planted. A study was conducted to determine CO2 sequestration potential in 7-year-old stands of Albizia procera (Roxb.) planted as both sole and in an agrisilviculture system in semi-arid conditions of Jhansi, Utter Pradesh, India. In the agrisilviculture system, annual crops, blackgram (Vigna mungo Roxb.) and greengram (Vigna radiata Roxb.) as a rainy crop; and mustard (Brassica juncea L.) and wheat (Triticum aestivum L.) as winter crop), were raised in association with trees. The total stand biomass in the agrisilviculture system was 61.7 t ha-1. The plantation had 41% less biomass than the agrisilviculture system. The allocation of biomass in different tree components was in the order of branch>root>main bole>foliage. The carbon concentration was higher in the branch (48.9%) followed by main bole (47.6%), root (46.8%) and foliage (44.8%). Trees stored 8.6 t ha-1 more carbon in agrisilviculture system than in the plantation. The CO2 sequestered by A. procera in the agrisilviculture system was higher (107.4 t ha-1) than the plantation.

Community forest exploitation and poverty reduction in the Lomié region, Cameroon.

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Preferred session
A5. Ecological sustainability: panacea or Pandora’s box?

Abstract
It is generally admitted that the industrial exploitation of timber in most timber-producing African countries, even though it has contributed to the consolidation of their respective gross domestic products (GDPs), has brought practically nothing to the populations that neighbour the zones in which these resources are exploited. This is why in 1994, Cameroon adopted a new forest legislation which put forward the concept of ‘community forest’, which is supposed to benefit rural local populations through their participation in the conservation and management of the forests. A study, using a questionnaire, was carried out in the three most important community forests (Lomié, East-Cameroon) in 2006 in order to determine the impact of this practice on the reduction of monetary poverty. By using the test for the comparison of means, we verified whether the total revenue received by the households together with their social expenditures before the period of exploitation were significantly different from those received after the period of exploitation (Null hypothesis (Ho : mean (variable 1 – variable 2) = 0; against Alternative hypothesis (Ha): mean (variable 1 – variable 2) < 0; where variable 1 and variable 2 represent the value of the studied variable before and after the exploitation of the community forest). The study revealed that
the practice of ‘community forest’ had a high monetary poverty-reduction potential. Through the creation of income-generating, and not necessarily small activities or employment, it contributed to the economic development and the improvement of the living conditions of the local rural people. Even though the implementation of the concept was constantly hindered by problems of poor management of resources generated by the activity, mainly due to the lack of training by the local rural people, the experience is worth encouraging.

**Market development for coconut-based agroforestry farms: evidence from the Philippines**

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**Preferred session** E4. Socioeconomics and agroforestry in the Pacific

**Abstract**

This paper focuses on initiatives for market development of coconut-based agroforestry farms in Quezon province, Philippines. It addresses the constraints faced by the small farmers and other market participants and analyses the problem of coconut logging (cutting of coconut trees for lumber) due to concerns about the coconut industry’s long-term sustainability and threat to the environment. The market development needs of farmers for enhancing the productivity of coconut-based agroforestry farms are primarily about access to capital, technical and entrepreneurial skills, equipment and tools, and market linkages and information. The recommended initiatives focus on the various possibilities for improving farmers’ income through a strategic and comprehensive market development framework that considers the following elements: sustainability of the coconut resource base; enhanced market competitiveness; policy measures; and institutional support services. Specific strategies should include: 1) effective implementation of the replanting programme and policy guidelines on cutting of coconut trees and coconut product standards; 2) re-orientation of extension programmes for a holistic package of services on technologies, credit, information, markets, and entrepreneurial skills; 3) strengthening farmers’ organizations to enable them to undertake viable value-addition and various marketing options; and 4) improvement of farm-to-market roads and immediate use of existing market facilities in the area.

**Keywords**: products, markets, value-addition, policy, support services

**Multifunctional features of wind break forest tree plantings in arid landscapes in Uzbekistan**

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops

**Abstract**

Uzbekistan is located in the arid region of Central Asia where insufficient water resources, dry air, a small area of forests (4.8% of total area), and strong dry winds (‘garmssel’) negatively affect agricultural production. Therefore, forests play a crucial role in the region in conserving and increasing water and land resources, landscape improvement, and biosphere sanitation. Climate and soil conditions of arid landscapes change considerably when forest trees are planted. So, air temperature in the cotton fields protected by forest-tree belts is 2.5 3.5 °C higher in spring and is 2.9 3.5% lower in summer than in unprotected landscapes. In summer the relative air humidity is 10 20% higher and soil moisture is 1.5 3.0% higher in protected landscapes. Forest plantations also improve air quality. One hectare of forests absorbs 5 t of carbon dioxide and produces 8 12 t of oxygen, 200 220 kg of aromatic hydrocarbon, and 350 kg of organic compounds during the vegetative period. In Golodnya Steep in Uzbekistan one hectare of poplar plantings absorbs 64 kg of air dust, elm trees and robinia absorb 210 kg and 1230 kg of air dust respectively. In arid agroforest landscapes intensive accumulation of humus (16%) in soil is observed, so too is the
number of soil microorganisms and an increase of the microbe coenosis in soil. An increase in crop yields is also observed in protected landscapes. So, yield of cotton in protected agroforest landscape is 308% greater than in unprotected landscapes. The number of actinomycetes is 30-35% greater in soils of agroforest landscapes than in pure agricultural landscape. Forest plantings, by draining soil water, prevent the rise of groundwater levels and soil salinization and waterlogging in arable lands. In arid conditions of Uzbekistan, forest plantings are also used by local people for recreation purposes, especially in the summer season because air temperature in forested lands is 9-12°C lower than in unprotected landscapes.

### Biological cycle of soil nutrient elements in an arid agroforest landscape

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**Preferred session** C5. Soil organic matter and nutrient cycling in multi-strata AF systems

**Abstract**  
A study of plant biomass development processes and nutrient cycles in arid agroforestry landscapes was carried out in Golodnaya Steep in Uzbekistan. It showed that in general the weight of tree species' phytomass is 683.33 t/ha. The main component of the phytomass (277.35 t/ha) is produced by Robinia pseudoacacia, of which 220.15 t is phytomass of above-ground plant parts and 57.2 t of below-ground parts. *Ulmus pumula* is the second highest producer of phytomass (208.8 t/ha), of which 158.80 tons is above-ground phytomass and 51.87 tons is below-ground. The biomass of *Platanus orientalis* and *Fraxinus pennsylvanica* is not large (15.2 t/ha and 30.93 t/ha respectively). During the study of nutrient substances in the plant soil cycle, chemical analysis of above-ground and below-ground biomass showed that the largest amount of nitrogen among studied tree species was accumulated in leaves (2.33%), branches (3.07%) and roots (0.65%) of poplar (*Populus xashofenii*). Trunks, branches and roots of this poplar species also contained high amounts of phosphorus (0.52%, 0.68% and 0.65% respectively). Considerable accumulation of nutrient elements was observed in agricultural crops cultivated in the landscapes protected with forest trees as wind break belts. *Mediticago sativa* grown in the fields protected with tree shelter belts had a total weight of 22.52 t/ha and accumulated 53.1 kg/ha of nitrogen and 5.73 kg/ha of phosphorus. The content of humus in a 1.0 m soil layer of light sierozem in landscapes with forest tree wind break belts was 88.5 t/ha which is 1.5 times more than in land that was unprotected by forest trees. The content of nitrogen in protected landscapes was 8.9 t/ha which is 1.1 times more than in unprotected fields. Nitrogen, at 5.46 kg/ha, phosphorus at 1.84 kg/ha and potassium at 14.91 kg/ha is received by the soil from fallen tree foliage every year.

### Green gold of Central Asia: potential of *Pistacia vera* to contribute to livelihoods of forest dwellers

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**Preferred session** E1. Hot or cold: the role of underutilised crops for AF

**Abstract**  
Central Asia is the place in the world where wild populations of *Pistacia vera L.*, the only species with edible pistachio nuts in *Pistacia genus*, are still growing. *Pistacia vera L.* is a tree of 6-7 m of height, with a wide globe-shaped crown. Young branches and scions are smooth and red-brown; old branches are covered with rough bark of an ashen-grey colour. Leaves are dense, wide-oval or egg-shaped, of light-green colour, glittering on the top and lustreless below, and are 3, 5- or 7-obed. Pistachio is dioecious plant. As a rule there are more male trees (55-70%) than female in natural stands. Pistacia vera is an extremely drought-resistant plant. This valuable biological trait of pistachio allows it to grow under conditions of low water resources, low soil moisture, dry air and high air temperatures (+50°C), which are characteristics of the ultra-continental environment of the foothills in Central Asia. At the same time, pistachio is resistant to low temperatures (-41°C). Due to their strong, deep-root root systems, pistachio trees prevent soil erosion in the mountains, especially at times of flash flooding. Drought-resistant pistachio is an invaluable...
Small-scale homestead agroforestry products and their utilization in the Old Brahmaputra floodplain area of Bangladesh

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Preferred session
A1. Multistrata agroforestry systems with perennial crops

Abstract
The homestead agroforestry system is an age-old traditional small-scale forestry practice in rural Bangladesh. It plays a great role in the subsistence livelihoods of rural Bangladesh. Segmentation of the agroforestry components in the homestead can provide a detailed scenario of the contribution and dynamics of this system. To ascertain the contribution of the homestead agroforestry components to the rural livelihoods of the Old Brahmaputra floodplain area of Bangladesh, a multistage simple random sampling was conducted. The study was undertaken to determine which products contribute to the rural livelihoods at what scale. A total of 14 agroforestry products and their utilization practices in the traditional homesteads were identified. All portions of three products were found to be utilized by the households and all portions of only one product were found to be sold to the market. The rest of the agroforestry products were both utilization by the household and sold to the market. It was revealed that from the sale of the products, a household owner earned USD 470/year. Fuel supply, fruit production, vegetable production and protein supplementary sources were found to be important contributions of the homestead agroforestry system. The study shows an effective combination of the agroforestry components in the homestead, which are capable of supporting the subsistence livelihoods of the rural people of Bangladesh. It suggests some more research activities are needed to explore the sociobiological interactions between the agroforestry components. The findings of the study may be important for rural development policy makers in Bangladesh.

Multifunctional wind break/shelterbelt plantations: adaptation to sustainable livelihood in arid regions

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Preferred session
B9. Collective action for tree-based rehabilitation of degraded lands

Abstract
The hot arid region of India, covering an area of about 32 million ha, is spread across states of Rajasthan (61%), Gujarat (20%), Haryana (4%), Punjab (5%) and Andhra Pradesh (7%). Productivity remains restricted due to an un-conducive environment, a limited choice of crops and aberrant weather conditions. The constraints faced in hot arid regions are limitations imposed by weather, high biotic pressure and degradation of natural resources due to erosive winds. Protective forestry adaptations such as shelterbelts or wind breaks in arid regions may potentially improve livelihood security through simultaneous reduction in wind speed and halting processes that degradation natural resources (soil and water), thus creating favorable microclimatic conditions for better growth of agricultural crops and the production of fodder and fuelwood. In the present circumstances, the study critically reviews the contribution of wind breaks or shelterbelts to the conservation of natural resources (soil and water), climate moderation, augmentation of agricultural production and other benefits, and the provision of better opportunities for livelihoods of the people of the arid region. The wind breaks and/or shelterbelts in fragile ecosystems essentially reduce vulnerability and
add to security in sustaining livelihoods particularly in those areas that are prone to wind-related hazards coupled with frequent droughts and famine. Considering multifunctional roles of wind breaks and well-being of society, the horizontal development and expansion of such protective agroforests need to be strengthened by innovative designs, suitable species, and incentive-based policies. The future thrust of research will be on impact evaluation and identification of critical attributes of wind breaks or shelterbelts and other protective plantations in order to fulfill multi-dimensional objectives for achieving livelihood security of desert dwellers.

Keywords: agroforest, arid zone, livelihood, wind erosion, soil conservation, microclimate and tree-shelter

Does phenotypic plus-tree selection for breeding affect nuclear genetic diversity in Allanblackia floribunda (Clusiaceae)?

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Preferred session
A8. Integrating genomics in agroforestry

Abstract
Allanblackia floribunda is a tropical forest-tree species that is valued for its seeds, which are rich in hard fat consisting mostly of stearic and oleic acids, and are reported to lower plasma cholesterol levels, thus reducing the risks of heart attack. Studies on tree improvement in the species for fruit and nut production are underway, and 20 plus-trees have been selected from wild stands to constitute first generation breeding population, raising concerns about the maintenance of genetic diversity in both breeding and production populations. Using 8 informative microsatellite loci, we: (i) assessed the genetic diversity of 10 populations each of 30 individuals in wild stands in Cameroon, and of the breeding population; and (ii) tested the hypothesis that genetic diversity in the putative breeding population is not different from that existing in the wild. The 8 loci were variable, and high levels of genetic diversity (A=4.96; HE=0.59) were found within populations in wild stands, whereas a weak differentiation (/? = 0.048; RST=0.061) was found among populations. Under the assumption of infinite allele model, 8 of the 10 surveyed populations showed signs of deviation from the mutation-drift equilibrium, suggesting Pleistocene population bottlenecks and fluctuations in effective population size. Mantel's test did not make it possible to identify any relationships between genetic and geographic distances, suggesting that there is no isolation-by-distance. A Neighbor-Joining dendrogram showed a population structure that could be explained by historical and geographic factors. Mann-Whitney tests did not identify any significant difference in genetic parameters between wild stands and the breeding population, indicating that breeding A. floribunda from 20 trees would not reduce nuclear genetic diversity. However, a slight increase in inbreeding was observed in the breeding population, and implications for genetic diversity conservation during tree improvement in the species are discussed.

Conservation status of underutilized tree species: a case study of tamarind (Tamarindus indica L.) in Benin

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Preferred session
A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
The conservation status of many underutilized fruit tree species which support local African populations in terms of food and income such as tamarind remains poorly documented despite its importance for their management. In this study the viability of tamarind populations in Benin was assessed. In order to characterize the species' viability in three habitat types (gallery forests, savannah woodlands and farmlands), its population structure was assessed through forest inventories of dendrometric characteristics and diametric structures of the trees. Tamarind trees’ density and regeneration were found to be relatively low, suggesting that tamarind populations may not be self-sustaining. Nonetheless, significant variations occurred between habitat types at P<0.001. The density of mature trees in gallery forests was found to be 3 to 8 times higher
than that of savannah woodlands and farmlands. The regeneration comparison followed the same scheme. Although diametric structures’ coefficients of skewness indicated declining populations, the lowest median value of diametric structure found in gallery forests might suggest a relative stability of tamarind populations in this habitat. The results of this study indicate that gallery forests may be the best habitat for tamarind in situ conservation. Apart from in situ conservation, other management strategies are needed in order to maintain the declining populations, which are an important source of food, medicine, wood and fodder for local populations. Domestication and the planting of young individuals in farmlands are needed as far as ex situ conservation and sustainable utilization are concerned.

**Conservation of baobab (Adansonia digitata L.) through regeneration assessment in Benin, West Africa**

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

Although the baobab tree is a key economic species due to its multiple uses by rural communities in West Africa, several authors have pointed out a lack of natural regeneration. This study aims to explain the factors which might be involved in the natural regeneration problem of the species. Allelopathy – as a possible explanation for the lack of natural regeneration – was tested using three methods: seedlings found under mature trees were counted in fallows and cultivated land; seeds were planted under mature trees of different species; and 1-month-old seedlings were transplanted under mature baobab trees. Germination and survival percentage were calculated. More seedlings were found in the fallows than in the cultivated plots, which suggests that agriculture contributes to the low baobab regeneration. Germination percentage was found to be lower under mature baobabs than other savannah tree species. The survival percentage of transplanted seedlings did not differ depending on the distance to mature baobab trees. These results suggest that there is some kind of allelopathy, as germination was low under adult baobab trees. However, as seedling survival after transplantation was high, allelopathy might just influence germination and not seedling survival. Seedling transplantation seems to be a potential method for contributing to baobab regeneration and subsequently to the conservation of the species.

**Managing conflicts over state forestland through soft systems methodology: the case of Benakat Research Forest, South Sumatra**

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**Preferred session** E4. Socioeconomics and agroforestry in the Pacific

**Abstract**

Large areas of forest in Indonesia are not managed well due to conflicts over the status of the land. Lack of government clarity on the main functions to be achieved complicates interactions with other stakeholders. Soft systems methodology (SSM) provides an approach to making the various perspectives explicit, and has been used successfully in various complex situations. The main objective of the SSM surveys is to develop an understanding on the divergence of stakeholder opinions on achieving desirable and feasible change. Research was initiated in a neglected management block within Benakat Research Forest in South Sumatra, known as the ‘Agroforestry Block’. The intervention phase of SSM, based on reflective facilitation, can enhance social learning among actors with opposing views, so that new pathways emerge for the future use of the Agroforestry Block. This phase has, however, not yet significantly changed the attitude of participants involved.

**Keywords:** conflict, governance, research forest management, soft systems methodology
Demonstration of value-added products in wild/hill mangoes for improving food and livelihood security in tribal areas Andhra Pradesh, India

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Preferred session
A1. Multistrata agroforestry systems with perennial crops

Abstract
The wild mango trees found in the tribal areas of Dandakarnya region in Andhra Pradesh, India are ‘land races’ or old varieties which are highly resilient and drought resistant, which we cannot afford to lose. Various varieties of these fruits have been nourishing tribal life both in terms of tribal food security or livelihood security and culturally. Trees are huge structures. Tree habitat is observed in interior and remote forests, hills, hill valleys, stream beds, common lands of hamlets and roadsides in the forest. Due to its value, the tribes never cut the wild mango tree while practising shifting cultivation. In fact, they encouraged its propagation in village common lands, (shifting cultivation) and in agricultural lands. This is part of their traditional agroforestry systems. An attempt was made to document varieties of wild mangoes through a participatory approach, and to document the morphology of the wild mango fruit. Thirty-nine varieties of wild mango were recorded. Reasons for depletion of wild mangoes were studied. A fruit estimation study was conducted to understand wild mango production in the hamlets. By-products derived from wild mangos using indigenous methods were documented; and after documentation of the participatory knowledge system, some of the varieties were chosen for processing. Fruits were processed, and preserved products were developed. So far 9 value-added products have been standardized. Some of these are: a preparation of pickles with selected varieties; a paste preservation; a dried sour and sweet slices preparation; sour paste; and paste pickles. An attempt was made to upgrade the local knowledge system through a capacity building programme aimed at the adoption of hygienic practices to make quality by-products. About 100 women were trained on by-product preparation through intensive training programmes.

Sustainable land use practice through non-wood forest products (NWFP) farming: participatory agroforestry methods in Andhra Pradesh, India

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Preferred session
B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract
Andhra Pradesh, India, is the traditional home of nearly 33 tribal groups and most of these communities are found in the upland region. The area is a semicircular, scattered, broken chain of mountains, hills and hillocks and has an altitude range from 50 m to 1110 m. The climate is tropical sub-humid and the average rainfall varies from 1200 mm to 1400 mm. The region is a reservoir of floristic diversity. Southern tropical secondary dry deciduous forests are extensive. Tribal groups are engaged in shifting cultivation and collection of non-wood forest products (NWFP). An increasing need for cash income, deforestation and unscientific irregular procurement of NWFP have lead to an imbalance between indigenous people’s livelihoods and the forest ecosystem. In addition to this, the overemphasis on commercial aims of NWFP-based cooperatives has lead to irregular and unscientific collection of NWFP, which has endangered economically important species. On the other hand, the increase in population has lead to a shift from shifting cultivation to settled cultivation. While practising shifting/settled cultivation, the tribal communities leave important forest trees in earmarked patches, according to the traditional practices of agroforestry. An attempt was made to restore economically important NWFP species in settled/shifting cultivation. Economically and culturally important tree species such as Sterculia urens, Pongamia pinnata, Caryota urens, Mangifera indica (wild mango), Modhuca langiölia, Artocarpus heterophyllus, Semecarpus anacardium, Cochlospermum religiosum, Strychnos nux-vomica, Strychnos potatorum, Momordica dioica, Palmyra palm, Tamarindus indica and Thysanolena maxima were selected using...
a participatory approach. Based on interest and the need of the community or individual, some of these species are being promoted in shifting cultivation. In addition to these, large-scale cashew, coffee, rubber and palm oil-based introduced agroforestry systems are prevailing in the region. The synthesis of both native tree-based and introduced agroforestry systems can be concluded to be sustainable land-use systems for forest lands degraded under shifting cultivation. It provides an alternative livelihood for the local people.

Rational use of treated wastewater in the southeast region of Kazakhstan

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Preferred session  B2. AF for salinity control and land rehabilitation in Central Asia
Abstract  Using treated wastewater for irrigation of trees has been practised in southeast Kazakhstan. In this region, steeply peaked additional demand has been met through the use of water from Sorbulak Lake (with a maximum capacity of 1022 MMCM and an area of 60.2–62 km2) which accumulates treated wastewater. It is major, stable and essential water source for agricultural production in the region. Treatment and reuse schemes are based on mechanical treatment and biological purification and accumulation in the lake. An experiment was conducted with poplar hybrids and Sogdian ash, mulberry, quince trees and dogrose during 2000 2005. An estimation of treated wastewater showed that water could not be discharged to open water sources because the concentrations of TDS, pH, mineral oil, Cu, Fe, Br and F were below standard. Results indicated that the use of wastewater during longer periods did not cause significant salination. Heavy metals in the soil profile (0 100 cm) under trees were within the permissible limit. Wastewater applied to irrigation resulted in a high content of heavy metals (Cd, Cr, Ni, Pb, and Co) in poplar tissue. The maximum survival rate, height and diameter of trunk were observed in poplar hybrids. If soil reclamation and additional purification of treated wastewater are not carried out, then there is a potential risk of problems related to soil alkalinity and uptake of trace elements in tree tissue. Treatment systems can be improved by sustainable, soil-based post-treatment techniques. Further development can increase the irrigation area to 1 mln. ha. The use of wastewater can reduce demand for irrigation water, and can also reduce impacts on the environment. The practice provides a vital resource to enhance tree productivity, decrease reliance on chemical fertilizers, as well as promote the reduction of discharge into the Illi River. Using treated wastewater for reforestation is economical in regions where sufficient land is available.

Sugarpalm (Arenga pinnata) agroforests as a source of livelihood for farmers and orangutan in Batang Toru, North Sumatra

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Preferred session  A3. Role of agroforestry in landscape-scale conservation strategies
Abstract  Trade-offs between livelihoods and biodiversity conservation can be analysed by exploring values of species that provide tangible benefits to humans and other living things in the landscape. Aren or sugarpalm (Arenga pinnata (Wurmb) Merr.) is a multipurpose palm tree with economic value found in the orangutan conservation area in Batang Toru Forest Block, North Sumatra, Indonesia. Aren grows spontaneously in agroforest in Batang Toru; at elevations more than 800 m where rubber is not very productive, it is a primary source of livelihoods. For cash income local people extract aren sap and produce brown sugar and – in the non-Muslim part of the landscape – the traditional alcoholic beverage tuak. Its black leaf fibres are used to produce ijuk; and its fruits, kolang-kaling, are edible and fetch a good price in local markets. The critically endangered Sumatran Orangutan (Pongo abelii Less) also consumes aren sap and fruits, as do palm civets (Paradoxurus hermaphroditus Pallas), a species that is not threatened (IUCN red-list species, 2008). Farmers say the seeds of aren are spread by these animals. Aren commonly grows on slopes
and has a dense root structure that prevents soil erosion. The study collected data on the mutual, competitive and complementary benefits of aren to humans, orangutans, palm civets and other wildlife. Assessments were made of: i) aren’s importance in the local socioeconomy (livelihoods, culture, markets) at different elevations; ii) traditional aren management and the potential for further domestication; iii) aren’s current use and potential role in environmental conservation; and iv) local people’s perceptions and strategies for environmental conservation. The results of the study can contribute to the current debate on global strategies that seek to enhance local livelihoods as a means to strengthen conservation of local biodiversity resources.

Key words: biodiversity, agroforest, trade-off, NTFP, aren, palm civets

Status of homestead agroforestry and farmers’ preferences: a case study in central Bangladesh

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract Homestead agroforestry plays an important role in the rural economy of Bangladesh. Farmers grow different tree species in their homesteads for timber, fruits, fodder and fuelwood. A clear understanding of the physical characteristics and economic role of homestead agroforestry in rural livelihoods is vital for ensuring sustainable resource management. So, the aim of this work was to investigate the present status of homestead agroforestry and farmers’ preferences concerning species selection form a total of 150 randomly selected homesteads in central Bangladesh. The selected homesteads were categorized in four groups: marginal, small, medium and large. The study results suggested that income and production of homestead agroforestry on a per hectare basis are influenced by the landholding size, farmers’ economic condition and level of education. Among the identified plant species almost 51% were economically useful in the investigated area. The most common fruit species were mango (Mangifera indica, 31.3%), jackfruit (Artocarpus heterophyllus, 18.6%) coconut (Cocos nucifera, 9.7%) and other types of local fruit species. The timber species teak (Tectona grandis, 14.4%), mahogany (Swietenia mahagoni, 11.6%), koroi (Albizia procera, 18.3%), eucalyptus, and medicinal plants (Azadirachta indica, Terminalia arjuna) were also available. Farmers’ preferences considering the species selection were influenced by their economic condition and landholding size. The large and economically solvent farmers were more likely to prefer good quality timber-producing species (teak, mahogany, etc.) different types of fruits species and fuelwood, whereas small and medium-scale farmer always preferred to produce common fruit species and fast growing trees (koroi, eucalyptus). From this study it is concluded that homestead agroforestry can be a potential subsistence income-generating land-use practice in the study areas and farmers’ knowledge about the selection of appropriate species composition can be enhanced by proper education and training.

Neem-based agroforestry systems for enhancing the productivity of drylands in Tamil Nadu

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Preferred session A10. Dryland agroforestry R & D
Abstract In Tamil Nadu, the productivity of drylands is being reduced by erratic and uncertain rainfall. The adoption of neem-based agroforestry systems is a viable option for increasing the productivity of drylands because neem is the best-suited tree for drylands. The tree’s versatility is that it survives in very extreme climates and grows in variety of soil types. In Tamil Nadu, neem trees are found growing scattered in the fields surrounded by crops, which appear to be quite unaffected, and
they are also found on the boundaries of the fields, where they meet the local demands for timber, fodder and fuel. The results of a compatibility study revealed that there was the least reduction in growth and yield of intercrops was due to the effect of neem trees. Among the intercrops raised, cowpea and horsegram were found to be highly compatible. The results showed that these agricultural crops (cowpea and horsegram) were more beneficial in boosting the growth of neem trees. The neem-based agroforestry system also improved the soil fertility in terms of available soil N, P, K, Ca and Mg. An allelopathic study demonstrated that the neem tree was less toxic in terms of its allelopathic effect. Hence, considering all the above factors, neem-based agroforestry systems are found to be economically viable for enhancing the productivity of drylands.

Germination of some *Myrtus* provenance from Tunisia in salin and water stress

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Preferred session C3. Agroforestry, water quality and env amelioration

Abstract The effects of water potential on germination were studied in 23 provenances of *Myrtus* from different bioclimatic zones in Tunisia. Water potential between 0 and -10 bars was obtained using polyethylene glycol 6000 (PEG-6000) solutions. Seeds were planted in petri dishes full of sterile perlite, and kept for 28 under light with a 16 hour photoperiod at 15 000 lux, at 25°C. A low water potential induced a reduction in germination percentage and germination speed. Significant variations between the provenances were found even under control conditions. The provenances from humid regions were the most susceptible to water stress, and their germination percentage showed significant reductions at -8 bars. These differences in germination ability of provenances might be attributed to intraspecific variations resulting from the effects of natural selection and genetic pool background.

Key words: *Myrtus*, germination, polyethylene glycol, water potential

Role of agroforestry among pastoral communities in drylands: the case of Ruaha Landscape, Tanzania

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Preferred session A.11. on Silvopastoral Systems

Abstract The paper describes the role agroforestry plays in drylands where the community is characterized by pastoralism. The lack of both water and in most cases the existence of poor soils, make it very difficult for the local community to get engaged in agroforestry. The community’s need for and interest in using agroforestry is also diminished by their domestic animals that feed on tree seedlings. The communities have undertaken land-use planning and dutifully allocated land for crop agriculture, agropastoralism and pasture for their animals. The crop agriculturalists are the only community members who have shown interest in planting trees but they have also been hampered by domestic animals, which feed not only on their crops but also on their trees. This situation is not improved by the fact that they plant trees on the periphery of their croplands. The paper concludes with an outline of several practical recommendations for the communities to follow.
Contribution of bird manure to the agronomic effect of Faidherbia albida parkland in the cotton-production zone of Burkina Faso

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Preferred session: C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract
This study estimates the contribution of avifauna and cropping systems to soil fertility improvement in Faidherbia albida parkland. A pot experiment was carried out in a greenhouse in the research centre of Farako-Bâ. The soils used in the experiment were from a Faidherbia albida parkland at Dossi, a village located in the cotton-production zone of western Burkina Faso. Bird manure was collected under Faidherbia albida trees and its effects on cotton growth and development was determined using daily measurements in the pots. Chemical analysis showed that bird manure contained important quantities of organic matter (57.5%) and nitrogen (7.2%) but lower quantities of phosphorus (1.3%) and potassium (1%). Cotton plants had a better development and growth when bird manure was only applied to soil or combined with mineral fertilizer and when cotton was grown on a soil in which the previous crops were cereals (maize or sorghum). Planting cotton on a soil where the previous crop grown was maize or sorghum had no significant effect on the increase of cotton generative branches. Growing cotton on soil taken from under the tree crown or on soil previously cropped with sorghum or chemical fertilization showed positive effects on the number of cotton plant flower buds.

Key words: Faidherbia albida, avifauna, bird manure, soil, fertility, cotton.

Contribution of raindrop washes to the agronomic effect of Faidherbia albida parkland in the cotton-production zone of Burkina Faso

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Preferred session: C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract
Crop production in the Sahel is limited by nutrient availability. This study aimed to estimate the contribution of avifauna, crop rotation and trees to soil fertility and crop production improvement. A pot experiment was carried out with soils from Faidherbia albida parklands in the cotton-production zone of West Burkina Faso. The treatments consisted of two soil sampling places (under the crown of Faidherbia albida and outside the crown), three types of previous crop (fallow, maize and sorghum) and two levels of fertilization (normal raindrops and raindrop washes). Results showed that between 30 and 80 days after sowing, the height of cotton plants was affected by the sampling place and the previous crop. Raindrop washes contained nutrients with potential to improve soil fertility, even though their application to the soil had no significant impact on cotton plant development. No significant difference in the number of nodes and generative branches was observed between factors, except for sampling place. Nutrient content in cotton plants was also affected by the soil sampling place, the previous crop than by the fertilization. Further studies will be needed to better underline the impact of raindrop washes on cotton production.

Key words: Faidherbia albida, avifauna, rain drop washes, soil, cotton.
Understanding the elements and levels of interactions in food security components to rebuild livelihoods among beneficiaries

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Preferred session E4. Socioeconomics and agroforestry in the Pacific

Abstract

The purpose of this study was to draw a FSL model which investigates the contribution of agroforestry to rebuilding livelihoods in the post-conflict districts of Amuru and Gulu. The major interaction which results in improved livelihoods, these includes the following components/ forms have at one time be in supply both (humanitarian) or development/recovery. However, the following have to exist. • Environment components i.e. Agro forestry/energy conservation. • Agricultural component • Income generation component Element of each components/forms include: • environment rehabilitation through agro forestry practices, energy conservation and nutrition strategies e.g. fruit tree growing/horticulture. • supply of food crops and animals like goats and cows. This enhances the arrangement and complexity of the agro forestry practices in the system. • the elements includes money making activities for example revolving fund, skills development on tailoring, carpentry and joinery, brick making and investment development. Livelihoods results from long term interactions between the 3 components Agriculture, environment and income generating activities in space with good management. It results from ability to acquire assets, skills and knowledge to attain a means of living. The livelihoods systems become sustainable when resilience factors such markets and adequate policy implementation to support production in recovery phase are in place with adequate monitoring tools in place. However, copying strategies have both negative and positive effects at this stage. The ability of societies/ returnees to resist the negative copying strategies accelerates the recovery of the livelihoods at more improved and sustainable manner backed up by more realistic durable solutions. The findings will result into FSL model, publications, Posters and Magazines.

Top working of minor fruits to augment income from dry sub-tropics of India

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Preferred session A10. Dryland agroforestry R&D

Abstract

The vegetation in the dry sub-tropics of India is dry deciduous and thorny in nature. Irrigation facilities are meager and groundwater is scarce and consequently crop productivity is low. Therefore, mixed farming is predominant. Boundary plantation and homesteads are most common forms of agroforestry. They are naturally regenerated and perpetuated by farmers for timber, fodder and fruits. A survey of Bundelkhand region indicated a density of 11.2 trees/ha on field bunds. Ber (Zizyphus spp.) constitutes 40% of the tree population. Karonda (Carissa spinarum) is the predominant shrub on the wastelands. However, returns from such plants are low due to inferior fruit quality. They are a good coppicer, well adapted to edapho-climatic conditions and able to withstand biotic pressure. There is a need to top work these wild plants with improved varieties to enhance farmers’ incomes. Both the species respond well to top working. Available improved varieties fetch 5 10 times higher market returns. Top-worked plants grow vigorously on account of well-established root systems and ability to avoid damage by animals. The technique requires severe pruning of the plant during the dormant season and budding on the coppice shoot with improved variety scion. Top-worked plants start bearing fruits from the very next year. Like rootstock, top-worked plants of Zizyphus spp. can be pruned every year to harvest fuelwood and fodder in addition to good quality marketable fruits. Top working in Zizyphus spp. can be done throughout the year, except during the extreme winter season (December January), employing patch budding; while is can be done on Carisa spinarum in May June, employing shield budding. A trained budder can perform 50 100 operations in a day with 40 80% success depending upon practice.
Calliandra calothyrsus the potential for optimizing the BNF by selecting effective provenance × Rhizobium combinations.

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Preferred session A7. Biological dinitrogen fixation in AF systems

Abstract Species within the genus Calliandra are among the most widely used tree legumes in agroforestry systems. Calliandra calothyrsus has by far received the greatest International attention, especially in eastern and southern Africa. Under our nursery experiments, C. calothyrsus has consistently outperformed the other lesser-known Calliandra species such as C. houstoniana, C. juzepczukii and C. longepedicellata. In order to optimize biological nitrogen fixation (BNF) potential with the nodule-forming bacteria (Rhizobium), we undertook a series of experiments to investigate the relationships between both symbiotic partners (C. calothyrsus and Rhizobium) under nursery and field conditions. Firstly, under greenhouse conditions, we tested two C. calothyrsus provenances (Flores and San Ramon) inoculated with 16 different Rhizobium strains, and eleven C. calothyrsus provenances (Flores, Alotenango, Barillas, Santa Maria, Ixtapa, Union Juarez, Bonampak, San Ramon, Madiun, Georgesville and La Ceiba) inoculated with two Rhizobium strains (CCK12 and CCK20A). The inoculation effect on growth was positive but variable according to C. calothyrsus provenance and type of Rhizobium strain used. In the second experiment, we tested a selection of C. calothyrsus provenances (Georgesville, Union Juarez, Alotenango and Barillas) and Rhizobium strains (CCK13 and CCK12) in three soil types with different characteristics (e.g. clay, sandy, half-clay half-sandy). Our results showed that the symbiotic effectiveness was significantly affected by soil characteristics but not according to the provenances. In the field, 19 months after plantation, we were able to demonstrate a significant effect of the C. calothyrsus provenances on plant growth and nitrogen derived from atmosphere (Ndfa), whereas the inoculation effect became less significant on plant growth 11 months after plantation. In conclusion, our results demonstrated a strong interaction between C. calothyrsus provenance and Rhizobium strain, which should be used if the benefits of inoculation are to be achieved at the nursery level or in the field.

How to improve the competitiveness of forest businesses in Latin America: an examination of the methodology of IADB’s forest investment attractiveness index

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Preferred session A4. AF in Mesoamerica: perspectives and challenges

Abstract Latin America continues to experience high rates of deforestation. Between 1990 and 2005 the region reduced its total land cover from 51% to 47%. The causes of deforestation in Latin America are manifold, but the main factor is increased food prices, which have made land use more profitable. Other factors include deficient legal frameworks, overregulated forest sectors and a simple lack of law enforcement. The forest investment attractiveness index (IAIF) was developed by the Inter-American Development Bank (IADB) in order to improve the specific conditions affecting forest businesses in Latin America and enhance competitiveness among forest businesses in the region to attract foreign direct investment and help minimize environmental impacts, while providing further income for the rural sector. However, the methodology of the Index favors large countries over smaller ones. Upon closer examination of the IAIF methodology, a number of questions and concerns arise. The applied methodology assigns a weighting factor of 1 to the supra-sectoral factors, a weighting factor of 2 to the Inter-sectoral factors and the highest weighting of 4 to the intra-sectoral factors, meaning that intra-sectoral factors are considered to be significantly more important than inter-sectoral factors, and even more so than supra-sectoral factors. Investments in the forest sector are usually made for the long term, therefore, macroeconomic conditions and performance appear to be crucial to foreign investment decisions, especially in the case of political stability, one of the supra-sectoral factors. Another concern is the use of linear functions in the calculation of several indicators related to country size, making differences within small countries, though important in relative terms, inadequately reflected in the IAIF.
The EFFECT of microwater harvesting techniques on soil moisture in eroded soils of the arid zones in the Showak area (Sudan)

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract This study was conducted in the Showak area during the 1999-2000 season. U-shape and l-shape water microcatchment treatments were compared with control. Seedlings from 6 tree species, Acacia tortilis subspp. radiand, Acacia millifera, Acacia seyal, Zizyphus spinacia, Balanites aegyptiaca and Moringa olifera. Gravimetric moisture content was determined after the rainy season. Results indicated that U-shaped microcatchment increased moisture content to an average of 17.9 compared to 13.1 for control. The percentage survival rate increased in the microcatchment for all tree species.

Rehabilitation of degraded river-line in the Mount Kenya region

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract The Rutui River has its source in Mount Kenya’s forest and has eight tributaries. The river is the source of 55 registered water intakes and supplies water to over 1258 rural households and the Kerugoya town population. Built along the river, are 7 microhydro power plants. Further, it is a tributary of the Thiba River, which is itself a tributary of Tana River. The latter is an important source of water for the seven folks dams, which generates most of the national hydro power. However, pollution and declining water volume have posed challenges to the Rutui River users resulting in the formation of the Rutui River Water Users Association. Participatory ground truthing revealed the following challenges: 1) institutions, namely schools, coffee factories and dispensaries, discharged sewage into the river; 2) pit latrines and livestock sheds were close to the river; 3) there are illegal diversion of irrigation water; 4) exotic trees including eucalyptus are planted close to the river line; and 5) cultivation occurs too close to the river. A multi-institutional and multi-disciplinary team formed thereafter spearheaded an awareness campaign on the need to conserve and protect the river. In partnership with the community, Africa Harvest established high-quality indigenous tree seedling nurseries for rehabilitation. The community voluntarily stopped cultivating near the river line and the eucalypts were replaced with indigenous trees. By 2008 Africa Harvest, in collaboration with the Ministry of Energy and other partners, had facilitated the planting of over 25,000 indigenous trees along a 10 km stretch. The tree establishment is over 80% and its success is due to site matching and community ownership. Key outcomes were: the community has an income from sale of seedlings; enhanced skills on silviculture; access to clean water throughout; and fully functional microhydro dams supplying clean electricity to about 400 households. At the national level, there was an increased supply of water to the hydro dams.

Agroforest development and strategy plan in Georgia

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract The distribution of forests in Georgia is uneven. Forest covers about 35-37% of the country, including the major part of the mountainous area. Along with the forest-rich regions there are
areas with less than 10% forest. The forests are situated mainly on steep mountain slopes, and fulfill an important function in preventing soil erosion, having a water-retaining and water-regulating ability. Forest sector rationalization and institutional development is one component of the World Bank-assisted Georgia Forests Development Project. The output from this component will be a detailed phased and costed plan for the institutional and financial development of the state forest sector. The outcomes that the Action Plan will support are: improved organizational and operational performance; sustainable multipurpose forest management; and an increased contribution to Georgia’s economy. The component has been designed in three phases. Before the 1990s, in order to protect biodiversity and ecosystems of the country, a wide net of national reserves was created. Georgia has 15 designated national reserves with a total area of more than 168 800 ha, 2.4% of the whole territory, and all protected areas cover approximately 20% of the country's territory. In support of the development of protected areas in Georgia certain actions have already been performed: Borjomi Kharagauli National Park was established in 1999 with financial support from the Government of Germany; within the Black Sea Integrated Management programme supported by the GEF and the World Bank, implementation of a system of protected wetland areas in the coastal zone of Georgia–Kolkheti National Park is in progress; in order to expand the system of protected areas in East Georgia, the establishment of Tusheti National Park and Protected Landscape, the National Park of Vashlovani, and development of the oldest Lagodekhi Reserve commenced in 2002. The project is supported by GEF/World Bank.

Smallholder farmers’ preferences and strategies to cope with price fluctuation of agricultural commodities: case study in Bungo District, Jambi Province – Indonesia

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Preferred session E4. Socioeconomics and Agroforestry in the Pacific

Abstract The prices of agricultural commodities commonly influence farmers’ preferences and decisions on type of agroforest management that they intend to implement in their garden. Increased prices of agricultural commodities will increase farmers’ motivation to intensify their agroforest garden into a more monocultural system. In comparison to agroforest, monocultural systems provide a higher benefit for the farmer, as long as the price of the main crop is stable or increasing. But, when the price of the main product decreases, an agroforestry garden will provide more income security than the monoculture system due to more diverse products from agroforestry than a monoculture system. A current case study in Bungo district, Jambi Province, Indonesia, where rubber agroforest used to be one of the major sources of the local community’s livelihood, provides a useful example on how smallholder farmers’ decisions in changing their rubber agroforest management into a more monocultural system have threatened farmers’ livelihood security at times when rubber and oil palm prices decrease to about 60% its previous price. Hence, based on interviews and discussions with farmers combined with findings from a previous study on farmers’ preferences in rubber agroforest management in Bungo, we identified smallholder farmer strategies and preferences to cope with the situation. Discussion on the result of this study provides important lessons in understanding the important role of an agroforest system in providing livelihood security for smallholder farmers.

Keywords: rubber, oilpalm, agroforest, livelihood security, monoculture
Effect of nitrogen and phosphorus fertilizers in seed quality and yield of *Phaseolus vulgaris* L.

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**Preferred session** C5. Soil organic matter and nutrient cycling in multi-strata AF systems

**Abstract**

The common bean (*Phaseolus vulgaris* L.) is an important food and cash crop in sub-Saharan Africa (SSA). It is the cheapest source of protein for humans, and common bean yields in Kenya are relatively low (700 kg/ha) compared to yield potentials of 3000–5000 kg/ha. An increase in population coupled with continuous cropping has resulted in a decline in soil fertility in western Kenya. Organic manure at the farm level is also unavailable in sufficient quantities to replenish the low soil nutrient status. The aim of this study was to determine the effects of N and P fertilizers on seed quality and yield of common bean (*Phaseolus vulgaris* L.). The study consisted of three field experiments with 4 levels of N as CAN and 4 levels of P as TSP (16 treatments), and was carried out over one season. The results of the study indicated that soils in the three sites were acidic and deficient in N and P, adequate in Ca and Mg, and crop uptake of N and P depended on the initial soil N and P contents, coupled with added fertilizer inputs. Application of N and P fertilizers to soil N and P was significant together with N and P uptake, growth in height, trifoliate leaves, pods per plant, dry matter yield, and seed yield. However, seed purity, seed vigour viability, and seed moisture content were not significant indicating that seed quality in all the three sites was found to be high. Studies indicated that seed quality was caused by other factors. Secondly, fertilizer provides a remedy to soil acidity and nutrient deficiencies respectively in western Kenya. N-fixation capability of common bean enhances its suitability for intercropping within farming systems in the region.

Recognizing the multifunctions of agroforestry in the philippines: lessons from the field

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**Preferred session** E4. Socioeconomics and agroforestry in the Pacific

**Abstract**

Agroforestry is an age-old practice of growing woody perennials in combination with agricultural crops for the twin purpose of conservation and socioeconomic productivity. It is claimed to have various functions such as biodiversity conservation, rehabilitation of degraded lands, creation of sustainable rural communities, and most recently, mitigation of climate change. Despite these claims, the question has been raised whether these functions are real or just a product of imagination. Agroforestry is still being questioned as to how this land-use approach compares with other land uses such as monoculture, forestry, and mining activities. This paper examines the socioeconomic and environmental contributions of the different agroforestry systems/models in the Philippines based on the results of the research entitled Characterization and Assessment of Different Agroforestry Models in the Philippines, which: a) documented the different agroforestry systems that are being practised in the selected areas in the Philippines with emphasis on the economic, environmental and social functions; b) analysed the economic and financial viability of the different agroforestry systems/models; and c) assessed the impact of agroforestry on the biophysical, socioeconomic and environmental conditions within the farmers’ farms and the farming community. This paper argues that the multifunctionality of agroforestry is indeed real as indicated by the research results and testimonies of the agroforestry practitioners.
Pastoralist and desapiating land

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract         Big threat to conservation,new developments and its negative impact to both livestock and wildlife.

Utilization and population structure of Sclerocarya birrea in agroforestry systems versus W National Park in Karimama District, Benin

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract         The sustainable management of the W Regional Park and its peripheral areas is based on a trade-off between conservation and the generation of livelihood means for local populations who live on forest-based resources. This work is a study of the potential of a local edible fruit tree (Sclerocarya birrea [A.Rich] Hochst) to contribute to the sustenance of local people by assessing its local uses and population status, by investigating its size and class structure in agroforestry systems as compared to the protected area. An ethnobotanical survey was carried out with a total of 159 respondents randomly selected in all sociocultural and professional groups around the protected area in Karimama district, Benin. Dendrometric parameters were recorded on individual trees in temporary plots in both types of land uses. Sclerocarya birrea was found to be a multipurpose use species. The whole plant (bark, fruits, kernel, leaves, root and wood) is used as food, medicine, animal husbandry supplies and material for carving. The largest trees were found in agroforestry systems where saplings are scarce, showing a gap in transition from seedlings to adult trees. The species density is about 9 times higher in the protected area than the agroforestry systems where it regenerates naturally and successfully but faces human threats (felling, burning, ring-barking, uprooting of seedling) for agricultural purposes. This study of how communities use this forest species, the nutritional, medicinal and cultural benefits they derive from it, is an important preliminary step in its propagation in agroforestry systems and its domestication.

Effect of the rest technique on the native species regeneration in the Northeast Morocco.

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract         In northeast of Morocco, under human pressure and persistent dryness, the pastoral and forest ecosystems have experienced continuous degradation. Rehabilitation actions with the rest technique showed a great effectiveness in improving the vegetation cover and the biodiversity. The objective of this study was to evaluate the impact of rest on the rehabilitation of forest rangelands. The methodology consisted of measurements of vegetation parameters such as biomass, vegetation cover and the floristic composition. The results showed that the rest may improve natural regeneration of several trees and shrubs species such as Pinus halepensis, Quercus ilex, Salsola vermiculata and Artemisia bleached on grass alba.

Keywords: Morocco, northeast Morocco, natural regeneration, native species, rest, pastoral ecosystems, forest ecosystems.
Forest Farming Network: maximizing income potentials for farmers and non-farming private landowners in a unique collaboration with the USFS

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Preferred session B4. Agroforestry in Europe: land reclamation
Abstract Appalachian hardwood forests offer a vast cornucopia of non-timber forest products which have been harvested for generations to provide much-needed local income. Only recently has attention been directed to research and development of best management practices for extrapolation of native plant production requirements and yields at the landscape level. The Forest Farming Network (FFN) is a unique and exciting new collaborative programme between the United States Forest Service (USFS) and landowners designed to improve resource management, floristic diversity, and maximize the income potential of private forested lands. This programme initiated by the National Agroforestry Center, enhances local natural resources (forests) by planting, restoring, and monitoring herbaceous native plant species which traditionally have been wild harvested for food, medicine, and decoration. Although the initial focus is in the southwest Appalachian Mountains of Virginia, as understanding, interest, and support broadens for this profitable landcare practice, the FFN can be expanded to other regions of Virginia or other states. This poster examines the opportunities and challenges of establishing rigorous science protocols for replicated trial plantings of selected forest botanicals, determining viable harvest methods, and sustainable harvest levels utilizing volunteer farmer and non-farmer landowner scientists.

A comparative analysis of genetic variability of Acacia senegal (l.) willd. in Kenya based on quantitative and molecular approaches for gum production, seed and growth traits

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Preferred session A8. Integrating genomics in Agroforestry
Abstract Acacia senegal is an African multipurpose tree species, highly valued for gum arabic production and other multiple uses. Twelve quantitative traits and RAPD and ISSR diversity among four populations of the species in Kenya were studied. The dendrogram derived from the quantitative traits distinctively divided the populations into two groups: the Garissa and Wajir populations in one group, and the Samburu and Baringo populations in the other. Trees were larger, taller with greater pod and seed traits in the Samburu and Baringo populations than the Garissa and Wajir populations. Conversely, trees had lighter seeds, more branches and higher gum yield in the Garissa and Wajir populations than in the Samburu and Baringo populations. This was congruent to that of combined RAPD and ISSR data, showing geographically proximal populations being more closely related than geographically distant populations. A high gene diversity index was observed (H=0.283) for the molecular data. Much of the variation resided within the populations (86%). It was concluded that, though molecular markers are more useful than quantitative genetic data in population genetic studies of A. senegal, both sources of information should be used in defining evolutionary important units for conservation. Both molecular and quantitative data provide useful information important for delineation of particular zones for germplasm conservation and improvement.
The agro-ecological sustainability of the Sahelian parkland systems: their contribution to the rural communities’ livelihoods

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Preferred session: A10. Dryland agroforestry R&D

Abstract

The Sahelian parkland systems have sustained rural communities’ livelihoods for generations by providing a range of essential products and services. However, the Sahel is one of the regions most vulnerable to climate change. The climate has undergone recurrent variations of significant magnitude resulting in a southward shift in rainfall isohyets, thus accelerating desertification, biodiversity shifts and reduced livelihoods in rural communities. Although farmers have managed Sahelian parkland systems for at least 1000 years, concerns have been raised about the sustainability of these agro-ecosystems due to human population growth, droughts, desertification, unsustainable management practices and controversial natural resource and tenure policies. Parklands are often dominated by a few economically important native tree species, while other native species are relatively rare and confined to marginal lands. Landscape diversification may improve ecosystem functioning and improve livelihoods of rural communities. Diversification should target not only natural forests but also the parklands. Several diversification programmes have promoted exotic trees in the semi-arid zones, but this has raised issues about increased water use. Therefore, diversification should focus on native tree species for the Sahel. In this paper, we discuss the distribution and growth patterns of native tree and shrub species in the Sahel, the importance of conserving these species, and some advances in participatory domestication such as farmer-managed tree regeneration that are not only contributing to the conservation of these native species but also improving the sustainability of the parkland systems. To ensure future sustainability of the parklands, key gaps in knowledge must be addressed. For example, which niches can support higher levels of biodiversity in agro-ecosystems in the Sahel; how can water-use efficiency be improved in these agro-ecosystems; what are the socio-economic and environmental trades-offs at both the farm and agro-ecosystem level, and how can these trade-offs be minimized?

Responding to climate change in crop production

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract

Since the early 1970s, environmental scientists have expressed concern that there is a global climatic change due to the disruption of the dynamic equilibrium of the ozone layer. In Uganda, the seasons are no longer consistent and reliable because of this climate change. This has resulted in unexpected droughts, floods and constant rains among other things, resulting in unpredictable crop failure. This is a global concern that can be fought from the grass roots through local initiatives like afforestation and proper disposal of ozone depleting substances. The main climatic elements are solar radiation, temperature, wind and moisture which largely determine the global distribution or crops as well as crop yields within a given climatic zone. Daily seasonal or annual varieties in the values of the climatic elements are of great importance in determining the efficiency of crop growth. Soil moisture is the source of water for the crop. Rainfall, evaporation rate, and soil characteristics control the state of soil moisture. When the soil moisture is excessive, all the soil pores are completely filled with water, then a waterlogged condition prevails. In such a situation free movement of air within the soil is impeded and compounds toxic to the roots of the plants may be formed. The extreme is the condition of drought in which the amount of water required for evapo-transpiration exceeds the amount available in the soil. Unless this deficit is made good by rainfall or irrigation, the plant will begin to wilt and die. This is another climatic parameter that affects crop growing. Extreme climatic conditions constitute to grave hazards to agriculture and therefore need to be well explained to the farmers.
Ex situ performance of wild Arabica coffee populations in southwest Ethiopia

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Preferred session: A6. Ecophysiological bases of agroforestry-system design

Abstract
Arabica coffee accessions, which have been collected from 4 wild coffee populations (Bale, Bonga, Birhane Kontir and Yayu), were established at the Jimma Research Center, southwest Ethiopia. The populations differ in rainfall gradients, drier in the southeast and moist in the southwest areas. Sixty accessions, fifteen from each locality, were evaluated for their ex situ performances and variability in desirable traits (yield and yield components, disease resistance, insect tolerance and quality). This paper focus on the findings of the interdisciplinary research works under field and laboratory conditions. In addition, future research areas on the use and conservation of the precious genetic resources of Arabica coffee germplasm and its natural forest habitats in Ethiopia, its birth place, is presented.

Rubber agroforestry systems in Indonesia and impact on livelihoods and the global environment:synthesis of 15 years of research

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract
Improved rubber agroforestry systems (RAS) have been introduced and tested since 1994 through a collaborative research program with ICRAF and CIRAD. After completing an on-farm trial network with 100 fields in 3 areas in Sumatra and Kalimantan, farmers have been monitored for 15 years in order to assess impact of technological change and context evolution. The 1994-2007 period has been characterized by completely different contexts: good rubber prices (1994-1996), severe economic and political crises combined with low rubber world prices (1997-2001) and recovering with high rubber prices (2002-2007). Meanwhile, farmers organizations have been allowed, oil palm took has been added to the landscape, tree tenure has been modified allowing farmers to take advantage of tree biodiversity. When rubber could have been condemned at the end of the 1990s compared to oil palm, rubber and rubber agroforestry systems not only survived but took a far greater place in local farming systems. The hypothesis of complementarity between oil palm and rubber systems has been confirmed; meanwhile ecological services as well as economic advantages of agroforestry practices have been taken into account by institutions and integrated by producers in their farming and livelihood strategies. Positive externalities such as soil fertility maintenance, biodiversity conservation, ‘useful biodiversity’ valorization (fruits and trees), long-term income stability and risk aversion, can now be taken into account in farming systems’ strategies and income evaluation. Fifteen years of research results on RAS have led to significant knowledge on farmers’ strategies and innovation processes that can provide useful recommendations for further development.

Emerald (MRILD) concept ‘Multi Role Integrated Indigenous Landscape Design’

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Preferred session: B6. Agroforestry as a tool for landscape restoration

Abstract
The scale restoration of regional ecosystems for long-term biodiversity benefits can also provide sustainable fuel production. Leveraging energy needs can play an important part in ecosystem
reintegration at a landscape scale. The biomass industry is able to be flexible in fuel needs. Consequently there is an opportunity to develop a biomass industry which utilizes processes that are sympathetic to the ongoing functioning of indigenous ecosystems and landscape-scale processes. Fuel resources based on ecosystems can lead to long-term resource security (particularly relevant for a future climate flux scenario) by leveraging ecosystems benefits of self adaptation, self regeneration, pest and pathogen resistance, and of particular relevance to the Australian continent, fire resistance. The Emerald Concept (MRIILD) discussed is derived from the title “Multi Role Integrated Indigenous Landscape Design” or MRIILD. This globally applicable concept is designed to create insights in strategic regional and national planning by creating carbon-neutral on-demand power, materials, real biodiversity outcomes and significant carbon sequestration in cost effective ways. The Emerald Concept (MRIILD) tackles the complexity and scale of global and local crises holistically and delivers a pragmatic, flexible and achievable solution. Government departments have the opportunity to work together on a single project that has the potential to deliver mutually beneficial solutions. For the agroforestry and biomass industry to be recognized as ecologically responsible and sustainable, efforts must be made towards valuation of all landscape and biosphere functions and that a complete biomass energy producer of the future must deal with both technology and the production and management of the resource base for true green credentials to be gained. The Emerald Concept (MRIILD) is a simple method of visualizing an entire healthy landscape based on pragmatism for the achievement of lasting social and environmental outcomes.

Soil manipulation in microcatchment formation to enhance Grewia tenax (Forsk.) Fiori hedgerows survival and establishment in arid and semi-arid conditions

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Preferred session A10. Dryland agroforestry R&D

Abstract The establishment, growth and production of Grewia tenax utilizing 2 soil arrangements in circular microcatchments was investigated to determine whether the use of topsoil for bund formation, while leaving the subsoil for seedling planting, had a marked effect on the proper growth of the juvenile seedlings. The 2 soil arrangements in the microcatchments included: topsoil for bund formation with subsoil in the planting pit; and vice versa. The first trial was done in the dry season by irrigation and repeated under rainfed conditions with supplementary irrigation. The layout of the experiments was a randomized block design with four replications. The planted seedlings were left to grow in the field for a period of 6 months. Variables studied included survival percentages, plant height growth, root collar diameter; branching, and biomass yields. Results were varied at the start, with significant differences (P < 0.05) noted for height and number of branches but as the plants became well established highly significant differences (P < 0.01) were noted for all growth variables under study with plants growing in the microcatchment with topsoil used in the planting pit exhibiting superior traits. Although the plants growing in the microcatchment performed better than the control, the survival percentages of plants in the microcatchment with topsoil used for bund formation were lower than in the control. On the whole, this finding shows that even though water is essential for plant growth and production in arid and semi-arid conditions, alteration of the topsoil for the excavation of microcatchments has a tremendous impact on proper growth of juvenile plants.

Economic value of gully biological rehabilitation and the benefit of sustainable fortification

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract In addressing watershed degradation problems a number of interventions have been made in
Ethiopia, of which biological rehabilitation is one. Biological rehabilitation and its implications on the economics of the society have rarely been addressed. This means the cost incurred in rehabilitation programmes and the resulting benefit has not been clearly justified; instead it has largely been taken as a panacea approach. Hence this study attempted to develop valuation methods of biological rehabilitation, by formulating a technique in valuing the rehabilitation in monetary terms, incorporating the major costs and returns of the rehabilitation. Moreover the study constructed scenarios, to gain opportunity cost information about the future. For the purpose of this study 4 model-rehabilitated gullies in Ethiopian highlands, were studied. The data used were obtained from a physical data survey and supplemented with secondary sources. The total cost and return values of the data were compared monetarily through opportunity cost computation. Then the values were extrapolated to calculate the opportunity cost of the gully in the year 2021 (maturation age of the trees). The results indicated that in 2007, by taking the smallest and largest of the study gullies, the rehabilitation benefit reaches Birr 918,049.62 and Birr 4,651,167.22 for each gully, while rehabilitation investment cost was Birr 154,178.24 and Birr 205,712.15 for the same year and gullies respectively. Under optimal management at the year 2021 these benefits will reach up to Birr 29,644,486.24 and Birr 116,368,436.40 for the same gullies respectively. While the cost in 2021, will be Birr 108,137.52 to Birr 135,999.97 respectively. The results clearly indicate that investment in gully rehabilitation may be an economically viable short-term proposition however; the long-term benefits are far more pertinent propositions. Hence there is a strong case for sustainable management of rehabilitated gullies in view of the very high economic benefits from the gully rehabilitation.

Impact of public policies on agroforestry systems in Kerala, India

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract Public policies affect farming especially when they constrain farmer activities, either by putting constraints on farmers’ decisions or providing them with new opportunities. This is particularly true in the Kerala State, where traditional agroforestry systems abound. Despite their pervasiveness, such practices are yet recognized by the development community in Kerala. Nonetheless, agroforestry systems are fundamental features of rural landscapes. They are also sustainable production systems and harbingers of agrobiodiversity, host a wide variety of cultivated crops and shelter a large number of forest trees and wild plants. However, many of them are facing the danger of extinction. This is partly because of a trend towards a simplification or even a replacement of mixed-species production systems by monospecific cropping systems. A general apathy towards agroforests has resulted from: the commodity-centric agricultural policies oriented towards plantation crops; the general lack of awareness among the development community about the intrinsic worth of mixed-species production systems; and the managerial hassles associated with usage of modern inputs in mixed-species systems have resulted in. Forest policies that aim to protect high-value forest tree species, may also have contributed to the decline of agroforestry in Kerala. For instance, restrictions in timber extraction from farmers’ fields under the guise of protecting natural forests from the farmers, often act as a disincentive for farmers to maintain mixed-species tree-based production systems. However, in the global context of the challenges associated with food security, climate change mitigation and poverty alleviation, a re-orientation of the public policies in relation to agroforestry in Kerala is warranted, as most of the small and marginal farmers of the state rely on agroforestry for subsistence. This paper, based on field-based enquiries in Trivandrum and Wayanad districts, explores constraints and opportunities that exist for agroforestry in Kerala.
Climate change and Africa’s wetland forest resources management: the impact of oil and gas exploitation in the Niger Delta of Nigeria.

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Preferred session C4. Mitigation and adaptation to climate change

Abstract
There is substantial evidence to indicate the threat faced by Africa’s Wetland forest resources in the 21st Century due to unsustainable oil and gas exploitation. Forests and trees in African countries are vital assets offering environmental benefits and sustaining livelihoods since time immemorial. In most of Africa, forests play multifaceted roles which include religious and cultural functions, food production, employment, income generation, recreation and environmental services. Examples are biodiversity conservation, nutrient recycling, protection of microclimates and indigenous lifestyles. These functions need to be recognised, protected and factored into sustainable land use in Africa vis a vis an African climate change mitigation and adaptation framework that is predicated on sustainable management of its forest resources. In this paper, the author identifies the impacts of oil and gas resource exploitation in the Niger Delta of Nigeria, on forest resources, as a case study; and considers the unthinkable scenario of Africa’s continuing neglect of its Kyoto targets.

The paper aims to push current research boundaries on climate change and sustainable forest resources management based on harmonized forest legislation that allows for regional integration of migration corridors, through the use of conservation easements, and joint or transboundary forest management agreements. The paper discusses community participation and forest resource benefit sharing that allows across-the-board capacity building, and a unified institutional-cum-legal framework that can bring about integrated sustainable forest resource management in the African continent.

A one million hectare forest sanctuary in Mindanao

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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands

Abstract
Mindanao’s remnant forest has an estimated 1 million hectares remaining, barely 10% of the island’s landmass. The continuous threat from invasive development of logging, mining and plantations, fragmented the forest to half a dozen blocks of lowland, montane ecosystem and residual corridors. The key strategy identified to secure these blocks is empowering forest tribal people to lead protection and development. Ancestral land titles and sustainable development plans are popular among mainstream tribal people. Assistance in securing these is provided by NGO’s and the Philippine government’s indigenous people’s commission. Various tribal people set up practical forest management regimes anchored on common cultural values such as: sacred sites, extraction-hunting-gathering areas and agroforest zones. Sacred sites are also designated wildlife sanctuaries. Extraction areas are set aside for rattan and NTFP harvesting, hunting and trapping wild foods and gathering of medicinal plants. Agroforest zones are primarily food sufficiency swidden food-crop farms mixed with abaca, coffee, falcatta, fruits and other traditional commodity crops and livestock. The model wildlife sanctuaries established are essentially governed by tribal rules and agreements among elders and guardians. Recently, barangay and municipal ordinances were secured and integrated into formal ancestral domains for sustainable development and protection plans. Forest harvesting plans were agreed upon with tribal land owners and permits coordination with the forestry agency. Agroforest ventures in abaca growing, processing and trading were executed by various tribal organizations with entrepreneurs, local governments, agroforest institutes and NGOs. A tribal gathering was held and a pledge of an initial 660 000 hectares forest under the regime was executed through tribal compact. An agreement was forged by elders to strengthen each other through networking, alliances, exchanges and partnership with civil society and government.
Impact of exclosures on biomass production and fuelwood supply: the case of Douga Tembein, Tigray, Ethiopia

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Preferred session: B7. The role of degraded lands in biofuel production in SE Asia

Abstract
This research assessed biomass production from two dominant woody species (Acacia etbaica and Euclea racemosa subsp.schimperi) and evaluates the potential of exclosures to supply fuelwood to the local community in Tigray, Ethiopia. Replicated 5-year-old and 10-year-old exclosures were sampled. Above-ground biomass was determined using destructive sampling. A questionnaire survey on 40 randomly selected households, and field observations were conducted to assess the patterns of fuelwood sources and consumption. The woody biomass produced from Acacia etbaica was significantly (p < 0.05) higher compared to the biomass from Euclea racemosa subsp. schimperi. From the two investigated species, 27.5 Mg ha⁻¹ of woody biomass was produced annually from 114.6 ha of exclosures. Based on the estimated daily consumption (0.63 kg d⁻¹ per person) of fuel wood by the local community, the estimated biomass production would cover only 9.4% of their yearly fuelwood demand. Biomass from trees and shrubs are the major source of fuelwood. The amount of fuelwood consumption varied with size of the households. The majority (95%) of the respondents stressed the difficulty of getting fuelwood due to severe degradation of vegetation cover. Although exclosures are important to alleviate fuelwood shortages, their current contribution is very low compared to the huge demand of fuelwood. The respondents put forward options such as large-scale plantation and using improved stoves and biogas technologies to minimize the problem of fuelwood shortage. Timely silvicultural management interventions that can increase biomass production from exclosures are also needed.

Effectiveness of exclosures to control soil erosion, and local community perceptions on soil erosion in Tigray, Ethiopia

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Preferred session: B6. Agroforestry as a tool for landscape restoration

Abstract
This study investigates the effectiveness of exclosures in the fight against soil erosion and how they are perceived as a means to control soil erosion by the local community (farmers and local experts). The revised universal soil loss equation (RUSLE) was used to estimate potential soil erosion. Data on local community perception were obtained from a survey of 62 farm households and five local experts. In-depth interviews and group discussions were also held with the farmers and local experts to obtain additional information. Additionally, non-participant field observation was undertaken to determine the severity of soil erosion in the study site. The RUSLE results agreed with the farmers’ (67%), and local experts’ opinion that erosion at study area is severe and affects the quality of lives of residents. A significant difference (at p < 0.1, or 90% confidence interval) in the estimated soil loss among treatments was observed. The estimated soil loss from free-grazing lands was 47% higher than soil loss from exclosures, which illustrates that exclosures are effective in controlling soil erosion. The majority of farmers (70%) also rated exclosure effectiveness in controlling soil erosion as high. Local communities were optimistic about the chances of rehabilitating degraded lands and making them productive. However, the majority of farmers (60%) do not consider population growth as a cause of soil erosion. For the majority of interviewed farmers, poor land management is more important. We recommend that efforts to create awareness within the rural communities should focus on the link between high population growth, environmental degradation and poverty. The optimistic view of local communities can be considered as an asset for the planning and development of degraded land rehabilitation efforts.

Key words: Ethiopia, exclosures, local experts, perception, rural community, soil erosion
Hagenia abyssinica (Bruce) J.F. Gmel. in Galessa watershed, central Ethiopia: potentials as source of plant nutrients

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract

The depletion of soil nutrients in the highlands of central Ethiopia is a potential threat to agricultural productivity and sustainability. Studies were conducted from 2004 to 2006 at Galessa watershed to: collect information on the growing niches and benefits of Hagenia abyssinica (Bruce) J.F. Gmel.; evaluate the effect of H. abyssinica on soil fertility; and assess the chemical composition and other quality characteristics of the foliage and flower buds of H. abyssinica. Participatory rural appraisal and questionnaire survey approaches were used to study the growing niches, histories and benefits of H. abyssinica. Soil samples were collected at 0 15, 15 30 and 30 50 cm depths and 0 75, 75 150 and 150 225 cm radial distances from the bases of H. abyssinica. Thesooil samples were analysed for pH, organic C, total N, available P and exchangeable cations. Similarly, foliage and flower bud samples were collected and analysed for macronutrients, lignin, soluble phenolics and condensed tannin. The farming communities at Galessa watershed identified more than 10 service and product benefits of H. abyssinica. Among the benefits, the fodder and soil fertilizing values of H. abyssinica were mentioned substantially. The foliage N content of H. abyssinica was comparable to other indigenous species of the highlands. The total N content at 0 15 cm depth versus 75 cm radial distance was 6.60 mg g-1 as compared to an amount of 5.66 mg g-1 at 0 15 cm depth versus 225 cm radial distance from the base of the trees. In general, the soil in the vicinity of H. abyssinica contained a substantial amount of soil nutrients. Hence, the soil fertility-improving potential of H. abyssinica should be explored in the high altitude areas, where soil erosion and soil nutrient depletion are critical problems.

Nitrogen transfer mechanisms between legume trees and associated crops: a simulation study

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Preferred session A7. Biological dinitrogen fixation in AF systems

Abstract

Conventionally, the main contribution of legume trees to nutrient cycling in agroforestry systems is considered to be their provision of nitrogen-rich pruning residues and foliar litter, which during decomposition release nutrients for uptake by associated plants. Substantial transfer of N between legume trees and crops has, nevertheless, also been observed in systems where tree prunings are exported from the site. To increase understanding on the below-ground processes related to N cycling, we have developed a dynamic model for simulating N transfer between legume trees and associated crops, including (i) exudation of nitrogenous compounds from legume tree roots, (ii) N transfer to mycorrhizal symbionts linking the root systems of the plants, and (iii) above and below-ground litter of the legume tree. In contrast to litter, root exudation and mycorrhizal networks enable direct transfer of symbiotically fixed N between plant species without the interference of soil microbial organisms, and thus potentially enhance crop nutrient acquisition in N-limited systems. The model is applied to testing assumptions on N transfer processes, which include: (i) that exudation of N compounds occurs mainly as passive diffusion, and its benefit to the recipient plants is importantly affected by competition with soil micro-organisms, and (ii) that mycorrhizal N transfer is driven by source sink relationships such as N concentration differences between the
donor and recipient plants, and augmented by the extent of mycorrhizal colonisation within plant roots. The model is parameterized for an experimental cut-and-carry fodder production system of *Gliricidia sepium* legume trees and *Dichantium aristatum* grass in Guadeloupe, Lesser Antilles. The model simulates N transfer with a daily time step, and is currently non-spatial, but generalization and implications of the model results at a system level are also discussed.

**Economic impact of climate change on Israeli Agriculture**

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**Preferred session** C4. Mitigation and adaptation to climate change

**Abstract**

Climate changes, followed by the accumulation of green house gases, are expected to have a profound influence on agricultural sustainability in Israel, a semi-arid area characterized by a cold wet winter and a dry warm summer. The intention of this study is to explore economic aspects associated with agricultural production under a projected climate-change scenario. To this end we apply methodology known as the ‘production functions’ approach to two representative crops: wheat, as the major crop in Israel’s dry southern region; and cotton, representing the more humid climate at the north of the country. Adjusting outputs of the global climate model had CM3 to the specific reproach locations. We generated projections for 2070–2100 temperatures and precipitations for two climate scenarios; net revenues become negative under the severe scenario, but may increase under the moderate scenario depending on nitrogen applied to the crop. Distribution of rain events was found to play a major role in yield production. By contrast, under both scenarios cotton evinces a considerable decrease in yield, resulting in significant economic losses. Additional irrigation and nitrogen may reduce farming losses, unlike changes in seeding date.

**Key words**: Climate change, Israeli Agriculture, Economic Impact.

**The concept of policy advocacy on mainstreaming gender equity in climate change initiatives in Africa.**

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**Preferred session** C4. Mitigation and adaptation to climate change

**Abstract**

The recent trends in climate change in Africa have caused several alternations of climatic conditions. Climatic conditions are still the predominant factor affecting agricultural productivity and natural resources systems. These systems are part of human society and the economy, and how reactions to climate change are been developed on different levels is of high relevance. The negative impact of climate change on food production, water resources and other natural resources is significant. Climate change is characterized as an important threat, in which Africa and its poor population are often characterized as ‘most vulnerable’. Experience shows that community-based management is achieved when women’s voices are heard and a broad range of social, economic, environmental and political issues that can inhibit participation both by men and women are responded to. Putting women at the centre involves recognizing their rights to enjoy healthier and more productive lives through access to clean safe water, adequate sanitation, water for agriculture and other socioeconomic activities. Women must participate in natural resource management and also have the right to participate in decision making concerning climate change issues. Women belong to communities and the wider civil society, so government and other agencies need to engage women as active agents of change and not just as vulnerable victims. This paper draws experience from the Eastern Region, Oda District Assembly Area of Ghana, where Women International Coalition Organization (WICO) Africa, working in collaboration with the Liberation Women’s Development Association (LIWODA) to strengthen the role of women within Achiase Village and its environs and help them to play an active role as key agents of change in climate
Agroforestry in the Torres region of Rio Grande do Sul, Brazil: tradeoffs or synergies?

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Preferred session  
A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

This research examined the agroforestry initiatives that have been implemented in southern Brazil, and the main findings suggest that it is possible to promote a ‘positive-sum’ relationship between agricultural production, livelihood enhancement and environmental conservation. The impetus for this work is a major concern at the present time, usually framed as ‘sustainable development’, that is, the urgency to provide economic goods and services for a growing population, and to concurrently preserve tropical ecosystems. The investigation compared two groups of banana producers who had adopted either conventional or agroecological methods. The research site was the Torres region, northern coast of Rio Grande do Sul State, located within the Atlantic Forest Domain, one of the most threatened ecosystems in world. Data were collected from June 2005 to December 2006 using questionnaires, meetings, and direct measurements taken at the study sites. Farmers were asked about the size of their plots, the inputs utilized for production (fertilizers, pesticides, lime, manure, etc.), yields, labour, marketing prices, and management practices. A phyto-sociological inventory was carried out in a sub-group of eight agroforestry systems, within the group of agroecological farmers. Overall results indicated that agroforestry banana production systems are slightly less productive in physical terms (kg ha⁻¹). However, these systems had better economic performances measured in terms of net income per hectare and labour productivity. In addition, they were contributing more effectively to a number of environmental services: biodiversity conservation, carbon sequestration, reduction in pesticide use, and lower consumption of petroleum-based inputs. These results provide a basis for designing planning strategies aimed at reducing the adverse effects of intensive agricultural activities and enhancing social, economic, and ecological sustainability of this region, and possibly elsewhere. The investigation was part of a PhD program in Natural Resources at Cornell University, and was partially sponsored by the Fulbright-OAS Ecology Initiative.

Developing of quality germplasm of *Jatropha curcas*: a requirement for biodiesel production in Ghana.

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Preferred session  
B7. The role of degraded lands in biofuel production in SE Asia

Abstract

With the recent increasing prices of crude oil in the country, there is a growing interest by both government and individuals in *Jatropha curcas* for biodiesel production to mitigate the fuel crises. According to the drafted Bioenergy Policy of Ghana (2008), the government is collaborating with the private sector with the aim of developing about 1 million hectares of *Jatropha* plantation throughout the entire country in the next 5-6 years. The questions left unanswered are: why will farmers grow *Jatropha*, and where will the farmers source their planting material? It is likely farmers will plant from any easily available source. If there are no variations in genetic resources of *Jatropha curcas* found in the country in terms of growth performance and yield, then there will be no loss of opportunity. But if there are superior genetic resources of the plant then good opportunities will be missed by not using planting materials with higher yield potentials and other more desirable plant characteristics. Therefore research on *Jatropha curcas* genetic resources is imperative. The main objective of this paper is to report on research methodologies for successful propagation of *Jatropha curcas* in Ghana. It will present the farmers’ indigenous ecological knowledge of *Jatropha curcas*. The preliminary results of the screening of *Jatropha* vegetative resources from the 10 regions of Ghana will be discussed.
Forest-based agroforestry practices: innovation and a promising practice for poor and landless people in Nepal

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Preferred session  A5. Ecological sustainability: panacea or Pandora's box?

Abstract  Forest-based agroforestry practice has been found to be the most promising practice for poor and landless people in Nepal. Forest-based agroforestry practice has increased in Nepal since the transfer of legal rights to local communities to manage nearby forest areas as community forests. As a result, Community Forest User Groups initiated the implementation of various forest management activities. Following to the legal provisions and with the aim of supporting poverty reduction goals, the Asia Network for Sustainable Agriculture and Bioresearches (ANSAB) encouraged and facilitated communities to allocate degraded forest land to the landless poor for the purpose of growing high-value plants. The process involved revisions to forest management plans, technical input into the improved design of agroforestry activities including planting and harvesting techniques, facilitation of the establishment of processing cooperatives, and assistance with the development of market linkages. As a result, poor and landless people of rural communities are receiving benefits from the production and marketing of plants such as palmarosa and citronella (essential oils) and lemon grass (herb) in national forest areas. These practices have helped to generate additional income for poor people (NRs. 3500 per household) while at the same time encouraging them to conserve the forests by increasing forest cover and species density. This is an innovative practice which has the potential for replication elsewhere under similar conditions.

The role of local government units in mainstreaming climate change adaptation in The Philippines

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Preferred session  C4. Mitigation and adaptation to climate change

Abstract  The Philippines is one of the most vulnerable countries to climate-related disasters that could be exacerbated by climate change. We present the experience of a local government unit (province of Albay) in mainstreaming climate change adaptation in the Philippines. The case of the province of Albay shows the key role of local governments in promoting climate change adaptation. Provinces which experience frequent and severe climate hazards are more likely to be aware and responsive to the need for climate change adaptation. Local government units at the provincial scale (meso scale) do have resources to commit to climate change adaptation. This is illustrated by their efforts at mangrove rehabilitation. The potential role of agroforestry systems in climate change adaptation in the province is discussed.

Annual bird dynamics and the use of coffee and cacao agroforest, silvopastoral systems, sugar cane and forest landuses in Turrialba

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Preferred session  A1. Multistrata agroforestry systems with perennial crops

Abstract  Most studies of biodiversity in agroforests collect snapshots of information collected over very short periods of time. In contrast, CATIE’s Bird Monitoring Program (BMP) has completed a year and a
half of continuous monitoring of avian biodiversity in the 6 land uses that dominate the Volcan Central Talamanca Biological Corridor, including 4 agroforestry systems. We capture, identify, measure and mark birds caught by mistnets in 2 coffee agroforests, a cacao agroforest, live fences in a pasture system, sugar cane fields and secondary forest. The focus of our efforts is to understand how land management, land-use change and climate change impact bird populations, including the capacity of forest dependant species to use agroforestry systems as corridors, and habitat. Since we began our research efforts in January of 2008, the BMP has gathered information on body condition, habitat preference and movement of more than 115 species, and 2000 individuals. More than 65% of these species and 45% of the individuals were found in coffee agroforests. These number increase for migratory species, where 69% of the individuals have been observed in coffee agroforests. In addition, we recaptured migratory species returning to agroforests following the summer migration, indicating that agroforests seve as important habitat for migratory species. Long-term datasets are critical for management recommendations that consider impacts of habitat conversion in the corridor, coffee agroforests in particular are rapidly being replaced with sugar cane plantations with low conservation value. We demonstrate how critical long-term data are for developing evidence-based conservation strategies for biodiversity conservation, such as increasing the complexity and connectivity of live fences in pastures and timing the pruning of agroforests to avoid nesting periods of resident species, among others.

Institutionalization and legalization of watershed users in the Amhara region

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Preferred session D3. Policy formulation and stakeholder engagement in NRM
Abstract The present-day government policy in rural development focuses on watershed treatment and rehabilitation, which is believed to bring about substantial changes in the beneficiary communities. The allocation of huge amounts of funds by the government or donors, and efforts made by the watershed communities result from that policy. Ever more rural areas are selected for substantial investments in their watersheds. The communities, as the owners of the natural resources in their respective areas, actively take part in planning and implementing of the activities, and overall technical support is provided to them by agricultural and rural development offices with substantial donor contributions. In most of these watersheds encouraging results have been registered with regard to gully rehabilitation, hillside treatment, water well development, road construction and other socially and economically important activities. But these achievements do not seem to be sustainable in all areas. Even though there are differences from one area to another, most of them share the experience of destroyed or ill-maintained erosion-control structures or plantations. The same sites are often rehabilitated consecutively year after year. The Government services in general, most of the donors and communities in particular do not seem to have found a solution for this problem. Any development initiative has to operate within the prevailing legal framework. However, existing comprehensive policies, proclamations and regulations pertaining to natural resources, land and forest management do not seem to be sufficient to bring about the expected change in sustainable land use. Therefore, complementary measures in organizational development at the level of the resource users are crucial. Institutional set-up with legal documents which bind every user can change the situation fundamentally. The current paper tries to describe the approach that has been put into practice and to look at the experience gained so far.
The cost of carbon sequestration under community forest management in Nepal Himalaya

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Preferred session
C1. AF, climate change, biodiversity conservation

Abstract
This paper sets out to estimate the cost of carbon sequestration based on the sequestration rates measured in the field in 3 community-managed forests in Nepal. The paper starts by reviewing the cost of reducing carbon from other forestry projects globally as cited in various literatures in such a way that it can be compared to the community forest management (CFM) abatement cost from Nepal Himalaya. It then explains the type of baseline needed for community forest management to be able to participate in REDD policy. This paper estimates the cost of producing carbon credits under different management scenarios and conducts gross margin analysis so that the break-even price of carbon offset for each site is estimated and the net benefit under different scenarios is determined. To participate profitably in carbon trading, the net gains must be above what the community forest users have been currently deriving, so this paper analyses whether the net gain under carbon trading will be attractive or not to the locals that have been managing their forests.

Evaluation of some biotic factors affecting the incidence of Hypsipyla sp. (Lepidoptera: pyralidae) on Khaya anthoteca (Meliaceae)

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Preferred session
C1. AF, climate change, biodiversity conservation

Abstract
Khaya anthoteca is one of the precious timber species for construction in Mozambique and has been widely exploited for export as part of the country’s economic development efforts. However, damage attributed to the lepidopterous borer Hypsipyla sp. have been recorded in Mozambique and several other countries, reducing tree growth and increments. Details of the extent of damage by this pest in Mozambique are not known; and this work was carried out with the aim of evaluating the effect of plant size in attracting the insect pest, and the presence of the pest’s natural enemies. Quadrangular 16 m2 plots were marked in Khaya anthoteca plantations aged years in Moribane, Manica Province and central Mozambique. Observations included infestation levels and the attack levels per plant inside the plot. Measures of plant height, diameter at breast height and stem quality by assessing number of branches and stem shape, were taken per plant. On average, infestation levels reached 30.6% of total plants in the stands. Results show that Hypsipyla sp. tend to infest smaller trees up to 4 m high, with infestation levels of 57.7% which may result in reduced growth with potential effects on timber size and quality. In terms of attack levels, smaller plants were also more affected by the borer. In this study, infestation by Hypsipyla sp. was more intense in stems showing poor quality, which appeared to be a consequence of the larval activity. At the study site, the borer in its larval stage is highly infested by a parasitic nematode, reaching a parasitism percentage of 47. This natural enemy could be considered for further studies for use as biocontrol agent to reduce Hypsipyla sp. incidence.

Key words: timber quality, borer infestation, natural enemy
Influence of tree leaf quality and application method on soil CO2 concentration, cabbage yield and weed infestation

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Preferred session
C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract
Agroforestry is recommended and practised for better soil management and sustainable crop production. Application of pruned materials to the soil may improve soil physical and chemical properties and ultimately influence crop yield. Since fresh-pruned materials are added to the soil, there may be an increasing trend of soil CO2 concentration due to decomposition. In general, higher soil CO2 concentration has a detrimental effect on crops. This effect may be higher in tropical regions because of the higher decomposition rate of organic matter. Field experiments were conducted to examine the soil CO2 concentration, water retention and cabbage production as influenced by mixed and surface application of fast (Gliricidia sepium) and slow (Swietenia mahagoni) decomposing tree leaves in Bangladesh during the winter seasons of 2005/06 and 2006/07. Results showed that soil CO2 concentration was remarkably higher in the mixed treatment of G. sepium leaves than in the control and surface application of S. mahagoni leaves; while it was higher in the deeper soil (30 cm) compared to top soil layer (15 cm) irrespective of measurement dates in both the years. Cabbage head yield was significantly higher in mixed applied treatment application of G. sepium leaves than the control treatment. However, mixed application of G. sepium leaves gave 1.8, 6.8, 6.9 and 10.9% more yield than the surface application of G. sepium, mixed and surface application of S. mahagoni leaves and control treatments, respectively. There was a significantly higher weed infestation in the control treatment than other treatments. Among the applied leaf treatments, the lowest weed dry weight was noted in surface application of S. mahagoni. The results indicate that although soil CO2 concentration was higher in the G. sepium leaf treatment, it was not detrimental for cabbage yield and mixing of the leaves may be more effective to retain more soil water and higher crop yield.

Socioeconomic and cultural aspects influencing the adoption of indigenous agroforestry systems: a case study from Karnataka, India

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Preferred session
D4. Incorporating local knowledge in agroforestry science

Abstract
Mandya district, which falls in the southern dry agro-climatic zone of Karnataka State in South India, harbours an indigenous agroforestry system with various species of ficus planted in rainfed agricultural lands. These trees provide numerous direct benefits (fuel, fodder, shade and timber) to farmers and also perform various crucial ecosystem services such as soil and water conservation and supporting local biodiversity. But in recent times, owing to the advent of assured irrigation facilities and subsequent land-use changes, ficus trees are being substantially replaced with various fast growing exotic species. Disappearance of ficus trees from farming systems in the long term may lead to a decline of valuable services, leaving people with few alternatives to protect their livelihoods. In this study, socioeconomic and cultural values of this traditional system were elicited through detailed household surveys and participatory rural appraisal undertaken in Mandya district. Semi-structured questionnaires were administered to a sample group of 100 farmers categorized on the basis of number of ficus trees in their farms. Farmers without any ficus, but other MPTs, and farmers without any trees at all were also surveyed to assess the socioeconomic and cultural factors determining the adoption of ficus-based system. Results indicated that in addition to direct benefits, farmers also value the indirect benefits provided by native trees in terms of ecological and cultural services. Expectations on potential monetary benefits from highly subsidised modern agricultural/agroforestry systems appear to have driven farmers to forego these valuable services and shift to intensive systems with economically profitable trees that rank low in ecological and cultural values. The study highlights the need for policy incentives for indigenous systems, which
have the potential to offer sustainable livelihood options to rural poor, without depleting the natural resource base.

Promoting tree crops farming to mitigate climate change effects: lessons from oil palm farming in Kenya

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Preferred session C4. Mitigation and adaptation to climate change

Abstract
Global climate change is real and a major threat to rural livelihoods and food security in the 21st Century. Greenhouse gases (GHGs) and land-use changes such as deforestation for agriculture and urban growth, amongst others, are the major causes. At present Kenya’s forest cover is less than 2% compared to the required 10% for a country to sustain life naturally. Climate change is expected to increase droughts, floods and other extreme weather events adding to stress on water resources, food security, health, infrastructure, and thus, overall development. Most African communities are vulnerable to these impacts mainly because of the high poverty levels, reliance on rainfed agriculture, lack of access to technology and cultural practices. While the poor in general are the most vulnerable group, their agricultural systems and management is critical in adaptation and mitigation measures. As governments strive to feed their spiralling populations, appropriate policies are required that will cause the least GHG emissions or leave behind the smallest carbon footprint and conserves biodiversity. Promoting perennial tree crops such as oil palm, mangoes, cashew nuts and coconuts offers more opportunities to mitigate and conserve biodiversity compared to annual crops. Their mean productive life span is about 30 years. Thus, the annual land clearing and preparation processes are not required, resulting in lesser GHG emissions, the planted trees are perennially green and sequester CO2, they generate revenue and the plantations conserve biodiversity. Literature shows that the life cycle analysis (LCA) of the cultivation and fruit processing of oil palm, a fine oil crop that produces edible oil to feed the world, has a mean total GHG emission of 31.4 g CO2-e/MJ as compared to, for example rapeseed, an annual oil crop which has 47 g CO2-e/MJ. Similarly, it has the highest land productivity compared to soybean, sunflower and rapeseed whose average oil yield/ha are 3.68, 0.36, 0.42 and 0.59 respectively. As such, 6-10 times less land is needed to produce oil if oil palm is the choice. It has a high CO2sequestering capacity (29.3 tonnes of CO2per hectare annually) compared to other oil crops.

Assessment of an exotic tree fruit market at Lisala, DR-Congo

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract
In Lisala, a diagnosis and design (D&D) survey was conducted with farmers on 5 exotic fruit tree species that were among those introduced in 1992 by CEUM-LOKO Rural Development Centre. The objective was to: evaluate organoleptic values of targeted species and their impact on the market chain; identify problems obstructing fruit tree farming; and formulate recommendations for solutions to these problems. Concerning the organoleptic values of 5 species including *Citrus auratium* (local species), the following average rating marks were obtained: *Garcinia mangostana* (5.3), *Nepheleium lappaceum* (5.3), *Passiflora edulis* (3.7), *Pouteria campechiana* (3.3), *Citrus auratium* (2.0) and *Pouteria caimito* (1.3). The prices ranged from USD 2.00 to 3.57 per kg for *Garcinia m.*, and USD 0.40 0.71 for *Nephelium l.*. There were price growths of 78.5% and 77.5%.

We found that the market for the first two species was ‘monopole’ and for the others was ‘oligopole’.

The identified and rated problems were: lack of plant nursery tools (4.3); lack of financial assistance (3.0); a long biological cycle of the first two species (2.0); and the rotteness of some fruit species (1.3). Therefore, if we want the exotic tree fruit market to be an opportunity and a driver of agroforestry land use, we think that the market competition has to be changed from imperfect
to perfect. To reach this goal, we propose that donors take into account these recommendations: improve credit facilities; support extension services (NGOs); promote farmers’ capacity building; and create fruit storing and processing infrastructure.

Can biomass transfer improve nutrient use and productivity of mixed crop/livestock systems?

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract
In most of sub-Saharan Africa, crop and livestock production systems are inextricably linked. In the mixed crop/livestock farming systems, crop residues and protein-rich biomass from leguminous trees provide a feed supplement to livestock. In turn, animal manure has been the most important source of nutrients for crop production. Recently, the use of biomass from fodder and fertilizer trees to improve soil fertility has received considerable research attention. However, in many studies the livestock production aspect is decoupled from crop production and vice versa. As a result, synthesis of the essential linkages is lacking. We therefore undertook a comprehensive review and meta-analysis of studies across southern and eastern Africa with the aim of evaluating the evidence for benefits derived from biomass transfer practices in terms of animal performance, manure production, soil nutrient availability, crop yield, crop residue yield and economic gains to farming households. The analysis shows that biomass transfer can improve animal performance, manure production, soil nutrient availability, crop yields and residue yield thereby improving nutrient use and productivity of mixed crop livestock systems. We therefore conclude that biomass transfer offers opportunities for improving nutrient-use efficiencies and farm productivity by linking trees, crops and livestock in mixed farming systems.

Restoration of equatorial rainforest slopes of Mabonji in Meme Division South West Province, Cameroon.

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
Mabonji is a very hilly rainforest area of Meme Division of the South West Province of Cameroon. It has important biological diversity and rich volcanic soils, which attract a lot of people, especially farmers. Located at latitude 4°3’ N and longitude 9°3’ W, it has an equatorial and semi-temperate climate with an average annual temperature of about 25°C. There is a distinct dry and rainy season with the rainy season lasting for about 7 months beginning in March and ending in September. The objective was to conserve the forest slopes of Mabonji for sustainable development covering an area of about 18,000 hectares, with a population of about 3000 inhabitants practising different land-use systems. Data were collected through interactive and participatory methods. The priority was to assess the area by taking an inventory of the biodiversity, ecological habitats, different forest and land-use practices employed by local people and the legislative framework governing the process. Three pilot sites were selected, on which trial farms were established using an ‘agrotropic-rainforestry’ farming approach. The process lasted for 18 months, during which farming plots where prepared by groups of local people on slopes through: selective felling of particular trees, ‘thinning’, creating light spaces for cropping; raising of seed nurseries; and cultivating and planting. Alternative income-generating activities were introduced including snail farming, pig farming and the cultivation of non-timber forest products (NTFP), which farmers considered during off seasons as a ‘bush allowance’. Water catchments in the area were demarcated and protected. Results indicate that the understanding of the immediate environment was enhanced by different land-use practices and the adoption of a sustainable participatory agrotropic-rainforestry approach. Finally,
natural resources of forested slopes could be sustained for the long term by enabling local people to be proactive, immediate custodians of this environment.

Key words: agrotropic-rainforestry, conservation, local people, governance, rainforest.

Using a participatory-GIS approach with FOSS4G tools: addressing the GIS needs of community-based agroforestry projects

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract

Agroforestry projects which aim to improve local policy making require intensive knowledge of tree-crop combinations under local environmental conditions, as well as the participation of the local community. Thus, the use of the participatory geographic information system (PGIS) approach is indispensable in agroforestry projects because of its capacity to integrate various biophysical information and stakeholder perspectives in GIS analysis. Although GIS is still an expensive technology, recent innovations in the development of free and open source software for geomatics (FOSS4G) has made significant reduction in costs, which are desirable for GIS researchers in developing countries. FOSS4G is free of charge under public licensing agreements because the codes for developing specific GIS applications are publicly accessible. In this paper, we present an on-going PGIS collaboration between a farmer group, local government, NGO and academia in addressing the GIS requirements of community-based agroforestry projects in Claveria, Misamis Oriental, The Philippines. FOSS4G tools are applied to facilitate in the selection of appropriate tree species suitable for the area, as guided by the revised land-suitability evaluation method of the Food and Agriculture Organization (2007). Local people are trained to participate during data collection, management and analysis to encourage local appreciation of GIS. The research questions are defined with the participation of the local people to produce maps that are acceptable to the community. As an example, we present an accessibility analysis of marketing agroforestry products using monetary fare costs instead of distance-based measures because we found that the people perceived accessibility in terms of monetary costs. We also present a review of various FOSS4G tools and evaluate their usefulness to agroforestry research and local policy-making. This paper highlights the value of combining PGIS approaches with FOSS4G tools to capture local spatial perceptions and enhance the appreciation of GIS outputs for local policy-making.

From agroforestry parklands to integrated agroforestry landscapes: village land in transition

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

In rural Africa, traditional agroforestry has significantly marked the landscape. The regression of forests or woodlands is a long process of alternative occupations of space in which mostly treed landscapes alternate with more or less clear-felled croplands. This alternation nurtures a well-known traditional landscape, the so-called agroforestry parkland which dominates the village land of most African lands that are close to villages and forest agglomerations. This type of landscape, whose role in the subsistence strategies of people is largely known, is rapidly receding giving way to either badly bared lands with a signature of poverty and lack of management and maintenance, or well-organized alternative and stable land uses in which the farmer decides on and guides the processes of change. Agroforestry, along with improvements in local social organizations, has come of age and is rich enough in species, techniques and systems to be the first system in unmanaged wastelands to replace the traditional tree-cum-crops systems in sub-Saharan Africa and in particular in Sudano-Sahelian Africa. There are a number of approaches and systems that could help build and put in place positive pathways for the modification of rural landscapes.
Agroforestry has been developing tools to that effect. The challenges are: i) maintaining the indigenous biological diversity; ii) developing village land fertility and productivity; iii) combating landlessness and poverty; and iv) sustaining food production and security. These mighty challenges can and will be met, but only if the sciences and techniques of agroforestry are well managed and properly disseminated and transferred to where it matters and to the people who will incorporate them into their main day-to-day subsistence and production activities. This is the final challenge of agroforestry in rapidly moving rural worlds.

### Agroforestry systems, a real alternative for a sustainable development for ‘small farmers’ in Chile.

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

The campesinos (smallholder farmers) in Chile own more than 8 million hectares in rural properties, with an average of 50 hectares per farmer. The main objective of the campesinos is to provide food, care and money to cover their basic needs. They organize their lands for crops, prairies and livestock production, although the land is mainly forest land that is eroded, and only a small area is utilized to generate new forest plantations, which in the last five years have been less than 2 ha per property. This is one of the reasons why reforestation activity did not increase in this kind of smallholder properties, although in Chile there are more than 2 million hectares without forest cover belonging to campesinos which can be afforested – there is even a special law to promote reforestation in small farmers’ properties in Chile. The other reason is that the extension program was trying to use the same reforestation strategy that was used in the past with the forest companies and large farming lands, which are not compatible with small farmers, therefore this strategy did not work. Because of that, the Forest Research Institute (INFOR) with the Institute for Agriculture Development (INDAP) studied an alternative model for reintroducing forests in campesinos’ lands, using trees in a natural way, with an agroforestry arrangement, that allows them to get their basic needs through crops, livestock, and wood for energy and timber, but all on the same land; this was done in a way that is altogether compatible with natural resource conservation, land and water biodiversity, and encouraging campesinos to remain on their farms. This new approach has been well received by these producers, which has enabled new land to be used in agroforestry systems, such as silvopasture, windbreaks, alley cropping and riparian buffers.

### A perspective on the establishment of tropical agroforestry systems in Xishuangbanna, southwest China

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops

**Abstract**

By simulating the multi-layer and multi-species structure of a tropical rain forest, more than 10 new models of agroforestry (constructed plant community) were established in Xishuangbanna, southwest China for the purpose of increasing bioproductivity and improving ecological, economic and social benefits of tropical plantations. Of these, the rubber tea community has widely extended to the tropical areas of Yunnan, Guangxi and Hainan provinces. This model covers more than 13 000 ha and makes significant economic incomes in Hainan Province. These models, however, require adaptive management under the background of drastic global change.
A case study on the evolution of the Kenya Forest Service to accommodate the changing forest landscape.

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Preferred session: D3. Policy formulation and stakeholder engagement in NRM

Abstract
The paper is an attempt to record the changes that the forestry sub-sector in Kenya has undergone since the country’s first forest policy evolved in 1903. It will highlight the major policy shifts the sub-sector has undergone in order to accommodate changing paradigms in the management of forest resources. It is hoped that this paper will offer valuable lessons to policy makers on the global nature of ownership of forest resources and hence the vital need to develop policies that accommodate local, national, regional and international needs. A major shift in resource management styles will be revealed, from a centrally controlled system to a more participatory approach. Other highlights will be on the shift towards a holistic management of forest resources and incorporation of payment for services produced by well-managed forests. The paper also challenges policy makers in developing nations to ponder whether their institutions are poised to take advantage of the Clean Development Mechanism by having in place an appropriate policy framework for effective engagement within the Kyoto Protocol and the post-Kyoto Protocol environment. Lastly, the major objective of this paper is to highlight the need to develop policy options that will ensure the continued vital role of forests in the livelihoods of communities living around them.

Soil carbon, nitrogen and organic phosphorus contents under cacao agroforestry systems in Bahia, Brazil

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Preferred session: C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract
In Brazil, cacao (Theobroma cacao) agroforestry systems are adopted and promoted mostly in highly weathered soils with acidic pH and low fertility. Therefore, it is important to optimize nutrient cycling in these systems to maintain sustainable production. The objectives of this study were to determine the soil carbon (C) content; soil microbial biomass C, nitrogen (N), and phosphorus (P) content; extent of soil C and N mineralization; and total and labile (fast mineralization) soil organic P in different cacao agroforestry systems in southern Bahia, Brazil. Three systems were selected: cacao under Erythrina glauca, cacao under natural forest (‘Cabruca’), and a cacao germplasm collection area, all in reddish yellow Oxisols or Inceptisols. Soil samples were collected from 4 depth classes (0–5, 5–15, 1–30, and 30–50 cm) for soil C and organic P analysis. Microbial attributes were measured on only the 0–10 cm depth. Mean soil C ranged from 74 to 99 Mg ha-1, microbial C from 174 to 357 kg ha-1, microbial N from 117 to 212 kg ha-1, and microbial P from 3 to 9 kg ha-1. The amount of soil C mineralized ranged from 22 to 61 kg ha-1 and that of N from 60 to 81 kg ha-1. Total organic P content ranged from 68 to 1,446 kg ha-1 and labile organic P from 33 to 62 kg ha-1. This study shows that cacao agroforestry systems store relatively high amounts of C in the soil and consequently have a potential to increase the soil quality and reduce atmospheric CO2. The high amounts of soil microbial biomass and organic P could be relevant for cacao nutrition considering the low amount of N (24 kg ha-1) and P (5 kg ha-1) exported through cacao seed harvest.
Shaded perennial agroforestry systems contain relatively high quantities of soil carbon (C) because of continuous deposition of plant residues; however, the amount of C sequestered in the soil will vary depending on the turnover time and the extent of physical protection of different soil organic matter fractions. The objective of this study was to characterize soil organic C pools in relation to different soil aggregate-size classes in different soil layers up to 1 m depth in cacao (Theobroma cacao) agroforestry systems (AFS) in Bahia, Brazil. Soil samples were collected from 4 depth classes (0–10, 10–30, 30–60, and 60–100 cm) under 3 land-use systems in reddish-yellow Oxisol: 1) 30-year-old stands of cacao with *Erythrina spp.* (*Erythrina poeppigiana*) as shade trees; 2) cacao under natural forest (Cabruca); and 3) an adjacent natural forest. The soil sample from each layer was separated by wet sieving into 3 aggregate-size classes (>250 µm, 250–53 µm, and <53 µm). Cacao AFS have exceptionally high C sequestration potential. The organic C stock in the 0–100 cm soil layer did not vary among different systems (mean: 302 Mg ha⁻¹); however, in the 0–30 cm layer, the order was: Cabruca > cacao with *Erythrina spp.* > natural forest (154, 118, and 84 Mg ha⁻¹, respectively). The C concentration was higher in the silt-and-clay fraction, followed by the micro-size (53 253 µm) and macro-size fractions (250 2000 µm), but the relative proportion of the 3 size classes was such that the C which accumulated in the macro-sized, micro-sized and silt-and-clay-sized fractions were about 93, 24, and 9% of soil C, respectively. Sixty percent of the total soil C in cacao AFS are located inside the aggregates that represent physically protected C.
L’association des cultures vivrières ou de rente avec l’anacardier (agroforesterie à base de l’anacardier) fait partie de plus en plus des pratiques culturales des producteurs du Centre du Bénin. Il est donc important d’examiner les incidences de cette nouvelle forme d’utilisation des espaces agricoles dans la dynamique de l’occupation du sol dans un contexte où la dégradation inquiétante des écosystèmes naturels du fait principalement des activités agricoles fait l’objet des débats à toutes les échelles nationales et internationales. Les données utilisées sont obtenues par la documentation et les investigations de terrain auprès des différents acteurs (producteurs, agents du développement rural, etc.). L’utilisation de la statistique descriptive et des outils cartographiques a aidé à traiter les données et informations collectées et d’analyser les résultats obtenus. La recherche montre que la pratique agroforestière basée sur l’anacardier a permis de reboiser les jachères agricoles et contribue à freiner l’itinérance des producteurs à la recherche de nouvelles terres agricoles. Cette nouvelle pratique permet ainsi une gestion plus durable des espaces agricoles. Elle mérite d’être encouragée car elle semble constituée un système beaucoup plus durable susceptible de constituer une alternative à la technique de culture itinérante traditionnellement pratiquée. Mots clés : Centre du Bénin ; agroforesterie à base d’anacardier ; espaces agricoles ; gestion durable.

Wheat-based agroforestry systems under rainfed ecosystem

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Prefereed session C3. Agroforestry, water quality and envirnomental amelioration

Abstract These experiments were conducted during winter at the university farm. A wheat crop was intercropped with poplar (6 8 year old) at 5x3 m spacing in randomized block design with 3 replications and later modified to split-plot design with 50,100 and 150% of the recommended dose of nitrogen with and without poplar leaf mulch. The results revealed that 150% of the recommended dose of nitrogen and without poplar leaf mulch gave the highest grain yield during the 2nd year. The highest grain yield was recorded under poplar with sowing on 15 November plus150% of the recommended dose of nitrogen without poplar leaf mulch. As the date of sowing advanced, the wheat yield (grain and straw) tended to decline. The same trend was also observed in open areas as compared with under poplar trees. The wheat yield in general was high where no mulch was applied.

Cacao cabrucha agroforestry systems: case studies in Bahia, Brazil.

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Preferred session E3. Cabrucha agroforestry system of Bahia, Brazil: economics, environment, and social services

Abstract In many agricultural zones of the world, scientific evaluations of cacao cabrucha agroforestry systems have been insufficient, however, in South Bahia, the main Brazilian region of cacao production, research data consolidates the benefits of this agricultural system. Studies in Bahia have shown: 1) high soil aggregation and soil loss under cacao cabrucha, confirming its efficiency in controlling erosive agents the value of the erodability was 1,15 x 10-6 kg s-1 m-4; 2) soil quality indicators are higher for the cabrucha system in relation to cassava; 3) species richness of forest areas is 65 species/0.25 ha, whereas areas under cacao cabrucha there are 20 species/0.25 ha – there is no significant difference in litter fall (forest: 1.02 ± 0.32 Mg/ha; cacao cabrucha: 0.92 ± 0.32 Mg/ha) and soils under both systems show equivalent amounts of nutrients; 4) the substitution of the forest for the cacao cabrucha system (sub-forest) did not alter the total soil organic carbon and its fractions; 5) agroforestry gardens with cacao show from 68 to 97 different species used as source of income and food staples for the rural family; 6) the homegardens have better...
physical, chemical and biological soil properties than the monocropping system; 7) the change from cacao cultivations to husbandry/pasture, has increased the inappropriate land use in South Bahia, including recommended areas for permanent preservation. Most results indicate that cacao cabrura as an agroforestry system, which closely resembles natural forestry, is becoming a strategy of vital importance for the maintenance of natural resources.

Key words: soil quality, soil conservation, home garden, species richness, organic carbon, protected area.

Coastal afforestation for climate-resilient development: a case study on Bangladesh

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Preferred session C4. Mitigation and adaptation to climate change

Abstract

This paper attempts to capture a sustainable approach to climate change adaptation through coastal afforestation through participatory governance in order to enhance the resilience of vulnerable populations, settlements, and ecosystems in areas exposed to coastal hazards including sea-level rise. This paper is also aimed at introducing a number of risk-reduction strategies such as: (i) land reclamation, stabilization and optimum utilization through coastal afforestation; (ii) community-based forest either co-managed or joint management; (iii) mangrove or wetland restoration; and (iv) innovative ways of securing potable water for vulnerable coastal communities. This paper also suggests 3 layers of green defence along the coastline to reduce coastal risks including sea-level rise, coastal erosion and salinity intrusion. This coastal green defence may compose of a first layer of sediment-trapping mangrove species in the tidal zone, followed by a second layer of tall trees to serve the purpose of wind and wave breaks, and a third layer consists of agro/social forestry including horticulture or orchards. In order to ensure the sustainability of such an initiative, it is felt necessary to engage all stakeholders concerned in building adaptive capacity by enhancing institutional mechanisms to support adaptation in coastal communities and sensitization of policy makers in understanding coastal policies that incorporate agroforestry, watershed management, biodiversity conservation and climate change risks, and developing channels for improved cross-sectoral collaboration on climate change risk management. This paper will capture the following anticipated outputs that will result from implementing climate change risk reduction measures: (i) afforestation and watershed management as a means to reduce climate change risk and achieve sustainable land management are found to be effective if participatory governance is established; (ii) implementation of climate risk-management measures to additional regions vulnerable to climate change, including variability; and (iii) promotion of alternative climate-resilient livelihood opportunities for coastal communities.

Agroforestry practices in Malaysia: integrating plantation crops with timber species

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Preferred session E4. Socioeconomics and agroforestry in the Pacific

Abstract

This research has been conducted to gather information about the integration of plantation crops such as oil palm (Elaeis guineensis) and rubber (Hevea brasiliensis) with timber species such as sentang (Azadirachta excelsa) and teak (Tectona grandis). The study involves government and private agencies and farmers practising this type of agroforestry activity. In plantation crops, the main reason for integration with timber is for long-term and additional income for the farm operators. It has been found that the most common type of integration involves rubber and sentang implemented by smallholder farmers to supplement the low income generated by rubber. Integration was also taken up during replanting of the main crops to supplement the loss of income during non-productive periods. The research has shown that most respondents applied the normal agricultural management practices, as in mono-cropping, but have not experienced any adverse
effects in relation to plant growth and yield (both the crop trees and the timber species). This indicates that integration of timber and crop trees is a viable approach to improve farm income. However the respondents did indicate the need for more technical advice from relevant agencies to improve the implementation of their integration programmes and acquire better outcomes in terms of yields and income.

If trees could talk with policy makers, what would they say?

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

This paper documents successful negotiations and agreements of projects that promote sustainable management of natural resources, such as in the case of forests which are directly managed by communities. In the literature there has been very little detailed documentation on means and protocols or methods of successful negotiations and agreements in Southeast Asian communities to promote sustainable management of forests. The innovation described here is that the authors present a matrix of elements and factors gleaned from all the cases reviewed. This negotiation/agreement matrix shows qualitative descriptions of the elements/factors that can help serve as a guide to various stakeholders who enter into the negotiation process. Among the elements is a description of: 1) negotiation as a legitimate process itself; 2) The presence and characteristics of highly skilled mediators and other actors that directly facilitate or strengthen linkages or networks; 3) capacity building (what capacities to put in place); and 4) giving attention to before and after agreements and arising conflicts with respect to customary and state authorities; and many other things.

Relationship between deforestation and malaria epidemics: is forest conservation critical to human health?

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**Preferred session** B6. Agroforestry as a tool for landscape restoration

**Abstract**

Deforestation erodes human well-being and economies. It causes loss of biodiversity, decreases agricultural productivity, amplifies flood risk and severity, and contributes to climate change. Furthermore, recent scientific studies indicated that there is a link between deforestation and malaria epidemics. This study found that malaria epidemics were correlated with deforestation by demonstrating that the risk of being bitten by the primary malaria-inducing mosquito was nearly 300 times higher in cleared areas than in undisturbed forest sites. The major factor for the substantial increase in the mosquito-biting rate was attributed to deforestation followed by agricultural cultivation and replacement of the forest by shrublands. Another study showed that forest clearing around settlements increases the risk of malaria by creating areas of standing water in which mosquitoes lay their eggs. In this paper, how environmental modifications such as deforestation and climatic changes affect malaria transmissions have been elaborated. Additionally, the perception of farmers on the relationship between deforestation and malaria epidemics in Ada’a and Liban Woredas, Ethiopia, is discussed based on the data collected from November to December, 2007. It was concluded that conservation in general and agroforestry practices in particular are critical to human health and environmental sustainability. Therefore, conservation of forests’ genetic resources is an important tool in disease prevention strategies. Raising awareness of officials at different levels and local communities on the link between deforestation and malaria epidemics as well as the need to integrate conservation and health policies is highly recommended by this work.

Key words: biodiversity conservation, deforestation, malaria, perception.
Rehabilitation of traditional grazing resources in Rajasthan: the vital sign of pastoral economy in arid zone of India

Abstract
Grasses suited for desert ecosystems have been supporting livestock populations for decades and sustaining the pastoral economy in the arid region of Rajasthan. However, the increase in density of the livestock population from 13.4 per sq km in 1956 to 27.91 per sq km in 2001 coupled with the manifold increase in the human population has caused a reduction in grazing lands; pasture change from 8.89 million ha in 1956 to 6.84 million ha in 2001, and fallow land from 10.2 million ha in 1972 to 5.76 million ha in 2001, has increased by many times the grazing pressure on grazing resources. The area under traditional grazing resources – gauchar, oran, beeds, bada beeds, jods, adaw, bhelwars or choili etc – has declined. Due to overgrazing most grazing resources such as these are in a degraded form with poor productivity. Traditional practices for management of grazing resources of by the community at village level with the system of kar and/or go-had (grazing boundaries) have also disappeared. The continuous decrease in grazing resources and increase in livestock population coupled with changing cropping patterns has led to conflicts between pastoralists and herders, and between herders and farmers. The alarming situation warrants and investigation into the opportunities (protection, reseeding, scientific grazing which allows resting period to pasture, integrating silvi-pasture systems etc.) and the issues (free grazing, herd size linked with equity on community grazing land, pastoral migration etc.) for conservation and rehabilitation of pastures and other grazing resources in arid regions. Sensitization of people and capacity building at village level to ensure people’s participation, development of a grazing calendar, establishment of fodder banks, and formulation of a grazing policy both at state and national levels, would augment forage productivity of these shrinking grazing resources and encourage their better management on a sustainable basis.

Key words: grazing lands, thar desert, orans, gau-char and go-had

Characterization of agroforestry interventions and their suitability for climate change adaptation and mitigation in semi-arid areas of northwest Tanzania

Abstract
Despite the role of agroforestry on rehabilitation of degraded lands little is known about the contribution of agroforestry-based interventions on carbon offsets in many arid and semi-arid regions of the world including Tanzania. In line with recent efforts aimed at the development of a programme for climate change mitigation through reduced emissions from deforestation and degradation (REDD), a study was conducted in Shinyanga region in northwest Tanzania to assess the potential of agroforestry interventions and natural woodland conservation for carbon sequestration and emissions reduction. The study characterized various agroforestry interventions to determine: 1) species composition and stocking density; 2) litter and herbage biomass production; and (3) an estimate of carbon in all above and below-ground pools. Rotational woodlots, fodder banks, natural regeneration in situ conservation, or ‘Ngitili’, boundary tree planting and homestead planting were identified as potential agroforestry technologies for carbon capture. Promising fast-growing species in woodlots were Acacia spp., Azadirachta indica, Cedrella odorata, Gmelina arborea, Melia azedarach, Samanea saman, Senna siamea. Gliricidia sepium, Leucaena leucocephala, L. pallida and L. diversifolia, and Acacia spp. were suitable species in fodder banks and agro-silvopastoral systems. Stocking density was variable among species and interventions. Herbage biomass...
production varied (P<0.05) from 1.64, 1.95, 2.88 and 3.17 mega gram (Mg) dry matter (DM)/ha for boundary tree planting, fodder banks, Ngitili and alley cropping, respectively. Alleys produced (P<0.05) lower litter biomass (1.45 Mg DM/ha) than Ngitili, fodder banks and boundary planting (1.87, 2.57 and 3.26 Mg/ha, respectively). There was no difference (P>0.05) among interventions in both total biomass (4.24 4.70 Mg DM/ha), and estimated organic carbon (2.12 2.37 Mg C DM/ha). These agroforestry interventions represent important carbon sinks and means of mitigating climate change. Incentives for farmers through carbon trading would promote scaling up of these interventions leading to increased conservation of natural resources and poverty reduction among the communities in Shinyanga.

Nutritive potential of selected Atriplex species and other potential shrub fodder species of dry lands of the Central and West Asia, and North Africa (CWANA) region

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Preferred session B2. AF for salinity control and land rehabilitation in Central Asia

Abstract Shrub and tree fodder species represent a potential option for rangeland rehabilitation and environmental conservation in many drylands although little is known about their nutritive value in different ecotypes. A study was carried out to assess nutritive potential in terms of chemical composition and digestibility of 15 shrub-fodder species germplasm comprising Atriplex spp. (A. canescens, A. halimus, A. lentiformis, A. nummularia, A. polycarpa, A. torreyii), Artemisia herba-alba, Ceratoides papossa, Haloxylon aphyllum, Kochia prostrata and Salsola vermiculata (experiment one). A second experiment was carried out to investigate variability in chemical composition and digestibility of three botanical fractions (leafy foliage; pods, fruits and seeds; and edible stalks and stem) of Atriplex spp. (A. canescens, A. halimus), Haloxylon aphyllum and Salsola vermiculata established in steppe rangelands of Aleppo Province, Northern Syria.

In both experiments, comparisons between species were made on the basis of chemical composition, crude protein, neutral detergent fibre, acid detergent fibre, in vitro dry matter digestibility (DMD) and digestible organic matter digestibility (DOMD). Digestibility of these shrubs could be ranked in declining order of A. nummularia > A. lentiformis > A. canescens > A. halimus > H. aphyllum > K. prostrata > C. papossa > A. torreyi > A. polycarpa > A. herba-alba > S. vermiculata. Differences in nutritive values of these shrub species could be ascribed to differences among species, provenances and botanical fractions in accumulation of nutrients, and extent of fibre lignification. All the species had high levels of CP > 100 g/kg DM which have potential as protein supplements to ruminants fed on low-quality roughages that often have less than the 80 g CP/kg DM feed needed for efficient rumen microbial function. Adaptability of some species, e.g., A. nummularia could be limited to its high susceptibility to cold stress. Establishment of A. canescens, A. halimus and S. vermiculata forage plantations in Syria would be further supported by their high biomass productivity, their high adaptability and resilience to cold environments.

The role of eucalyptus in agroforestry systems

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Preferred session A6. Ecophysiological bases of agroforestry system design

Abstract The role of eucalyptus in agroforestry systems, mainly in Africa, will be discussed in view of fuelwood production, competition with crops, and water use. Productivity and biomass accumulation will be compared using data from different regions; competition with crops will be evaluated based on field experiments and published data; and the consequences of different spatial arrangements of trees will be discussed (line versus. block plantings).
Climate change adaptation and mitigation: women are part of the solution

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract: All human beings are directly or indirectly affected by climate change. The impacts of climate change, however, vary from one place to another. In Ghana, about a hundred years ago, the natural forest covered about 1/3 of the surface area. The forest provided formal and informal employment. Now, only 20% is not damaged. The coastal areas had mangrove which created a conducive environment for fish to lay eggs and care for the fingerlings before they are escorted into the sea to grow during certain periods of the year. Human activities over the years have resulted in decline of the natural resources (forest) and water bodies. The depletion of the forest has contributed to the change in the climate. For the past few years, farmers have realized that the change in climate has affected the production of their crop. In Ghana they experience too much rain or too much sunshine. Rural women, who form the majority of the farming population, are part of the solution in as much as they contribute to counteracting some of the effects of climate change through indigenous or new-adaptation techniques such as sustainable agricultural practices and mitigation strategies including, tree planting and the sustainable management of forests. Rural women are thereby helping to make this world a more liveable place. Rural women were educated and realized the need to plant trees to support and revive the climate. World Rural Women’s Day, October 15 2008, had the climate change theme “Rural Women are part of the solution”. Women and families in Ghana planted 1000 trees including fruit trees on that day in order that they could sit under the trees and eat the fruits, and so that the trees would support improvements in the climate.

Oran: a traditional system of community action for tree-based rehabilitation of wastelands

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Preferred session: B9. Collective action for tree-based rehabilitation of degraded lands

Abstract: Village commons and community forests, grazing and uncultivatable lands are referred to as “wastelands” in revenue categories in India, particularly in Rajasthan. Of the various types of community lands, perhaps the most significant are the community forests known locally as Orans. There are local differences in institutional arrangements for Orans and, of course, differences in biodiversity composition, however they display a common feature: they are all community oriented in their use and management. Given this wide distribution and shared orientation it is important that we recognize and build on the strengths, taking into account the need for adapting to changing contemporary contexts. Three stages can be seen in the evolution of Orans and community contexts over the last half century or so. In the earliest stage the relationship between the Oran and the community seems to have been a mutually-supportive and beneficial one. With the disintegration of local communities and institutions we enter the second phase. The modern institutions that have supplanted them, have displayed little interest in the management of Orans. This is also manifested clearly in the weakening of informal village institutions that held the community together. The stage is now set for the evolution of phase three, in which it is clear that conserving the resources of the Orans from the biodiversity point of view is crucial, whilst it is also evident that modern institutions need to include ecological issues in their portfolio of priorities, which they are lacking at the present. On the basis of KRAPAVIS’s experiences over 16 years of working with communities for the betterment of Orans, it is clear that: 1) Orans contribute to the conservation of biodiversity in situ, whilst also evolving in response to contemporary needs; 2) Orans contribute to the livelihoods of local communities; and 3) institutions must be developed that are workable in today’s conditions.
Fruits and seed production of brazil nut (*Bertholletia excelsa*) in an agroforestry system in Confiança region, Roraima State, Brazil

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract

The agriculture activity of monocultures in the Amazon region has always been characterized by incompatible practices. There is not much knowledge about the Amazon species in intercropping or in agroforestry systems. The brazil nut is one of the main components of agroforestry systems (AFS) localized in the northern region of Brazil. The silvicultural behaviour of the species results in the brazil nut being considered as one of the most promising species for restored areas in either agroforestry systems or homogeneous stands. This study aimed to show production data of fruits and seeds of the brazil nut in AFS installed in forest areas since 1995 at the Experimental Station Confiança, Cantá, Roraima State, Brazil with coordinates (02º15’00” N; 60º39’54”E) on the property of Embrapa Roraima, located 90 km from the city, Boa Vista. The climate of the region is classified as Ami (Köppen) and has monsoonal influence. The mean temperature during the year stays around 26 29 ºC. The dominant soil in the region is classified as red-yellow distrofic argisol with low fertility levels. The system contains timber trees components such as Carapa guianensis, Goupia glabra and Pithecellobium saman and fruit trees components such as Theobroma grandiflorum, Bactris gasipaes and Coffea canephora. The space between rows and trees is 2 m x 3 m, totalling 1840 trees/ha. The results recorded during 2007 were on 68 measured trees, of which 40 (60%) were productive, the number fruits produced ranged from 1 to 53 (mean 9.9); number of seeds from 15 to 1016 (mean 154), and the seed weight changed between 155 g and 9 kg (mean 142 kg). The relation of seed weight to seed fruit was on average 0.151. The tree with the best development produced 53 fruits and 9 kg of seeds. These data fallow course to the maturity of brazil nut.

Sacred sites in the landscapes of the Lake Victoria region: community domestication for conservation and development

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Preferred session: B6. Agroforestry as a tool for landscape restoration

Abstract

Sacred sites are found in virtually every community in the landscapes of the Lake Victoria region of East Africa. They were in the past places reserved for worship of the gods and places of sacrifice whenever a community faced difficult times. These included for example delaying rains or famine. Owing to these sacrifices and taboos the sites acquired a somewhat eerie presence in the landscape and have therefore been relatively better conserved. They are a repository of community cultural artefacts replete with associated folklore. Equally important is the rich biodiversity conserved in these habitats including indigenous fruits and herbal medicinal plant resources that were part of indigenous cuisine and heath-care systems. These resources are faced with the imminent threat of extinction and yet they constitute community priority species for conservation. These resources can be conserved through domestication and integration into farming systems. Prerequisites for such intervention include development of simple propagation methods for community nursery adoption. The indigenous fruits can be marketed as part a new ecotourism package with cultural artifacts, folklore and traditional performing art in a uniquely exciting ecotourism package.

Key words: sacred sites, biodiversity conservation community priority species for conservation, domestication of indigenous fruits and herbs, cultural artifacts, folklore, indigenous cuisines, ecotourism

Agroforestry potential in the Nile River Basin, Ethiopia: a challenge to counterbalance farm land fragmentation
Abortifacient activity of mahogany seed oil

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Preferred session E1. Hot or cold: the role of underutilised crops for AF

Abstract Swietenia mahogani Jacquin (Mahogany) was previously reported to exhibit abortifacient activity. Due to lack of scientific information regarding the abortifacient activity of mahogany seed oil, there are pregnant women who still use mahogany seed for the treatment of illnesses such as hypertension, cancer, amebiasis, chest pains and intestinal parasitism. This study was focused on the determination of the abortifacient activity of fixed oil of mahogany seed and identification of the constituents present which may stimulate this activity. The fixed oil was extracted by boiling and characterized in terms of the percentage oil yield, colour, odour, taste, specific gravity, boiling point, Reichert Meissl value, Polenske value and Kirshner value. The chemical constituents of the oil were analysed by using GC, TLC and HPLC. Pregnancy of albino rats was determined by the veterinarian. The extracted oil was administered through the gavage method based on 1ml/100g body weight. The percentage yield of oil extracted from the air-dried seed of mahogany was 12.36%. The mahogany seed oil had a characteristic dark yellow colour and bitter taste; the specific gravity at 25°C, was 0.9692; boiling point wasaf 134 189°C; Reichert Meissl value, 4.4; Polenske value, 0.24; and Kirshner value, 10.852. The mahogany seed oil contains twenty six components as read in the chromatogram of GC. alkaloids; linoleic acid and oleic acid were found to be present in the oil using TLC and HPLC. These substances are known to be abortive. The fixed oil of mahogany seed has an abortifacient activity in the 2nd week of pregnancy of albino rats. Eight out of 10 pregnant rats exhibited bleeding in less than 1 day after the administration of the mahogany seed oil, while, with misoprostol, 9/10 rats bled in more than 1 day. The mahogany seed oil is more effective than misoprostol in terms of abortifacient activity.
The use of multi-functional woody species for gully restoration in Tigray, northern Ethiopia

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Preferred session: B9. Collective action for tree-based rehabilitation of degraded lands

Abstract: In the highlands of northern Ethiopia, land degradation and associated gully erosion are significant. Moreover, the irreversible loss of soil and biodiversity has serious ecological consequences, and constitutes a severe threat for sustainable agriculture and forestry. In that context, the use of multifunctional species for integrated land restoration is highly promising. Although the protective role of vegetation has been demonstrated in many studies, efforts previously made in using woody species for erosion control in the research area are very limited, and when applied, survival of the planted seedlings is very low. Lack of experience concerning species suitability and establishment techniques are two important bottlenecks. Therefore, the objectives of this research were to collect more relevant ecological information on woody species selected for gully stabilization, to study the factors determining their successful plant establishment, and to evaluate their effect on further gullying and environmental conditions. To enable this, a field trial was set up for seedlings of 6 different woody species (Acacia etbaica, Sesbania sesban, Dodonaea angustifolia, Psidium guajave, Cordia africana and Faidherbia albida). The experiment was established at two sites with different soils (vertisol and sand colluviums). At each site, seedlings were subjected to different treatments of watering, sheltering and gully position. Plant establishment and growth were evaluated as a function of growth conditions and management. Land use, detailed topography, gully characteristics, runoff discharge, changes in sediment deposition characteristics in the gully, and several climatic as well as soil characteristics were also evaluated.

Achieving sustainable development depends on project excellence

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Preferred session: D2. Integrating disciplines through agroforestry education

Abstract: Millions of people depend on the wise public investment of billions of dollars allocated annually. Tragically, too many of these projects fail to achieve their worthy objectives. The world is growing tired of these costly failures, and there is now a growing reluctance to invest in development. The response to this dilemma is simple: we do not need fewer projects for improved development; we need to create successful projects that meet their worthy goals! I draw upon my 40 years of project experiences that include service in the military, environmental consulting, the commercial timber industry and many positions in the higher education setting. These projects have taken me throughout the world. I know that successful project management requires a unique combination of leadership and management skills, and that these can be acquired skills. Managers are often entrusted to allocate precious human and financial resources with little formal preparation in project management. They are immersed in a sink-or-swim environment and most of them sink. An alternative approach is to provide project management practitioners with proper mentoring and efficacious tools that can give them the confidence they need to engage in a comprehensive project plan. This presentation will cover the following 3 key areas of successful project management: priority setting, people leadership, and process management. Drawing on research and applied experiences, the author will demonstrate how a working knowledge of these 3 areas; combined with enhanced leadership and management skills, can deliver a successful project that is on time and on budget, and that meets the sponsor’s expectations. An investment in people’s education is always a wise investment. The return on investment for successful development projects is healthy people living in a healthy environment. We cannot afford to fail in such a worthy endeavour!
Promoting carbon sequestration through participatory land-use planning by poor resource farmers in arid communal areas of Zimbabwe

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Preferred session C2. Carbon sequestration in agroforestry

Abstract Participatory extension approaches are needed to promote the adoption of key farming programmes and systems that enhance carbon sequestration and increased yields in arid communal areas of Zimbabwe. Participatory rural appraisal meetings and field assessments were employed to gather data on resource potential and key agricultural processes affecting soil carbon dynamics in Tagwira village, Mwenezi District. Results indicated that 14% of farmers in the village practice reduced-tillage farming, while (88%) practice residue mulching in their gardens. Only 4.7% use cover crops in arable lands, while 24% have poorly maintained woodlots. Grazing land is adequate to meet the current livestock. No energy crops are grown in the village but almost 88% of the farmers practice crop rotation. Maps and action plans were produced indicating community plans for improved food security. Incidentally, all the action plans also contribute to carbon sequestration. It was proposed that there should be sustainable utilization of existing resources to promote carbon storage in the soil. The study recommended the documentation and promotion of technologies that would result in both carbon sequestration and increased yield as the later will reduce greenhouse gas emissions. This is the initial survey on carbon sequestration through proper land management. Financial support is required to analyse the amount of carbon in the soil together with yields obtained under each land-management technique to enable farmers to appreciate the derived benefits. This will enable easier adoption of the technologies by other farmers.

Incidence of mistletoe (Loranthus spp.) and tree dryness on rubber trees: implications for rubber-based agroforestry systems

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract The incidence of mistletoe and tree dryness in rubber trees (Hevea brasiliensis) were evaluated in 5 clones planted in the Cameroon Development Cooperation industrial estate of Sonne. Mistletoe bushes were inspected from tree to tree for representative features of each clone and the infestation was calculated by considering the infested trees as a percentage of the total number of trees inspected. A clonal variation in susceptibility to mistletoe infestation was observed and it ranged from 50.81%. Based on the clones studied, clone PB 217 had the highest incidence of tree dryness (10%) while the least was observed for the RRIM 706 clone (2%). Incidence of tree dryness was calculated by calculating the number of trees whose tapping panels were dry and not being tapped as a percentage of the total number of trees inspected. A significant clonal variation in girth of trees was observed between mistletoe-infested and uninfested trees. The effect of mistletoe infestation on girth varied significantly amongst clones. There was no direct relationship between incidence of mistletoe infestation and the development of tree dryness. Considering the two factors incidence of mistletoe and tree dryness some clones were not suitable for rubber-based agroforestry systems as land productivity may be very low. The results of this study could be used for the breeding of clones that are resistant to mistletoe attack and tree dryness.
Local ecological knowledge as key to managing the trade-off between biodiversity and livelihoods in Fouta Djallon, Guinea

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Preferred session: D4. Incorporating local knowledge in agroforestry science

Abstract

The trade-off between local livelihoods and biodiversity conservation has few win-win solutions. Over centuries, communities living in the Fouta Djallon watershed have maintained biodiversity-friendly indigenous practices in a landscape that is a global biodiversity hotspot and the source of major rivers of West Africa. Current pressures include loss of forest and tree cover, unsustainable forms of agriculture and vulnerability to climate change. We documented and analysed the local ecological knowledge of communities of Foulai ethnic background in Guinea in relation to biodiversity conservation and agroforestry development. Five local practices were identified with potential for reducing the livelihood biodiversity trade-off: wood fencing, traditional mixed-tree gardens (agroforests), shifting cultivation, crop fallow rotation, and community-led watershed protection. Agroforestry options were tested with the farmer’s initiative and vision-based approach (FIVA) combined with collective action. In the pilot area of 60 000 ha, a start was made with: 279 ha of improved agroforests through natural and assisted regeneration; 30 ha of enriched community forests; and improved live fencing and crop-fallow rotation with improved manure pits. During this study, local informants reported that key wildlife populations showed signs of recovery and half of the households surveyed reported increased income indicating livelihood improvement. A combination of collective action in planting ‘framework’ trees and assisted natural regeneration was aligned with local knowledge of and preferences for tree diversity. Supporting smallholder agroforests emerged as strategy for enhancing ecological services, but may require additional incentives to offset opportunity costs for foregone intensification.

The role of non-timber forest products in the development of forested landscapes: evidence from southwest Ethiopia

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Preferred session: D1. Forest farming of non-timber forest products in N America

Abstract

Millions of people throughout the tropics make extensive use of non-timber forest products (NTFP). These products have received much policy and research attention for their perceived potential to contribute to sustainable rural development and tropical forest conservation. NTFP production makes up part of multi-enterprise household activities and is carried out in a variety of forest and/or agroforestry production systems. This paper investigated the role of NTFP in the household livelihoods of rural communities and the evolution of a forested landscape in the highlands of southwest Ethiopia. The following questions are addressed: a) what is the contribution of NTFP to household incomes, and b) what (agro) forestry management practices are undertaken in order to maintain and increase NTFP income? The study is based on survey data from a sample of 150 households engaged in crop farming and production of NTFP in southwest Ethiopia. The local people are engaged in multiple household activities including annual and perennial crop production, collection of forest products and off-farm employment. Fifteen main NTFP were collected, of which forest coffee, spices, honey, and bamboo are the most important ones. Most of these NTFP are only used locally, but some play an important role for income generation. This income represents 50% of the total income portfolio of rural households. The most important NTFP in the study area is forest coffee. Due to its high value, the households not only collect coffee from the natural forests but also actively manage the forests and forest gardens. Honey production involves a combination of extraction from natural forests to improved production techniques in agroforestry systems. The study demonstrates the process of gradual incorporation of highly valued NTFP in agroforestry systems and the co-existence of different forest production systems in forested landscapes.

Keywords: Ethiopia, household livelihood, non-timber forest product, forest income, forest production systems
Assessing the suitability for cacao in Bahia State (Brazil) by combining a farming systems approach with the agro-ecological zone

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Preferred session: A6. Ecophysiological bases of agroforestry-system design

Abstract

In the Brazilian State of Bahia, cacao (Theobroma cacao) is mainly grown under agroforestry farming systems. A farming system is defined as a group of farms having similar land resource, farming technologies and objectives, household characteristics and constraints. A major problem that is common across cacao agroforestry farming systems in Bahia is low cacao productivity. This study aimed to investigate the main environmental and management factors that constrain cacao productivity in Bahia and to produce a spatial assessment of potential productivity for this State. Initially, the main cacao agroforestry farming systems in Bahia were characterized as (i) agribusiness farms, (ii) family farms, (iii) land-reform settlement farms and (iv) traditional farms. The second step was to identify key factors that influence cacao productivity in these farming systems. The main factors determining yield included the shading level, population density, cacao genotype and disease control efficacy as well as soil quality. Quantitative relationships accounting for these factors were incorporated in the parameterization of an Agro-Ecological Zones model for Bahia State. The model was then used to produce a 30 arc-second resolution mapping of attainable cacao yields and suitability for the State of Bahia. Estimated potential yields ranged from 400–2100 kg/ha for traditional cacao varieties to 700–3000 kg/ha for a hybrid cacao variety. Potential yields depended on radiation, temperature and water availability. Currently, yields achieved range from less than 50 kg/ha on marginal land to 1750 kg/ha per year on the most suitable and intensively managed land. Results obtained can help to design improved research and extension interventions aimed at increasing regional cacao productivity levels by promoting management practices tailored to the specific farming system and region considered.

Agroforestry, land connectivity and biodiversity conservation: butterfly dispersal in fragmented agricultural landscapes in the Pontal region, Brazil

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

Agroforestry systems are thought to act as ecological ‘stepping stones’ and increase landscape connectivity in fragmented agricultural areas. By using the dispersal behaviour of butterflies as an indicator of habitat permeability, this study evaluated the effectiveness of agroforestry in providing land connectivity for biodiversity conservation. Baited Van-Someren Rydon traps were set up 150 m apart from each other creating a grid that captured and recaptured travelling butterflies in the fragmented agricultural landscape in the Pontal do Paranapanema region, located at 22°32’17.88” S and 52°22’34.18” W in São Paulo state, Brazil. Forest-caught butterflies were marked and released at different points of two grid areas, which were 2.1 and 2.4 km² respectively. Preliminary results show a higher number of individuals and species diversity of butterflies in agroforestry systems such as shaded coffee plots and homegardens, compared to cattle pastures and monoculture plots of sugarcane and cassava. The forest specialist butterfly species that can be found in agroforestry systems include Hamadryas februa, Hamadryas epinome, and Memphys trypha. In addition, butterfly dispersal trajectories in the Pontal region make use of agroforestry systems as transitional habitats to reach nearby forest fragments, second only to direct flights from one forest fragment to another. In conclusion, this study confirms the value of agroforestry systems as an environmentally friendly practice that can act as ecological stepping stones assisting travelling butterflies and help improve landscape connectivity for biodiversity conservation in fragmented agricultural areas.
Adaptation strategies to climate change and variability impacts

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Preferred session C4. Mitigation and adaptation to climate change

Abstract The climate change, which is popularly termed an inconvenient truth, is not only an environmental challenge but also a development problem all over the globe. Due to the inadequate capacity and strategies for preparedness, mitigation and adaptation in Africa, it is therefore imperative to increase awareness campaigning on climate change. This will largely help the vulnerable communities in the country to understand the impacts and possibly the mitigation and local adaptation strategies that will reduce impacts of climate change to the bearest minimum.

Development of sustainable land-use systems on degraded tropical land for biofuel production in Belize, Central America

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Preferred session B7. The role of degraded lands in biofuel production in SE Asia

Abstract Development of sustainable land-use systems on degraded tropical land, using *Jatropha* for biofuel production in Belize, Central America, is an interdisciplinary research and capacity development project conducted by a group of local and international partners and institutions with leading expertise in the fields of *Jatropha* cultivation and processing, life cycle assessment, natural resources management and community participation. *Jatropha curcas* was chosen because of its high potential in marginal land and possibilities for livelihood improvement.

Climate change and its impact on agriculture in Kenya: capturing the potential of agroforestry systems

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Preferred Session C4. Mitigation and adaptation to climate change

Abstract This paper examines and documents the potential effects of climate change on agricultural production in Western Kenya, a context within which agroforestry innovations have become to be recognized as vital in helping smallholder farmers adapt to climate change. Since the 1970s, agroforestry systems have continued to acquire precision as one of the most promising sustainable agro-ecological technologies. Much of this work has been motivated by the perceived benefits of achieving sustainable food production and poverty alleviation through scientific research and research-related activities in the field of agriculture and forestry. Drawing on recent fieldwork in Western Kenya and secondary data sources, this paper describes how climate variability exacerbates agricultural production and the kinds of technologies and organizations that will be needed if new forms of scientific knowledge are to benefit vulnerable populations. Preliminary findings show that climate change is already having great effects in Kenya, and will continue to affect the livelihoods of many people in the years to come, especially those living in marginalized environments. The situation is further exacerbated by other factors such as extreme poverty, hunger and malnutrition, loss of biodiversity, disease burden, and land degradation, among others. Climate change presents formidable challenges at the household level and has a multiplier effect on the national economies, and without urgent action climate change is likely to undermine the progress in the attainment of the Millennium Development Goals in developing countries.
The paper underscores that adoption of agroforestry innovation by smallholder farmers has the potential to increase agricultural production, restore soil fertility, and sequester carbon while decreasing vulnerability to the negative impacts of climate change. The paper concludes that there is a dire need to move climate change and variability into socioeconomic development plans to ensure that adaptation is fully integrated into national development policies and funding instruments.

Zoning and suitable land use patterns for landscape agroforestry development

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
Agroforestry is a sustainable land-use approach to alleviate the conflict between forestation and demand for agricultural lands. This research aims to establish an approach to agroforestry development in Khlongphoo-Khlongpook Watershed, Trat province, eastern Thailand. Zoning was formulated by using classes of watershed, slope, elevation and distance from the main stream; resulting in 5 classes (Zones 1-5) which were mapped using GIS. An agroforestry index (AFI) was set to evaluate sustainable level (SL) of 7 land uses which were represented by using 8 indicators: soil loss, organic matter, plant diversity, net profit, time dispersion of income, input self sufficiency, risk and uncertainties, and food security. Weighting and scoring techniques were used for both steps. In addition, the SL of land uses was determined with AFI values as follows: lowest (1.0-1.8), low (1.8-2.6), moderate (2.6-3.4), high (3.4-4.2) and highest (4.2-5). The land uses in each zone were planned by using AFI. The results showed that the AFI value of complex agroforest, forest, rubber plantation mixed-fruit orchard, mixed-tree plantation, fruit orchard, and pineapple were 4.39, 3.84, 2.64, 2.64, 2.19 and 1.58 respectively. For land-use patterns in each zone, it was found that complex agroforest and forest can be practised in all zones. In addition, rubber plantation, mixed-fruit orchard, and mixed plantation can be applied in Z3, Z4 and Z5. Fruit orchard can be practised in Z4 and Z5. Meanwhile, pineapple can be only practised in Z5. It is recommended that agroforestry patterns in Z1 and Z2 should be designed to maintain forest functionality. At least simple agroforestry or woody plantation should be designed in Z3 and Z4 and all land uses can be practised in Z5.

Articulation of Islamic values toward sustainable development: a case study in Sungai Pisang, West Sumatra, Indonesia

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract
‘Lawik sati rantau batuah’ (ocean has fortune, land has sacredness) is a proverb that reflects how the tribal community in Minangkabau perceive nature.It has cultural and religious meanings that united a paradigm of life.Two contradictive mainstreams are transcendental representing Islamic value and naturalistic representing cultural value lives in harmony and balance.This mutual accommodation had completed each other that produce certain Islamic practices. It also enriches the Islamic pluralism that allows various interpretations and understandings. A case study conducted in Sungai Pisang village in which people continue the tradition of tolak bala, turun kalangan, balimau to sacralize nature and human relationship. This condition significantly influences community perspectives and the sustainability of nature through community-based natural resources management that refers to Islamic understanding. A cross-culture communication study had implemented in this research to explore the articulation of Islamic value toward sustainability of natural resources in frame of cultural diversity. A dialog between two different poles processes human and nature relationship to be a unique dialectic that meets in interest of sustainability. The
continuity of process draws community characteristics that appear in social behavior, perspective, and process of decision-making. This research used purposive sample technique. The research results showed the religious practice that is broken down from Islamic values could not separate from natural resources management practices and praxis. The culture-religious practices orient to face nature uncertainty has an influence to communality of community. Sustainability of natural resources depends on the capacity of community to sustain their culture-religious-ecological practices and praxis.

Implications of climate change for African agroforestry systems: research challenges and opportunities

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Preferred session C4. Mitigation and adaptation to climate change
Abstract Climate change scenarios suggest that temperatures in Africa are predicted to rise by 1°C by 2030 and by 3°C by the end of this century. Rainfall in many parts of Africa is predicted to decrease, and even in eastern Africa where rainfall is predicted to increase, this is likely to be in extreme rainfall events and associated with periods of drought. Agroforestry systems are considered to provide a buffer for smallholder farmers to survive the hotter and drier climates and to assist in the mitigation of climate change. However, agroforestry systems are likely to be negatively affected by climate change and examples will be given of some of the possible impacts of climate change on agroforestry systems. Mitigation is likely to be reversed by extremes of temperature and drought while the yield and quality of highland coffee and fruit trees are likely to be reduced. This provides research opportunities to evaluate the role of shade trees in reducing temperatures for coffee agroforestry systems and the introduction or selection of cultivars of fruit trees better able to withstand high temperatures and/or drought. In selecting indigenous fruit trees for domestication, consideration will need to be given to the future climate scenarios for the target region. As crop failures force small-holder farmers in marginal areas to convert to livestock systems, fodder shrubs suited to these systems will be required. The research challenges and opportunities of these and other agroforestry systems will be discussed.

Prosopis cineraria-based agroforestry Systems: a renewable source of energy in the arid and semi-arid regions of India

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract Prosopis cineraria (L.) Druce is a very drought tolerant and multipurpose leguminous tree species growing naturally in the arid regions of India, Pakistan, Afghanistan, Iran and Arabia. In India it is also called the “Golden Tree”, and is a natural component of various agroforestry systems in southwest Haryana and Rajasthan, which experience very low and erratic rainfall. In a systematic and extensive survey conducted during 2006 07 and 2007 08 it was observed that P. cineraria-based agroforestry systems met the major energy needs of rural masses, brick-kilns and other rural industries. Fuelwood of P. cineraria and coal used to be the main fuels for brick-kilns, but with the steep rise in the prices of coal, fuel wood has become the major source of energy. A survey determined that with the development of indigenous technology, straw of Indian mustard and cluster bean (important field crops under P. cineraria-based agroforestry systems) has being used to fire more than 98% of the brick-kilns in the last decade. Fuelwood from pruning and lopping mature trees is being used by rural households for cooking food. The existing population of P. cineraria was found to improve the fertility and physico-chemical properties of the soil and yield/production of almost all the field crops grown under its canopy. Hence from this survey it is clear that P. cineraria-based agroforestry systems are a renewable source of energy for the abovementioned
stakeholders and also helpful in conserving the fragile ecosystem of areas which have adverse climatic conditions of high temperature, high wind velocity, low and erratic rain fall.

Key worlds: Prosopis cineraria, renewable, energy, agro-forestry systems * Krishi Vigyan Kendra, Jhajjar (Haryana)

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Preferred session A5. Ecological sustainability: panacea or Pandora’s box?
Abstract Latanye (Coccothrinax barbadensis) is a palm used mainly for making brooms in St. Lucia. A socioeconomic study by Lyndon John of the Forestry Department detailed the vulnerable nature of the Latanye broom industry. There is a high demand for these brooms bought locally and regionally. Strategic alliances with governmental and non-governmental organizations and the users of Latanye resulted i

The study of agarwood (Aquilaria filaria) plantation growth in the Merapi mountain area with agroforestry systems in Slemen Regency, Yogyakarta, Indonesia
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Preferred session E4. Socioeconomics and Agroforestry in the Pacific
Abstract Agarwood (gaharu) is one of the species of tree that produces of oleoresin (gubal) in the stem or root. This species is gradually declining in number as a result of over cutting by collectors. Furthermore the species must be conserved by planting Aims of this research were: 1) to determine agarwood growth (diameter and height) in the agroforestry system; 2) to determine environmental factors that directly influence agarwood growth; 3) to determine the effect of agarwood plantation on conservation of the soil and water in the Sleman Regency area, Yogyakarta, Indonesia; 4) to determine the suitable habitat for agarwood planted in a mix with Paraserienthes falcataria; and in a mix with Salak pondoh. The study area was divided into 2 blocks. First, agarwood planted together with Salak pondoh; and second, agarwood planted together with Paraserienthes falcataria. A T test was used too determine the effect of these models. The results of the research were: 1) the agarwood species planted with Salak pondoh (block 1) was better than the other block; 2) the agroforestry system using mixed cropping with Salak pondoh significantly gave a good microclimate that was suitable for growing agarwood plantations; 3) the agroforestry system conserved the soil and water in Sleman Regency area; and 4) mixed-cropping with agarwood and Salak pondoh have economic potential, especially for increasing local community income.

Tree crop association and interaction in vegetable agroforestry systems
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Preferred session E4. Socioeconomics and Agroforestry in the Pacific
Abstract Intensive commercial vegetable production under monoculture systems is not sustainable. However, integration of trees compatible with vegetable crops offers potential for enhanced sustainability. The objective of the SANREM CRSP Vegetable Agroforestry Project is to integrate trees with intensive vegetable systems in Southeast Asian watersheds. Vegetable agroforestry system (VAF)
Assessments and experiments were conducted in the Philippines, Taiwan, Indonesia and Vietnam using timber trees, fruit trees, and cashew nuts in combination with commercial and indigenous vegetable species. Farmer perceptions and experiences, light transmission, tree growth, crop growth and yield were collected to determine productivity, adaptability, competition, complementarity and profitability. In the Philippines, suitable trees were *Eucalyptus robusta*, *Eucalyptus torillana* and *Acacia mangium* with tree line spacing of 25–30 m. Promising commercial vegetables were cabbage, cauliflower, carrot, bell pepper, eggplant and yard-long bean. Indigenous vegetables included Amaranthus Jute, and Malabar spinach. Positive complementarity was observed between tree height and amount of canopy left after tree pruning, but negative on canopy width. In Taiwan, outstanding fruit tree species were *Anona reticulata*, *Artocarpus heterophyllus*, *Chrysophyllum caimito*, and *Tamarindus indica*. Tree vegetable competition is non-existent during the early tree establishment stage and yield of vegetables increased by 29% to 53% when the trees were 2 years old. In Indonesia, vegetables grown under trees at medium shade resulted in yield increases of 5% to 180% over full sunlight, whereas heavy shade reduced yields of fruit vegetables (eggplant, chilli, and tomato) and had no negative effect on leafy vegetables. In Vien Nam, planting vegetables in between cashew trees increased cashew yield. These studies showed mounting evidence that a new horizon in agroforestry research has been discovered, that is, for several vegetables, yields are higher in agroforestry systems than in open field conditions.

**Assessment of the effectiveness of the Protected Area Management Board of Mt. Kitanglad Range Natural Park and Bataan Natural Park**

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**Preferred session** E4. Socioeconomics and agroforestry in the Pacific

**Abstract**

The enactment of R.A. No. 7586 otherwise known as the NIPAS Act of 1992 that mandated the creation of a Protected Area Management Board (PAMB) in all declared protected area sites in the country was a very significant step towards further empowering various stakeholders in the protected areas. The two protected areas mentioned in the study were analysed for their organizational structures and the effectiveness of PAMB (output, process and input variables). Their experiences and lessons learned were also analysed and as a matter of policy it seems that the highly politicized membership of PAMB in Mt. Kitanglad resulted in a productive PAMB, unlike the PAMB in Bataan Natural Park. Policy analysis was also done in this study. The recommendations of this study are: the composition of PAMB must be multi-stakeholder and multi-disciplinary, and local government executives surrounding the areas must be involved as members and not be able to authorize representatives to participate on their behalf; policy formulation and implementation must be clear at the LGU level enabling them to support the PAMB with budget allocation and sustained operations. In order to support a project, the PAMB members must be informed about all details of the project; the authority and power of the PAMB members must result in empowerment. The objectives of protection for the environment and also of constituents must be clear to local government executives for them to support programmes and projects, which can be both for environmental protection and use and empowerment of people by providing them with livelihood opportunities.

**The role of agroforestry in Brazil’s National Policy for Environmental Management of Indigenous Lands**

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

Indigenous lands represent approximately 12% of Brazil’s territory and 27% of the Brazilian
Management development of community forestry in Pandeglang District

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

Forests play an important role in people’s socioeconomic and cultural systems and profoundly influence their sense of place, ideologies and identities. People living in communities within and around forests use forest products for their livelihoods when agricultural and other economic activities are inadequate to sustain the household economy. Therefore, development of community forestry outside forest areas is one solution to solve forest resources pressure. Pandeglang District is one community forestry development centre in Banten Province which uses agroforestry techniques. Its usefulness is not only in improving environmental sustainability, but also in getting wood and other benefits from various plants that farmers cultivate. However, there are some problems with the community forestry development in Pandeglang. The aim of this study was to analyse the kinds of problems that have hampered the development of community forestry in Pandeglang District. Descriptive qualitative analysis based on a survey method was used in this study. The results showed that there are: 1) no relevant guidelines in community forestry management, 2) limited human resource skills; and 3) ineffective organizations of community forestry. To solve the problems and develop the community forestry in Pandeglang District some suggestions are made. They are: a) create guidelines to repair the community forestry management system and markets; 2) improve the human resources skills (community forest management, technology, and institutions); and 3) develop effective community forestry institutions both in the government and at the community level.

Learning in the midst of crisis: opportunities for sustainable land use in the uplands

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract

In the uplands of the Philippines, the fuel and fertilizer price shock in 2008 coupled with hydroclimatic uncertainties have brought economic constraints to monoculture farming systems and have driven farmers to explore other options that are economically viable. Field research has
shown that farmers are willing to learn more of cost-effective technologies or revisit other options they have learned from conservation NGOs including organic farming and agroforestry. Under this backdrop, a social learning package is proposed to harness their willingness to learn. Joint Analysis and Design (JADE) is an analysis and options exploration undertaken jointly by farmers and researchers in a social learning environment. This learning framework will use water and nutrients – the limiting factors of productivity – as an entry point to improve farmers’ understanding of their social and biophysical environment. In this way, farmers’ knowledge derived from experience and institutions can be blended with researchers’ knowledge in a two-way learning process. Efforts to introduce conservation on fragile lands have been mired with promises of high income from monoculture and fuel-dependent agriculture. But with the cost of fuel and fertilizer being unstable, an opportunity to repackage technologies in a joint learning platform can be taken to show farmers the path to an efficient, equitable, sustainable upland agriculture.

Gestion Des Parcelles Agroforestières dans les Forêts Communautaires dans le Département de la Kadey, Region De L’est Cameroun.

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Preferred session A2. Agroforests in Humid Tropical Africa

Abstract Les forêts communautaires sont les portions des forêts du domaine non permanant que l’Etat attribue à une communauté représentée par une entité juridique afin qu’elle gère de façon autonome pour améliorer les conditions de vie de la communauté. Afin de contribuer à la gestion durable de ces forêts, une étude a été menée sur la gestion des parcelles agroforestières à l’intérieur de ces forêts dans le département de la Kadey, province de l’Est. Deux approches méthodologiques faisant intervenir les inventaires botaniques et les enquêtes auprès des ménages ont été utilisées. Les résultats révèlent qu’il existe deux systèmes agroforestiers dans les forêts communautaires explorées à savoir : le système agrosylvicole et le système agrosylvopastorale. 150 espèces agroforestières ont été identifiées avec une dominance des arbres fruitiers sauvages. Environ 80 % de ces espèces sont en même temps à usage alimentaire et source de revenus. Les impacts positifs et négatifs qui découlent de l’exploitation de ces forêts sur les systèmes agroforestiers ont été identifiés. Les mesures d’optimisation et d’atténuation de ces impacts ont été formulées. La caractérisation des systèmes traditionnels d’exploitation des espèces agroforestières recensées a mis en évidence une interaction entre les catégories d’utilisateurs, les types d’utilisation, et les revenus moyens obtenus. Mots clés : Forêt communautaire, gestion, système agroforestier, espèce agroforestière, département de la Kadey.

A review of status, trends, and challenges of agroforestry education at Botswana College of Agriculture: the way forward?

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract Almost 15 years after its introduction, agroforestry has remained one of the smallest course/programme offerings to students in departments at Botswana College of Agriculture (BCA). This could be attributed to national and institutional factors. At the institutional level, the major determinants to mainstreaming agroforestry as a course/programme include the limited capacity and number of teaching staff, facilities and library resources, weak coordination among concerned departments in developing a relevant curriculum, weak leadership or lack of support, and limited funding. A testament to this is the offering of agroforestry as a course only to some students in the Crop Science Department, only amongst 16 programmes ranging from higher Diplomas to Graduate degrees (MSc). At the national level, on the other hand, these factors include, among others, an unclear delineation of functions and responsibilities of concerned government agencies,
inadequate opportunities for employment of graduates, and differing development priorities and policies in the absence of a globally acceptable typology of agroforestry land uses. This paper attempts to discuss these challenges and map the way forward for an interdisciplinary collaborative approach that highlights the potential and opportunities of integrating agroforestry education in other programmes at BCA.

Farmers’ reactions to agroforestry in Greece

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Preferred session B4. Agroforestry in Europe: land reclamation

Abstract Silvo-arable agroforestry that comprises widely spaced trees intercropped with arable crops is an old practice in Greece. In several areas, traditional silvo-arable systems occur with different combinations of trees and crops depending on the ecological zone and agricultural practices. Farmers’ opinions play a very important role for the future of these systems. A study was carried out at the Municipality of Askio (located in northwest Greece) where several traditional silvo-arable systems still exist. A special questionnaire was used in 2003 in order to record farmers’ reactions to agroforestry. Twenty farmers covering all ages were interviewed. Most of the silvo-arable systems are maintained due to crop subsidies by the EU and the farmers, mainly tenants, cared only for the crops and not for the trees. In the few cases where the owners themselves were involved in the cultivation of the systems, the inputs in terms of fertilizers, pesticides, etc., were limited. In the areas where land was consolidated and irrigation became possible, the owners and farmers eliminated the trees in order to increase the crop yield and facilitate the use of agricultural machines. Silvo-arable agroforestry was promoted in the area with the establishment of 3 modern systems and with seminars and conferences. A second questionnaire was applied during 2008 in order to explore the evolution of farmers’ opinions on agroforestry systems since 2003.

Conservation and utilization of fast disappearing and underutilized edible wood savannah species of Adamaoa region of Cameroon

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Preferred session E1. Hot or cold: the role of underutilized crops for AF

Abstract In Cameroon, where the diet is dominated by starchy staple foods, wild foods are essential sources of proteins, vitamins, minerals and amino acids. The majority of these foodstuffs are still being harvested from the wild. This paper aims at examining and documenting local available wild edible foods with a focus on sustainable development and rational utilization of tropical biodiversity and demonstrating the pressing and compelling need for their conservation. A census of locally available wild vegetables used as food was carried out and their nutritional and economical importance highlighted. Among the biodiversity foodstuffs found, food products from local biodiversity that were in the greatest demand in the area included: cereals such as Kissaar (Dactyloctenium, Cenchrus or Eragrostis seed grains, ground in thick porridge), zanina (Amorphophallus roots boiled), Ngibbi (Cenchrus seeds, pounded to porridge), jeda (Amorphophallus tubers, boiled); fruits and seeds, among which the most frequently used were found to be jujube fruit (Zizyphus jujuba), tamarin fruit (Tamarindus indica), figs fruits (Ficus sycomorus, Ficus platyphilla), the date palm of the desert (Balanites aegyptiaca), palm trees (Hyphaene thebaica) also called doum, and the ronier (Borassus flabellifer). We may also point out wild food sources of sodium such as plants whose ashes are used to obtain salt by solifluction of vegetable, sek gayna (mon) or literally “salt of stems” for example, Hygrophylla spinosa. The established wild food list composition indicates that they are potential nutrient sources and contribute significantly to income generation at household levels, for the local population. These products are also rich in vitamins and minerals; they are undoubtedly valuable as supplements to the millet-based diet of the local rural populations. The maintenance of the use of these wild resources seems very important in order to enhance awareness of stakeholders on the importance of preservation of biodiversity.
Adoption of agroforestry innovations in Barra do Turvo (São Paulo, Brazil)

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Preferred session: A5. Ecological sustainability: panacea or Pandora’s box?

Abstract
Agroforestry has been developed for 6 years in Barra do Turvo. In this poor State of São Paulo in Brazil, these farming systems bring technical alternatives to family agriculture in crisis due to low soil fertility, rigid environmental laws, a shortage of land, and difficulties of commercialization. These new farming systems are developed according to the agroforestry model ‘based on regeneration’ which rests on the principle of plant species succession and aims at a sound management of natural resources. In Barra do Turvo, this model is used in abandoned banana plantations and on degraded soils. Technico-economical and social impacts of the introduction of these systems were evaluated. Farmers have developed different strategies regarding innovation: some of them have mastered the agroforestry techniques; others are producers in transition who combine crops and agroforestry techniques or use agroforestry to diversify their livelihood systems. Finally, some farmers are only interested in agroforestry to get resources from the project. The agroforestry project provides farmers with a regular income. The income of farmers without cows or of farmers who are in the process of capital accumulation with animals is improved but work productivity is not greater than in shifting cultivation. The introduction of agroforestry is economically risky because it requires a lot of work. In addition, the average cost of establishing agroforestry is lower than the cost of systems that have the same aim of covering the soil. As for the social impact, new jobs are created, farmers’ networks are activated but conflicts appear. In conclusion, this study of impacts shows that subsidizing agroforestry is legitimate in pursuing sustainable development. But it also shows many deficiencies: it is important to reinforce the access to markets, to better exploit local biodiversity and to guarantee the right of using the native species that are present in future agroforests.

Vegetative propagation and growth performance of Oxytenanthera abyssinica by culms cuttings for Agroforestry systems

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Preferred session: A10. Dryland agroforestry R & D

Abstract
Agroforestry is known as the deliberate use, cultivation and management of trees in sequence or simultaneously with crops in agriculture farms. Resource-poor farmers in the tropics and specifically in arid lands, have planted and managed trees for fuelwood, construction materials, house building, huts, shade, fodder, fruits and other by-products. Other uses include small enterprises such as handicrafts, pencils for writing, stakes, handles of tools, making beds, sitting stools and chairs. The various products and uses play a key role in the rural economy and provide off-season employment opportunities. Moreover it will have a role in aspects of environmental protection, preventing degradation and erosion of soil, in landscaping, shelterbelts, hedges and amenity. The intensification and stabilization of existing small-scale farms through innovative agroforestry can benefit poor by increasing food security and providing added income. Introduction of improved vegetative propagation techniques in agroforestry improve and speed up the domestication of threatened indigenous multipurpose trees and the new plants are true-to-type to the mother plant. In addition, this is expected to cut costs of plantations when compared to the more conventional ones, shorten the period of production and get homogenous plantation with clone selection. Management and improvement of propagation techniques should have priority in research and development programmes in Sudan. The aim is to protect, conserve and expand existing resources as well as new plantations for indigenous and exotic germ plasm in different ecological zones. This paper aims to describe the role of vegetative propagation of some selected promising multipurpose tree species that are used and recommended for agroforestry systems; these species include Grewia tenax, Acacia nilotica and Eucalyptus camaldulensis.

Key words; agroforestry, multipurpose trees and shrubs, vegetative propagation, bamboo
Early soil and water management effects on growth and fruit production in grafted Uapaca kirkiana and Vangueria infausta in Malawi

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Preferred session
B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract
Despite their vital contributions to the livelihoods of many people in southern Africa, indigenous fruit trees (IFTs) of miombo woodland have not been deliberately cultivated until recently. Unlike exotic fruit trees, field management practices for optimum fruit yield and superior fruit attributes are yet to be developed for many IFTs. This study was undertaken to evaluate the effects of early soil amendment (fertilizer and manure application) and dry-season irrigation on the fruit production and fruiting precocity of grafted Vangueria infausta and Uapaca kirkiana. Different treatment combinations of inorganic and organic fertilizer, and irrigation were applied in factorial design during early tree establishment. The results showed that soil amendment and irrigation applied during early establishment of V. infausta and U. kirkiana did not significantly influence fruit yield from the first year of fruit production. Fruiting started 3 years after planting in both species, but there was a lot of fruit drop in U. kirkiana until the 4th year. Tree mortality for U. kirkiana was higher than that of V. infausta. It is concluded that V. infausta and U. kirkiana growth and fruit yield does not depend on soil amendment and dry-season irrigation applied during early tree establishment and that V. infausta has an earlier fruiting stability than U. kirkiana.

Landscape restoration through agroforestry innovations: lessons for the future

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Preferred session
B6. Agroforestry as a tool for landscape restoration

Abstract
Agroforestry innovations inculcate various types of landscapes with integrated features representing spatial diversities. Many traditional systems and practices have gone through a substantial change due to social and economic pressures and have been fragmented over the years. This paper presents the findings of an action research project involving over 145 households in a mosaic of villages,

Abstract incomplete at time of going to press.

Investigation of desiccation tolerance of Uapaca kirkiana, Strychnos cocculoides, Garcinia buchananii, and Syzigium cordatum using farmer friendly techniques

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Preferred session
A6. Ecophysiological bases of agroforestry-system design

Abstract
Indigenous fruits play a vital role in the livelihoods of many communities in Malawi. Despite their valuable contribution towards peoples’ livelihoods, not much research has been carried out on them. This study was conducted to determine the optimum moisture contents for maintaining seed viability and seedling vigour of the species. Seed was dried to various targeted moisture contents following IPGRI protocol. Analysis of variance was performed on arcsine-transformed data. Germination vigour was expressed as the number of days to reach 50% germination. There were
significant differences between moisture contents in terms of germination percentages in all the species. *Strychnos cocculoides* was desiccation tolerant and orthodox. *Syzygium owariense* seed was recalcitrant and desiccation intolerant. *Uapaca kirkiana* seed showed intermediate behaviour. *Garcinia buchananii* was recalcitrant and desiccation sensitive. Further research is required on the storage of seed that has shown recalcitrant behaviour. In depth study of *U. kirkiana* seed, which has been classified as recalcitrant in previous studies, is required.

**Domestication of agroforestry tree species for dryland Sahel: an overview**


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**Preferred session** B8. Participatory tree domestication (PTD) for land rehabilitation  

**Abstract**  
The Sahel is a semi-arid landscape on the southern edge of the Sahara desert, which is under continuous threat from climate change, deforestation, land degradation, unsustainable cropping practices, loss of biodiversity and aggravated poverty, hunger and malnutrition especially of rural poor communities. This situation reduces both the capacity of tree/shrub populations to adapt to environmental change and the potential gain that farmers can realize from selection. However, parklands systems have successfully sustained the livelihoods of many generations of Sahelian populations by providing a range of essential products and services. Yet, many trees and shrubs from the systems remain semi or undomesticated. Participatory domestication of tree species, which in the Sahel has involved the evaluation of their performance for adaptability to prevailing conditions, has been an important element in the development of various agroforestry methods and technologies that have been proven to be efficient in combating desertification and enhancing livelihoods. These methods and technologies include the planting of indigenous fruit and vegetable trees, establishment of agroforests or woodlots and development of fodder tree species. Fruit and vegetable tree farming is practised in the Sahel using indigenous fruit tree species suitable for cultivation under Sahelian conditions, such as baobab (*Adansonia digitata*), tamarind (*Tamarindus indica*), shea nut tree (*Vitellaria paradoxa*) and ber (*Ziziphus mauritiana*). These trees prove to be better adapted and more productive. Most natural tree species may be able to regenerate naturally on-farm but need farmers’ efforts in protecting the young trees against damage by humans and browsing animals. In the Sahel, *Acacia senegal*, *Bauhinia species*, *Combretum species*, *Faidherbia albida*, *Guiera senegalensis*, *Piliostigma reticulatum* and *Prosopis africana* have been successfully naturally regenerated by rural populations. *Pterocarpus species* and *Clitoricida sepium* remain popular fodder tree species on-farm. These species and technologies, if massively adopted, will provide a good basis for re-greening and rehabilitating the Sahel and ensuring impacts on livelihoods of rural populations.

**Diversity of uses of tree species in agroforests of Guinée Forestière (Guinea, West Africa)**

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**Preferred session** A2. Agroforests in humid tropical Africa  

**Abstract**  
Guinée Forestière is located in the southwest of the Republic of Guinea. This is a forest geobotanical area with a rural population. In this region, traditional agricultural systems preserve some diversity of forest species through agroforests. The area devoted to coffee-based agroforests has been increasing over the last 25 years. Floristic composition, uses of forest species and farmers’ practices in these systems remain poorly understood. From botanical records conducted in 7 villages in the west of Guinée Forestière, chosen to represent the diversity of contexts in the region, and from surveys of the villagers on the uses of forest species, we suggest a first characterization of diverse uses of agroforest tree species of Guinée Forestière. An inventory was made of 232 species, including 189
The potential of bamboo resources for agroforestry practices in climatic threatened environment: a theoretical and empirical view

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Preferred session  C2. Carbon sequestration in agroforestry
Abstract
Bamboo resources are underutilized in most developing countries though empirical evidence exists on their use for agroforestry purposes. Reports indicate that about 1500 documented uses, including some with environmental and ecological potential, have been reported worldwide. In the discourse on climate change, new adaptation and mitigation options are being explored. The recent IPCC and AIACC reports have concluded the inevitability of climatic stress and threats, which will intensify in the coming years and impact developing countries greatly. A number of adjustments are required using renewable natural resource like bamboo in developing countries. Though bamboo resources can serve this purpose, little information exist on the extent of exploration of native and exotic bamboo species for use on marginal and degraded lands in Ghana and other developing countries. In this paper, the potential of *Dendrocalamus strictus* and *Bambusa vulgaris* were highlighted for use in agroforestry practices in Ghana. The shorter gestation period, soil binding quality and higher carbon sequestration abilities of these species were emphasized. This was done through a literature review, interviews, field observations and some preliminary studies. It concluded with a clarion call for further research and creation of awareness on the use of the native and indigenous bamboo species in agroforestry practices for food security and environmental stability in the climate.

Key words: bamboo resources, agroforestry, climatic threats

The contribution of agroforestry-based products to mitigate the impacts of HIV/AIDS in Kenya

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Preferred session  E5. Rewards for the environmental services of agroforestry
Abstract
There is a growing body of literature suggesting an increasing importance of the link between agriculture and health as a response to the impacts of HIV/AIDS in many parts of the developing world. Agroforestry can play a very important role in rural livelihood sustainability in the face of increasing poverty and health epidemics. It can enhance food security, provide additional food sources and medicinal products, provide income-generating activities that are not labour intensive, can mark ownership of land, and offer a safety net of subsistence and income. Agroforestry systems enable farmers to diversify their incomes and increase farm productivity for household consumption (nutritional and medicinal products) and additional income generation for meeting the costs associated with disease burden. Some findings include: 1) At the community level, programmes incorporating agroforestry activities are central to promoting sustainable options for HIV/AIDS management. 2) Maintenance of on-farm tree diversity was consistently revealed throughout the household responses and reflects the preference of farmers to be able to meet a wide variety of needs. 3) Farmers see themselves first as consumers of tree products and second as producers. 4) There is extensive awareness and identification of medicinal species growing on farms and in the wild that hold important medicinal value for communities. In conclusion, there are numerous
opportunities to expand on the already existing potential of agroforestry for HIV/AIDS-affected communities by scaling up adoption of successful technologies and practices through community-driven integrative approaches. This can focus on the following areas: income generation from tree selling; diversifying fruit tree species (for household consumption and/or income generation); expanding value-based nutritional information; and tapping into the available medicinal resource base through approaches to integrate medicinal tree cultivation, use and marketing for benefits in the agricultural and health sectors in East Africa.

Market opportunities for the poor from agroforestry

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Preferred session E1. Hot or cold: the role of underutilized crops for AF

Abstract
In most parts of the world, but particularly tropical and sub-tropical countries, the poor and disadvantaged may be observed supplementing their livelihood with tree products derived from agroforestry systems. This is true whether the trees are owned by them (such as multipurpose trees cultivated on tiny homesteads in Bangladesh), or whether they only have rights of access to the products (such as karité [Shea sp] harvested by women in the Sahel from trees owned by men). However, for the poor to be able to significantly improve their livelihoods from the sale of agroforestry products, they need a sound knowledge of the market – tailoring products to market demand, organizing timely production and supply, fixing prices at an optimal level, etc. It is possible to make markets work in favour of even the very poor, especially where a full analysis of the value chain is made, and appropriate points of intervention identified. This paper documents the experience of a number of Swiss-supported agroforestry projects that have promoted interventions to this effect. It focuses on experiences in Bangladesh (where, for example, medicinal plants are grown on homesteads in partnership with an industrial company, which processes them), Pakistan (where, amongst other initiatives, fibre from the dwarf palm [Nannorrhops ritchieana] or mazri is used to make a variety of handmade products), Nepal (where medicinal herbs are increasingly cultivated and processed by members of community forest user groups), Mali (where women extract ‘butter’ from the nuts of the karité tree), and Central America (where small Costa Rican and Nicaraguan farmers are supported in the marketing of fair trade and organic products). The paper outlines some of the similarities and contextual differences in approach, and highlights lessons learned, particularly from a gender and equity perspective.

Mycorrhizal fungi inoculum production on maize for the indigenuous legume Isoberlinia doka (craib&stapf) domestication in Benin

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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands

Abstract
Isoberlinia doka fungal soils were sampled from Wari-maro forest and used as arbuscular mycorrhizal fungi (AMF) stock in a pot culture experiment. These fungal soils have the ability to serve as a source of mycorrhizal inoculum for crop plants. For this purpose, Glomales under Isoberlinia doka were trapped on maize (Zea mays) and a completely randomized design with 16 replications and 7 treatments was used. The data, treated by analysis of variance with 5% of significance, revealed that the N-uptake and growth parameters such as above-ground and root biomass as well as root colonization and number of AMF spores of the maize plants were greatly affected. Plant N-uptake was increased (1.5, 2, and 4 times compared to control soil, for inoculum coming under forest, fallow, and field respectively); the above-ground and root biomass were increased (1, 1.5 and2.5 times compared to control soil, for soils coming under forest, fallow, and field respectively); the percentage of maize root colonization with arbuscular mycorrhiza (AM) was also increased 2, 3 and 3 times compared to control soil, for inoculum coming from forest, fallow, and field respectively. The relative mycorrhizal dependency varied from 8.39%
Agroforestry practices, charcoal production and agricultural productivity in Ghana: lessons for adaptation to climate change

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Preferred session: A6. Ecophysiological bases of agroforestry-system design

Abstract

Earlier work on the impact of charcoal production on farm lands showed significant increase in nutrient level and yield of cereals. With the projection that charcoal and fuelwood production will increase to about 66 tonnes, from 14 tonnes, by 2020 the influence on any agroforestry practice will be significant. Whilst variation in its use may be marginal for many years to come, the concern of the impacts of charcoal production on the forest resources base and agricultural productivity is gaining increased attention worldwide. In this study, the impacts of the earth mound technique on soil properties were assessed through field observations and soil analysis in charcoal-producing communities in the eastern region of Ghana. In the design of agroforestry techniques in climate-threatened environments, consideration of the impact of these practices will influence significantly the performance of any agroforestry practice with minimal cost in the coming decades, especially in charcoal-producing regions of the world. The implications for productivity of agricultural land were highlighted. It was recommended that further research should be conducted into the impact of the earth mound method on forest health and agroforestry practices in general in the wake of climate risk, in order to create a balance between human needs for charcoal and agricultural productivity.

Key words: agroforestry, charcoal production, climate risk, utilization.

Silvopastoral systems under organic production norms in the Paraná River Delta, Argentine.

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Preferred session: A.11. on silvopastoral systems

Abstract

The aim of this research was to describe the environmental and productive components that characterize a real silvopastoral system (SPS), under organic production norms in the Paraná River Delta, Argentine. The total surface of the system is of 186 ha. It is located between latitudes of 32º 5´ South and 34º 29´ South. It is a waterlogged plain of approximately 17 000 km2 inside a wetland. The climate is tempered with average precipitation of 1100 mm. The forestation consists of guides from 2-year-old Populus spp. planted at 6 m x 6 m. First, there was a mechanical control of undergrowth during the autumn and winter, to rejuvenate the grassland. During the 2nd spring calfs were introduced (0.5 cow /Ha). Some of the main forage species of this grassland are Lolium multiflorum, Bromus unioloides, Paspalum dilatatum, Glyceria multiflora, Leersia hexandra, Echinocloa helodes, Panicum pervambucense, Panicum elephantipes, Carex riparia, Paspalum urvillei, juncus sp., and Alternathera philoxeroides. In autumn the dry leaves of poplar were buried mechanically to activate the bank of seeds of the forage species. The main forest pest is the ant, which was controlled with techniques and products allowed by the organic production norms. The animals fed directly on the grassland. The water stations were internal channels that conveyed the water, and were also used for the plantations of poplar. The service is with pasture-mate, in spring (September at December). In the handling of the animals, food of appropriate nutritional quality was provided, the herdsmen ensured enough rests to lower the parasitic load, and situations that stressed the animals were avoided. The sanitary control was natural, avoiding routine preventive treatments, and antiparasitics were not used. All the animals were identified individually.
Forest Management and Biodiversity Conservation

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Preferred session: C1. AF, climate change, biodiversity conservation

Abstract

Agroforestry systems of the Mediterranean Basin are the result of interaction between natural, anthropic and historical factors. They are an environmental matrix providing suitable habitat for a huge number of plant (Abies alba, Acer spp., Betula pendula) and animal species (Dryocopus martius, Picus viridis, Accipiter gentilis). The Rural Development Policy (RDP) 2007–2013 endows measures to protect and enhance the EU’s natural resources and landscapes in rural areas; the resources devoted to axis 2 of RDP contribute to protect biodiversity and preserve high nature-value farming and forestry systems and traditional agricultural landscapes. This study aimed to present a pilot project to develop a feasible and cost-effective monitoring protocol for determining biodiversity associated with forests in relation to their management. Study areas are located in the Monte Marzano Natural Reserve (40°43′40″N 15°17′36″E) and in the Monti Picentini Regional Park (40°43′40″N 15°17′36″E). These 2 protected areas of Southern Italy are characterized by the presence of beech woods managed in different ways. Monte Marzano woods have been treated by succeeding uniform cuttings for production purposes, Monti Picentini woods have been treated by both non-coetaneous cuttings and succeeding group cuttings following sustainable ecological criteria. Four wood parcels were selected, in each parcel a 1 km transect was drawn and tracked once a month to monitor signs of mammals’ presence. A buffer area was defined around each transect line to set 30 counting points to analyse how the management and possible fragmentation could affect the bird community. The woodpecker community will also be studied, using the playback method, as indicators of forest bird diversity and as a target species for ecological connectivity analyses.

Participatory approaches to assess tradeoffs for ecosystems services of agroforestry systems

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

As wildland ecosystems continue to be converted to agricultural production, the availability of ecosystem services (e.g. water purification, forest products, pollinator habitat) they once provided are diminishing. Diverse agroforestry systems could instead provide many of these ecosystem services but the adoption of these practices has been limited in both developing and developed countries. A number of factors explain the lack of adoption, but perhaps most critical is the lack of community engagement in identifying and evaluating tradeoffs of ecosystem services across agricultural landscapes. In this paper, we argue that a community-based strategy for assessing the tradeoffs of ecosystem services for differing agricultural systems is needed. While scientists have developed reasonable methods of quantifying ecosystem functions (i.e. basic ecological processes), there is an urgent need to engage communities in identifying and prioritizing ecosystems services, which are by definition ecosystem functions that are deemed useful to humans. Prioritization is an important part of this strategy because there are inevitability tradeoffs among services. For example, if water quality is recognized as a priority, the opportunity cost of planting trees to protect waterways may be reconsidered. Therefore an interdisciplinary and participatory approach to evaluate these tradeoffs within the community is required. We will present a framework for the evaluation of tradeoffs that will entail strategies for developing the minimum biophysical dataset required for an educated assessment and methodologies for a participatory approach to prioritizing community ecosystem service needs. The participatory approach will include analysis of local and regional biophysical parameters and incorporate methods such as stakeholder analysis, ranking and prioritizing exercises, scenario building, and transect walks. Outcomes from this framework
will address both long-term and short-term needs as well as onsite and offsite services and seek to engage in currently developing markets for ecosystem services (e.g. green house gas mitigation).

Agroforestry the future of global land use

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Preferred session E4. Socioeconomics and AGROFORESTRY in the Pacific

Abstract Expectations for agroforestry as ‘the future of global land use’ are greater today than ever before. However, if current efforts to understand, develop and disseminate agroforestry technology are to have an impact and meet the current expectations, its deployment, as a newly organized branch of applied science, must take place with a clearer than usual view of the human context of supposed land-use improvements. We should acknowledge that the kind of agriculture that peasant farmers actually do is the kind of agriculture that’s friendly to biodiversity, and that ‘smallholder farmers are good’ and ‘big-scale farmers are bad’ for forestry conservation. There is a need to consider the practical application of sustainable practices in agroforestry hence the requirement for education, training, extension and transfer of technology to the users. The overall objective of agroforestry research and development is to increase land productivity, tree products and services in the country. Research in agroforestry should address the role of social sciences in evaluating and shaping the future nature of agroforestry participation and research practice. The consideration of social science would better address complex social, economic and environmental concerns of land. Research should also consider, in particular, the role women play in natural resources management. It has become increasingly apparent that R&D in agroforestry in many countries is hampered by a lack of appropriate policies; and has been identified as an area of high priority. Mobilization of funds towards R&D in agroforestry support should also be enhanced in order to ensure agroforestry practices impact positively on sustainable natural resource management. In considering agroforestry this paper looks at the role of the farmer, institutional capacity building, technology transfer, training, the participatory aspect and mobilization of funds as contributions towards ‘agroforestry as the future of global land use’.

Use of tree forages to support livestock in the drylands

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Preferred session A.11. on silvopastoral systems

Abstract An experiment was conducted to examine the contribution of *Maerua angolensis* and *Zizyphus mucronata*, mixed on a 1:1 ratio as a supplement to growing small east African goats. Twenty goats were assigned to 5 groups and randomly assigned 5 treatments of metabolic body weights (W0.75) in 0, 15, 20, 25 and 30 gDMW0.75 of graded levels of *M. angolensis* allocated in a randomized complete blocks design. Proximate composition showed that the OM and CP of *M. angolensis*, *Z. mucronata* and the 1:1 mixture were 941, 929, 935; 321, 200 and 261 g kg^-1 DM, respectively. The TEPH and TET for *M. angolensis* (11 and 3 mg kg^-1 DM) was lower than for *Z. mucronata* (72 and 41 mg kg^-1 DM) and the mixture had average values (42 and 26 mg kg^-1 1 DM). The TEPH and TET for *M. angolensis* (11 and 3 mg kg^-1 DM) was lower than for *Z. mucronata* (72 and 41 mg kg^-1 DM) and the mixture had average values (42 and 22 mg kg^-1 1 DM). The C. gayana hay was low in CP 54 g kg^-1 DM. Hay intake was similar (406 468 g d^-1) across the treatments (P<0.05) and increased with supplementation (406 g d^-1) for the control and (533, 605, 617 and 653 g d^-1) for treatments 2, 4, 3 and 5, respectively. The control animals lost weight (-4.9 g d^-1) and the supplemented groups gained 12.9 28.1 g d^-1. In the digestibility trial, dry matter digestibility (DMD) was significantly lower for the control (677 g kg^-1 DM) than the supplemented groups (892 930 g kg^-1 DM). Treatment 3 with a total DMI of 617 g DM d^-1, 4.3% of body weight, ADG 28.1 g d^-1, rumen HN3-N of 12.7 mg 100 ml^-1 and a nitrogen retention of 3.86 g d^-1 showed the best results. It is concluded that the 1:1 mixture of *M. angolensis* *Z. mucronata* with a CP of 261 g kg^-1 DM is an adequate protein supplement. Growing small east African goats can thus be supplemented at the rate of 149 g DM d^-1, when fed a low quality (5.4% CP) basal diet. It
is concluded that tree forages in the drylands are potential protein sources for livestock and more studies should be done on improvement strategies.

Climate change adaptation in Fulchari and Shaghata Upazila of Gaibandha District, Bangladesh.

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract
Climate change all over the globe is a hazardous environmental problem. In Bangladesh, the impact of climate change is causing panic. Agricultural land loss and food insecurity are major consequences of climate change. Natural disasters are increasing day by day due to climate change. Climate change adaptation and mitigation are much needed to ensure sustainable development. In this study, to understand climate change in Fulchari and Shaghata Upazila of Gaibandha District (northern Bangladesh), climatic indicators such as humidity, rainfall, temperature etc. were measured in the study area. These parameters were measured for natural forests, open space, bushes, commercial forest sites, agricultural land, water bodides, settlement etc. and the data obtained were correlated. Data collected over several years by the Bangladesh Meteorology Department (BMD) were also analyzed. This study examined: land use patterns and their consequences; major cropping pattern and production; conversion of agricultural lands for other purposes; land degradation and trends of crop productivity; different vulnerability/risk factors affecting crop production with extent and severity; indigenous knowledge to cope with climate change; and climate change adaptation strategy, etc. The study methods were: participatory rural appraisal (PRA), focus group discussion (FGD), land use study (satellite imagery and aerial photograph), in depth interview, experts’ opinions, and field observation, etc. The main aim of this study was to correlate trends of climate change in Gaibandha districts of Bangladesh and justify how to adapt to climate change in the study area.

Technology development for quality wood production in a silvopastoral system in Paraná River Delta, Argentina.

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Preferred session: A.11. on silvopastoral systems

Abstract
The Paraná river Delta, occupied1.75 million ha. The Low Delta region, near Buenos Aires City, has 350 000 ha. The landscape is a typical wetland ecosystem with rich biodiversity. The climate is temperate, with a rainfall average 1000 mm/year. In these agroclimatic conditions, the Low Delta is the Argentinean region with more salicaceas (Populus spp. and Salix spp.) plantations. In recent years, farmers in the Low Delta have grown salicaceas plantations in silvopastoral systems incorporating bovines. One of the problems in Delta silvopastoral systems is the absence of efficient technology. To assist farmers in this situation, the Facultad de Ciencias Agrarias de Universidad Nacional de Lomas de Zamora, the EEA INTA Delta and Ederra S.A, collaborated on a project (Proyecto de Investigación y Desarrollo, PID 441-2003). The central axis of this silvopastoral project is the traditional forestry model. The new project focuses on quality wood production for sawn timber (furniture’s, tables, boards, etc.) not for the paper industry. This silvopastoral system combines forestry activity with cow-calf operation. The plantations for quality wood have 6 m x 6 m spacing. The cattle graze on the excellent grassland that grows under the salicaceas plantation. The objectives of the project were to investigate: 1) identification and selection of the best plantation materials for silvopastoral systems; 2) plantation design; 3) water management in the silvopastoral system for trees and animals; 4) cultural labours; 5) identification of forage species and evaluate nutritional value; 6) grassland management; 7) herd management; and 8) animal welfare.

Key words: silvopastoral system; Populus sp.; Salix sp. Paraná River Delta; cow calf operation; quality wood.
Inheritance studies in whitewood (*Endospermum medullosum LS Smith*) provenances and families in Vanuatu

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Preferred session: E4. Socioeconomics and agroforestry in the Pacific

Abstract

Whitewood (*Endospermum medullosum LS Smith*) is a very important timber tree in Vanuatu. It is relatively easy to grow and early maturing. This tree species is contributing to Vanuatu’s economy in a big way in terms of employment and revenue but its stands are getting thinner due to continuous logging and lack of replanting. Therefore to establish a breeding programme, inheritance studies were conducted on a 4-year-old whitewood family trial established by the Vanuatu Department of Forests under the South Pacific Regional Initiative on Forest Genetic Resources (SPRING). A total of 97 whitewood families with seed lots collected throughout Vanuatu were assessed using a row column design. Characteristics of economic importance such as tree height, diameter at breast height (dbh), wood volume and survival rate were included in this study. Ranking of the trees within and between families was based on a differential weighting system for different characteristics. Therefore an economic weight of 1 was assigned to height, and 2 to dbh. All the trees in the trial were ranked but only the 20 best trees in the ranking were discussed in detail with the focus on the 5 best trees for their utility in hybridization programmes to improve whitewood provenances. Heritability (h²) was calculated using mean and variance components with a coefficient of relationship (r = 0.3) for various characteristics. Heritability for height was 0.21±0.017, for dbh 0.09±0.027 and wood volume 0.20±0.00. Although low heritability values were obtained in this trial, which showed a large effect of environment on characteristics of economic importance, by assigning different weights to height and volume and selecting better provenances further improvement in whitewood population can be achieved.

Chemical composition, antioxidant and antimicrobial activities of *Aucumea klaineana* Pierre essential oil

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Preferred session: A2. Agroforests in humid tropical Africa

Abstract

The essential oil isolated from the resin of *Aucumea klaineana* Pierre (Burseraceae) by hydrodistillation was analysed by capillary gas chromatography. The analysis used a combination of retention indices and combined gas chromatography/mass spectrometry (GC/MS), and led to the identification of 28 components. This oil contained mainly mono terpenoids (96.06%) in which p-acetyl anisole was the single benzenic compound (0.18%). The predominant constituents in the essential oil were -3-carene (72.31%), p-cymene (3.76%), limonene (4.04%), terpinolene (6.28%) and -terpineol (4.34%). The antioxidant and 2, 2-diphenylpicrylhydrazyl (DPPH) radical scavenging activities of *Aucumea klaineana* essential oil were determined. Butylated hydroxytoluene (BHT) was employed as positive control. The essential oil showed antioxidant and weak DPPH radical scavenging activities, and it displayed the inhibition of lipid peroxidation. The antibacterial and antifungal activities of the oil were also evaluated. The essential oil exhibited antibacterial and antifungal activities against the all strains tested. The best inhibition zones were obtained for *Shigella dysenteria* CIP 5451 and for *Candida albicans* ATCC90028.

Key words: *Aucumea klaineana*, essential oil, antioxidant and antimicrobial.
Contributions of tree crops in compensating carbon emissions in upland and peatland

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Preferred session
C2. Carbon sequestration in agroforestry

Abstract
Expansion of plantations replacing natural forest has received criticism from the environmental community because of the CO2 emissions generated. Time-averaged C stocks of such plantations in comparison to the primary or secondary forests and shrubs that they replaced were analysed under upland and peatland conditions. Land clearing rapidly generates significant emissions from tree biomass burning, or slowly through decomposition under no-burn conversion. Carbon stocks of upland primary and secondary forests and shrubs were assumed as high as 300, 130, and 15 t ha⁻¹, respectively. For peatland, additional CO2 emissions were derived from burning of peat surface layers and peat decomposition due to drainage. Carbon stocks under peat forest and peat shrub were estimated to be 200 and 15 t ha⁻¹, respectively. Several tree crops in upland systems have a time-averaged C stock that exceeds that of a mosaic of grassland and secondary forest. Under peatland conditions, the depth of drainage determines emissions. Oil palm plantation requires a drainage depth of 60 cm, and its recurrent emissions from peat decomposition exceed the increments in palm biomass; the C budget therefore is negative, regardless of initial land use. Rubber trees do not require more than 20 cm drainage and thus can thrive in peatlands managed for low emission scenarios. When primary forests are converted to oil palm plantation, the estimated average net annual CO2 emissions are 71 and 13.2 t/ha/yr, respectively for peatland and upland. If shrub peatland is converted to oil palm, the net CO2 emission is 55 t/ha/yr and that of upland is 6.7 t/ha/yr. The real economic benefit per unit C CO2 O2 emission (‘opportunity cost’) of peat forest conversion into plantation is much lower than $5/t of emitted CO2, rendering the possibility of paying of legitimate conversion rights through the Reducing Emissions from Deforestation and Degradation (REDD) mechanism.

Tree change: the Australian Master TreeGrower phenomenon

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Preferred session
D2. Integrating disciplines through agroforestry education

Abstract
The Australian Master TreeGrower (MTG) programme is primarily an agroforestry participatory outreach and extension project for farmers that not only acknowledges their land management experience but harnesses it in support of other farmers, researchers and policy makers. Since 1996 the MTG programme has delivered regional educational courses, training in peer group mentoring, prepared extension information and tools, coordinated national extension events and supported regional farm forestry networks. In just over a decade almost 2000 farmers have become ‘Master TreeGrowers’ having completed one of the 90 or so regional courses conducted across Australia. More than 50 of them have received further training as Peer Group Mentors and are now paid to support their neighbours in the establishment and management of their agroforestry projects. The MTG has progressively become an integral component of state and regional extension programmes. In recognition of its widespread success, the program was awarded the AUD10 000 Eureka Prize by the Australian Museum for Excellence in Environmental Education in 2000. The real impact of the MTG programme appears to be very much greater than what might be expected from a series of short courses for farmers and regional advisers. It has played a pivotal role in redefining how people think about agroforestry practices and extension in Australia and the role landholders can and should play in the research and development of revegetation options. It is this less tangible impact of the MTG programme that, after 12 years, is beginning to be evident in the way industry, governments and communities view commercial tree growing on farms and, increasingly, in positive landscape change on the ground. This is the ‘MTG phenomenon’.
Accelerated forest recovery through forest rehabilitation: cases from Malaysia

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Preferred session  B9. Collective action for tree-based rehabilitation of degraded lands

Abstract  The natural recovery of degraded logged-over forests can be accelerated by various technical approaches, from restoration and rehabilitation (for low to medium damage) to reclamation (for severely degraded forest). In view of that, many areas have been replanted with fast-growing indigenous tree species. This paper will elaborate primarily on the results obtained from 3 replanting projects, namely, the UPM-Mitsubishi project (in Bintulu, Sarawak), the UPM-Forestry Department project (in Pasoh, Negeri Sembilan), and the Forestry Department-JICA project (in Chikus, Perak). The project in Pasoh, for example, has been planted with only 10 species (comprising mainly fast-growing species), whereas the Bintulu project has been replanted with 126 species, ranging from slow to fast growers. These two figures are much lower compared to the number of species naturally occurring in a hectare of primary forest, which is approximately at 150 to 250 per ha. Within 15 years, the 3 planted forest areas have recovered 3 to 4 canopy layers of herb, shrub, lower tree and dominant (out of 5 layers in the primary forest), which is considered to be significantly faster than the natural recovery. In terms of the height recovery of the species, *Shorea leprosula*, one the fastest growing species from the Bintulu project attained an average height of 18 m after 15 years of planting (MAI of 1.2 m). The same species planted in Chikus recorded better MAI, ranging from 1.26 to 1.36 m, whereas the one in Pasoh attained the lowest MAI of 0.84 m. It is interesting to note that 15 species (some dipterocarps, e.g. *S. leprosula* and *S. macrophylla*) started to produce fruit, eight years after planting. *S. macrophylla*, for example, normally starts to bear fruit normally after 15 to 16 years. Details on species and stand recovery, as well as comparison to other rehabilitation projects will be included in the paper.

Smallholder production of agroforestry germplasm: experiences and lessons from Brazil, Costa Rica, Mexico and Peru

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Preferred session  B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract  The production and sale of agroforestry germplasm by small farmers and community landholders seems to represent an interesting development opportunity: smallholders would benefit from increased income, while buyers would benefit from increased availability of good quality germplasm. We critically examine experiences with some such programmes in Brazil, Costa Rica, Mexico and Peru and, based principally on this analysis, suggest conditions under which smallholder germplasm production is likely to be commercially feasible.

The role of local government units in mainstreaming climate change adaptation

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Preferred session  C4. Mitigation and adaptation to climate change

Abstract  The Philippines is one of the most vulnerable countries to climate-related disasters that could be exacerbated by climate change. Here, we present the key role of local government in promoting climate change adaptation by showing the experience of a local government unit (province of
Albay) in mainstreaming climate-change adaptation in the Philippines. This shows how climate change came to be considered by the local government through: 1) the emergence of champions among local government officials; 2) climate change as a significant consideration within local government decision making and in land-use plans; and 3) mobilization and allocation of financial resources to commit to climate change adaptation. Provinces that experience frequent and severe climate hazards are more likely to be aware of and responsive to the need for climate change adaptation. We also highlight how climate change issues can be integrated into existing climate-related management initiatives such as avoiding or limiting impacts from strong typhoons and heavy rainfall, and also on the impacts on natural resources, which is illustrated by their efforts at mangrove rehabilitation. Two specific institutions, CIRCA and APSEMO, are discussed to give a clear view of how Albay is doing the work. The potential role of agroforestry systems in climate change adaptation in the province is discussed.

Mycorrhizal status of *Boswellia*-dominated dry deciduous lowland agroforests of Ethiopia

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Preferred session
C3. Agroforestry, water quality and environmental amelioration

Abstract
Different approaches have been employed to restore degraded dry deciduous forests in Tigray, Northern Ethiopia. Research has been done on use, distribution, population structure, chemistry of gum, and impact of interference on *Boswellia Commiphora* woodland, but there have been no reports from an under-ground perspective. A rehabilitation approach for revegetation of degraded ecosystems must begin with the evaluation of the mycorrhizal status and with the isolation, identification and characterization of the native AM fungi in the target area. Even though AM fungi can promote the ecological conservation and sustainable production of non-timber forest products by accelerating the establishment of seedlings, there are no published reports on the AM status of the dry deciduous forests where *Boswellia* dominates. An investigation of the roots and rhizosphere soil of 32 indigenous tree species revealed that all the species are colonized with arbuscular mycorrhiza. This is the first report on the mycorrhizal status of most of these species. *Glomus* is the dominant genus among the four genera, including *Acaulospora*, *Gigaspora*, and *Scutellospora*, identified. The average number of spores found is comparable to other similar tropical forest studies. Results indicated those arbuscular mycorrhizas are common in the dry deciduous lowland forests of Ethiopia. Therefore due attention should be given in seedling production and rehabilitation efforts to increase and maintain the mutual association to an acceptable range for the successful restoration of the degraded *Boswellia*-dominated dry deciduous lowland forests of Ethiopia.

The role of traditional agroforestry practice in biodiversity conservation and poverty alleviation: the Pendjari Biosphere Reser

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Preferred session
A2. Agroforests in humid tropical Africa

Abstract
This study discusses the socioeconomic determinants which explain the people’s choice in Pendjari Biosphere Reserve to include local species in their traditional agroforestry systems. It also points out the reasons which explain how these systems can be contrary to new agroforestry systems developed by researchers. We used questionnaires and interviewed 120 households to collect data on reasons which support the household’s choice to integrate into their farming systems indigenous trees whose products have traditionally been gathered from natural forests.
Multinomial logistic regression analysis revealed that the choice of dwellers in Pendjari Biosphere Reserve to integrate indigenous trees in their farming system increased with land availability and decreased with availability in the natural vegetation. In the same way, the utility of a species to farmers and its market value determine whether the head of the household chooses that particular species for use in the farming system. Concerning gender impact on the people’s choice which indigenous trees to grow, the multinomial logistic analysis point out that women favour plant species more than men. All species integrated into farming system are multipurpose species. For 80% of our research sample, this is being done in order to provide marketable products from farms that will generate cash for resource-poor rural and peri-urban households. However, according to 67% of respondents, in Pendjari Biosphere Reserve area, the expansion of these traditional agroforestry systems are facing a number of constraints, of which the most important is the lack of knowledge about species’ biology. Complementary studies are needed for a better understanding about these systems.

Market’s risk and production uncertainty as drivers of agroforestry land-use diversification for smallholder teak growers in Gunu

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Preferred session B9. Collective action for tree based rehabilitation of degraded lands

Abstract Markets are always changing. To remain aware farmers must consistently update their market information. Most smallholder farmers consider only the most basic market information when making land management and crop production decisions. Having little understanding of market specifications and market channels results in an unfavourable bargaining position and low prices for smallholder farmers’ products. Farmers also have high risk due to production uncertainties. Studies were conducted in Gunungkidul, Indonesia in 2007-2008 intended to analyse the livelihood strategies, marketing risks and production uncertainties of smallholder teak growers and their diverse agroforestry land-use systems. A farmer survey was conducted with 263 farm families and a tree garden inventory on 227 of 756 teak tree systems. Four types of teak production system were identified: monocultures (kitren); border plantings around non-irrigated agricultural fields; dry upland fields (tegalan); and homegardens. Data showed 50.6% of teak systems are tegalan and simultaneously used to cultivate cash crops, 22% are kitren, 22% are homegarden and 5.4% are border plantings. This land-use system reflected farmers’ livelihood strategies. Teak is planted as a ‘green cash deposit’ to meet urgent cash needs. Because farmers are in a cash-desperate situation when selling teak, they frequent receive low prices and/or sell before trees reach the point of greatest economic return. To maximize return and adapt to rapidly changing markets, the farmers need to: improve their understanding of market specifications and market channels for their crops; develop tree management decision scenarios in production and marketing; produce and provide the most-demanded commodity and offer a high return at the right place and time; conduct collective marketing to overcome smallholders marketing constraints; and communicate with consumers about environmental, social and competitive value as a strategy to enhance the value of their teak crop.

Key words: market, land use, livelihood strategy, Agroforestry, Teak.

Productivity of Pentadesma butyracea and morphological characterization of its fruits in Benin.

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Preferred session A5. Ecological sustainability: panacea or Pandora’s box?

Abstract Pentadesma butyracea (Sabine) is a multi-purpose tree from the Clusiaceae family. It provides a
diversity of non-timber products to indigenous people. In particular, fruit kernels are transformed into butter for cooking and cosmetics. Unfortunately, natural stands of *P. butyracea* are seriously threatened in Benin while basic information essential for its sustainable conservation is still lacking. Productivity per unit of time and area and the amount of sustainable yield that can be prescribed for harvesting are part of these information needs. It was in this situation that the present study aimed to: 1) assess *P. butyracea* fruit productivity according tree diameter at breast height and years; 2) characterize *P. butyracea* fruits from the point of view of their morphology; and 3) establish a regression model that links the fruits productive characteristics to their morphometric characteristics. Forty productive trees were followed during 3 production seasons. It emerged that: *P. butyracea* fruit productivity varied according to tree diameter at breast height and site. Optimum fruit productivity was observed in the 45-55 cm diameter class. The species fruit productivity had annual variations that are able to be explained by the rainfall regime that leads up to the flowering period. According to their shape, morphometric and productive characteristics, *P. butyracea* fruits were categorized into 4 groups. The best multiple regression model linking fruits’ productive characteristics to their morphometric characteristics, that was obtained was: \[ \ln(Wa) = 2.094 + 0.028 + 0.0001De + 0.1014 \text{ with: } R^2=0.9782; \text{ Adjusted } R^2 = 0.9781; p < 0.0000; \text{ residual standard deviation (S) = } 0.42130 \text{ and (where: Wa = almond weight; Lf = fruit length; Df = fruit median diameter; De = endocarp diameter and Wf = fruit weight).}

**Wood properties of *Gliricidia* (*Gliricidia sepium*) intercropped with cocoa in Malaysia**

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**Preferred session**
E1. Hot or cold: the role of underutilised crops for AF

**Abstract**
Trees planted from agroforestry practices can become valuable resources in meeting the wood requirements of many nations. *Gliricidia sepium* is an exotic species introduced to Malaysia mainly for providing shade, as live fencing and for providing shade for cocoa and coffee plantations. Despite much literature elsewhere on its multipurpose function in terms of ecological and social well-being, very limited information exists on the characteristics and wood properties of *G. sepium*. This study investigates wood physical properties (specific gravity and moisture content) and fibre morphology (fibre length, fibre and lumen diameter and also cell wall thickness) of *G. sepium* at 3 age groups (i.e., 3, 5 and 7 years of age). Wood samples were obtained from the Malaysian Cocoa Board located at Jengka 23, state of Pahang, Malaysia. In this area, *G. sepium* was planted to provide shade for cocoa plantations. Specific gravity (0.72) was significantly higher (p<0.05) for the 7-year-old than 5 (0.41) and 3 (0.35) years-old groups with a mean of 0.43. Mean moisture content was 58.3% with no significant difference between tree ages. Fibre diameter (22.4 \( \mu\text{m} \)) was significantly lower (p<0.05) for the 3-year-old group than 5 and 7-year-old groups (26.6 \( \mu\text{m} \) and 24.7 \( \mu\text{m} \), respectively. Means of fibre length, lumen diameter and cell wall thickness were 0.83 \( \mu\text{m} \), 18.3 \( \mu\text{m} \), and 6.2 \( \mu\text{m} \), respectively, with no significant differences detected between age groups. Further calculation on the coefficient of suppleness and runkel ratio suggest that wood from *G. sepium* may have the potential for insulation board manufacture and paper making. However, future studies should experiment with the utilization of this species for these products to determine its full potential.

**Key words:** *Gliricidia sepium*, specific gravity, fibre length, fibre diameter, lumen diameter and cell wall thickness.

**Identification of morphological variation of annona in Sri Lanka.**

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**Preferred session**
A6. Ecophysiological bases of agroforestry-system design

**Abstract**
Annona is a genus of tropical fruit trees belonging to the family Annonaceae. Members of the Annonaceae family were identified as major alkaloid-bearing plants. An alkaloid with anti-tumour activity was identified from 5 species of *Annona* that are available and used as fruit trees. These
species are sugar apple, *Annona cherimola* Cherimoya and *Annona glabra*. Most annonas are deciduous. The fruits vary from species to species with differences in shape, size and colour. The flowers are pollinated by insects, although fruit production is usually very poor. *Annona muricata* is the most common species in Sri Lanka. Ripened fruits are eaten fresh, sap of the fruit is used to prepare drinks and ice cream. Immature fruits are cooked and eaten as a vegetable. All parts of the sour-sop tree are used in natural medicine in Sri Lanka. Sugar apple *Annona squamosa* is a small shrub (2-4”), its fruits are soft with creamy white flesh. The common sugar apple has a green skin but dark red varieties are also available. *Annona reticulate* is a tree of 20-35 ft. It has an advantage over other annona’s in that they tend to ripen slightly later in the year than their relatives. *Annona cherimola* is subtropical and available only upcountry. *Annona glabra* is medium-sized tree of 40-50 ft. Pond apples can stand immense flooding and spend weeks at a time with their roots under water. The pond apple is very useful as a rootstock for others. An average fruit yield is 50-100 kg/tree and the commercial life of a tree is about 15 years; and it is a multipurpose tree. The trees are easy to cultivate, require comparatively little care and do not suffer from serious pests and diseases.

Community actions and strategies for rattan sustainable development

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**Preferred session** D3. Policy formulation and stakeholder engagement in NRM

**Abstract**

This paper presents community actions and strategies for rattan sustainable development which are used in an ITTO-funded project (ITTO PD 334/05 Rev. 2 (I)) entitled ‘Demonstration and Application of Production and Utilization Technologies for Rattan Sustainable Development in the ASEAN Member Countries’. The project aims to strengthen ASEAN collaboration to reduce poverty at the community level through a network that supports and prioritizes the urgent needs and concerns for the development of the rattan industry. One of the components of the project is a pilot demonstration which is the heart and backbone of this project. The pilot demonstration showcases the mature, well-developed technologies that ensure sustainable production of quality rattan poles for the industry. This component focuses on the application and dissemination of rattan production technologies that involve community participation primarily to uplift the socioeconomic conditions of the target communities. Further, the project provides technical assistance and training for the communities to apply these technologies. Since this project caters to the community, the approach used is to establish the nursery and plantation demonstration plots by the communities engaged in rattan production. This approach should be applied to all participating ASEAN countries which include Cambodia, Indonesia, Lao PDR, Myanmar, The Philippines, Thailand and Viet Nam. The activities include site selection, community organizing, survey of seed sources, collection of rattan seeds, construction of seed beds, sowing of seeds, nursery establishment and maintenance and protection of nursery, out planting, plantation establishment, maintenance and management. Community participation is the key to make rattan plantation establishment successful.

Microbial activity, organic C accumulation and 13C abundance in soils under alley-cropping systems after 9 years of recultivation of quaternary deposits

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**Preferred session** B4. Agroforestry in Europe: land reclamation

**Abstract**

The impact of alley cropping on post lignite mine soils developing from quaternary deposits after 9 years of recultivation was evaluated on the basis of microbial indicators, organic C and total N contents, and the isotope characteristics of soil C. Soils were sampled at 0-3, 3-10 and 10-30 cm depths under black locust (*Robinia pseudacacia* L.), poplar clone (*Populus* spp.), and the transition zone and the middle of alley under rye (*Secale cereale*). There was no significant vegetation effect on microbial properties probably, due to the high variability, whereas organic
C and total N contents at the 0-3 cm layer were significantly higher under black locust and poplar than in the transition zone and rye field. Organic C and total N contents, basal respiration, microbial biomass and microbial quotient decreased with soil depth. Soil organic C and total N contents more than doubled after 9 years of recultivation, with an annual C and N accretion rate of 162 g Corg m⁻² year⁻¹ and 6 g Nt m⁻² year⁻¹. The values of microbial properties indicated that the soils are in early stages of development; the C isotope characteristics confirmed that the sequestered C was predominantly from C3 plants of the alley-cropping systems.

Practising agroforestry in plantation forest contributing community livelihoods: a case from Sagarnath, Nepal

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Preferred session A5. Ecological sustainability: panacea or Pandora’s box?

Abstract

The Government of Nepal introduced the concept of managing semi-mechanised plantation forests to maximize and sustain the supply of fuelwood for domestic and industrial use in the late 1970s when about 13 000 ha of land was managed under Sagarnath Forestry Development Project (SFDP) in the central terai region of Nepal. The management option for such plantation forests is also involved local communities in agroforestry cultivation. Local communities used cereal and medicinal and aromatic plants within the plantation area for 3 years. A clear-felling operation was carried out in 500 ha of eucalyptus plantation annually, in which about 1500 families, mostly poor, are involved in Taungya cultivation (a form of intercropping). With a formal agreement contract with SFDP, these farmers continue to grow agricultural crop (mainly maize, mustard) for 3 years when a new plantation has grown up to certain height (sapling stage). A preliminary assessment shows that a 5-member family can secure food and sustain itself from the production of intercropping for at least 9 months. Moreover, local communities are also involved in medicinal and aromatic plant (MAPs) cultivation under the intercropping system. Presently, about 200 ha of land are contracted for such MAP cultivation, linked to the involvement of a private company. These MAP cultivators are earning about 40 000 Nepali rupees (USD 600.00) per ha of land annually as net profit from the sale of MAP to local traders. Despite the fact that practising agroforestry contributes a lot to local livelihoods, building trust among local communities has always been a major bottleneck. A comprehensive participatory management prescription on agroforestry within the plantation will ensure the optimum benefits to forest production and the local people. If managed properly, local communities will receive much of the benefits from agroforestry while increasing the productivity of plantation forests.

Assessment of ‘climate change-driven terrestrial plant biodiversity response in Sikkim Himalayas by developing models using GIS

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Preferred session C4. Mitigation and adaptation to climate change

Abstract

Anthropogenic activities are thought to be the primary force for global climate change. Understanding how vulnerable forest ecosystems are to climate change is a key requirement if sustainable land use and forest management is to be achieved. The proposed research on aspects of the impact of climate change on biodiversity would help policy makers in developing and designing effective long-term responses in terms of suitable mitigation and adaptation strategies. It would also be helpful in predicting the species of Sikkim Himalayas in India which might go extinct as a result of climate change when climate change deletes the ecological amplitude of the species. Three general classes of models for assessing the impact of climate change on vegetation distribution, 1) equilibrium biogeographical Models, 2) Frame-based transient ecosystem models, and 3) dynamic
global vegetation models (DGVMs), cannot be applied straightway to Sikkim Himalayas as they mostly operate at a coarse spatial resolution and represent vegetation at the level of biome or plant functional types, rather than at the species level. Species-level modelling is being done for predicting the responses of threatened, keystone or target species. The bioclimatic limits would be defined on the basis of physiological processes and their physical limits. Biotic interaction between species and dynamic responses of vegetation like migration, competition and succession would be captured in to the model. For vulnerability analysis, response of trees to climate-driven phenological and biophysical variables would be analysed in their fundamental regeneration niche. For inclusion of local specificities like terrain complexity, altitude and aspect, the digital elevation model (DEM) would be integrated into the models on a geographical information system (GIS) platform.

**Some experiences in forest rehabilitation and afforestation in dryland areas of Mongolia**

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**Preferred session** C6. Agroforestry and reconciliation ecology

**Abstract**

Forests in Mongolia, which have a very significant role in ecological conservation of the country, are shrinking year by year under the negative impact of forest fires, harmful insect damage, illegal logging activities and uncontrolled grazing. According to New Law on Forests of 2007, the Mongolian Government is paying more attention to expanding reforestation and afforestation activities in some areas in order to reduce land degradation and deforestation in dryland regions of Mongolia. Due to negative human activities, forest disturbances such as forest fire, illegal cutting and over grazing in forest area of Mongolia deforestation and forestland degradation of the country is increasing continuously. This means that forest degradation and deforestation in certain areas of Mongolia is the leading factor in increased of land erosion and land degradation. With this situation, reforestation and afforestation have become very crucial countermeasure to restore dryland ecosystems. Despite the above-mentioned situation of deforestation, the implementation of degraded forestland restoration work has not met the overall needs and demands for reforestation work or the requirements for ecological forest conservation of the country. A major issue relating to ecosystem management and reforestation and afforestation in Mongolia is related to difficult site conditions (another important issue is fire protection). In many situations forest plantations are becoming an intensive land-management activity and an economic investment in the country. Forest plantations can also be taken up for site rehabilitation and as a conservation activity depending on needs and purpose of ecological restoration work in the selected areas of the country. Efforts at planting trees in the desert ecosystem so far have been small due to technological, funding and climate-related problems.

**Agroforestry: perspectives and performance in Indonesia**

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**Preferred session** D3. Policy formulation and stakeholder engagement in NRM

**Abstract**

The increasing population and competing needs for land among land-based developments have required the Government of Indonesia to allocate state forest land into protection and production areas to balance development and conservation. Based on the Spatial Plan in 32 provinces, 60 million hectares of the production areas are allocated for production forests. The forests are managed as a source of timber and non-timber forest products, as well as environmental services. With the increasing needs for food, water and energy, it is believed that the forests could be best managed to supply the country’s demand of those needs by practising agroforestry. However, shifting the forester’s paradigm from timber management to an agroforestry system would need a deeper understanding of the agroforestry concept and strong commitment to implement the
The Forest Stewardship Council (FSC) was created as a market-linked tool for promoting responsible forest management (FM) in response to accelerating deforestation, particularly in tropical regions. At its heart is the philosophy of finding consensus solutions through a multi-stakeholder approach. After in-depth stakeholder consultation, the FSC sets standards for responsible FM, also in agroforestry systems. Among others things, the FSC system is rights- and equity-based and dedicated to protecting peoples’ rights and demonstrating social benefits. These relate to tenure and use-rights to the land and forest resources, the protection of customary and legal rights, the enhancement of community well-being and the encouragement of the efficient use of the forests’ multiple products and services. The promotion of community-managed forests is high on FSC’s strategic agenda. The FSC acknowledges that community-managed (agro) forestry systems can play important roles in addressing climate change by reducing or preventing greenhouse gas emissions and/or increasing carbon sequestration in situations where business-as-usual management practices are improved. The FSC further acknowledges that there are potential risks associated with developing forest carbon projects and markets, including threats such as forest conversion, forest degradation (expansion of industrial logging areas), and violation of indigenous peoples’ rights. In late 2008 the FSC has warned that any moves to set up a carbon market around avoided deforestation should not lose sight of the other environmental and social issues (including benefit sharing of carbon revenues) that intertwine in forest management. In November 2008 the FSC membership commissioned the FSC to explore the role that FSC’s accreditation, governance and certification can play in frameworks to mitigate climate change by maintaining and/or increasing carbon stocks. A range of options shall be examined, focusing on their risks and opportunities, including those stated above. The paper will explore the activities planned by FSC focused on community-managed systems.

With examples of Forest Stewardship Council (FSC)-certified farm forestry from China, Guatemala and Kenya the authors demonstrate how the process towards certification and the FSC certificate has brought a range of benefits to agroforestry communities. The FSC was created as a market-linked tool for promoting responsible forest management (FM) in response to accelerating deforestation, particularly in tropical regions. At its heart is the philosophy of finding consensus solutions through a multi-stakeholder approach. Although equity-based and dedicated to protecting peoples’ rights and demonstrating social benefits from the beginning, the concept of FSC certification...
was originally not designed for agroforestry operations in the tropics. Today FSC considers it a priority to address the needs of the small communities with regards to better understanding and managing the forests, through special programmes for group certification and for small and low-intensity managed forests (SLIMFs) also under agroforestry systems. Certification of FM and related processes can offer direct economic and indirect benefits: improved market access for products; better organization of FM and of the people involved; and consolidation of land tenure of customary rights. The FSC’s processes are acknowledged by aid agencies as tools to empower forest-dependent people. In Kenya some 600 farm forest managers provide certified material from sustainable agroforestry practices, which helped both to secure legally harvested raw materials for the Akamba group with 3000 handicraft workers and therefore their livelihoods and those of their families, as well as ensuring good economic and environmental land use. In China farm forestry companies comprise forest plantations and wood processing units, and after they found that forest certification would bring increased opportunities in terms of expanding its international market they have undertaken the marketing of their own products, and retailers such as Home Depot and B&Q are increasingly stocking FSC products. Similar positive results are reported from Guatemala. The paper explores these examples further.

Status and opportunities of agroforestry in Uttarakhand State of India

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract
The tree cover not only provides shade but also protects from wind and reduces much of the velocity of the falling rains. The root system binds soil together and allows water to percolate deep down into the ground. Its role is the sustenance of a massive population which depends on tree production for the satisfaction of daily domestic needs of fuelwood, fodder, food, fruits, fibres, and small timber, etc. The National Forest Policy (1988) of India emphasized that 2/3 of the area of hills should be under forest cover, but in Uttarakhand State a 24 442 km2 area (45.70%) is reported to be under forest cover, out of which very dense forests accounts only for 4002 km2 (7.5%) while 14 396 km2 (27%) forest area is under moderately dense forest and about 6044 km2 (11.30%) area is under open forests. Out of the total forest area of 34 662 km2, 24 638 km2 is under reserved forest, 9882 km2 is under protected forest and 131 km2 is unclassed forest. Tree cover outside the forest in the State is 13 090 km2 with a tree density of 15.40 trees/ha. Per capita forest including tree cover is 0.30 ha in this state. Agroforestry seems to be the best solution to increase the forest cover of the state. Agricultural land holdings of Uttarakhand State are small and scattered in hilly regions while they are medium and large in Tarai regions. Traditionally, the farmers grow a number of tree species on their agricultural fields such as Bauhinia variegata, Celtis australis, Dalbergia sissoo, Ficus spp., Grewia optiva, Morus spp., Populus spp., and Toona ciliata, etc. Agri-silvi-, horti-agri- and silvipastoral are the dominating agroforestry systems. The paper deals with the role and importance of tree species under agroforestry in Uttarakhand.

Methodological framework for integration of multidisciplinary data into coffee agroforestry systems: example of the CAFNET project.

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
Globally coffee is cultivated on 10 billion hectares in 80 countries. The coffee industry generates livelihoods for about 125 million people worldwide. The environmental impacts of these coffee plantations are large, yet coffee is seen as an eco-friendly crop as it is generally grown under shade. To better understand the benefits of coffee agroforestry systems (CAFS), an integrated approach is required. To this end, stakeholders of coffee, researchers, local authorities and government agencies
are involved in a participatory research and development project called CAFNET (Connecting, enhancing and sustaining environmental services and market values of coffee agroforestry). In India, coffee is estimated to cover around 350,000 hectares with a total annual production of 288,000 MT. About 85 percent of the area lies in the Western Ghats, one the hotspots of biological diversity. As part of the CAFNET project, researchers from different disciplines have come together to work on CAFS in Kodagu district, India. As a result of the magnitude and multidisciplinary nature of the research involved, one of the most important tasks was to understand and integrate data collected by researchers with backgrounds in ecology, economics, policy, agronomy, biophysics, social sciences and geo-informatics. In order to seamlessly integrate the different data, a landscape approach for collection of data was followed, as envisaged by the CAFNET framework. The idea was to come up with broadly applicable scientific outputs including ecosystem services that will benefit the stakeholders of CAFS. We present the framework used to integrate data collected from various disciplines. These data drawn from plot level were up-scaled to the landscape level using approaches drawn from geographical information systems and database management. Companion modelling was used to build scenarios that can be proposed to stakeholders to help them in their decision-making processes.

Success story of a Subabul-based farming system in southern India: a case study

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Preferred session A5. Ecological sustainability: panacea or Pandora’s box?

Abstract

Subabul (Leucaena leucocephala (Lam.) de Wit) a multipurpose tree was introduced in India for meeting the demand of fuelwood and fodder and to provide shade in plantation crops some 400 years back. Of late subabul has been integrated into the farming systems of southern India especially in coastal Andhra Pradesh and certain districts of Telangana by a large number of farmers as an industry-driven activity for pulpwood. A case study of subabul-based farming system in 4 districts of Andhra Pradesh was conducted during 2005-06 by a team of researchers from Indian Grassland and Fodder Research Institute (IGFRI), Jhansi, India, in collaboration with all relevant stakeholders: farmers, industry officials/research wings, and other line departments. The perceptions of 172 subabul-growing farmers and other stakeholders revealed 3 farm typologies, type I: subabul for pulp wood; type II: subabul with intercrops; and type III: subabul with animal husbandry and intensive fodder use. The farmers significantly (P<0.01) preferred the 1x1 m spacing with block plantations and wider spacing (2.5x0.75 m) was adopted when subabul was grown with intercrops. Emerging subabul-based agroforestry systems were identified during the study. Profitability of subabul in different typologies of farm was compared vis-à-vis annual commercial crops. Economic analysis indicated type III farmers with intensive fodder use and sheep rearing were found to earn higher returns (B:C ratio of 3.42) compared to other types. The carbon sequestration potential of the tree species was found to be 12.8 Mg Carbon ha-1 in Andhra Pradesh. Based on this analysis, opportunities for a better and more secure livelihood were described through improved bioresource flows in subabul-based farming systems.

Eco-physiological characterization of baobab (Adansonia digitata): dependence of photosynthesis on light intensity, temperature and CO2 concentration

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Preferred session A6. Ecophysiological bases of agroforestry-system design

Abstract

Baobab is an under-utilised fruit tree and an important food source for the rural poor. It grows in hot and dry environments in sub-Saharan Africa, where water deficit is one of the major constraints to agricultural production. It’s a fruit tree very well adapted to drought but very little is known about this mechanisms to drought adaptation. The overall research objective of this work is to characterise the eco-physiology of baobab (Adansonia digitata). In order to achieve this research
objective, we conducted gas exchange measurements to determine the photosynthetic variation of
the leaves of baobab seedlings. Photosynthesis was measured as a function of temperature using a
range of °C levels and varying light intensity. The experiment was conducted at the University of
Antwerp from 17 July - 9 August 2008. Seeds were collected in Mali, and planted in the greenhouse
in November 2007. In a first phase, photosynthesis was measured on all leaves of 3 plants. After
this initial greenhouse experiment, plants were transferred to a mini-phytotron and photosynthesis
was measured on the 4th topmost leaf using a series of light intensities ranging from 2000 0 µmol
m-2 s-1 and a series of °C concentrations from 0 2000 µmol CO2 mol-1 . Measurements started
48 hours after plants were transferred to the phytotron to allow plant acclimatisation and were
performed at a starting temperature of 40°C down to 25°C, in steps of 3°C. Results showed that
photosynthesis is higher in top leaves and in branches’ end leaves. Photosynthesis decreased with
increasing temperature from 25°C to 40°C and its rate was not affected by CO2 or light variation.
For the same level of temperature, photosynthesis increased from 0 800 µmol °C mol-1 and
become constant. This situation is similar for the light; photosynthesis increased from 0 750 µmol
m-2 s-1.

Empowering local rattan farmers in the ASEAN through access to information

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Preferred session  D5. E-learning and distance education in agroforestry
Abstract
This paper presents the strategies for empowering local rattan farmers through access to
information which are used in the project ITTO-Philippines-ASEAN Rattan Project, formally
titled, ‘Demonstration and Application of Production and Utilization Technologies for Rattan
Sustainable Development in the ASEAN Member Countries’, which is funded by the International
Tropical Timber Organization (ITTO). This project aims to strengthen ASEAN collaboration and
reduction of poverty at the community level through a network that supports and prioritizes the
urgent needs and concerns of the development of the rattan sector. How do we empower ASEAN
rattan farmers? The project believes that access to information is key to equitable sharing of benefits
derived from nature-based resources such as rattan. To provide ample information about the rattan
industry in general, the project’s website www.aseanrattan.org was developed and launched in
November 2006, and has as of today, a total of 71 pages which feature: production and utilization
technologies for rattan; training conducted by the project; ASEAN policies on rattan production
and utilization; marketing data; plantation development; and the Rattan Newsletter. Nowadays
farmers can access the cyberspace and digital world because governments provide infrastructure
for internet connections even in far-flung areas. In the Philippines, even the remotest islands are
now provided internet connection by private companies. This makes way for open access to
information provided in cyberspace. The website envisions the creation of a link between the
rattan farmers and rattan furniture makers with their target markets to enable them to access the
right market systems and pricing for their products.

Effects of silvopastoral system conversion into different land-use systems on soil
carbon and nitrogen storage

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Preferred session  C5. Soil organic matter and nutrient cycling in multi-strata AF systems
Abstract
In agricultural soils, the carbon stocks are affected by changes in land-use systems or management
practices. When silvopastoral systems are converted to arable lands, an effective decrease in soil
carbon stocks, mainly in upper soil layers is expected. The aim of this work was to evaluate total
C and N stocks in soil after conversion of silvopastoral systems to different land-use systems. The
study areas are located in northeast Germany and refer to different land-use systems comprising:
2 areas after 4 years of conversion from silvopasture to arable land (SP-AR) and grassland (SP-
GL); and 2 areas cultivated for more than 30 years under continuous arable land (C-AR) and silvopasture with apple trees and grass (C-SP). Carbon and nitrogen stocks were evaluated at 2 different depths (0 10 and 10 20 cm). Total carbon stocks ranged from 8.6 16.1 Mg ha-1 at 0 10 cm and from 7.7 13.4 Mg ha-1 at 10 20 cm depth. Soils under continuous arable land presented the lowest C stocks in the upper layer. After 4 years of conversion from silvopastoral system into arable land and grassland, total stocks of C and N had values similar to silvipasture when the 0 20 cm depth was considered. Carbon stocks declined by 47% from the 0 10 to the 10 20 cm layer in treatments where soil was not revolved (C-SP and SP-GL). Total nitrogen followed the same trend as carbon, with the lowest value at C-AR study site (0.87 Mg ha-1 at 0 10 cm). Except for C-AR, the C/N ratio was similar (around 12.5±0.2) for all land-use systems at 0 10 cm depth. Land-use conversion from silvopastoral systems in arable land led to a decline in the stocks of C and N in the upper layer.

Identification of restoration tree species by examining the natural succession and recovery after slash-and-burn farming in a tropical Vohimana forest in eastern Madagascar,

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract Slash-and-burn agriculture is a driver of deforestation and ecosystem degradation, with subsequently large effects on biodiversity. This study was conducted in the tropical Vohimana forest in eastern Madagascar, which consists of fragments of slash-and-burn patches, intermingled in between secondary and primary forest. By recording species richness, abundances, and composition of trees, shrubs and herbs in fallows of various age and land use history, and in the secondary and primary forest, we aim to examine how slash-and-burn farming (number of cycles per se and years per cycle), years since abandonment, and environmental factors (distance to primary forest and topography) may affect the natural succession and recovery of the forest ecosystem. We used ordination analyses to examine natural tree recruitment to identify potential restoration species that are early colonizers of fallows and occur naturally in the forest. Our results show shrub dominance the first years after abandonment, but increased species richness and abundances of tree seedlings and saplings from the youngest fallows to the secondary and primary forest suggest that natural recovery of the fallows will develop towards the diversity and composition of the secondary and primary forest, although it will take more than 30 years. A high number and intensity of slash-and-burn cycles led to a decrease in tree seedling and sapling richness and abundance, suggesting that reducing slash-and-burn intensity will reduce recovery period. Our approach was to identify tree species for active restoration, and 5 species are suggested based on their early establishment as seedlings in the fallows and their survival as saplings and adults through vegetation succession. These can be planted into abandoned fallows to speed up vegetation and soil recovery, such that fallows can be usable within the needed time and so that the extension of cultivated areas can be prevented. This study shows how restoration species can be identified by examining natural succession and recovery of degraded forests systems.

Economics of tree cultivation in dry land: a study of farm forestry in India

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract Land and trees occupy a significant role in maintaining an ecological balance and promoting economic development. Increased environmental concerns necessitated the promotion of tree-growing activities. Farm Forestry, an activity of growing trees on farmlands by farmers,
was implemented to meet wood-based requirements as well as to reduce pressure on forests by increasing tree cover, and arresting environmental degradation in India. The Farm Forestry programme encourages farmers to grow trees on farmland, especially in arid and semi-arid regions so as to make efficient use of fragile resources. Hence, it is a measure to resolve economic and environmental problems of ecologically disadvantaged areas, as well as to improve farmers’ incomes. This study examines the determining factors of farmers’ participation, the comparative economics of tree crop vis-à-vis other crops, and it also assesses economic viability of trees grown under the Farm Forestry programme in Karnataka, a Southern State in India. The study uses a cost-benefit analysis technique, excluding and including opportunity cost of tree cultivation, to assess economic viability of tree crops. The analysis reveals that food and cash requirements determine farmers’ decisions for tree growing, and that tree cultivation is remunerative and promises to improve incomes of farmers, especially of small farmers, in addition to improving natural resources of dry eco-regions.

Domestication of *Irvingia gabonensis* (Aubry Lecomte) by air layering

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**Preferred session** B8. Participatory tree domestication (PTD) for land rehabilitation

**Abstract** *Irvingia gabonensis* is one of the important indigenous African humid tropic fruit species. Methods have been developed for phenotypic selection and massive vegetative propagation of this species; but the techniques for the capture of desired traits through inexpensive technology methods are still lacking. A series of experiments were conducted to assess the effects of Seradix-2 (treated and untreated marcotts), branch diameter (less than 3 cm, and 3–5 cm of diameter), position in the crown (lower, middle and upper), and the combined effect of branch length and diameter (50 cm length, 2 3 cm diameter; 50 cm length, 4 5 cm diameter; 100 cm length, 2 3 cm diameter; 100 cm length, 4 5 cm diameter; 150 cm length, 2 3 cm diameter; and 150 cm length, 4 5 cm diameter) on the survival of *I. gabonensis* marcotts. After 12 months, the percentage of rooted marcotts was significantly higher (P < 0.05) in untreated marcotts (50 ± 7.3 %), than in treated ones (31 ± 6.7 %). The percentage of rooted marcotts was significantly higher in marcotts of 3 5 cm (46.9 ± 5.1 %), than in marcotts of 2 3 cm of diameter (32.1 ± 5.2 %). There was no significant difference between positions of marcotts in the tree. After 8 weeks, the best survival rate (40 %) was observed in marcotts with 100 cm of length and 2 3 cm of diameter. The lowest survival rate was observed in marcotts with 200 cm of length and 4 5 cm of diameter (10 %). It can be concluded from this study that *I. gabonensis* is amenable to marcotting but further studies are needed to improve the survival rate.

**Key words:** domestication, *Irvingia gabonensis*, marcotts

Agroforestry systems for biodiversity conservation in the Biosphere Reserve of Pendjari in Benin (West Africa)

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract** The Biosphere Reserve of Pendjari is known for it impressive floristic diversity. However, anthropogenic activities such as agriculture are causing modification and biodiversity loss in Pendjari. The agroforestry system is, nowadays, considered a sustainable land-use system. But different species are used for different goals. This study aims to: (1) characterize Pendjari land use vegetation, (2) determine the importance of agroforestry in agriculture, (3) identify the species included in this system and its goals. Data were collected following the two villages bordering the protected area. Phyto-sociological surveys were performed using Braun-Blanquet method. Inside 60 sampled plots of 30 m x 30 m, a systematic inventory of species used in agroforestry
has been made. To understand the usefulness of this system, structured questionnaires were administered to farmers and other people exploiting these areas. A descriptive analysis has been done with collected data. ‘Detrended correspondence analysis’ (DCA) revealed the impact of human activities on vegetation. The Pendjari land use is characterized by typical vegetation of disturbed areas. The natural savannah with two strata is reduced into one stratum with large distribution plant species predominant. Fourteen plant species are used in agroforestry systems. The most frequent, with the highest density, is *Vitellaria paradoxa*. This practice improves soil fertility and reduces soil erosion which is very high in the study area. Agroforestry is unfortunately limited to few farming systems due to the absence of cultivatable soil. It is necessary to promote the agroforestry system to reduce land-use pressure on the Park and improve soil fertility. Thus, sustainable use of biodiversity could be expected in Pendjari Biosphere Reserve.

**Key words:** agroforestry, protected area, land use, agriculture, biodiversity, benin.

**Structure and spatial distribution of traditional agroforestry systems in Togo.**

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

The presence of trees in agro-systems is a fundamental property of agrarian landscapes in tropical Africa. This study aims to analyse the spatial distribution of traditional agroforestry systems as well as their structure in Togo. Forest inventory and ethno-botanic investigations were carried out in several sites across the country. In each site tree inventory was done in plots of 50 m x 50 m, completed by a survey on the uses of species conserved in farms. Three types of traditional agroforestry systems were identified: homegarden, farm parkland (both of which extended across the study area), and multistage farms of cocoa and coffee plantations in southwest of Togo. The structure of these agro-systems varied according to latitudinal gradient and practices of local communities. Some agroforestry species like *Parkia biglobosa*, *Vitellaria paradoxa*, *Vitex doniana* have a large distribution spectrum, and others were restricted to specific climatic regions. The diversity index of Shannon increased from 0.51 bits in the north to 3.27 bits in the southwest region. There is a relationship between plant diversity of parkland and selectivity of species conserved in agro-systems by local communities. Wherever this selectivity is high, the parklands are mono-specific. Tree density on farms decreased from forest area to the north Sudanian zone. Tree species conserved on farms provide many non-timber products such as food (leaves, fruits, flowers), forage, medicinal plants, fuelwood, and material for construction and craft. They are also a major source of economic income in rural areas.

**Agroforestry systems of Togo’s forest zone**

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops

**Abstract**

The southern part of Atakora’s mountains (6°45’ – 8°15’ N and 0°30’ – 1° E) correspond to the semi-deciduous forest zone of Togo. Here, there is also an area of cocoa and coffee plantations under preserved forest tree species forming agroforests, which are the most widely distributed multistrata systems in tropical forest zones. This study was carried out on those systems with the objective of determining their typology. Data were collected in 141 homogeneous plots about 400 m² distributed in 64 sites. Within the plots, all forest tree species were inventoried. Data collected were submitted to multivariate analysis using community analysis package (CAP) for plots ordination and classification. The major agroforestry systems in the study area are: multistage farms (agroforests), parklands, fallowlands and homegardens. These agroforests are classified into several sub-types according to distribution of the dominant crop and forest tree species (coffee agroforests, cocoa
Phanerophytes dominated the life form spectrum while on the other hand Guineo-Congolian species and introduced species dominated the phytogeographic spectrum. Of the 228 species encountered in the flora of these agrosystems, 69% were woody species, 19% were lianas and 11.8% were herbaceous species. They belong to 169 genera and 64 families. Leguminous (Mimosaceae, Caesalpiniaceae, and Papilionaceae), Moraceae, Euphorbiaceae, Apocynaceae and Rubiaceae were the richest families. The predominant species are Milicia excelsa, Albizia adianthifolia, Albizia zygia, Antiaris africana, Alstonia boonei, Aubrevillea kerstingii, Ceiba pentandra (timbers), Elaeis guineensis, Musa sapientum, Persea americana, Mangifera indica, and Citrus sinensis (fruit species). They provide marketable products which give farmers some substantial benefits. Moreover, speculators of others areas base their economy on this business. Coffee and cocoa are also an important income source for both farmers and the country.

Key words: Togo, agroforestry systems, forest, typology.

Participatory Evaluation of Flemningia congesta (macrophylla) for livestock fodder in the Terai region of Nepal

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Preferred session A.11. on silvopastoral systems

Abstract Flemningia congesta (macrophylla) has recently been introduced to Nepal as a forage species, and there is little information on optimal management regimes and its adoption by Nepalese farmers. The objectives of this study were therefore; (i) to measure the effects of cutting height and intervals on Flemningia biomass production and fodder quality, (ii) to evaluate Flemningia on-farm for its potential in the Nepalese farming context, and (iii) to develop a strategy for the participatory selection and evaluation of agroforestry species. The effects of 3 cutting heights; 25, 50 and 75 cm and 2 cutting intervals of 12 and 16 weeks on biomass production and fodder quality were determined in an on-station experiment in Chitwan district, designed as a randomized block with a split plot arrangement. Sixteen on-farm trials and over 350 informal dissemination (participatory agroforestry species evaluation (PASE)) trials were organized through dairy groups and livestock farmers during 2001 to 2004. In the on-station experiment, 75 cm cutting height and 16 weeks cutting interval resulted in higher biomass yield during 2001-2002. In the on-farm trials and PASE, farmers observed that cutting Flemningia at more than 50 cm height increased survival rate and biomass yield when they practised 2-3 cuttings each year. Shorter cutting intervals resulted in higher concentrations of phosphorus (P) and potassium (K). This is especially noteworthy as farmers feeding this forage to lactating cattle were able to reduce supplemental feeding of calcium (Ca) and phosphorus (P). Our experience suggests that PASE is an effective means of selecting, evaluating and promoting agroforestry species in developing countries like Nepal.

Key words: dairy groups, forage, on-farm experimentation, farmer’s participation, participatory agroforestry species evaluation (PASE)

Diversity and use of indigenous fruit trees in the traditional agro-silvo-pastoral systems of the Nuba Mountains, Central Sudan

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Preferred session A.11. on silvopastoral systems

Abstract Largely situated in the Sahelian zone, the Nuba Mountains face the typical problems characterizing the ‘Sahel Syndrome’. The predicted effects of climate change in this region are likely to further increase these problems. While indigenous fruit trees (IFT) are considered an important natural
resource to mitigate environmental degradation and to alleviate rural poverty in many countries of
the tropics and subtropics, little is known about IFT in Sudan. Since 2002 more than 30 IFT with
multipurpose uses were identified in the Nuba Mountains. Among the most important species are
Adansonia digitata, Balanites aegyptiaca, Grewia tenax, Tamarindus indica and Ziziphus spina-
christi. The fruits are collected by the local population particularly by women and their children and
used for home consumption. Such fruits are valuable to secure the survival of the poor, specially
during food shortages and pre-harvest periods. Some fruits are also marketed and provide cash
income. G. tenax fruit which is known to be very rich in iron (up to 10 mg (100 g)−1) fetch 17 times
the price of sesame on local markets. Our results indicate the existence of a considerably high
morphological intra-specific diversity which merits further study. For example, four different fruit
shapes (sharply ovoid, narrowly-ellipsoid, cylindrical-ellipsoid and globose) of A. digitata were
identified. IFT play an important role in the traditional homegarden (jubraka) systems where they
are often grown for food and fodder or as shade trees, hedges, and living fences. However, rapid
transformation into commercial vegetable gardens occurs at the expense of trees. The function
and diversity of IFT in traditional and transformed jubraka systems in the Nuba Mountains will be
further studied within a recently approved project funded by the Deutsche Forschungsgemeinschaft
(DFG).

Sap flow in coffee: comparison of two methods (heat balance and heat dissipation),
calibration and applicability in the field

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Preferred session
A1. Multistrata agroforestry systems with perennial crops

Abstract
A correct evaluation of coffee transpiration is required for many purposes, such as hydrological
services, drought, sustainable irrigation, even in regions where water is not a limiting factor. Two
sap flow methods are commonly used in order to assess transpiration of individual plants: i) the
Granier’s method, based on the thermal dissipation, yields sap flow density, but this requires
a specific calibration; and ii) the energy balance method (e.g. Dynagage®), which provides a
calibration-free measurement of sapflow, but with inherent drawbacks (price, fragility, intolerance
of the plant). It was hypothesized that an adequate combination of both methods would allow
efficient and long-term evaluation of coffee sap flow in the field. We tested both methods on 2
m high adult coffee plants, transplanted in containers and acclimated in a greenhouse 6 months
before the experiment. Nine plants were equipped with sap flow probes, 6 Granier (half were 2
cm long and half were 1 cm long), and 3 with Dynagage®. Diurnal transpiration of all plants was
controlled gravimetrically using an electronic scale (daily error < 1% of transpired water), after
covering the soil. We obtained good correlations between every sap flow method and gravimetry.
R2 ranged between 0.71 and 0.94 and was higher for Granier’s probes. The CV was less than 25%.
Both methods were reliable. As expected, the Dynagage® probes yielded non-biased estimations
of transpiration, whereas the home-made Granier’s probes required a specific calibration: we
recorded distinct calibration coefficients for the 2 cm and for the 1 cm probes. We confirmed
that the natural thermal gradient in the stem of these short trees was not negligible. Taking into
account in every method allowed a significant improvement in the estimations of transpiration.
We concluded that Granier’s probes were attractive for coffee sapflow in the field, considering
their cost-effectiveness, accuracy and suitability for long-term monitoring, but provided that they
were duly calibrated using Dynagage® periodically in the field.

Litter fall, decomposition and nutrient release of Senna macranthera leaves and their
influence on coffee yield and environmental factors

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Preferred session
A1. Multistrata agroforestry systems with perennial crops
Abstract

Litter quality, deposition, decomposition and nutrient release are several important characteristics for the suitability of tree species to coffee agroforestry systems. Our research focussed on a native species from the Atlantic Forest, *Senna macranthera*, and aimed to: a) describe and quantify litter deposition and to assess its influence on coffee yield and some environmental factors; b) characterize the composition of senescent and green leaves; and c) characterize green-leaf decomposition and nutrient-release kinetics. In an agroforestry system, we selected 40 coffee plants; around each plant we established concentric bands from 0.3 m, 3.1–5 m and 5.1–7 m. Within each band we counted the number of *S. macranthera* trees. We then measured the litter fall, shade intensity, soil moisture and soil content of phosphorus and potassium next to each coffee plant. Coffee yield was measured for each plant in 2005 and 2006. Senescent and green leaves were characterized, and green leaves were used in the decomposition kinetics study. Each *S. macranthera* tree deposited 12 kg of litter per year. The highest litter quantity was deposited between November and February, an interval in which coffee plants demand large amounts of nutrients. Litterfall deposited in autumn and spring, between 0.3 metres, positively affected the coffee yield, as did litterfall between 3.5 meters that was deposited in spring. Litterfall did not affect P or K soil content, or soil moisture. Green leaves have higher amounts of N, P, lignin and polyphenols than do senescent leaves. The dry matter presented a t½ of 25 days and the leaf-N a t½ of 29 days. The results suggest that *S. macranthera* did not exhibit biological nitrogen fixation. Mass production by pruning must be studied in order to improve the contribution from *S. macranthera* in coffee agroforestry systems.

Agro-landscapes resilient to climate change in Tanzania

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Preferred session C4. Mitigation and adaptation to climate change

Abstract

Rainfed mixed-crop livestock systems of northeast and central Tanzania are likely to be severely affected by numerous changes caused by climate change and its impacts. This project aims at assessing the regional impacts of climate change on agro-landscapes and environment in Tanzania (Morogoro) and at designing adaptation strategies for small-scale agriculture. Assessments involving local partners and farmers on related land use sectors such as forest, hydrology, nature conservation and biodiversity are considered. Driven by regional climate change scenarios, integrated agro-ecosystem models are used to assess combined climate change and management effects on crop production, water resources and soil fertility. These agro-ecosystem models are linked closely to hydrological models. Working together, stakeholders develop options for management practices in potential future agro-landscapes based on the same regional climate change scenarios. Historical vegetation maps and descriptions of Tanzania have been identified and are currently being evaluated to create a local database of tree species. It is expected that many of the preferred tree species will be featured among the 201 tree and shrub species selected as useful to farming and pastoral communities of Tanzania, hence information on management and potential use of these species will be readily available. Socioeconomic surveys will be used to explore smallholder farmers’ readiness to adopt the recommended species, adapted to the relevant climate scenarios. Results contribute to the selection of suitable indigenous tree species in the development of the good practices. The added value of including trees in farming systems will be evaluated using the water, nutrient and light capture in agroforestry systems (WaNuLCAS) model. This project will contribute to the development of farming systems and livelihood strategies that are robust across a range of possible future agro-landscapes. Introducing adapted agroforestry systems is expected to significantly contribute to the enhanced resilience of these landscapes.

Policy options and institutional innovations for agroforestry land use

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract
Agroforestry has played very important roles in the lives of rural and urban Liberians from time to time. Many people in Liberia gather and domesticate non-timber resources from the forests. Some of these traditions continue to this day and are an important part of the people’s heritage, embedded in their cultural fabric, and part of the national identity. The need for the Government to formulate policy that will subsidize farmers who produce tree and crop seedlings cannot be over-emphasized. These subsidies will enable farmers to engage in small-scale seedling production enterprises, which will stimulate action to improve their income generating capacities and livelihoods, as well as provide environmental benefits to Liberia and the rest of the world. It is a fact that agroforestry involves a diversity of many possible land uses, however, policies on prices, farmers’ credit opportunities, agroforestry education, and agroforestry inputs greatly affect the farmers’ production efficiency, thereby discouraging their involvement and adaptation of agroforestry systems. Hence, it can be theorized that developing and strengthening integrated development programmes for the eradication of poverty through agroforestry and promotion of agro-based alternative livelihood systems in areas susceptible to degradation, will enhance farmers’ financial security while providing environmental benefits (e.g. regulating the water cycle and climate, preventing soil erosion, keeping rivers clean, recycling nutrients and pollinating plants) for the rural poor. Agroforestry has an excellent potential for sustainable land use but requires sound policies that will encourage the rural dwellers that live around the fringes of the forest to develop and adapt the system to promote sustainable land use.

Modern silvo-arable agroforestry in Portugal and its potential for CO2 sequestration

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Preferred session C2. Carbon sequestration in agroforestry
Abstract
Agroforestry has been a traditional system present in Portuguese landscapes for centuries covering large areas of the territory. The tree species in these systems are mainly two types of oak, that cover about 1 million ha (about 10% of the territory), either as silvopasture or silvo-arable land, providing different products such as fuelwood, fodder acorns and cork. An agroforestry research community and results have been growing in the last decades and lately, modern agroforestry designs have been suggested in Europe. The modern systems, particularly silvo-arable, have adapted designs to machinery, contrary to the random design of traditional systems, and are open to industrial tree species, including fast-growing trees. This flexibility is attractive, not only for the wood and pulp industry, but also in the carbon sequestration needed to help meet the Kyoto Protocol country targets for afforestation areas. Yield-SAFE is a parameter-sparse, process-based dynamic model for predicting resource capture, growth and production in agroforestry systems. It has confirmed results of previous research in the estimation of the competition of resources, and the present work calibrates this model for Portuguese forest species. The calibration allows the evaluation of land-use scenarios of modern agroforestry systems and helps to quantify the potential contribution of this system in the national carbon balance. Moreover, the results can help decision makers to draw implementation rules and targets for the establishment of new agroforestry systems at the national level.

Impact of participatory tree domestication on farmer livelihoods in West and Central Africa

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation
Abstract
Lessons and experiences on integrating fruit crops into farming systems in central and eastern provinces

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Preferred session E1. Hot or cold: the role of underutilised crops for AF

Abstract Integration of fruit crops into farming systems is a common practice in Kenya especially with small-scale farmers. This is the case because small-scale farmers prefer to have several enterprises in the same farm unit as a way of spreading risks and maximizing returns. Practising of this system is becoming even more common these days with continued reduction of land size per household. There are many advantages when fruit trees are integrated into a farming system such as prevention of soil erosion. On the slopes of Aberdares ranges in Nyandarua district, Central Province for example, temperate fruit crops such as apples and pears are grown together with other fruit crops and also to prevent soil erosion. Fruit trees also help in maintaining soil structure by reducing the impact of the raindrops on the soil. In addition, fruit trees create a microclimate favourable for crop growth especially in very hot areas. Other advantages include wind breaking and nutrient recycling. Mango, which is a quite hardy crop, has mitigated food shortages caused by prolonged drought in districts such as Kitui and Makueni in Eastern Province. In these districts, mango trees provide food and income to the affected household during times of drought. Besides these, trees of mango, avocado and other fruit crops provide fuelwood when pruned thus reducing deforestation. There are however some challenges experienced with integrated systems; for example diseases and insect pest management of different crops in the system may become more difficult, and there could be the likelihood of chemical drift from one crop to another during chemical application. This is made worse by the fact that the approved chemicals for fruit crops are not necessary the same as for other crops. Mechanization may also become more difficult to apply with an integrated system considering the small size of the land. Other challenges include competition for nutrients, water and sunlight between fruit and other crops, thus reducing the yield potential of individual crops. It can however be concluded that the advantages outweigh the disadvantages and therefore farmers should be encouraged to adopt integrated production systems.

Strengthening markets for agroforestry products and services: experience of forest trade unions in Africa.

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract Workers in the forestry and building sector have reaffirmed that the supply of timber for industrial growth depends on the availability of raw materials in farms. Based on the experience and lessons learnt from trade union involvement in community forestry in Kenya, Uganda and Ghana, worker organizations are jointly going into partnership with wood-based industries, and communities to support agroforestry initiatives in form of plantations, woodlots, boundary plantings and homegardens. In Ghana, timber and woodworker unions have established 240 acres, while in Kenya, 3 unions, namely the Printing Union, Quarry Union and Building Union have engaged 30 small-scale farmers to create woodlots while in Uganda, the Building Union has established 30 hectares in collaboration with communities. The importance of stakeholder consultations and partnerships in developing agroforestry livelihood support systems and water springs in the farms, is assessed. Findings from the workers’ initiatives have opened opportunities for training in social forestry and development of work-based tree planting campaigns such as Workers Memorial Day as means of creating awareness in tree planting to groups that were initially forgotten. Analysis of the supply chain from the farms indicates that forest markets will be influenced by voluntary forest certification schemes and integration of social standards in the development of sustainable forest management. The social aspects under consideration include the Core ILO Labour Standards and Health and Safety concerns. Lessons learnt in creating markets for the farm-based products will be
influenced by value-addition processes from the farm to the industries, and how social costs will be managed in the entire supply chain. The findings further weigh options for using forest certification to ensure a continuous supply of wood for industries from the small farm holdings.

Key words: certification, livelihoods, markets, standards, trade unions

Experiences in agroforestry: the case of the global environment facility small grants programme, Ghana

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract
The Global Environment Facility (GEF) Small Grant Programme (SGP) in Ghana was launched in 1992 and has gone through four operational stages. As a global funding mechanism, the GEF/SGP in Ghana supports community level initiatives that promote sustainable economic growth and social development within the GEF focal areas. The programme integrates poverty reduction as a critical entry point in environmental management and human development. It operates on the belief that global environmental problems can best be addressed if the local people affected by the problems are involved and there are direct benefits and ownership of the process. Agroforestry is an integral part of all activities undertaken at community level initiatives in environmental preservation projects. It is the core of all focal areas biodiversity, land degradation and desertification control, climate change mitigation and POP elimination. At the community level, families, farmers and individuals take keen interest in agroforestry in their eagerness to preserve the global environment. Women and children especially have zeal in putting their land into agroforestry. There are so many experiences in the field of agroforestry, (relating it to biodiversity, land degradation and climate change) to share, document and research further. People at the grassroots level have so much to offer in agroforestry and need lots of support to carry out their initiatives.

Carbon sequestration and water-use by forested areas across the Sudanese gum belt

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Preferred session C2. Carbon sequestration in agroforestry

Abstract
Drylands cover 47% of the world’s land area and offer considerable potential for carbon (C) sequestration. This potential, however, is largely constrained by water scarcity. Increasing C sequestration can contribute to the mitigation and restoration of degraded drylands through including nutrient and soil water retention, and promoting infiltration rather than surface runoff generation. In order to assess the value of including tree species in agroforestry systems we have studied C sequestration and water use of forests across the ‘gum belt’ of Sudan. We derived C pools in forest biomass and soil (0 1 m) using aggregated forest inventory data collected by Forest National Corporation, Sudan and soil data from the Harmonized World Soil Database (FAO). Average stem volume/ha values, calculated from inventory plots on a 10 x 10 km grid were calculated for 1:250 000 Satellite Map Sheet Series of Sudan, were converted to C pools using a wood density value of 0.65 t dm m-3 and a C content value of 50%. Soil C pools were calculated for sandy soils (Arenosols) and clay soils (Vertisols and Regosols) using C percentage, bulk density and depth values for mapped soil units. Monthly mean water use (actual evapotranspiration) was estimated using a water balance model, WATBAL, and estimates of moisture contents at field capacity and permanent wilting point using soil texture data and published pedotransfer functions. Necessary climate data (rainfall, temperature and sunshine hours) were derived for each map sheet using the local climate estimator, LocClim (FAO). Once the model has been calibrated, we intend to look at the impacts of a number of climate change scenarios on water use and availability using simulated climate change data. The spatial pattern of current biomass and soil C pools will be evaluated in relation to location and soil type, and the impacts of climate change will be assessed.
Farmer’s practices in coffee agroforests of ‘Guinée forestière;: interacting paths over several farmer generations

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Preferred session A2. Agroforests in Humid Tropical Africa
Abstract

In ‘Guinée forestière’ (Guinea) where the majority of the population depends on the production and trade of agricultural products (especially coffee, palm oil and kola nuts), a significant increase in forest-like vegetation areas has occurred in the last 30 years. The conversion to coffee agroforests surrounding villages and major roads is increasing. These coffee agroforests are composed of a multi-strata structure with coffee and kola trees as well as various other tree species. Coffee agroforests share village-cultivated areas with rice cropping systems and associated natural regenerated stands of native oil palms and new plantations of improved varieties of oil palm. As the equilibrium between these systems is crucial for the economic and ecological sustainability of current cultivation, we need a more refined understanding of coffee agroforest dynamics in Guinée forestière. Nieng and Boussedou were chosen as socioeconomic and agro-ecological representative villages of the western part of Guinée forestière. Surveys were conducted amongst approximately 30 farmers in each village. Our results showed that without farm inputs or external investment, these systems provide a long-term stable income due to the progressive renewal of coffee trees. A historical analysis of both farms and agroforests plots showed a high adaptability at the plot level. This may allow increased diversification at the farm level by modifications of plant community composition and structure as well as by supporting existing cultural techniques. Our historical analysis approach also revealed a high diversity at the coffee farm level; gradual increases over several generations allows for an integration of production and heritage management. Faced with increasing land pressure, young farmers develop news practices. Some farmers intensify coffee production by reducing shade in their agroforests or by developing new oil palm plantations. On the other hand, some farmers develop new areas into agroforests, by expanding into the surrounding savannah.

Training of youths in agroforestry: NGOs’ collaborative initiative towards stakeholders participation in desertification control

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Preferred session D2. Integrating disciplines through agroforestry education
Abstract

Over the years, desert encroachment has become a nightmare, which has threatened the existence and survival of human and animal populations on the fringes of the Sudano-Sahelian agro-ecological zones of West Africa, including Nigeria. It has also defied all strategies adopted by the three tiers of government in Nigeria at arresting its further spread southwards. The strategies adopted by Leventis Foundation Nigeria (LFN); a national non-governmental organization (NGO) in collaboration with Pro Natura International (PNI); an international NGO, is expected to significantly increase the participation of the rural farmers in the fight against desert encroachment and improve on the sustainability of the traditional land-use systems. With provision of infrastructure and motivating incentives, youths are ‘recruited’ and trained in the art and science of agroforestry practices. This is expected to enhance their commitment to employ these practices, and encourage such practice by other youths within and among their communities in the semi-arid zones of Nigeria, on completion of the training. This initiative has far reaching implications for the success of the hitherto applied strategies by the various tiers of governments over the years. The adoption and improvement of these strategies will encourage those stakeholders that have a major interest in establishing an enabling environment for the control of desert encroachment to take crucial role(s) in such control.
Improving agroforestry tree products market chain: case of Congo Basin

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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands

Abstract Priority setting conducted by ICRAF and partners in West and Central Africa coupled with market surveys of main agroforestry tree products (AFTPs) clearly indicate that a considerable amount of income is generated from the sale and marketing of AFTPs. Although AFTPs play an important role in livelihoods of resource-poor farmers, these farmers usually put their hopes on potential gains generated from marketing of AFTPs. However, scientists and stakeholders working in the rural areas faced many unanswered questions such as: What is the real potential market of AFTPs? Could the latter contribute to rural poverty alleviation? How well organised are the farmers to derive substantial income from the sale of AFTPs? The present paper aimed at developing strategies to improve the AFTPs market chain in order to help farmers of the Congo Basin get the right income from the sales of their products. Results from different sites in Cameroon and DRC indicated clearly that farmers can increase their income by at least 35% as a consequence of using efficient strategies such as marketing AFTPs based on the sub-sector approach and collective action. Moreover, developing post-harvest technologies and improving on-farm production methods were found to be very influential in the development of chain value. All these initiatives, however, need to be supported by access to credit systems, training, land and resource tenure, availability of appropriate technology and accessibility to market information. Finally, the paper presents a comprehensive matrix for the strategy to be used for improving the value chain of AFTPs of the region.

Coffee-based agroforests in southwest Ethiopia: tree structure and diversity

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Preferred session A2. Agroforests in humid tropical Africa

Abstract Ethiopia is famous in the agroforestry community for the richness and diversity of the homegarden systems developed by local farmers. Ethiopia is also famous because it is the country of origin of Coffea arabica L. Coffee is nowadays an important cash-generating resource for smallholders in Ethiopia. Two smallholder coffee production systems have been described in the scientific literature: i) cultivation in homegardens, in the various parts of the country where ecological conditions are favourable to its growth, and ii) harvesting from the few remnants of ‘natural’ forests in the Kafa zone, where the tree grows wild or semi-domesticated. Here, we report and describe coffee-based agroforests encountered between Jimma and Agaro, in the southwest. These agroforests appear as forest patches, a few tens to hundreds of hectares in area, in a rural landscape usually dominated by croplands, homegardens and pastures. They make up a third of the smallholder coffee production system, clearly different from the two others. After exposing a typology of the agroforests encountered, we present and analyse our data collected through interviews and field inventories that allow characterization of the ecological basis of this system: forestry (establishment, tree management); tree structure (density, vertical stratification, basal area, DBH distribution); and tree species richness and diversity (various indices) at various stages. We conclude in detailing one important finding, that, contrary to most reported agroforest examples, these coffee-based agroforests have been built by farmers on cropland and pastureland, not on forest land. Consequences of this finding in terms of contribution of local farmers to the sustainable development debate are presented.

Key words: agroforest, coffee, tree stand, biodiversity, Jimma, Ethiopia
Effect of root pruning on water competition and yield in two rainfed *Grevillea* maize agroforestry systems in Laikipia, Kenya

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**Preferred session** A6. Ecophysiological bases of agroforestry-system design

**Abstract** Trees and living fence elements in agroforestry systems (AF) generally reduce water losses through evaporation due to their shading and wind shelter effects. However, their own water consumption may compete with the crop plants. The effect of pruning the shallow tree roots on the water availability for crop plants was studied in an AF system with *Grevillea robusta* trees and maize in Laikipia in Northern Kenya. The two sites are characterized by a semi-humid to semi-arid climate, deep clay soils and rainfed cultivations of small-scale farmers. On each site, the AF system with no-tillage mulching maize cultivation as well as a no-tillage mulching (M) and a local tillage (L) maize cultivation in open fields were installed in 1985 and observed until 1999. The monitoring included meteorological observations (daily), systematic soil water content measurements at several depths and distances from the trees (weekly), maize crop and stalk yield (seasonally), as well as sporadic tree growth (diameter and height) and harvested tree biomass. In most years, the no-tillage mulching cultivations (M, AF) showed higher water availabilities and produced more maize crop yield than the local tillage (L) cultivation. Maize yield of the AF treatment was often slightly lower than that of the M treatment but had the advantage of the additional tree biomass harvest. Pruning of shallow tree roots successfully increased the availability of water for maize without an effect on tree growth. In some years with intermediate amounts of rainfall, this effect made the difference between crop failure in the not pruned and a reasonable yield in the pruned part of the AF plots.

Insights into the factors related to the adoption of improved live fences in Mali

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**Preferred session** D2. Integrating disciplines through agroforestry education

**Abstract** During the dry season, in Mali, farmers traditionally protect their market crops against roaming livestock with the help of dead fences made of crop residues or thorny tree branches, or live fences consisting of euphorbia planted close to one another. In the last decade, ‘improved’ live fences composed of multipurpose trees have been promoted as an alternative to these types of fences. However, many constraints impede their adoption. A study was therefore undertaken in eleven villages of the Segou region in order to characterize the agricultural production units using improved live fences and identify the factors determining their adoption. Results show that the agricultural production units using this agroforestry technique have access to more labour force, agricultural equipment and livestock than non-users; this raises concerns about its accessibility to the poorest farmers. On the other hand, the use of improved live fences by farmers is determined by variables related to information and training. Although they are useful in protecting cultivated plots, improved live fences are also used in the delimitation of the land. Therefore, they play an important role in land appropriation. Such a movement towards land division is not viewed in a favourable light by some village authorities, impeding the adoption of improved live fences. In other villages, however, this agroforestry technique is widely accepted, indicating a profound change in land management.
Biophysical and socioeconomic sustainability of agroforestry systems in the Amazon

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Preferred session: E2. AF-based livelihood strategies for smallholders in the Amazon

Abstract: The main objective of this work was to evaluate the biophysical and socioeconomic sustainability of agroforestry systems (AFS) implanted in the state of Roraima. The study took place in experimental fields in the state of Roraima, with information generated between 1995 and 2007. Two agroforestry models were studied, being composites of annual cultures at the beginning of the implantation followed by banana tree (Musa sp. cv. Missouri); Inga (Inga edulis); Gliricidia (Gliricidia sepium); Cupuassu (Theobroma grandiflorum); Palm Heart (Bactris gasipaes); Brazil nut (Bertholletia excelsa); Cupiuba (Goupia glabra). The low fertility of soil affected the growth and the productivity of the annual crops; cassava had the best results. The biomass from the pruning of Inga and Gliricidia contributed to the maintenance of soil fertility. Cupuassu was the most productive species and became the most important component of the AFS. The AFS studied were financially viable and generated revenue in each year of the study. The benefits generated by annual crops were not sufficient to overcome the costs of the systems, except for cassava, which has a broad tradition in the Amazon, and has been able to pay off the costs of establishment. Considering the cultural and economic performance of cupuassu, this component should be considered as a priority for AFS in the region. The optimized agroforestry model (OAM) increases productivity and rentability. The scenario studied, considered as a means of planning, deploying and managing AFS, was found to be an efficient practice for selecting models with agroforestry species with the greatest aggregation of value and profit. AFSs, when deployed and managed properly, are systems for production and use of land that use the planting of annual and perennial crops for a long period, are available to prevent fires and deforestation in the Amazon region.

Agroforestry practices, opportunities, threats and research needs in the highlands of Jeldu and midlands of Guder Wederas of Western Shewa zones of Oromia region, Ethiopia

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract: Understanding of local practices and knowledge are very important for promotion and introduction of agroforestry intervention options, research and development endeavours. Informal and formal surveys were conducted at Jeldu and Guder district in two peasant associations (PA) of Western Shewa zones of Oromia region, Ethiopia in 2006-2007; their objectives were to describe and understand indigenous agroforestry practices, identify and characterize tree species, and identify constraints for tree planting and expansion. For the informal survey, individual and focus group discussions, a transect walk, key informant interviews, and physical observation were employed. Similarly, for the formal survey, structured questionnaires were developed, pre-tested, enumerators were recruited and trained. One hundred households (50 per district) were randomly selected and information was collected and documented. The common agroforestry practices at both study sites were scattered trees on farmlands, trees on gullies and rivers, homegardens, live fences, grazing lands, farm boundaries and around fences. Hagenea abyssinica, Dombeya torrida, Leonotis ocymifolia, Pilostigma thonninig, Maytenus ugaliness, Eucalyptus globules and Buddleja polystacha are abundant at Jeldu where as Acacia abyssinica, Cordia africana, Croton macrostachys, Olea africana, Eucalyptus camaldulensis, Adhatodea schimperiana, Ensete ventricosum, Salix subserata, Acacia albida, Carissa edulis, Cupressus lusitanica, Podocarpus glacial, Entada abyssinica, Ficus vasta, Sesbania sesban, Albizia scimperiana, Ficus sur, Euphorbia tricuali, Vernonia amygdalina, Acacia decurrence, Celtis africana, Maytenus senegalensis, Premna
Olinia rochetiana, Momusops kummel, Croton macrostachys, Psydrax schimperiana, Aningeria altissima and Myrica salicifolia are familiar at Guder. Free livestock movement, land shortage, poor access for the tree seedlings and termite hazard are the major bottlenecks that hinder the expansion of tree planting activities outside homesteads. Soil erosion, feed shortage; wood shortage and depletion of soil fertility are the critical problems in the study areas. Investigation of feed value and soil improving characteristics are some of the aspects of potential indigenous trees and shrubs that need priority research attention.

Quantifying impact of restricted cattle access to surface waters: eastern Canada

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Preferred session B3. Riparian system effects on soil and water quality
Abstract
Faecal matter derived from livestock can negatively impact surface water quality. Beneficial management practices that keep livestock directly out of surface waters can potentially improve water quality. This four-year study compared stream water quality among an unrestricted livestock pasture system (livestock allowed to directly interact with stream) and a restricted pasture system (livestock excluded from interacting with stream via fencing and off-stream watering systems) in eastern Ontario, Canada. Water quality endpoints included: indicator bacteria, pathogens, parasites, nutrients, and sediment. Microbial source-tracking methods were employed to identify the nature of faecal sources and potential changes in source as linked to season and seasonal pasturing activities. Cursory findings suggest there was slightly greater stream contaminant loads from the unrestricted pasture system, relative to the restricted pasture system. Parasite and indicator bacteria concentrations increased after cattle introduction for both systems. Generally, livestock exclusion practices modestly improved water quality, significantly protected riparian wildlife habitat, and reduced degradation of stream morphology.

Targeting high-value trees to regenerate degraded landscapes and watersheds in Guinea highlands

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Preferred session B1. Quantifying the role of AF in modifying watershed functions
Abstract
Planting trees is one of the most effective ways of conserving natural environments and also addressing climate change as trees and forests have been proven effective in carbon sequestration, biodiversity protection, income generation and watershed protection. In Guinean ecosystems, unsustainable land uses and practices like slash and burn cultivation, charcoal burning, bush fires and overgrazing, have led to drastic reduction of forest cover, biodiversity loss and land productivity decline, setting the stage for increased competition for access to natural resources and consequent conflicts between resource users. It is hypothesized that agroforestry knowledge and practices may provide solutions to mitigate threats through applied innovative approaches. This paper shares recent experiences and lessons learnt from the Fouta Djalon Highlands while providing scientific evidence on agroforestry-based mechanisms for environment conservation. In an attempt to reverse land-cover conversion, approaches such as FIVA (Farmers’ Initiative and Vision-based Approach), participatory domestication and collective actions are combined with non-cash rewards options to showcase the importance of Agroforestry to mitigate deforestation and conserve natural environments. The combined approaches showed about 45% of inhabitants in target sites have integrated high-value trees on farms. The initiative significantly increased agroforests and woodlots in the study sites through about 150 000 growing trees in and out of classified forests. This rehabilitated more than 200 ha for better land-use options and 22 ha around protected watersheds. The study confirmed the imperative multidisciplinarity of environmental issues even in terms of applied approaches to reverse deforestation. Reduced pressure on remaining forests, improvement in vegetation cover as habitat for biodiversity such as chimps, other mammals
and birds species, were also observed. Moreover, trees provide more global environmental services such as climate change mitigation while opening doors to communities benefiting from enhanced tree products.

Cork oak sustainable mediterranean forests in Portugal

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract Cork oak landscapes are among the best examples of balanced conservation and development anywhere in the world. They also play a key role in ecological processes such as water retention, soil conservation, and carbon storage. Cork trees are harvested every nine or ten years. The trees are not cut down and can be expected to live for 200 years. Cork oaks are found in scattered stands of indigenous growth; they require no soil preparation, irrigation, pesticides or herbicides. Harvesting is almost entirely manual with the only use of power equipment being the occasional tractor to carry harvested wood to a central location. For one year all management procedures were followed, analysed, registered and discussed in a documentary that is now presented as a science dissemination article.

Jatropha curcas and coffee trees in Kenya

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract After an inventory of the main projects on Jatropha curcas plantings in Kenya, some of them were selected for explorations according to soil types, climate conditions and agro-management practices. Amongst all the visited sites, one combines both Jatropha curcas and coffee plantations. The aim of this study was to compare soil benefits when coffee or Jatropha curcas are planted. The poster presents a comparison of the impacts on soil of these two plantings in a big farm belonging to an international planting company. Two parameters have been selected, soil coverage is analysed by soil surface feature measurements and soil properties measured at two depths (0 5 and 10 15 cm): these features are particle size analysis, extractable analysis, pH, and total carbon soil content. Considering the land-use systems used by the company, which applies conservation tillage for Jatropha Curcas and ploughing tilling with weed control for coffee trees, protection against erosion is better in Jatropha fields, but coffee plantation takes in more carbon than Jatropha.

Enjeux Economiques De L’agroforesterie Dans Les Exploitations Agricoles Des Zones De Forets Humides Au Cameroun

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Preferred session B8. Participatory Tree Domestication (PTD) for land rehabilitation

Abstract Au Cameroun, l’intégration des arbres, comme le Calliandra calothyrsus dans les exploitations agricoles, est perçue comme l’une des solutions durables à la pression sur les terres. Un essai a été mis en place dans les jachères, sous un dispositif en bloc complètement randomisé avec 5 traitements (couloir, équidistant, grappe, bordure et contrôle). Cette communication tente d’analyser les enjeux économiques de ce système et d’ébaucher les perspectives pour une utilisation durable de l’agroforesterie. Les résultats montrent que l’agroforesterie à des effets significatifs
sur l'utilisation de main d'œuvre, la suppression des mauvaises herbes et la fertilité des sols. Le dispositif en couloir a été préférentiellement choisi par les paysans (62,5%). La rentabilité basée sur les données d'essais réalisés sur les cultures de maïs et arachide cultivées en association a été estimée. Ainsi, l'analyse économique de tous ces systèmes, nous permet de remarquer qu'à court terme, certains traitements engendrent des bilans positifs (technologie en couloir, en bordure, jachère naturelle de 2 et 4 ans), alors que d'autres dégagent plutôt des pertes (technologie en équidistance, et en grappe), chez le paysan. Ces marges bénéficiaires sont de 70 466 FCFA, - 8 675 FCFA, - 27 786 FCFA, 8 725 FCFA, 81 111 FCFA et 262 571 FCFA respectivement pour les dispositions en couloir, en équidistance, en grappe, en bordure, les jachères naturelles de 2 et de 4 ans. Une comparaison des profits engendrés par la culture de maïs et arachide en association, montre que les quatre nouvelles technologies, ne sont pas rentables par rapport aux systèmes de jachères naturelles de 2 et de 4 ans. Les efforts doivent cependant être poursuivis par les différents intervenants du monde rural, afin d’améliorer davantage ce système d’agriculture intégrée, et promouvoir de ce fait sa durabilité.

Economics of bioenergy from *Jatropha curcas*: promises, opportunities, and constraints in Kenyan context

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**Preferred session** C6. Agroforestry and reconciliation ecology

**Abstract**

The recent growth in demand for biofuels can offer an unprecedented opportunity to support agricultural industries and provide rural employment in developing countries. More importantly, production of their own fuel would be of tremendous benefit to poor farmers in remote areas. Historically, small-scale farmers have not gained substantially from agricultural value-adding processes, hence sound policies that can guide and promote the nascent industry of biofuel production needs attention with regard to greater farmer ownership. Among biofuel crops, *Jatropha curcas*’ perceived potential as a cash crop for producing energy from marginal land without large inputs and for diversifying income activities for poor farmers, has recently created a great deal of attention in sub-Saharan Africa, including agricultural-based, oil-importing countries such as Kenya. The number of *Jatropha* plantations has grown since 2006 across diverse agro-ecological conditions in Kenya. To date, most activities involve small-scale production (i.e., individuals, NGOs, or outgrowing schemes with smallholder farmers) intended to promote rural development. Several large-scale investment plans are also being developed by foreign and domestic interests on government-owned ranches, although none have yet been established. Recently, there has been increasing concern that the lack of agronomic knowledge regarding issues such as optimal seed germplasm, best management practices, and nutritional requirements, as well as uncertainties over the development of reliable output markets, might discourage farmers from planting. All stakeholders have expressed a strong need for intellectual support with regard to *Jatropha* and other potential biofuel crops to ensure their sustainable productivity and viability. This study attempts to assess the gaps in our knowledge of *Jatropha* and to help guide future research activities; it uses an extensive literature survey, preliminary results from a baseline survey, and comparative assessments of ongoing activities in the field.

Woody invaders in wood-deficit country: the case of *Prosopis juliflora* (Sw.) DC. in Ethiopia

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**Preferred session** A10. Dryland agroforestry R&D

**Abstract** *Prosopis juliflora* (Sw.) DC. is an extremely hardy tree species that thrives in harsh environmental
elements, which are barely tolerated by other plant species. The species usually escapes and becomes an invasive weed. Currently, it is one of the hotly debated topics worldwide. The global invasive species programme has registered many species of *Prosopis*, including *P. juliflora*, as one of the dangerous invaders threatening biodiversity globally. In Ethiopia, it is highly condemned for its invasion of large grazing lands and threat to native plant diversity in the Afar National Regional State (ANRS) and Dire-Dawa area, in the northeast and eastern lowlands of the country, respectively. Conversely, the tree is versatile with great socioeconomic and ecological importance in providing fodder, fuel, timber, shade and food. The species can also play a very significant role in carbon sequestration, soil fertility improvement, soil salinity reclamation and fixation of sand dunes. It is the source of income for millions around the world. Likewise, many people in ANRS and Dire-Dawa area also generate substantial amount of money from sales of Prosopis charcoal and fuelwood. In ANRS, cooperatives have already been established to deliver Prosopis charcoal directly to big markets in Addis Ababa and other cities in the country. Based on preliminary surveys, people around Dire-Dawa city obtain an annual total income of over USD 164 000 from sale of Prosopis fuelwood to the city. The socioeconomic and environmental potential of Prosopis is still far from being met in Ethiopia where rampant deforestation has critically endangered the forest resources of the country and has led to a wood deficit of over 30 million m^3^ per annum. This paper discusses the actual and potential importance of the species as well as challenges to its management and utilization in Ethiopia, and puts forward recommendations.

**Key words:** Ethiopia, Afar National Regional State, Dire-Dawa, socioeconomic and ecological importance, invasive species.

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### Economic analysis of kiwifruit production in tea plantations as an agroforestry practice in Giresun Province of Turkey

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**Preferred session**  
A9 Agroforestry in Northern Europe

**Abstract**  
Tea production has a great importance in the Black Sea region of Turkey since the first tea plantations in 1939. Tea plantations have reached 76 600 ha and 202 698 farmers have been farming as a small-scale farmers. In 2006, tea production reached 1 100 000 tonnes. Both the public sector and private sector are involved in the tea market of Turkey. Kiwifruit is produced in 21 provinces of Turkey. Kiwifruit production in Giresun has started with the adaptation trials of the Hazelnut Research Institute. The aim of planting kiwifruit in Giresun Province was to cover the income lost by hazelnut producers because of periyodisite in hazelnut production. When kiwifruit was adopted and accepted by the farmers in Giresun Province, some tea producers started to produce kiwifruit in their tea plantation as an agroforestry practice. In this study, an economic analysis of tea, kiwifruit and tea, and kiwifruit combinations, in Giresun Province of the Black Sea coast of Turkey was undertaken to compare and evaluate their sustainable use.

**Key words:** tea, kiwifruit, economic analysis, agroforestry.

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### Carbon sequestration and root development of systems of soil use in the Colombian Amazon

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**Preferred session**  
A.11. on silvopastoral systems

**Abstract**  
The purpose of this research was to describe the correlation between root development and carbon capture in pastures of *Brachiaria humidicola* and *B. decumbens* associated with legume and grass in monoculture, as well as degraded pasture, in two dual-purpose livestock farms located on flat topography and slope, in the Colombian tropical rainforest ecosystem. The evaluation took 996
samples from soil and analysed carbon content using the Walkley and Black, 1934 method, and determined root biomass. The main results show that pasture *Brachiaria humidicola* associated with leguminous crops has higher correlation coefficients between weight of roots and capture of carbon in degraded pastures. The values of the coefficients are 0.78 and 0.83, for flat topography and slope. The greatest root development of all studied grasses, which occurred with permanent grazing, was found in the first 10 cm of soil; it was 6.4 and 7.0 tonnes of MS ha-1 in sloping and flat ground respectively. These values contrast with those found for the depth of 10 20 cm; which, for the same topography, which was reduced to less than 1 ton of MS ha-1. There is a strong association between the weight of fine roots of pasture improvement and greater quantities of carbon sequestration.

Characterization and financial analysis of an agroforestry system in the western Amazon

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Preferred session E2. AF-based livelihood strategies for smallholders in the Amazon

Abstract One of the main problems of agriculture and livestock farming in the Amazon is the low capacity of maintaining productivity over the years, and consequently the increased areas covered by secondary forest. Agroforestry systems are important as a strategy for carbon sequestration, maintenance of diversity and income generation. The objective of the work was to characterize the multistrata agroforestry system, to identify the technical coefficients, and carry out a financial analysis. We used the method of technological panel, with selected key informants from project RECA and researchers from the Embrapa Acre who had recognized experience and knowledge in agroforestry systems. The agroforestry system was defined with the species, spacing and number of plants per hectare as follows: cupuacu (6 x 8m), 221; coffee (4 x 8 m), 300; teak (8 x 18 m), 65; banana (6 x 8 m), 143; and açai (4 x 8 m), 288. The technical coefficients for the implantation and maintenance of 1 hectare of the model were used as parameters for the financial analysis. The NPL (10% pyear) calculated was of USD 6761. The value of the BC (6% p.year) was 1.34. Remuneration of labour-family was USD 19, greater than the opportunity cost of USD 10. The agroforestry system shows economic viability, beyond the environmental benefits.

Achieving economic diversification and environmental sustainability through agroforestry in St Vincent and the Grenadines

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Preferred session C3. Agroforesty, water quality and environmental amelioration

Abstract Banana has been the lifeline of St Vincent and the Grenadines for many decades. However, declining prices, the removal of preferential access to European markets, the high cost of production, and the inability to compete with other producers has made diversification a necessity. The decades of monoculture of bananas on the island has led to a vicious cycle of small-scale farmers who are economically and socially marginalized, a result of the decline of banana prices, and a negative spiral of environmental and natural resources depletion that is increasing vulnerability to natural disasters and climate change. Among the natural resources and environmental changes as a result of monoculture are increased river siltation, damage and destruction of riparian vegetation, decline in crustacean river populations as a result of chemical pollution of rivers and waterways and river bank collapse. This paper will discuss efforts by the Ministry of Agriculture, Forestry and Fisheries, including the Integrated Forestry Management Project, to address declining watershed quality through agroforestry. Small-scale farmers are intercropping using medicinal and niche-market species such as Neem (*Azadirachta indica*) and Mauby (*Colubrina elliptica*) in their banana fields. Intercropping allows for the diversification of small-scale producers from traditional
Growing trees: the green solution to climate change

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Preferred session C4. Mitigation and adaptation to climate change

Abstract
Growing trees on the prairies of North America poses some challenges for growers. ForestFirst has been working with growers, researchers and government for seven years. ForestFirst has seen growers’ viewpoints of agroforestry evolve and change. Initially, growers were mainly looking for an alternative crop for their rotation. Now, many growers recognize the value of tree crops used in climate change adaptation and mitigation strategies. With the advent of carbon-trading markets cap and trade systems, the significance of trees grown for carbon sequestration has become evident to farmers, energy companies and investors alike. This recognition means many growers are seeing the opportunity to have both environmental benefits and economic benefits of growing trees in a long term plan for offsetting carbon to reduce greenhouse gas emissions. In an international move to green energy, production of wood fibre for the bioenergy market is a good fit. Wood fibre biomass is an excellent and efficient source to feed many end-use products, such as ethanol, biofuel, biodiesel and pellets. Not only does wood fibre cost less to produce, both environmentally and economically, than other bioenergy feedstocks, the technology that drives production for outputs is further ahead than those for grain, straw and oilseed-based sources. Seeing this interest grow, ForestFirst uses two delivery models for tree production: a community-based model and a corporate model. As part of the community model, ForestFirst is looking at using effluent to irrigate tree crops that focus on environmental and cost issues faced by many municipal administrations. The corporate model includes growing willow and hybrid poplar for biomass and for the carbon market. Both of these models focus on addressing climate change and can be used for community development.

Préservation des espèces pionnières et fertilisantes dans les systèmes agroforestiers au Togo, un moyen de restauration des sols

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Preferred session C2. Carbon sequestration in agroforestry

Abstract
Deux stratégies sont utilisées par les paysans dans la zone à caféiculture au Togo pour restau- rer la fertilité des sols des paysages agraires, d’une part dans les jachères de savanes où apparaissent des espèces pionnières et d’autre part dans les plantations de cafésiers dépourvus d’arbres fournissant l’ombrage aux cultures de rente. Dans les jachères de savanes, deux modalités sont observées : la première consiste à préserver les ligneux pionniers qui y apparaissent et qui évoluent progressivement vers la forêt semi-décidue en passant par des stades successifs ; la seconde consiste à introduire dans ces jachères de jeunes plants de cafésiers et autres essences utiles, ce qui permet d’entretenir aussi bien ces essences pionnières que les cultures associées jusqu’à la transformation de ces parcelles en une véritable plantation de rente. Dans les plantations de cafésiers, suite à une rénovation de cette culture au Togo dans les années 70, rénovation selon laquelle, les nouvelles variétés devraient, semble-t-il se développer à la lumière sous l’abri de toute concurrence, toutes les nouvelles plantations ont été donc débarrassées de leur couvert arboré nécessaire au bon développement de cette culture de sous-bois. Dès lors, cet arbuste, privé de son microclimat a connu un important dépérissement avec pour conséquences, la chute de sa productivité. Conscients de la situation, les paysans ont réitéré leurs anciennes pratiques qui consistent à préserver les arbres dans leurs plantations de rente. L’exemple le plus spectaculaire est la préservation de diverses
Complementary uses for the Quercus suber L. agroforestry system to increase its economical and environmental sustainability

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**Preferred session** B4. Agroforestry in Europe: Land reclamation

**Abstract**

The cork oak (*Quercus suber*) agroforestry system called ‘montado’ in Portugal is characterized by low density forest stands where the forestry component is conducted together with agriculture and grazing. This tree species grows in the countries surrounding the Mediterranean basin and in northern Africa under harsh conditions in land areas of low capacity for agricultural use. The ‘montado’ system is a very balanced way of using the soil and contributes to improve poor soil quality. Presently, this system is managed almost exclusively towards the production of cork and the montado is progressively being substituted by monofunctional forests. It is therefore desirable to find complementary uses for this system, without competing with cork production, that assure its long-term sustainability both economically and ecologically. Cork oak wood is nowadays used only as fuelwood, but has been used for naval construction in the past because of its high strength and durability. The wood has a strong aesthetic character and is potentially suitable for higher quality end uses. The objective of the present work was to study some of the cork oak wood properties that influence its visual presentation, quality and technological performance in order to evaluate its potential for high-quality products. We concluded that the large multisseriate wood rays are responsible for the cork oak’s aesthetics and are characterized by large variability introducing rich and pleasant visual dynamics to the wood. They also contribute to the species’ resistance to hydric stress because tall and large rays have a larger water storing capacity and are better able to cope with periods of water shortage. The wood has a large number of vessels with small diameter ensuring sustained water transport with less vulnerability to water stress. Moderate industrial drying, adjusted to the particularities of the species, is recommended.

Agro-extractive systems of palm trees: market, resource management, and local perceptions of livelihood-enhancing agroforestry.

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**Preferred session** E2. AF-based livelihood strategies for smallholders in the Amazon

**Abstract**

The role and function of Amazon palm trees in combination with agricultural and forestry activities illustrate agro-extractive synergies. This agro-extractive system is presented as an expanded context for agroforestry systems in the forest margins. The synergy provided by palms is a tacit support for biodiversity and soil quality, while contributing to income generation and livelihoods though both monetary and non-monetary benefits. The objective of this study is thus to compare two rural communities in the Brazilian and Surinamese Amazon according to the effect of their market integration in terms of: 1) practices of natural resource use; and 2) local perceptions about the importance of the agro-extractive system. The study presents a socio-environmental description of the two communities that strongly rely on palm species. The high market integration context is a Brazilian community located in an area with high pressure for land-use change. Babaçu palm (*Attalea Speciosa*) has been part of the local economy since the 1930s, with products being processed and even exported. Collective action has been apparent in the community more than two decades. Conversely, the low market integration comprises a community within Suriname’s more preserved natural resources, including the Maripa palm (*Attalea Maripa*), used for the
production of cooking oil, which is marketed locally. The methodology used in this study included field observation, ethnographic interviews, focus group workshops, and the analysis of surveys designed in the RAVA project (www.iamazonica.org.br/rrava) of the Amazon Initiative consortium. The study in the Brazilian community examines the production strategies of 60 families during one year. The Surinamese community is examined through descriptive features of households and families combined with field identification of management practices. The analysis concludes by presenting differences in local perceptions of the contribution of agro-extractive activities to livelihoods, and major challenges perceived for strengthened agro-extractive/agroforestry economies.

Pilot project for a community approach to private land forest management

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract The purpose of this project is to design and pilot a process for the creation of a landscape-level woodlot management plan. This community approach will combine the individual landowners' goals and the objectives they have set for their land with the opportunities that arise from a ‘bigger picture view’ of looking across multiple properties. Some of these opportunities include, but are not limited to, 1) Increased awareness of economic, social, ecological and environmental implications of agricultural area forest management. Landowners who participate in this plan will acquire a more detailed understanding of the values of their woodlots and will be able to connect/communicate with their neighbours on related issues (forest stewardship, watercourse protection, wetland/riparian areas/biodiversity protection, and forest health). 2) Creation of a private land forest inventory. The landowners will get a better understanding of the economic and ecological values encountered in their woodlots and the potential benefit of creating synergies by joint management efforts. 3) More diverse market opportunities for landowners. Combining the volumes of forest products (be it timber and/or non-timber products) will allow for a better reach into the market, and potential for consistent delivery and better pricing. It also will open up the market to industries requiring certified and managed wood fibre sources. 4) I awareness of outside programs.

Ecosystems functions framework – potential linkages with agroforestry

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Preferred session D2. Integrating disciplines through agroforestry education
Abstract This paper highlights the linkages between the ecosystem functions framework and agroforestry. Exploring these linkages has the potential to further promote the sustainable use of land in agroforestry. The ecosystems function concept (de Groot et al. 2002) provides a framework for an integrated assessment and valuation of the functions, goods and services of natural and semi-natural ecosystems. It is now widely recognized that the economies of the earth would grind to a halt without the services of ecological life-support systems (Costanza, et al. 1997). Therefore there is the need to highlight the presence of these ecological support processes within agroforestry systems. Agroforestry, with its ecological and economic interactions between tree and non-tree components provides a range of environmental goods and services which support human life directly and indirectly. These goods and services can be translated into ecosystem functions to provide the possibilities of exploring potential applications of the ecosystem functions concept for sustainable land use. Three main potential areas of application can be recognized. The first is providing a framework for a comprehensive description of the ecosystem’s functions, use and value of agroforestry systems; secondly it could create an awareness of unfamiliar ecosystem functions supported by agroforestry practices; and lastly, it could highlight and clarify possible trade-offs between stakeholders within the complexities of managing agroforestry systems.
In situ dry matter degradability of tropical forages with fruit flour diet of five arboreal species

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Preferred session: A.11. on silvopastoral systems

Abstract

The objective of this study was to evaluate the in situ dry matter degradability of grass star *Cynodon plectostachyus* (Cp), maize stover *Zea mays* (Zm) and sugar cane *Saccharum officinarum* (So) with diets of fruit flour of five arboreal species: tepame, *Acacia pennatula* (Ap), cascalote, *Caesalpinia coriaria* (Cc) and vainillo *Senna atomaria* (Sa), two no leguminous guacima Guazuma ulmifolia (Gu) (Sterculiaceae) and asmol *Zyziphus mexicana* (Zm) (Rhamnaceae). At the same time, the study sought to evaluate the nutritive quality and the fractions of fibre: neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose, hemicellulose and lignin. The kinetic test was carried out with a fistulated Holstein cow using nylon bags with 5 g samples of the forages. The periods of incubation were 0, 4, 8, 12, 24, 36, 48 and 72 h. The experimental design was completely randomized, with a split plot arrangement where the different flours of the tree species were evaluated. The mean comparison was conducted with Tukey’s test (P<0.05). The values of dry matter (DM) were of 31.77, 90.07 and 84.32% for Cp, Zm, and So, respectively, with a low content of crude protein of 5.35% for Zm, being the lowest, and 8.87% for Cp being the highest; the in situ dry matter degradability for Cp was of 66.69% with the diet fruit flour of Cc, with Gu it was 84.18% with a statistical difference (P<0.05); for (Zm) the degradability was 57.52 and 74.26% with Cc and Sa respectively, without statistical difference; finally for So there was statistically difference (P<0.04) between the diets, and the best value was 59.47%, with Sa. We can conclude that the use of fruit flour of arboreal native species is a viable option to improve the in situ dry matter degradability of the tropical forages and the best diet in this test comprised Sa.

Murdoch Lake Agroforestry Demonstration

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Preferred session: A.11. on silvopastoral systems

Abstract

This field demonstration was developed to show landowners the potential benefits of combining tree farming with traditional agricultural practices. The purpose is to allow Alberta farmers to see that raising trees and livestock or hay on the same land can be an economically viable practice, while providing wildlife and waterfowl benefits. The goal of a tree improvement programme is to develop fast growing aspen and poplar genotypes that would be suitable for use in agroforestry. Companies would be able to obtain portions of their fibre requirements from these privately owned woodlots. Silvipasture refers to planting trees with an agricultural crop, usually forage and could provide a new opportunity for Alberta farmers. Similar agro-forestry projects have occurred in the United States, New Zealand, Brazil, Australia and Africa. These experiments have shown optimum livestock and fibre production can be achieved through integrated land management. While information is available on the effects of grazing in pine, coconut, and eucalyptus plantations, little is available on how grazing affects species such as fast-growing hybrid poplar. This site hopes to answer many of these questions for Alberta farmers and in 2008 we hope to begin a silvopasture experiment in cooperation with Agriculture AgriFood Canada.
Utilization of subsurface water retention technologies (SWRT) for expanding agroforestry in arid and semi-arid regions

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Preferred session C3. Agroforestry, water quality and environmental amelioration

Abstract Subsurface water retention technology (SWRT) is a revolutionary technology for increasing water-use efficiencies by 20-fold. The potential impact of this strategic water and nutrient conservation initiative has exciting potential for improving food, fibre, and livestock productivity. SWRT soil treatments provide a continuous supply of highly available soil water solutions to root zones of tree seedlings, food and fibre crops in coarse-textured soils. The SWRT technology increases vegetable and food crop production by 50 to 400% while reducing soil erosion, management inputs and environmental contamination of groundwater. In 1966, Michigan State University developed thin asphalt barrier treatments that retained soil water and nutrients in the root zone of sandy soils. Today, these same water barrier-treated sands sustain 3-fold greater plant populations of rye cover crops with plant heights twice those on sand controls without water retention barriers. SWRT barriers have been successfully tested on sandy soils in three additional state research farms in the USA, also in Australia, Africa, the Middle East and Southeast Asia. The extremely low water-holding capacity of the 4 billion hectares of sandy soils lack soil water and essential plant nutrients due to insufficient rainfall and/or excessive leaching through soil profiles and are among the primary reasons for absolute poverty, human malnutrition and starvation among more than 3 billion people. This strategic global initiative is developing with partners from selected foundations, the private sector, academic institutions, international development organizations, and identified host country governments. Its goal is to establish an international consortium for prototyping, field testing, pilot technology transfer and large-scale implementation in the US and overseas particularly in the Middle East, Africa, China and Southeast Asia with subsequent large-scale implementation based on crop production potential, population food security needs, water use efficiency and cost-benefit considerations.

Cultivate plants and cultivate peace

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract ‘Cultivate plants and cultivate peace’ seeks to promote the urban agriculture practice among inhabitants, especially the poorest, in the city of Macaé, in the northern region of the state of Rio de Janeiro, Brazil. With the active participation of students and field professionals, the project multiplies and creates knowledge of qualifying families about the importance of urban agriculture, (organic and agroecological) its benefits and advantages, and forest conservation (Atlantic Forest) and reduction of deforestation rates in Macaé. The project promotes preservation and protection of natural resources, values of conservation (the biodiversity, water, beaches, mangroves, river resources and riverside vegetation), solid waste management, rational water and energy and food consumption. Some goals of this initiative are to generate knowledge and foster urban agriculture practices in order to have an inclusive, healthy and greener city. Further to this, families are able to trade fresh food as a product, improving the living environment and relationship between citizens. This initiative adopted an environmental, social, cultural and economic dimension by providing knowledge and information to the local population and strengthening their traditions. Features of the project include: i) promoting environmental education and ecological activities through the promotion of planting vegetables, trees, medicinal herbs in public and private places we don’t plant; e help people to do the planting; ii) promoting a sense of caring and responsibility for controlling pollution of natural resources, and avoid deforestation (Atlantic Forest); iii) promoting food consumption education and nutritional security; iv) qualify for planting, cultivating, selecting and preparing proper food at the household level; v) promoting health, such as planting on old
tyres wheels, retrieved from the riverside margins of the Macaé River. This action promotes the fight against dengue fever, which has a high level of incidence in the city; vi) promoting the participation of elder people, which is important in maintaining this traditional practice in urban and rural areas of the city.

Agroforestry as a strategy towards sustainable development of an IP community in Occidental Mindoro, Philippines

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract Occidental Mindoro National College, in partnership with Plan International, conducted the Sustainable Upland Development Program in Sitio Salafay, Monte Claro, San Jose, Occidental Mindoro, home to about 50 Buhid Mangyans. The agroforestry project, as one of the livelihood components, was implemented to increase the productivity of the community and help conserve upland resources. Community people were organized and worked collectively in the project. Thus, ownership is communal. Their interest in the establishment of the project was further aroused by carefully and clearly explaining to them its importance not only in the improvement of their living conditions but also to their environment. Other activities conducted were the ‘Lakbay Turo’, showcasing 0.5 hectare soil and water conservation techniques; and construction of a community nursery and fishpond. The project contributed to the continuous schooling of children because it was able to augment the food that their individual farms provide. Prior to the establishment of the project, dropping out of classes was rampant. School children stop schooling to look for food in their surroundings or just stay at home because they have not eaten. The project also augmented the table needs of the families, divided on the guidance of elders, based upon the degree of their participation. Likewise, it also improved cooperation, camaraderie and belongingness among the participants. As to its long-term impact, it is envisioned that the community shall have real development suited to their culture and shall be living in harmony with nature.

Establishing vegetable agroforestry systems research at AVRDC - the World Vegetable Center

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Tree-crop interactions in agroforestry systems involving vegetable crops have not been studied extensively because available research in agroforestry focuses on agronomic arable field crops. A vegetable agroforestry system was established at AVRDC – The World Vegetable Center to: 1) study tree-crop interactions in alley-cropping vegetable crops with tropical fruit trees in terms of competition and/or complimentarity; 2) investigate influence of tree crops on natural habitat and insect population in vegetable alley-cropping systems; and 3) evaluate total productivity and economic returns from high-value horticultural crops in an agroforesty system. Seedlings of twelve tropical fruit tree species: Anona reticulata, Artocarpus heterophyllus, Chrysophyllum cainito, Coffea arabica, Eugenia brasiliensis, Eugenia unilora, Pouteria caimito, Pouteria campechiana, Psydium littorale, Rollinia mucosa, Syzygium samarangense and Tamarindus indica were established in December 2005 at the AVRDC Organic Research Farm. Vegetable crops were sequentially grown in alley beds between tree hedgerows 10 months after tree establishment. Monoculture cropping of vegetables was established for comparison. The trial was conducted using a randomized complete block design with 4 replications. Establishment and initial growth of trees varied according to species. Outstanding species were A. heterophyllus, C. cainito, T. indicus and A. reticulata. Compared to a monoculture system, the marketable yield of vegetable crops increased 30 to 50% under the agroforestry system. The greatest yield increase was recorded
for eggplant (53%) followed by common cabbage (48%), tomato (35%) and cucumber (30%). Tree-crop competition for water, nutrient and light was insignificant during early establishment. Results suggest that integration of high–value vegetable crops in agroforestry systems can provide quick economic returns, helping small-scale farmers in the tropics in getting regular cash income. With limited literature on vegetable-based agroforestry research, the study findings significantly contribute to agroforestry literature and public policy for global rural development.

Contour hedgerow intercropping potential and existing problems in its extension on sloping land in subtropical China

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Preferred session C6. Agroforestry and reconciliation ecology
Abstract
Contour hedgerow systems, as a feasible alternative for the utilization and management of sloping land, have been proven to have great potential in economic and environmental advancement. However, some doubts still remain about its extension. Based on the results of experimental plots and a field trial in subtropical China, this paper presents the scientific evidence, achievements, problems and prospects relating to studies and extension of this system. Specifically, contour hedgerow intercropping provides more options for farmers to generate cash income and reduce agricultural risks through control of runoff and soil erosion, amelioration of soil fertility, extension of soil water capacity, and enhancement of multidimensional niches. Meanwhile, interspecific competitive interaction, particularly below-ground interaction (i.e., competition for water and nutrients, chemical interference), decreased grain productivity of intercrops, which influenced dissemination and extension of contour hedgerow intercropping systems. For instance, nitrogen-fixing hedge species (e.g., *Amorpha fruticosa*, *Leucaena leucocephala*) are usually selected for hedgerows in China due to the N they supply to crop growth. But this phenomenon was not observed when *A. fruticosa* was intercropped with soybean (*Glycine max*). Moreover, we used root partition to determine that the growth of *A. fruticosa* and soybean were significantly depressed when their roots intermingle. In addition, fluxes of soil carbon dioxide and nitrous oxide potentially increased relative to those of cropland, after *A. fruticosa* was implemented from 1–2 years. As a consequence, it is expected that contour hedgerow intercropping practice will be an appealing option for agricultural sustainable development and climate change mitigation and adaptation under the Kyoto Protocol in hilly and mountainous areas of subtropical China.

Evaluation of agroforestry systems in the Mid Hill regions of Nepal: a bioeconomic modeling approach

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract
Agroforestry has been widely recognized as a land-use option that increases livelihood security and reduces the vulnerability of soil resources. However, the adoption of agroforestry depends on its performance under the particular biophysical conditions and socioeconomic settings of the farmers. The present study evaluates the performance of agroforestry systems in a typical hill farming system of Nepal using bioeconomic modelling. A biophysical model SCUAF (soil change under agro-forestry) was used to predict biophysical factors such as crop and hedge yield, soil erosion and other soil properties under various cropping with and without agroforestry over 30 years. The SCUAF output result was incorporated into a cost benefit analysis to compare the economic viability of the agroforestry system. The analysis showed that the agroforestry system reduces soil erosion up to 60–65% and improves the range of soil biophysical measures such as carbon, nitrogen and phosphorus content of the soil. Improvement in the soil condition leads to comparatively higher crop yield than without agroforestry in the long term.
the agroforestry system performs well in conserving soil resources and maintaining crop yield, the cost of hedge establishment and terrace maintenance substantially reduces farmer income in the beginning, which makes it economically unattractive for farmers who have a short planning horizon. Therefore, a strategic policy for sustainable resource management in the hilly region should consider the multi-functionality of the agroforestry systems, and provide some economic incentives to the farmers for wider adoption of the technology.

Analysis of competition between maize and pigeonpea in semi-arid cropping systems

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Preferred session A10. Dryland agroforestry R&D

Abstract

The productivity of maize-pigeonpea cropping systems is dependent on effects of facilitative and competitive interactions on resource availability. Managing these interactions is crucial to farmers who are usually interested in optimizing yields of both crops to diversify food and income sources. We used a factorial experiment to examine yields and nutrition of maize and pigeonpea in response to cropping systems (continuous sole maize, intercropping and improved fallow of pigeonpea with maize), N and P fertilizers, and cattle manure, in Dodoma Tanzania. Objectives were to assess competition between crops and to determine how manure and fertilizer inputs can modify this interaction to enhance yield. Without fertilization, intercropping did not increase maize yield in relation to continuous sole maize, presumably due to nutrient competition. On the other hand, the improved fallow system without (1.2 Mg/ha) or with fertilizer addition (1.4 1.6 Mg/ha) increased maize yield compared to unfertilized sole maize (0.6 Mg/ha). This increase was associated with improved soil fertility by pigeonpea, reduced competition by sequential cropping arrangements, and fertilizer application. Similar results were also found for interactions between fertilizer and manure. High soil acidity and exchangeable Al probably promoted P fixation, and leaching of exchangeable Ca resulted in P and Ca deficiencies as depicted by vector diagnostic diagrams. Vector analysis also revealed that maize competed more strongly for nutrient, suppressing pigeonpea grain and biomass yields by 33% and 60%, respectively. These yield reductions indicate that pigeonpea did not recover from competition even after maize harvesting when competition was reduced. Optimizing yields of both crops would require the addition of a prescribed fertilizer rate when intercropping, but applications may be reduced by half under the improved fallow system due to alleviating interspecific competition.

Fuelwood production and soil carbon dynamics under rotational woodlot systems in semi-arid Tanzania


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Preferred session C2. Carbon sequestration in agroforestry

Abstract

Fuelwood extraction can accelerate deforestation and CO2 emissions through reduced plant cover and wood combustion. Tanzania, a pilot country in the UN programme for reducing emissions from deforestation and degradation (REDD), is considering implementation programmes and policies to decrease the deforestation rate. Agroforestry may reduce deforestation and greenhouse gas emissions through on-farm fuelwood production. This approach could benefit farmers economically through carbon trading schemes such as the clean development mechanisms and REDD. However, information on carbon sequestration capacity for most agroforestry systems is scanty, limiting future participation of farmers in these schemes. We evaluated the potential use of rotational woodlot systems to reduce deforestation and sequester atmospheric carbon based on long-term studies in eastern and western Tanzania. Wood biomass, wood carbon, and soil carbon from these studies were compared with those from both native Miombo vegetation and
continuously cultivated farmlands to indicate efficacy of fallow species in supplying fuelwood and sequestering carbon. Tree fallows, especially Acacia crassicarpa, Acacia leptocarpa, and Acacia mangium produced wood biomass (8.4 to 77 Mg/ha) that was sufficient to meet household fuelwood demands for 3 to 25 years. Such high yields indicate the capacity of tested species to supply fuelwood and reduce harvesting pressure on forests due to fast growth and intensive management. Tree fallows doubled soil organic carbon status (15.8 to 25.6 Mg/ha) compared to continuously cropped land, reflecting the importance of organic matter input from tree fallowing. These levels were higher than 15 Mg C/ha found in fallowed Miombo soils, but were similar to the carbon status noted in forest reserves. Organic carbon incorporated in soil micro-aggregates may act as a sink because these components are not easily degraded by cultivation. Although wood carbon can be released to supply household cooking energy, the amounts would counter increased CO2 emissions from clearing local forests for fuelwood supply.

Understanding the adoption and rejection of improved rubber agroforestry systems by traditional rubber smallholders in Indonesia

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract

The use of clonal planting material is important to increase the latex productivity of traditional rubber agroforestry systems among smallholder rubber farmers in Indonesia. There are technical, economic and social challenges associated with conversion from traditional to improved systems. Although the benefits of clone-based technology are significant and there are sustained programmes and efforts to promote it, its adoption by farmers has been less than satisfactory. Often the underlying reasons for the limited adoption of improved systems by farmers remain unclear. Why farmers adopt certain technologies faster than others remains an important question in the dissemination process. This paper is based on a study of technology adoption of the improved Rubber Agroforestry System (RAS) introduced by ICRAF (International Centre for Research in Agroforestry) in Jambi and West Kalimantan provinces in Indonesia. The new approach includes recommended clones but other traditional practice aspects of rubber cultivation are maintained.

In the study decision-tree modelling was used to determine the decision criteria of rubber farmers. Based on interview of farmers, the model helped to identify the main reasons, motivations and constraints that influenced farmers’ decisions to adopt or reject new technology. The results show that there were some significant differences in the adoption rate and process between smallholder rubber farmers in Jambi and West Kalimantan. The reasons for different adoption rates include differences in social, cultural and economic factors between these provinces. The role of demonstration plots, incentives, farmer group dynamics, extension support and factors such as pests and diseases, influenced farmers’ decisions. The results provide important clues in decision criteria and limitation in adoption; the information will be of importance to extension workers, researchers, and policy makers involved in promotion of new rubber technology. The application of the decision-model approach and the lessons learnt are also discussed in the paper.

Social dynamics and ecophysiology of a coconut-based agroforestry system in southern Mozambique

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract

Extreme climate (low rainfall and high temperatures) and poor soil conditions are major constraints to agricultural production for subsistence farmers in the southern region of Mozambique. A coconut-based agroforestry system is the main agriculture practice found in the Jangamo district of Inhambane Province. The system consists of several tree/crop layers and high species
diversity. A vegetation survey showed that the dominant trees were coconut (Cocos nucifera), mango (Mangifera indica), cashew nut (Anacardium occidentale) and citrus species, grown in combination with a variety of food crops, such as maize (Zea mays), beans (Vigna unguiculata), groundnuts (Arachis hypogaea) and cassava (Manihot esculenta). The system is in the form of homegardens, fulfilling most of the basic needs of the local population. However, in recent years, a decrease in the performance of this coconut-based system has been reported. The aim of this study was to assess the factors influencing the production and water use of this system in the Jangamo district. A socioeconomic survey showed that the average household size was 0.8 ha. The average production of the different fruits and crops was approximately 2000 coconuts, 150 kg yr^{-1} of citrus fruits, 50 kg yr^{-1} of cassava powder, and limited quantities of other fruits and crops, providing an average income of about $300 per annum per household. The heat ratio technique was used to assess individual tree water use of the four main tree species. Additional measurements of the soil water content and climatic factors were used to estimate the site water balance. Preliminary results showed that there were distinct seasonal and species differences in the plant water use. Niche differentiation and complementarity were clearly demonstrated between the different strata.

Exploring the role of forest tree species in cocoa plantations for adaptation to climate change in West and Central Africa.

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Preferred session C1. AF, climate change, biodiversity conservation
Abstract There are over 2.5 million cocoa farmers in West and Central Africa who depend on cocoa and associated trees for their main source of income contributing 60–75% of family income. Like other climate dependent activities, cocoa production is sensitive to climate variability and change, which in turn render the livelihoods of farmers vulnerable. There are on-going discussions on the need to create forest structures in cocoa farms as an option for diversification that is beneficial to farmers’ incomes and as a coping strategy for the fluctuating cocoa prices at the international market. Two main types of cocoa farms exit in West and Central Africa. There is the un-shaded mono-cocoa system commonly practiced in Côte d’Ivoire and Ghana, and the shaded system used particularly in Nigeria and Cameroon. In the shaded system, forest trees help to create a micro-climate favourable for cocoa tree development. Few studies till now have tried to explore the use of forest tree species as a tool to adapt to climate change in smallholder cocoa farms of West and Central Africa. In this preliminary reflection we: 1) review how climate change will affect the cocoa belt of West and Central Africa; 2) discuss the potential role of forest trees in adaptation to climate change in cocoa farms; and 3) stipulate why it is necessary to include cocoa systems in any national adaptation plan. The paper ends with a discussion on the additional services provided by forest tree species for livelihood in the cocoa belt of West and Central Africa.

Key words: cocoa, cocoa agroforest, forest trees, climate change adaptation, West and Central Africa

Ndanifor Community Garden Project (NCGP): using local knowledge and science to improve agroforestry practice in Cameroon.

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract In 1996 the association of unemployed workers in Cameroon, made up of graduates, registered Better World Cameroon (BWC) as an NGO in order to begin a process of dealing with rising unemployment and environmental degradation. Farmers in Cameroon are rapidly ageing, and under the negative pressure of globalization have become subsistence farmers; and even in the face of the present food crisis and the effects of climate change, the government is not prepared to encourage young people to undertake farming careers. BWC uses the Ndanifor
Community Garden Project (NCGP) as a grassroots agency to find ways of increasing practical know-how in developing land-use skills and capacity in youths to raise levels of innovation and collaboration across youth networks. NCGP also investigates the role vacant lot community tree nurseries, such as the operation ‘2000 Indigenous Trees’ we are currently conducting, can play in advancing learning, good practice, motivation and improving the application of recognized modern organic gardening and agroforestry. NCGP mobilizes and sensitizes graduates to realize that our re-conceptualized agroforestry and permaculture programmes (growing indigenous trees for conservation and mitigating climate change) are rewarding vocations for youth livelihoods and the environment. This work is increasing the level of public awareness of, and support for, cultural and biological diversity which are essential in both the short and long term for the attainment of the MDGs in Cameroon and for meeting the targets of the Convention on Biological Diversity. Urban and community gardens for promoting forms of agrobiodiversity and offering a food biodiversity learning resource is a very replicable idea. We are committed to supporting the replication of Ndanifor Community Gardens throughout Africa and beyond by sharing our story and our methodology.

**Agricultural production and forest clearing: the role of farming in the development of tropical forests in Western Kenya**

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies  

**Abstract**  
In the developing world, forests contribute in important ways to the well-being of many rural populations, providing many products and services. These populations often rely heavily on forests for goods such as wood for fuel, fodder for livestock, and building materials among others. Forests also act as reservoirs or catchments for rivers and streams. While forest use is nearly ubiquitous in the developing world, the degree of forest dependence varies considerably across households. For some rural households forests are a main source of livelihood, for others they serve primarily a supplementary role or as a safety net in difficult times. Households that are heavily dependent on forests are an important source of forest degradation, and tend to be quite vulnerable to the effects of forest decline. Thus there exists a ‘vicious circle’ in which the rural poor are both agents and victims of resource degradation. Forest degradation continues to be a critical environmental issue. This paper examines the land-use choices of peasant farming agricultural households in Kenya and investigates how agricultural production impacts on deforestation levels. The data used to explore these issues will be derived from representative households residing adjacent to forest ecosystems in Kenya. An empirical model will be used to investigate how household characteristics and other key policy parameters largely influence deforestation and production decisions. Among other things, it is expected that more sustainable production methods are unlikely to be adopted by a majority of households who are tied up in the poverty trap. Households with greater levels of wealth will cause less damage to the environment. Since reduced environmental degradation is assumed to be positively related to improved household welfare, the findings may suggest complementarities between strategies aimed at poverty alleviation and those towards forest conservation.

**Influence of human activities on shea natural regeneration dynamics in Côte d’Ivoire**

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**Preferred session** B6. Agroforestry as a tool for landscape restoration  

**Abstract**  
In Côte d’Ivoire, the agroforestry systems of the north are dominated by the shea and nereid parks. However, many are shea natural populations which disappear with the promotion of industrial culture and with agricultural mechanization. The main objective of this study was to understand how anthropic factors could shape the dynamics of shea natural regeneration. This survey has been
conducted in two zones (Tengrela and Korhogo) with about 40 sampling units. The 40 quadrats were set up in fallows and in peasant fields in various systems of cultures (manual, harnessed and towed) with 20 quadrats in each of the two study zones. The results of this investigation showed that the structure and the dynamics of shea natural regeneration varied from one zone to another, according to plant formation and the culture system practised. In the fallows, the number of young shea was 960 plantations in Tengrela compared to 636 plantations in Korhogo. In the same way, in the fields, there were 373 young plantations in Tengrela and 45 young plantations in Korhogo for the same sampled surface. Also, The number of young shea inventoried in the fallows was 3.82 times more important than in the peasant fields. Similarly, the number of shea adult trees observed is 2.5 times more important in the fallows that in the cultivated areas. In the fields, the rate of shea young plantations is 55% in the manual system, 39% in the harnessed system, and 6% in the towed system. The human practices significantly influence the structure and natural regeneration dynamic of shea.

Key words: natural regeneration - Shea – Côte d’Ivoire

Hydraulic lift study in native tree species in an agroforestry parkland of the West African dry savannah

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Preferred session A6. Ecophysiological bases of agroforestry-system design

Abstract Hydraulic redistribution (HR) in karité (Vitellaria paradoxa) and néré (Parkia biglobosa) tree species was studied by monitoring the soil water potential (ψs) using thermocouple psychrometers at four compass directions, various distances from trees and at different soil depths during the dry seasons of 2004 and 2005. A modified WaNuLCAS model was then used to deduce the amount of water redistributed based on ψs values for the upper 80 centimetres of the soil. Tree transpiration rate was also estimated from sap velocity, and the contribution of hydraulically redistributed water in tree transpiration as well as to evapotranspiration were determined. The results revealed on average that 61% of the psychrometer readings under karité and 42% under néré showed the occurrence of HR in 2004. In 2005 the figures were 31% and 23% under karité and néré, respectively. Soil under néré displayed significantly lower fluctuations of ψs (0.16 MPa) compared to soil under karité (0.21 MPa). The results of this study indicated that the existence of HR leads to a higher ψs in plant rhizosphere and hence is important for soil water dynamics. The simulation showed that the amount of water redistributed was approximately 73.0 L and 247.1 L per tree per day in 2005 for karité and néré, respectively. Soil under néré displayed respectively 60% and 53% of the amount transpired a day, and 14% and 26% of the evapotranspiration. The volume of hydraulically redistributed water by the two species may play a key role in maintaining fine root viability and ensuring these species are well adapted to the dry areas. Therefore, knowledge of the extent of such transfers and of the seasonal patterns is required and is of paramount importance in parkland systems both for trees and associated crops.

Contribution of agroforestry policies to sustainable land use

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract Deforestation, land degradation and climate change are, nowadays, the major challenges that are jeopardizing the sustainable development of the world. The creation and sustainable management of agroforestry systems can efficiently contribute to improving livelihoods of millions of people throughout the world, due to their capacity to provide multiple alternatives and opportunities to local communities to protect their environment and improve their income. This paper gives a
A broad overview of the products and services provided by agroforestry systems in some countries in the Mediterranean Basin and the Middle East. Particular attention is paid to the interrelationships which exist between forests and agriculture, and the role, when sustainably managed, in drought, desertification and climate change mitigation, poverty alleviation and livelihood improvement. The paper concludes with the necessity of a system of integrated and sustainable natural resources management (ISNRNM), with emphasis on sustainable agroforestry systems (SAF), and for which a framework for action (FoA) is proposed. This FoA is based on a participatory and multi-disciplinary approach, and it involves users, planners and policy makers at all levels. It also strikes a gender balance, and underlines the key role of NGOs and civil society, along with the enhancement of communication, and the sharing of knowledge and experience between scientists, experts and practitioners.

Functional characteristics of tree species and their use in the restoration of degraded sites in the Mabira forest, Uganda

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
Forest degradation is a major problem in many countries in sub-Saharan Africa and has resulted in the loss of species diversity and a service role of forests. Degraded forests can be restored if-human-aided efforts such as enrichment planting of some severely degraded sites are made to buffer the pressure on ecosystems. However, restoration requires information on the function of various components of the ecosystem in the establishment and maintenance of such an ecosystem. This study was done to: derive functional groups among tree species of Mabira Forest, describe the generated groups and predict the ecological role of the generated functional groups in restoring the degraded parts of the forest. The forest has undergone encroachment and uncontrolled exploitation since 1970 that has left some parts of the forest completely degraded and others with low biodiversity. We used a functional approach to classify 100 tree species into groups of similar succession function within the forest ecosystem. Eighteen morphological traits (relating to leaf, bark, stem, flower, sex and defence) of the tree species of Mabira forest were collated from several publications about the flora of Uganda. Traits such as leaf area and specific leaf area were measured by collecting leaves and determining area using ‘Compu eye leaf area’ computer software. Hierarchical cluster analysis with Genstat was used for generating the groups. Seven functional groups were generated, each represented by 3 39 species. The groups represent species in the various succession hierarchy of a forest ecosystem. Pioneer species and climax species were most represented in two groups. We recommend replanting the short-simple leaved pioneer species to restore completely degraded sites, mixed woody secondary succession species for medium degraded sites, and later succession species for parts that experienced disturbance more than 20 years ago.

Key words: restoration, degraded, classification, forest ecosystem

Threats and opportunities of Brazil’s National Plan for Native Species Forestry and Agroforestry Systems

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract
Several market studies show that the demand of forest products from native species will grow nationally and internationally. Additionally, consumers are conscious of the necessity for products made in sustainable ways. In this context, Brazil has a great potential to increase its production. However, even with all this potential, most of Brazil’s wood and non-wood production from native species is made with unsustainable methods, with no reforestation of useful species. In
addition, Brazil has 16.5 million hectares of degraded areas in the Amazon region that could be re-introduced to productive processes. On the other hand, Brazil has nearly 4 million smallholder farmers that should be incorporated into the market, in a way that maintains their food security. Thus, in order to create favourable conditions to improve the commercial production and the availability of products from agroforestry systems and native species, and at the same time to afford social, environmental and economics benefits, the Brazilian government developed a National Plan for Native Species Forestry and Agroforestry Systems. This plan is composed of the following thematic lines: information system, science and technology, seeds and seedlings availability, technical assistance and rural extension, credit, forest products market and commerce, legislation and monitoring and plan control. Therefore, the main aim of this study is to analyse the threats and opportunities of Brazilian agroforestry policies. In fact, there are many others public policies, but even though they are not directly connected they indirectly influence the agroforestry activities. So, making all these policies effective tools for agroforestry development, while creating a more sustainable land use, is one of the challenges of the Brazilian agroforestry policy.

Smallholder farmers’ perceptions of agroforestry systems in the Brazilian Atlantic forest region

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract The environmental, social and economic benefits from agroforestry systems have been proved in the last years. However, this kind of production system has a limited acceptance by farmers, especially by the smallholder farmers. In Brazil most of the farmers adopt the conventional agriculture method, i.e. monoculture production, so they are not used to planting and managing different plant species in the same piece of land. Therefore in some cases it is difficult for them to understand the complexity of an agroforestry system, whereas knowledge of the dynamics and the evolution of such a system are needed. The success of an agroforestry system results from the amount of work employed in the implementation and management of the system. Hence is crucial to know the farmer’s perception of this work in order to enhance the adoption of such technologies. In this context, the aim of this work is to verify the farmers’ perceptions about agroforestry systems in Guaratuba municipal district, which is located in the Brazilian Atlantic Forest, and to define the species to be used. Interviews were the main method used for the data collection and 39 people from eight different communities were interviewed. The interview followed a close-ended structure with some ranking questions. In total 25.6% of interviewees considered that agroforestry systems will not work, but 74.4% agreed that this system could be positive for the community. The proposed crops to be combined in an agroforestry system were: palm-tree (33.3%), cassava (12.8%), fruit trees (7.7%), marakuja (7.7%), banana (5.1%), bean (5.1%), maize (2.6%), sugar cane (2.6%), coffee (2.6%) and chayote (2.6%). Just 23% of interviewees have ever heard about the term ‘agroforestry systems’ but most of them know the practice and have an interest in it. In the face of this, agroforestry activities show a high adoption potential in the region studied.

Bamboo-based value addition through agroforestry – creating a sustainable future

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract Bamboo, which is a poor man’s timber, grows abundantly all over the world. However natural forests of bamboo are largely on hills and in valley regions. Though harvested commercially various bamboo species are grown on private farmlands under agroforestry have provided a rich potential for local value addition. Seventy percent of India’s population resides in rural area and there is immense demand for a fast-growing species with multipurpose usage, which can
be processed for local value addition. In tribal-dominated regions, especially Chhattisgarh State, efforts have been made to develop rural decentralized nurseries under agroforestry, involving farmers, women’s self-help groups to produce bamboo rhizomes. This itself is a source of income generation. Developed bamboo rhizomes are distributed to farmers, with 100 rhizomes free of cost, and if demand is more then it is provided at subsidized rates. Farmers are encouraged to plant on field bunds, as block planting on farmlands, and also on community lands through local bodies known as Panchayats. This is done under the overall supervision of forest management committees. Training programmes have been designed to conduct field orientation in vernacular language. To provide marketing opportunities for the above agroforestry produce, local markets have been surveyed. Additionally, at places where traditional bamboo-dependent families are working locally, known as Basods and Kamhars, community-based ‘processing centres’ have been established; in these centres, low-cost machines have been installed. Through training, in the treatment of bamboo poles and in design skills, very attractive products are being prepared, which provide additional wage earning to the rural craftspeople as well as providing green cover to the local environment, securing the foundation of a sustainable bamboo-based economy, providing livelihood and economic security.

Farmers’ innovative multistrata productive agroforestry systems in the Madhupur Tract of Bangladesh

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract
Madhupur Tract, three percent of the country’s land area, is one of the potential land types for diversified agroforestry practices in Bangladesh. Research was conducted in this land type to identify potential traditional agroforestry systems, their management practices and profitability over mono-farming from January to May 2007. The study was done through surveys and monitoring of the selected homesteads and their adjoining areas that had agroforestry practices. A total of 157 traditional and new agroforestry systems were identified depending on crop and tree combinations, of which Artocarpus heterophyllus (Jackfruit)-based systems was found to be dominant. Among the identified systems, the four top-ranked systems, jackfruit turmeric, jackfruit ginger, jackfruit brinjal and jackfruit chilli, were investigated thoroughly. From the study it was gathered that the farmers had been practicing these dominant systems for more than 30 years. The unit size of these systems varied but the average size of the farms was about 0.08 ha. Among the production systems, the jackfruit brinjal system occupied a relatively larger area compared to other systems. It was found that the planting materials of both trees and crops came from farmers’ own sources. None of the respondent farmers were found to follow recommended management practices for the tree component, except pruning/removing the dead and infected plant parts, but they followed management practices for associated crops. The average net return from agroforestry systems ($ 1900) irrespective of crop combinations was higher than non-agroforestry systems ($ 472) from one hectare of farm in a year. This indicates the profitability of agroforestry systems over mono cropping systems. Despite huge margins, there still remains ample scope for improvement of the systems by following scientific management practices.

Climate change and human activities in Bangladesh: `agroforestry` as a good option for food and economic security

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Preferred session C4. Mitigation and adaptation to climate change
Abstract

Agriculture is central to the livelihoods of the majority rural households in Bangladesh and it is likely to remain the largest operation for feeding the ever-increasing population. Recently, a number of climatic events and anthropogenic activities posed severe threats to crop production. Floods and waterlogging, cyclones and storm surges, salinity intrusion and drought are common but these events are occurring more frequently due to climate change. The most visible impacts of this change are sea level rise, erratic rainfall patterns, prolonged drought and devastating tropical cyclones. In addition, the country is increasingly becoming more vulnerable because of the rapid expansion of anthropogenic activities such as brackish-water shrimp farming, salt production, soil erosion, intensive use of agro-chemicals, unplanned urbanization and commercial activities. The cumulative effects of all these events are causing severe impacts on land-use patterns, agricultural production, forests, biodiversity, energy, water security as well as human and animal health. Under these adverse situations, the practice of agroforestry has appeared as a viable and potential option. A large number of traditional and new agroforestry production systems have been identified through several field studies across the country during the last couple of years. Among the identified traditional production systems, *Phonix sylvestris*, *Borassus flabellifer*, *Artocarpus heterophyllus*, *Mangifera indica*, *Areca catechu* and *Acacia nilotica*-based systems are the most dominant farmland production systems in addition to the multistoried homegardens and shifting cultivation (hill farming). The newly emerged agroforestry systems are *Litchi chinensis*, *Zizyphus auritiana*, *Psidium guajava*, dwarf *Mangifera indica*, *Swietenia macrophylla*, *Eucalyptus camaldulensis* and *Melia azedarach*-based tree species. All these systems are believed to be effective for counteracting the impacts of climate change and natural hazards as well as for improving the household food and economic security. Promotion and scale-up of those systems would be the best adaptation and mitigation option against rapid climate change.

Combating Land degradation through participatory reforestation in Western Kenya.

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

Western Kenya is characterized by massive deforestation for fuelwood, agricultural land and settlement. The net result is an increased rate of soil erosion leading to severe land degradation, reduced agricultural productivity, increased sedimentation of Lake Victoria and poverty amongst the local community. Earlier studies indicated that over 58% of households in the region live in absolute poverty. The Western Kenya Integrated Ecosystem Management Project attempts to address the issue of land degradation through a participatory reforestation approach. Local communities were sensitized and trained on tree nursery establishment to ensure the availability of adequate tree seedlings of assorted species for planting on degraded lands. One hundred of such nurseries were established with over 600 000 seedlings within 2.5 years. These were planted by the community on their farms as woodlots, boundaries and on severely degraded lands such as fenced off gullies. Alternative livelihoods such as horticulture and improved livestock were used to support the communities’ daily needs while engaging in land rehabilitation initiatives. Early results showed significant reduction in gully expansion rates of between 75% and 100%, which was attributed to the stabilization of the gully embankments as a result of the increased vegetation cover and reduced encroachment by humans and livestock. Awareness creation and community empowerment led to an increase of between 30% and 70% of community people undertaking reforestation as a strategy to sustainable land management in the study areas. Participatory reforestation seems to be a promising option for the communities in Western Kenya to reverse escalating land degradation and conserve the environment for future generations.
Fruit trait variability among and between Dacroydes edulis trees of seedling and vegetative origin.

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Preferred session: B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract

This study involved 14,940 Dacroydes edulis fruits, randomly picked from 498 trees of seedling and vegetative origins in two experimental sites (Mbalmayo and Minkoa-Meyos) in the humid forest zone of Cameroon. They were assessed for seven fruit traits: fruit and kernel masses, fruit length, width and pulp thickness and epicarp and mesocarp colour. Trees were grouped into four ‘varietal’ categories (A, B, C, D) based on their mean performance in each fruit trait (fruit mass, width, length and pulp thickness). Trees of vegetative origin (marcots) were generally superior in fruit traits to trees derived from seedlings and cuttings. Highly significant differences were observed in mean fruit mass, fruit width, fruit length and pulp thickness (p<0.001) between fruits from seedling, cutting and marcot propagant types. Fruit mass was more variable among trees derived from seedlings (CV= 47.91%) than that of trees derived from cuttings (CV=27.54%) and marcots (CV=22.42%). Significant tree-to-tree variation was recorded in fruit traits. Pulp mass had the highest correlation with fruit mass (r=0.976) and fruit width (r=0.877). Fruits were variable in epicarp and mesocarp colours and no considerable correlation existed between epicarp and mesocarp colours at Mbalmayo (r=0.151) and Minkoa-Meyos (r=0.103). From this study it is evident that trees with high fruit masses combined other interesting fruit traits such as mass, width, length and pulp thickness. In addition some trees poor in one trait are extremely rich in another trait. Therefore this study identifies elite trees from initially selected trees in seed/clonal orchards, which through control pollination between identified elite clones, could take advantage of specific combined abilities of unrelated superior clones and produce D. edulis progenies with heterosis in desirable traits that exceed that of the wild or parent population.

Sustainable livestock and agro-forestry integration in Heifer International Cameroon

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Preferred session: A.11. on Silvopastoral Systems

Abstract

Heifer International Cameroon (HIC) is a non-profit, non-governmental organization with a mission to end hunger and poverty and care for the earth with livestock as a point of entry. HIC, in line with the Millennium Development Goals, believes in the efficient use of local available resources in order to bring a positive change in the livelihoods of the rural poor, marginalized and vulnerable using environmental friendly practices. Ethno-veterinary medicine, which is the use of local materials from plants such as leaves, roots, seeds etc. in the treatment of animal diseases, is used as an alternative to the orthodox treatment, which is very expensive and at times not available. Ethno-veterinary medicine is cheap and farmers do save some money which otherwise would have been spent to buy orthodox drugs. Agro-ecological water catchments are protected by using agroforestry trees. Planting eucalyptus trees, bush fire and farming around water catchments is now a thing of the past. Live fences are constructed around livestock structures and act as wind breaks and prevent animals from roaming and spreading disease and destroying plants. This makes collection of animal waste easier and is used to make compost which is used on farms to increase the fertility of the soil. This is a very good alternative for chemical fertilizers which are expensive and usually not available. It is safe and cheap and farmers have increased their farm production and correspondingly their sales. The leaves of the agroforestry plants are used as forage for the animals especially during the dry season. These agroforestry trees are also being integrated with crops to boost production. The improved stove is used to combat indiscriminate felling of trees for fuelwood since it uses less wood. Money which otherwise could have been spent to buy fuelwood is saved and fewer trees are cut down.
Influence of economics and public policies on native species conservation in coffee agroforestry systems of Kodagu (India)

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract Socio-ecosystems are described as complex adaptive systems. Public policies aimed at influencing such systems, if considered inappropriate by local stakeholders, will be undermined by the emergence of alternative strategies subverting the proposed changes. Applying this concept to the field of natural resources management, in this paper we report how a set of laws and tenure rights aimed at protecting native species in a complex multi-strata agroforestry system actually could achieve the opposite result. We focus on Kodagu district in the Western Ghats of India. Kodagu produces 2% of the world’s coffee, mainly in small holdings (<10 ha). In an assessment of 114 coffee estates spread across the landscape, we identified over 240 tree species, both native and exotic, making this production system one of the most diverse in the world. This allows for cautious optimism regarding biodiversity conservation in human-modified landscapes. Yet over the last 20 years, intensification of the same production systems has resulted in gradual thinning of the shade cover and replacement of native trees with fast growing exotics, primarily Grevillea robusta. This replacement has been happening despite the existence of a framework of land and tree tenure rights and legal constraints designed to protect native species and the resources that they represent. Interactions between this framework and market forces driving intensification via coffee prices, wood demand, need for pepper stands, labour and input costs, have contributed to make G. robusta the obvious choice, at the expense of the native species that the framework was supposed to protect. Based on this scenario we explore alternative strategies that would tilt the balance in favour of native species without limiting the livelihood options of local farmers. Such alternatives, if developed endogenously may be more acceptable and therefore more likely to attain the original objective of conserving native species.

Tree species diversity in coffee agroforests around Mabira Forest, Uganda

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Coffee agroforests are important farmer-managed systems that play a great role in peoples’ livelihoods and biodiversity conservation around Mabira Forest in Uganda. These agroforests also act as buffer zones between the natural forest and the drier areas of the Lake Victoria basin. They therefore provide connectivity between the natural forest and the drier areas. There is sparse information on the contribution of the agroforests to biodiversity conservation. It is important to know how effective these agroforests are in the conservation of biodiversity. The overall aim of this study was to assess the contribution of coffee agroforests to tree species diversity around Mabira Forest Reserve. Seventy nine 0.1ha (20 m x 50 m) plots were established in nine villages around Mabira Forest adjacent to areas with four different forest exploitation histories (relatively undisturbed forest, disturbed forest, >5 km away from the forest boundary, and commercial coffee farm). A total of 874 trees belonging to 63 species were encountered. The diameter size class distribution showed that most trees encountered were < 40 cm DBH. There was higher species diversity (Shannon diversity index = 3.5) in the villages adjacent to undisturbed forest compared to those near disturbed or >5 km away from the forest. The importance value index (IVI) showed that the three most important tree species were Artocarpus heterophyllus, Carica papaya and Persea americana followed by Albizia chinensis and Ficus natalensis. These results show that coffee agroforests are important for maintenance of tree diversity. However, farmers especially those that are far from the forest, prefer to plant multipurpose, commercial (fruit) trees as a means of income diversification. This study has provided a baseline list of preferred tree species that are used by coffee farmers around Mabira Forest Reserve.
Traditional practices in shea tree (Vitellaria paradoxa) conservation in Uganda

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Preferred session D4. Incorporating local knowledge in agroforestry science
Abstract

The shea tree (Vitellaria paradoxa C. F. Gaertn), a characteristic tree of the savanna parklands of Uganda is the source of various economic products, the most important of which is oil. The shea tree is an important source of income for Uganda’s rural women and children who sell the oil in the local markets. Local community conservation of this tree is governed by a complex mix of traditions, customs, taboos, rituals and legends which are handed down from generation to generation and are neither found in written form, nor organized and structured in ways accessible to science. This study was conducted to document these traditional practices. Ninety-seven farmers from 9 districts of the shea belt of Uganda were interviewed between April 2007 and June 2008. Nine focus group discussions and farm visits/walks were also conducted in these districts. The traditional practices, taboos, legends, folklore, poems, songs and proverbs regarding the shea tree were documented. These range from issues regarding shea tree and fruit ownership to traditional punishments for errant community members who disregard the local norms in the use of shea trees and products. However, a combination of factors including wars, erosion of traditional lifestyles and cultures, poverty and education are eroding these community conservation practices. Documentation and the use of mass media, action plays/drama and public awareness are some of the possible avenues suggested to stem the erosion of traditional shea tree conservation practices.

How Machia is important for rural development in Turkey

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract

Many of the forest villages that are located in the Mediterranean and Aegean parts of Turkey are heavily under the effect of the Mediterranean climate. These regions have come into prominence with a rapid development of tourism in the last decades and the country’s economy has had a big income from these activities. On the other hand, the main incomes of forest villagers in Turkey are relatively low, being from agriculture, livestock and forest work. Because of this, when making ecosystem management plans, this regional economic structure must be taken into account. Land-use policies based on nature conservation must have a priority, and the vital activities of forest villagers should be shaped in accordance with these policies. In this context, agroforestry is one of the usable tools in these regions. Scrub communities in Mediterranean parts of Turkey are called macchia. Even though the biological and ecological richness of macchia weren’t known in the past, today ecologists and botanists are aware of its importance. The richness of macchia can be used as an important economic income to set against the economic losses of forest villagers that would appear as a result of the land-use policies based on nature conservation. Many woody species in macchia have economic value and are used in chemical, medical and food industries. The trade of some of them is intensively carried out by forest villagers, such as Ceratonia siliqua and Laurus nobilis. In addition to woody species, the number of herb species is very high in macchia. Many aromatic species like thyme are collected from their natural habitats. But it is not possible to say that this process is going on regularly. In this context, this work. Presents the actual usage of macchia lands and some suggestions about the forthcoming plans for these places in relation to rural development.
 Indigenous fruit trees and their contribution to household income: the case of *Dacroydes edulis* (g. don) hj lam and *Irvingia gabonen*

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**Preferred session** A2. Agroforests in humid tropical Africa

**Abstract**

A study to quantify the yields of individual *D. edulis* and *I. gabonensis* trees in different cropping systems and their contribution to household income was carried out in Elig Nkouma, Lekie Division, Centre Province of Cameroon. In view of the fact that older trees are more productive than younger trees, of particular interest was the relationship between the age of the tree and the yield. Sixty households were randomly selected for interview in the study site. The results indicate that yields of individual *D. edulis* and *I. gabonensis* trees vary depending on the age of the tree and the cropping system. Yields from *I. gabonensis* ranged from 3 kg/tree to 368 kg/tree with higher yields in food crop fields than in cocoa fields. For *D. edulis*, yields ranged from 4 kg/tree to 198 kg/tree with the highest recorded for trees in homegardens and the lowest in food crop/fallow fields. The results showed that women are mostly involved in the exploitation and commercialization of the products of these species. The quantity harvested per household was 441 kg of *D. edulis* fruits, out of which 72.6% is sold and 27.3% product consumed at home or given out as gift. For *I. gabonensis* 332.5 kg was harvested per household for that cropping season, out of which 29.2% was either home consumed or given as gift, and 70.7% of the product was sold. These sales represented about 20% of total income generated for that cropping season per household. The results indicate that the flow of market information within the study area is poor, the consequences being low prices offered to farmers. The production of *D. edulis* and *I. gabonensis* for income generation can be improved if the farmers are organized, have information on appropriate processing and storage techniques and market channels for these products.

Togolese experiences on agroforestry

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**Preferred session** B9. Collective action for tree-based rehabilitation of degraded lands

**Abstract**

Togo has five administrative regions (savanna region, kara region, central region, mountains region and maritime region). It is divided into five ecological areas. Following land degradation and a dry season in 1977, the government decided to create, in 1978, a forestry production policy to support the farmers to plant trees and educate them in new know-how to cultivate trees and improve their productivity. An Institute of Soil Restoration was established at the Agriculture Department. In forestry areas the farmers, schools, local government and the private sector created their own plantations. From 1970 1984, the first experience of agroforestry took place in two regions (savannah and maritime) having the most vulnerable areas of land and poor productivity. NGOs were undertaking the same initiatives. The objective of the forestry production policy is to distribute plants and advise the farmers to plant trees and other species of agroforestry. The Institute contributed to research and disseminated its results. After many years of practising agroforestry, what are the results? We know that many actors such as IFDC, administration, private sectors, University of Lome, are involved in supporting the livelihoods of the population. Our desire is to share and exchange experiences with other countries. It is important to know which partners are supporting the practices of agroforestry in my country and the agroforestry network links on the rest of the continent and in the international community .
To evaluate the multifunctionality of parkland systems in the buffer zone of the Biosphere Reserve of the W Park

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

The immediate periphery of the Park of W (Burkina-Faso, Niger and Benin) constitutes a space that has various stakeholder groups of permanent actors (farmers and managers of the protected area) or temporary actors (trans-human breeders and hunter tourists). For the farmers, it is about a space of food production, cash crops and land appropriation; it must play an agro-ecological role. For the other stakeholders it is: a sort of large corridor for the breeders’ cattle; a tank of a specific fauna for the hunter; and a space for maintenance of landscape mosaic and biodiversity gradients on the interface of the protected area anthropogenic zone for the land managers. The parkland system is the principal mode of land utilization, or at least the one which influences the landscape structure the most. In this, it is seen to be assigned a multifunctional role. The contribution of the parkland system to multipurpose agriculture and a multifunctional space will be analysed under three aspects: 1) an evaluation of the degree of satisfaction of expectations of the different actors; 2) a graphic modelling of the space-time organization of the agroforestry space-resources of the village territory; 3) other chorems which integrate the level of integration of the different uses on this territory.

The intertwining issues of forestry and upland agriculture

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Preferred session C2. Carbon sequestration in agroforestry

Abstract

In most developing countries in tropical Asia, population and economic growth are the most important determinants in the demand for forest products and services. Agriculture is the most important sector in the economies and an integral part of the forests. Forests are converted to agriculture permanently and by shifting cultivation as a way of increasing agricultural production and survival. The rural poor in the country in which agricultural productivity is low and access to available land and information is limited are the most likely to put pressure on forest areas resulting in continuing loss of forests and degradation. Simply forbidding access to the resource is not an option, but feasible production management options should be investigated. Efforts should be directed towards an improvement in the productivity and the sustainability of the production systems of the people directly dependent on forests and agricultural activity for their livelihoods, while environmental considerations are taken into account. The greenhouse gas (GHG) emissions caused by deforestation and agriculture together account for 40 percent of total emissions. Thus, the commitment of the developing countries to the reduction of GHG emissions is considered highly important. Forest area management, tree farming and agroforestry systems have great potential for carbon sequestration while providing food security. Since a market is emerging in carbon under the Kyoto Protocol’s Clean Development Mechanism (CDM), there is an increasing interest in carbon forestry projects. This paper shall present insights into the potential of some smallholder carbon forestry projects in the Philippines to assess the viability of such projects as cost-effective business models to trade carbon assets, and discusses the projects’ liabilities. With policy recommendations for institutional reforms and technical support for smallholders’ forest area management participation in the carbon market, the Philippines smallholder carbon emission reduction endeavours can be potentially suitable for various REDD mechanisms.
The village territory and its woody agrobiodiversity -like components of the buffer zones: an idea against nature?

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract
The management of the peripheries of protected parks remains an important environmental challenge. Two objectives are advanced: a limitation of the anthropogenic pressures, in particular agricultural expansion, and the participation of local populations so that buffer zones can be effective and sustainable. A buffer zone is often installed to constitute a ‘barrier’ of protection, that generally encroaches on part of the bordering village territories. If it is considered a means to satisfy the first objective, it can constitute an impediment to the second objective. Indeed, it adds only one lawful protection zone. Other land managers, in the minority, recommend the use of agroforestry systems, remarkable for their landscape and ecological structure, such as the agroforests. This is one step better but not sufficient. A change of paradigm would suggest that the presence of the territories adjacent to the protected area is not regarded any more permanent a threat, but as a land of potential agrarian and landscape transformations. In the case of the agroforests, a major fact is forgotten in the analysis: systemic and spatial interactions between the various components of the landscapes. To want at any costs to preserve the agroforests as an entity can bring to the opposite effect, insofar as the whole of the territory and the different changes which take place there are not taken into account. It is the landscape mosaic on a territory scale which should be recommended, like buffer zone, for a new role: a space of ecological gradients between the protected area and the remainder of the peripheral zone. This change, recommended for future plans of management for protected parks, accompanies other major institutional dynamics: political decentralization and scientific action research. Agroforestry examples of different tropical zones will be used to argue this point.

Production potential of perennial Sesbania species under irrigation in solid and hedge row planting.

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Preferred session A6. Ecophysiological bases of agroforestry-system design

Abstract
A research project was undertaken on perennial Sesbania species to study its suitability in solid and hedge row planting at the College of Agriculture Farm, Raichur (16 15 N latitude and 77 20 E) from 2000 2001 to 2003 2004. The experiments were conducted on red soil of sandy loam belonging to the Haplustaff order Alfisol. Composite soil samples were collected from 0 to 15 cm depth from each experiment site before initiation of the experiments. The first study was laid out in split plot design with three replications which involved two Sesbania species, Sesbania grandiflora and Sesbania sesban, at three plant densities (10, 20 and 40 000 pl/ha and three phosphorous levels (0 60 and 120 kg/ha) with and without VAM inoculation. The results indicated that edible, woody and TDM and fresh biomass increased in both the species at 12 and 24 months after sowing. Among the species, S. grandiflora produced higher edible woody and TDM than S. sesban at both stages. An increase in plants decreased edible, woody, TDM and biomass in both the species. Application of phosphorous caused a significant increase in all the parameters studied. VAM inoculation plus 60 kg phosphorous was on par with VAM plus 120 kg phosphorous. Another trial was conducted in randomized block design to study the effect of the addition of prunings (AP) with varying levels of RDF on the yield of maize and groundnut in an alley-farming system. AP coupled with RDF significantly recorded higher grain and pod yields in both maize and groundnut, respectively. The percent increase over the control in maize and groundnut was to the tune of 116% and 86% respectively.
Agrarian communication and resource networks:

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**Preferred session** D4. Incorporating local knowledge in agroforestry science

**Abstract**

Current and future challenges associated with land degradation, scarcity and climate change will have a significant impact on agroforestry practices with far-reaching consequences for system productivity and biodiversity, ecosystem services and food security. Such challenges will be paralleled with shifting farmer migration patterns, particularly as greater out-migration occurs in drought-prone regions. We examined the indirect impact of farmer movement and migration on agroforestry management practices. By determining communication network structures and network characteristics, particularly kin relationships, we assessed migratory affects on agroforestry management with a social network work analysis approach. The study was conducted in four agrarian communities in the cocoa-growing western region of Ghana, West Africa. Our results revealed that clearly structured communication patterns on agroforestry practices emerged within these communities. Information on agroforestry was noticeably sought from a smaller densely connected group, however this group was heterogeneous, as neither local nor migrant farmers are over represented. Migrant farmers represented 73% of highly sought farmers on agroforestry management practices, suggesting that social proximity did not control these informal communication structures. Of these highly sought farmers, 84% used external information, predominately from government institutions, thus functioning as bridging links between formal and informal networks, allowing for information transfer. Currently, we are expanding this network approach to examine changes in agroforestry management on a stakeholder level. We propose the utility of social network analysis within an agroforestry context to facilitate adaptive strategies to augment agroforestry resilience under a changing and uncertain climate.

Perceptions of local people towards biodiversity conservation and the role of agroforestry in Cagayan province, Philippines

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

One of the functional attributes of agroforestry is the ability to support biodiversity in the landscape. This research examines the knowledge and perception of the local people towards biodiversity conservation in the multifunctional landscape of the Peñablanca Protected Landscape and Seascape (PPLS) in Cagayan, Northeast Luzon, Philippines. The PPLS serves as a microcosm of biodiversity conservation in the Philippines with agroforestry as one of the major strategies for conserving biodiversity. These conservation activities are being implemented by various actors and organizations across different levels. In many cases, the knowledge and perceptions of the local people are neglected in the entire process which normally results in the failed adoption of the project or lack of sustainability in the long term. This paper presents the results of a field study on the community’s knowledge and attitude towards biodiversity and agroforestry projects. Semi-structured interviews were conducted among 120 households selected at random from four villages representing the upland and lowland communities of PPLS and its buffer zone. Likewise, representatives of various non-government organisations and government offices, including local government units were interviewed. Few respondents proved knowledgeable on biodiversity. However, the majority was aware of the presence of biodiversity and agroforestry programmes in their community, reporting about programme benefits in terms of food security and livelihood. Few respondents still continued to harvest biodiversity resources from the natural environment to meet their basic wood requirements and alternative food resources.
Smallholder farmers preferences and strategies to cope with price fluctuations of agricultural commodities

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Preferred session E4. Socioeconomics and Agroforestry in the Pacific

Abstract Prices of agricultural commodities commonly influence farmers’ preferences and decision making on the way they manage their agroforest and/or decide to replace them with other land-use systems. The increased price of a specific commodity will increase farmers’ motivation to intensify its role in their mixed-agroforest garden, and potentially move towards a monocultural system. In comparison to agroforests, monocultural systems may provide a higher benefit for the farmer, as long as the price of the main crop is stable or increasing. But, when the price of the main product decreases, an agroforestry garden will provide more income security than the monoculture system due the more diverse products from agroforestry than monoculture systems. A case study in Bungo district, Jambi province, Indonesia, studied the transitions from rubber agroforest, which used to be the major source of the local community’s livelihood, into a more monocultural system with rubber or oil palm as the main crop. Farmers’ livelihood security is now at risk with recent price decreases for rubber and oil palm to about 60% of the previous price. Based on interviews and discussions with farmers, combined with findings from previous economic analyses and studies of farmers preference in rubber agroforest management in Bungo, we identified smallholder farmer strategies and preferences in Bungo to cope with the uncertainty of prices. As the rubber agroforests have become of major importance for biodiversity conservation, with little natural forest effectively conserved, the farmers’ decision making needs to be understood before effective conservation strategies at the landscape scale can be devised.

Key words: rubber, oil palm, agroforest, livelihood security, monoculture

Searching for agroforestry farmers: stories of innovations in northern Philippines

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract A Regional Agroforestry Technology Information Kit (RATIK) was produced by the Department of Environment and Natural Resources (DENR) from 1991 to1995. It produces documents aimed at guiding farmers in different parts of the country to implement agroforestry and its support technologies. It was from a similar concept that is what is now known as Program to Enhance Non-Governmental Organization (NGO) / People’s Organization (PO) Agroforestry Capabilities for Food Security and the Environment (PEACE) of the Institute of Agroforestry (IAF) of the University of the Philippines Los Banos, was developed. Having started in 2000, PEACE-RATIK continues to document agroforestry practices and technologies addressing the needs for food, improved production, increased income, and sustained soil and water conservation. This paper focused on the experiences of agroforestry farmers in Northern Luzon, Philippines and their stories of resourcefulness, courage and perseverance in implementing agroforestry amidst seemingly insurmountable problems and challenges. The framework revolves around a set of criteria and indicators for the implementation of successfully or potentially successful agroforestry technologies and practices based on the premise of sound or well-designed agroforestry systems specified by the World Agroforestry Center (formerly ICRAF): productive, sustainable and adaptable/acceptable.
Production of *Jatropha* for biofuel and its derivatives

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Preferred session  
B7. The role of degraded lands in biofuel production in SE Asia

Abstract  
This project’s main objective is to improve the promotion of development investments in this new source of biofuel and contribute to the Millennium Development Goals by enhancing ecologically sensitive, pro-poor investments in *Jatropha* biofuel in the developing world such as Benin. Indeed, recently the energy crisis has struck the world and energy is an essential element in the process of development. The principal causes of the current oil shock are a strong increase in global demand for oil and the saturation of production capacity of OPEC. The availability of electricity and conventional fuels (kerosene, gasoline and diesel) is very limited in several regions. Climate change is partly due to greenhouse gases emitted by the combustion of petroleum products. This has prompted several countries to focus their research on alternative energy including biofuels. Biodiesel obtained from oil extracted from oil plants can replace diesel or kerosene and can be used for lighting, cooking and as fuel in diesel engines including grain mills, generators and vehicles. One oil plant is *Jatropha*, a tropical plant growing in the wild that can be used for the production of biodiesel. *Jatropha* promotes four main aspects of development, which combine to help assure a sustainable way of life for farmers and the land that supports them: renewable energy; erosion control and soil improvement; promotion of women; and poverty reduction. To summarize, the *Jatropha* system is characterized by many positive ecological, energy-related and economic aspects that are attached to the commercial exploitation of this plant. The more this plant is exploited, the better for the environment. The *Jatropha* system is being used extensively already in East Africa (especially Tanzania and Mali). Experiences in other countries may be useful in further development of this system in Benin.

Biofuel production and uses from agroforests within a land-management framework in rural Bangladesh

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Preferred session  
B7. The role of degraded lands in biofuel production in SE Asia

Abstract  
Biofuel is a major component of rural domestic energy in Bangladesh. Most of the biomass for biofuel is derived from forests. But the biofuel resources are dwindling rapidly with the decline in forests due to high population growth and agricultural expansion. Consequently, rural communities are increasingly dependent on crop residues to meet biofuel demands. The residues are collected and removed from the fields, and with it the stored nutrients, leading to lower yields. Agroforestry is a sustainable land-management system that can mitigate the major demand for biofuel and help to maintain livelihoods as a safety-net function. This research was conducted in northern Bangladesh and the data were collected by RRA, FGD, in-depth case study and a structured survey of 100 farm households. Data were analysed through qualitative methods largely following heuristics of causality, and through quantitative economic methods and models. Agroforestry in this region is practised in homestead and agricultural fields. It provides 80% of the biofuel biomass i.e., wood, tree branches, leaves, straw etc., the most common biofuels for cooking, and people of all classes use it. The availability of biofuel biomass offers many poor rural people access to an inexpensive and sustainable source of energy. The tradeoff between food and fuel is also most directly confronted by the small-scale farmers who have historically grown their own food, and agroforestry tends to carry lower production risks and greater adaptability to drought periods than many other cultivation systems. Within agroforestry, biofuel production could consist of small plots dedicated to annual or perennial crops as a part of integrated land-use systems. In the landscape context, this study proposes an increased emphasis on biofuel production through agroforestry systems that promote landscape multifunctionality by simultaneously delivering energy, rural livelihood benefits, biodiversity conservation, and a wide range of ecosystem services.
Influence of scale on the economic feasibility of carbon credit finance for smallholder forestry and agroforestry projects

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Preferred session: C2. Carbon sequestration in agroforestry

Abstract: Carbon offset revenue can be an important financial driver to expand and maintain sustainable agroforestry management. However, the small size and fragmentation of smallholder plots severely hamper their participation in carbon projects. Excluding this poorest and most widespread land-user group not only limits their economic development, but also effectively prevents land-use improvements in vast areas with high potential for climate change prevention and mitigation. This presentation examines the influence of scale on the economic feasibility of carbon finance for smallholder forestry and agroforestry projects, and proposes an approach to increase their inclusion. Small land parcels that are distant from each other or that have a narrow shape, such as hedgerows, are more difficult and expensive to measure and monitor for carbon than larger, contiguous plots. They are typically more labour intensive and the technologies are more complex: (a) fixed costs are higher, for example, for registration and for procurement of remote sensing images; (b) variable cost are non-linear with size, e.g. the work on remote sensing analysis, ground measurement, and third-party verification increases with fragmentation; (c) small plots create technical challenges in the relation between resolution and minimal mapping unit; and (d) small-scale land-use decisions by more users per area lead to more heterogeneous management styles and tree species. Scale also affects the financial viability through other factors, such as higher costs for capacity building, and social risks. For example, a larger number of landholders can increase the risk of project failure due to disagreements or stronger dependence on agricultural revenue with narrow margins; small deterioration in income can force them toward unsustainable practices. This presentation proposes solutions to deal with smallholder plots by developing a theoretical model that weighs the cost per megaton of carbon versus the average parcel size, density, and shape.

Conservation agriculture in Malawi: integrating agroforestry to enhance productivity and sustainability

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract: Conservation agriculture is an improved system of farming that involves minimal tillage of soil, retention of crop residues on the soil surface, weed control, intercropping and/or crop rotations. Environmental benefits include: 1) improvements in soil properties; 2) reduced runoff and loss of top soil; 3) maximum infiltration of rainfall; 4) weed, pest and disease control; 5) retention of soil moisture and nutrients; 6) carbon sequestration; and 7) lower carbon gas emissions from reduced burning. Conservation agriculture also saves much manual labour for land preparation and weeding, allowing the redistribution of labour for planting and managing other crops. This paper documents the agronomic, soil and economic benefits of conservation agriculture to mitigate the risks and vulnerability of smallholder farmers to climate change in Malawi. Although these benefits have generated strong interest in this practice, its wide-scale adoption faces challenges to break cultural norms of tillage and the initial costs of chemical inputs. In this context, the integration of agroforestry offers opportunities to attract greater support for conservation agriculture by increasing and complementing its many benefits to enhance productivity and sustainability. The practices promoted include intercropping and fallows with species of Tephrosia, Cajanus and Mucuna, and integrating Faidherbia albida, an indigenous tree commonly retained and planted on farms for its effects on crop yields. Apart from improving soils, these deep-rooted plants ensure good root development to optimize crop growth by breaking up hardpans formed from years of continuous hand-hoe cultivation. Secondary benefits include effects on Striga and other common weeds.
crop pests, as well as production of wood, fuel and fodder. Collectively, the impacts demonstrate huge potential to transform smallholder agriculture in this part of Africa with increased local capacity for adaptation to climate change.

**Distribution of organic C oxidizable fractions in soils**

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**Preferred session**  
C5. Soil organic matter and nutrient cycling in multi-strata AF systems

**Abstract**

Agroforestry systems can play a major role in the sequestration of carbon (C) because of their higher input of organic material to the soil. The importance of organic carbon to the physical, chemical, and biological aspects of soil quality is well recognized. However, total organic carbon measurements might not be sensitive indicators of changes in soil quality. Adoption of procedures that can extract the more labile fraction preferentially might be a more useful approach for the characterization of soil organic carbon resulting from different soils. This study aimed to evaluate organic carbon (C) fractions distribution in different soil layers up to 50 cm depth in cacao (*Theobroma cacao*) agroforestry systems (AFS) in Bahia, Brazil. Soil samples were collected from four depth classes (0 5, 5 10, 10 30 and 30 50 cm) under two cacao agroforestry systems (30-year-old stands of cacao with *Erythrina spp.* - *Erythrina glauca* - as shade trees) in Inceptsol and Oxisol, in Bahia, Brazil. The determination of oxidizable carbon by a modified Walkley-Black method was done to obtain four C fractions with different labile forms of carbon (fraction 1 labile fraction; fraction 2 moderate labile fraction; fraction 3 low labile fraction; and fraction 4 recalcitrant fraction). Overall, in the two cacao AFS, the C fractions generally declined with increase in soil depth. The C fractions 1 and 2 were 50% higher in the upper layers (0 5 and 5 10cm). More than 50% of organic C was found in the more labile fraction (fraction 1) in all depths for both soils. High value of C fraction 1 (more labile C): total organic C ratio was obtained (around 54 and 59%, on Inceptsol and Oxisol, respectively), indicating large input of organic matter in these soils.

**Agroforestry, an avenue for developing social responsibility in Managing Dampalit Watershed: the case of Mt. Makiling Forest Reserve**

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**Preferred session**  
A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

This study of agroforestry as a production technology for productive and sustainable resource management of the Dampalit watershed of the Mt. Makiling Forest Reserve (MFR) revealed significant contributions of the communities as co-managers in developing social responsibility. This study is part the ‘Participatory Development Program in Dampalit Watershed’ implemented by the Makiling Center for Mountain Ecosystems – College of Forestry and Natural Resources, University of the Philippines, Los Baños. The project’s main goal was to empower and build capacity of the farmer communities to implement upland development activities supportive of MFR conservation and sustainable management. The project, through the agroforestry intervention, made positive progress towards the end goal. The Development of the farmed areas in Dampalit into agroforestry farms has shown that the right farming practices ensured the ecological stability of the watershed. More farm produce and yield was generated and the productivity of the farm was sustained. The development of agroforestry demonstration farms (ADF) has also been an avenue for developing the social capacity for the Dampalit farmer communities. While carrying out agroforestry principles, the farmers have developed social skills, self esteem and confidence.
The three demonstration farms established through ‘bayanihan’, or group efforts, were based on community-developed criteria agreed upon by the farmers. Another unique feature of the ADFs are their pass-on benefit schemes, not only of the learnings and technological innovation but also of the monetary benefit. Farmer-cooperators receive a 50% share of the (gross) profit and the remaining portion is ploughed back to the farmers’ organization to generate capital for the next qualified farmer-cooperators. The ADFs encouraged other nearby farms to adopt the showcased agroforestry-related technologies. Some of the farmers who were then engaged in up-and-down the slope cultivation which causes accelerated erosion particularly in the steep slopes are now adopting the contour farming and hedgerow intercropping system.

**Beef cattle performance in a silvopastoral system in Brazilian Cerrado**

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**Preferred session** A1.1. on silvopastoral systems

**Abstract**

Silvopastoral systems are now a reality in Brazil. Degraded soils caused by continuous agricultural crops, extensive degraded pasture areas caused by poor management, and massive cutting of forest have been the major factors in increasing the interest for silvopastoral systems. One experiment was conducted in an area of Cerrado, in Minas Gerais state (Brazil), during the summer of 2006. A factorial 3x2 with three doses of nitrogen (0, 75 and 150 kg ha-1), and two forage offers (10 and 15% of LW), were evaluated. A complete random design with four replications and three periods of evaluation was used. Nelore beef steers, with initial weight of 185.5 kg were used in a put and take system. An increase (P<.01) on LWG per animal was verified only on the first period of grazing with increased nitrogen doses. This could be explained by the highest nutritional quality of the understory and highest dry production. The variation on the foraging offers (FO) of 10 and 15% did not affect the LWG, indicating that dose offers did not limit the ingestive behaviour of the animals. The LWG observed can be considered satisfactory since other research has showed animals gain about 0.6 kg in exclusive pastures of *Brachiaria brizantha* under full sun. The highest meat production was obtained with the highest dry matter production with nitrogen fertilization. Nitrogen fertilization and stocking rate adjustments should be considered in order to improve LWG, mainly in late summer and spring season, for the establishment and management of silvopastoral system in Brazilian Cerrado.

**Development of agroforestry that is well-adjusted for mountains of the Timbó region, South Bay area of Bahia, Brazil**

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops

**Abstract**

The Atlantic Forest is one of the biomass reserves that shelters a significant amount of the biological diversity of Brazil, and is one of most threatened of the world. The region of the mountains of Timbó has one of the last remnants of Atlantic Forest of the South Bay area in the State of Bahia. In this region, 371 families survive in small areas that do not exceed 6 hectares. These families rely on the natural resources present in the environment and put great pressure on them. Understanding the dynamics of the reproduction relationships and the conditions for quality of life of the families, challenges us to jointly build a scenario that harmonizes agricultural production and the conservation of natural values that the mountains of Timbó provide to everyone. In this context this project aims to develop, in partnership with family smallholders, an agroforestry system that is adapted to the region of the mountains of Timbó, with the objective of ensuring sustainable production by communities consistent with the Unity of Conservation (UC) of Timbó, and reducing the pressure of human action on the area, with the smallholders becoming allied conservationists. The methodology included the demonstrative unities (UDs) of agroforestry in
succession with arrangements that involve the main cultures of the region and native species with economical, energetic, wooden, production of honey and craft potential, presented through workshops involving smallholders and technicians. The productive initial arrangement was: cocoa (*Theobroma cacao* L.), banana (*Musa* spp.), corn (*Zea mayz*), bean (*Phaseolus vugaris* L.) and cassava (*Manihot esculenta* Cranz.) and at least 10 native species according to the availabilities of seeds, with preference given to leguminous pioneers of quick growth. The enrichment of the area with secondary species and climax will happen during the accompaniment of the UDs.

La compétitivité des produits séchés (fruits, légumes, ….) d’origine africaine sur le marché grâce à un séchage adéquate par l’

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**Preferred session** A2. Agroforests in humid tropical Africa

**Abstract**  
Les produits séchés (fruits, légumes ; ….) , d’origine africaine sont moins complétifs sur le marché à cause, de leur qualité douteuse, et de l’irrégularité de fréquence dans les approvisionnements . Le « Four Djilemo » est un four à combustible constitué de deux grandes parties : une chambre de combustion pour la production de la chaleur et chambre pour l’exposition des produits à sécher ou chambre de séchage. La source d’énergie est très variable : (bioénergétique, gaz et électrique) Ce « four Djilemo » permet d’obtenir des produits séchés de qualité supérieure, avec une régularité dans l’approvisionnement. De capacité variable entre 800 Kg à 1000 kg , tous les 48 à 72 Heures, il peut permettre à nos paysans de mettre sur le marché des produits de qualité supérieur,et compétitifs avec les autres produits importé de même nature. Le “four djilemo” est faite en matériaux locaux. il est d’utilisation et d’entretien facile. Il permet de sécher une grande gamme de produits (Dérivés de manioc,les fruits,les légumes).IL est adapté à toutes les bourses et dans toutes les régions. Pour les grandes productions il est possible de faire un système de batterie pour des quantités de produits variables Il peut constituer ainsi un élément de lutte contre la pauvreté dans nos campagnes.

**Windbreaks in the southeast United States**

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**Preferred session** A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**  
Promotion of windbreak installation and maintenance by professionals is envisioned as a tool to assist broad-scale conservation of biodiversity along with soil and water resources. A case study of windbreak and tree screens in Georgia and other southeast states in the U.S.A. indicates there are an increasing number of properties benefiting from linear and border plantings for wind protection, or, multiple additional uses. A closed-ended mail survey (return rate 43% of 653) during 2001 to all agriculture and natural resource agents and county foresters in rural counties of the Coastal Plain of Alabama, Florida, and Georgia, revealed that 40% knew six or more landowners in their work zones (at a 100km radius) with windbreaks, while 20% knew more than 20 landowners with windbreaks or shelter plantings. Installation of windbreaks is left mainly to the initiative of the land manager based on perceived need, as well as by recommendation, for protection or screening purposes. Linear field borders are credited with enhancement of wildlife habitats as well as soil and water conservation. For field and horticultural crops, windbreaks help reduce evaporation losses under irrigation; for livestock production, windbreaks provide shade to lower animal heat stress and around facilities act as filtration surfaces to disperse odour and dust-laden air. With the growing number of urban and organic producers, screens against pesticide drift and plantings as multi-purpose hedges or living screens provide opportunities for diversifying woody species in the landscape. The presentation will discuss data compiled on the diversity of species available for the variety of uses observed in the southeast U.S.A.
Is *Grevillea robusta* finally under threat? Incidence, severity, distribution and impacts of canker and dieback disease in Kenya

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Preferred session C1. AF, climate change, biodiversity conservation

Abstract

Grevillea robusta is a fast-growing multi-purpose tree, grown in many parts of the world. In Kenya, it is currently the most popular tree species on small-scale farms where it is grown for timber, fuelwood, shade, shelter, fodder, soil erosion control and also to improve soil fertility through mulching. For a long time, the species has been regarded as free of pests and diseases of economic importance. However, results from a survey carried out on 95 farms covering five agro-ecological zones revealed that *G. robusta* is susceptible to cankers, and shoot and branch dieback caused by five *Botryosphaeria* species. Our results also showed that there were significant differences (p<0.001) in disease incidence, severity and mortality across the agro-ecological zones where *G. robusta* is grown. Disease incidence increased from 8%, 15%, 29%, 57%, to 70%; severity also increased from 14%, 27%, 42%, 51% to 56%, while mortality, increased from 0.3%, 1%, 2%, 9%, to 20% from AEZ1, AEZ2, AEZ3, AEZ4, to AEZ5, respectively for three parameters. The disease, characterized by resinous stem cankers, and branch dieback, was strongly associated with agro-ecological zone characteristics, the drier the zone, the more disease. Our results also showed that the frequency of the five *Botryosphaeria* species of fungi *Neofusicoccum parvum*, *Lasiodiplodia theobromae*, *Botryosphaeria corticola*, and *Botryosphaeria sp.*, increased steadily from AEZ1 to AEZ5, while that of *Diplodia seriata* decreased on the same scale. Termite damage seemed to accelerate incidence, severity and mortality especially in the semi-arid areas. Pathogenicity tests showed that these fungal species were highly pathogenic on seedlings of *G. robusta*. This study reports the first detailed analysis of incidence, severity, distribution and impacts of *Botryosphaeria* canker and dieback disease on *G. robusta* across five agro-ecological zones in Kenya. *G. robusta* should be restricted to AEZ 1 3.

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Farmers’ perceptions, technology preference and factors influencing the testing of *Leucaena leucocephala* in Petén, Guatemala

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Preferred session A.11. on silvopastoral systems

Abstract

Livestock production and especially cattle raising is one of the most important livelihoods activities in rural Central America. In this region the cattle feed is mainly based in the use of tropical pastures. However, the pastures frequently suffer from seasonal drought and degradation processes that can lead to both economic losses and environmental problems. The Degraded Pastures Project CATIE-NORUEGA (DEPAPRO) was conducted in Central America with the aim of helping livestock farmers to address problems related to degraded pastures. DEPAPRO encouraged a participatory learning and experimentation approach for several technologies. The objective of this study was to document the farmers’ perceptions and technology preferences; and to identify factors influencing their willingness to test *Leucaena leucocephala*. The fieldwork was carried out in Petén, Guatemala. Four main elicitation techniques were carried out: informal dialogue, semi-structured interviews, focus group discussions (FGD), and field visits. The FGD sessions were based on participatory research techniques such as matrix ranking and scoring. Two sub-samples were used in the study, comprising 68 and 71 households respectively. The analysis included descriptive statistics, chi squared tests, and stepwise logistic regression models for exploring potential factors related to the testing of *Leucaena*. Results showed that farmers participating in DEPAPRO considered *Leucaena*, improved pastures and live fences as their favourite technologies. The farmers’ technology preference is influenced by the perceived benefits that the technologies can provide including shade and feed for the cattle, timber, fuelwood, and
Trade-off identification through values and perceptions of different stakeholders in developing rewards for agrobiodiversity in the uplands of Southeast Asia

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Preferred session E5. Rewards for the environmental services of agroforestry

Abstract This on-going research study explores the use of values and perceptions of the key stakeholders of the upland landscape to identify and understand the relationship and tradeoffs between human well-being and measurable ecosystem services (e.g. biodiversity, water filtering capacity and carbon storage) provided in the uplands through the management regime of developing payment/reward mechanisms for environmental services (P/RES) at household/community/landscape scales. Using the rapid agrobiodiversity appraisal (RABA) model, values and perceptions of the main stakeholders are integrated to determine whether a rewards/payment mechanism is worth pursuing negotiations. On the other hand, the FALLOW (forest, agroforest, low-value landscape or wasteland) model as an agent-based dynamic landscape model, will be parameterized and validated to explore temporal and spatial scale effects on the tradeoffs between goods and services produced in a landscape and a range of design aspects of P/RES. Specifically, this research tries to answer the question of: how the development of payment schemes affects the tradeoffs and synergies among environmental services in the agrobiodiversity landscapes of Southeast Asia? Three upland sites will be presented: 1) Ikalahlan Ancestral Domain, Philippines; 2) Lantapan, Bukidnon Philippines; and 3) Bungo, Jambi District, Indonesia. All of the sites have high agrobiodiversity importance for each temporal and spatial aspect. Among the expected outputs of this research are: 1) to recommend situations or conditions where reward mechanisms for agrobiodiversity can be an option while at the same time to identify factors that would constrain the development of payment or reward mechanisms; and 2) to test and assess RABA and FALLOW models as tools for negotiating and assessing ecosystem services tradeoffs, respectively.

Earthworm distribution in tropical secondary forest and rubber plantation of Xishuangbanna, SW, China

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Preferred session C6. Agroforestry and reconciliation ecology

Abstract To understand the influence of land use on earthworm communities, we studied the earthworm distribution and its relationship with environmental factors in rubber plantations and secondary forest of Xishuangbanna, SW China in January 2006. Our results showed that soil nutrients and organic C inputs from plants were reduced significantly, and earthworm communities were altered after secondary forest changed to rubber plantation. The density (52.27 ind·m-2) of tropical exotic earthworm’s (Pontoscolex corethrurus) was significantly higher than native earthworms (Amynthas sp.) density (0.53 ind·m-2) in rubber plantation. No significant differences were found between the two different earthworms’ densities and biomass in secondary forest. Amynthas sp.’s density (0.53 ind·m-2) and biomass (0.32 g·m-2) in rubber plantation showed a decreasing trend compared with those in secondary forest (6.93 ind·m-2, 7.76 g·m-2). An increasing population of P. corethrurus was accounted for by the larger proportion of its juvenile’s density and biomass. However, Amynthas sp.’s number was mainly composed of adults. Fine-root biomass of rubber plantation was positively correlated with the density of P. corethrurus. Our results suggest that...
vegetation change and soil nutrient decrease due to the conversion of secondary forest to rubber plantation promoted exotic earthworm reproduction. Meanwhile, the adaptive strategies of the exotic and native earthworms cannot be ignored.

Agroforestry scaled-up; biotic and abiotic stresses in indigenous trees of north India

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Preferred session A6. Ecophysiological bases of agroforestry-system design
Abstract During the past two decades, the increasing demand for industrial wood led to an unprecedented expansion of forest tree plantations especially on agricultural/farmlands through agroforestry, in northern India, which in turn led to increasing incidence of pests and diseases, including the emergence of new problems. Recent large-scale mortality of different agroforestry tree species in general, and sissoo (*Dalbergia sissoo* Roxb.) in particular in the foothills of the whole Himalayan range including countries like India, Pakistan, Nepal and Bangladesh, and khejri (*Prosopis cineraria*) in arid regions, are indications of what can happen if timely attention is not paid to develop management strategies. In India, the high rate of mortality was witnessed in various states, such as Bihar, Uttrakhand, Haryana, Delhi, Punjab, Himachal Pradesh and Uttar Pradesh. Presently, an attempt is being made to elucidate the various stress factors and insect-pests and diseases that represent a future threat to the agroforestry trees. The syndrome of die back is little understood and may involve many factors such as environmental (principal among them are particularly global warming, prolonged fogging in winter, and other stresses might be due to flooding, fluctuating underground water table), mechanized agriculture, change in land-use patterns and involvement of fungal pathogens such as fusarial wilt (*Fusarium solani*) and root rots (*Ganoderma lucidum*). The problem needs input from genetics to identify the resistant traits, application of biofertilizers, and AM-fungi in particular to mitigate the effect of biotic and abiotic stresses. Although the present level of information generated may be sufficient to provide immediate respite to the cultivators in the area, further investigations are required to provide a fillip to the unexplored factors and to intensify in-depth study of the known factors. A few areas of investigations are suggested.

Development of agroforestry education in Bangladesh

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Preferred session D2. Integrating disciplines through agroforestry education
Abstract Agroforestry education in Bangladesh is expanding gradually to meet the needs of the country. The first ever fully fledged Department of Agroforestry and Environment was launched at the Bangabandhu Sheikh Mujibur Agricultural University, a public university, in 1996; it offers higher agroforestry education leading to a Master of Science (MS) degree. Since then, Bangladesh Agricultural University, the oldest university, has taken a similar approach and offers a MS degree in this subject. Gradually all other agricultural universities and some technical universities have opened separate Agroforestry Departments offering similar degrees. At present six public universities are offering MS degree independently. Meanwhile, fundamental courses on agroforestry have been introduced into Bachelor of Science (BS) in Agriculture degrees in all agricultural universities and Bachelor of Forestry degrees in other universities. Simultaneously, a fundamental subject on agroforestry is being taught in the Diploma in Agriculture offered by Bangladesh Technical Education Board, and the Bachelor of Agricultural Education degree offered by Bangladesh Open University. Presently 1200 students at BS level and 1200 students at Diploma level are getting fundamental knowledge on agroforestry, and 20 25 students are obtaining a MS degree in each year from the abovementioned universities. Considering the need and experiences, recently a Doctor of Philosophy (PhD) programme with the minimum requirement of a 45 credit hour coursework and 30 credit hour research, has been launched at the Bangabandhu Sheikh Mujibur Agricultural
University. Although, agroforestry education is expanding very rapidly, qualitative improvement cannot be attained because of the shortage of specialists and research findings. However, it is expected that collaborative work with competent universities and research organizations across the world would help a lot to achieve the desired goal.

Shade trees and income diversification from coffee agroforestry farms: field evidence from Kodagu district, South India

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract India contributes to 5% of the world coffee production; 80% of this is Robusta (Coffea canephora) and 20% is Arabica (Coffea arabica) grown under the shade of multi-strata systems. These coffee agroforestry systems (CAFS) are located in the Western Ghats, one of the world hotspots of biodiversity. In 2008, an economic survey was conducted on 115 farms in 34 randomly selected villages of the Kavery watershed in Kodagu, the main coffee-producing district in the Western Ghats with 1/3 of the Indian production. The objectives were: i) to estimate the cost and benefit associated with coffee cultivation across different farm sizes; ii) to estimate the economic importance of inter-crops (pepper, cardamom, arecanut) and fuelwood in CAFS; and iii) to perform a preliminary assessment of the cost–benefit of shade management. Preliminary results indicate that cost of production is higher in medium farms (2–10 ha) than on small (<2 ha) or large farms (>10 ha). Labour (45%) and agrochemicals (17%) represent the largest expenditures. Although coffee is sold as dry cherries at the farm gate to middlemen, net income per kg of coffee is relatively high at 0.5–0.6 USD. The income to cost ratio is also high at 1.4, 1.2 and 1 for small, medium and large farms, respectively. This is due to the fact that the current Robusta price is high due to higher domestic demand (30% of the national production) and that Indian Robusta coffee benefits from a high premium on the international market due to its quality. The net income derived from intercrops accounts for 16% to 31% of farmers’ revenues. As the opportunity costs of shade tree coffee cultivation are increasing due to increasing market opportunities, initiatives to improve quality, reduce risks and compensate for the loss of productivity while enhancing eco-friendly management will be difficult to achieve.

Physiological variables of growth of coffee plants in agroforestry system and monocrops

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Preferred session A6. Ecophysiological bases of agroforestry-system design

Abstract Coffee is an important agricultural export commodity in the world, and the Brazil is in a leading position as the world’s largest exporting producer. However, the product is quite vulnerable to market price floating. In this scenario, diversifying products can be an important strategy to keep the economic equilibrium of the property, and cultivation in agroforestry systems can be an alternative. The objective of this work was to study the analysis of growth of coffee plants in agroforestry system and monocrops. The research was conducted at ESALQ/USP, in Piracicaba-SP (Brazil). The experiment was composed of adult rubber trees and coffee plants planted in December of 2001 inside and outside rubber tree plantations. The treatments were constituted by an irradiance gradient (25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 98, 99, 99.5 and 100%), formed by coffee plant rows planted at different distances from the rubber trees: within (agroforestry system), interfacing the rubber plantation and in monocrop (full sun). The experimental design was random blocks with 11 treatments and 4 replications. The rates calculated concern a period of 30 months, taken between the first collection of data, at 8 months after planting coffee plant, and the last
collection of data, at 38 months after planting. The analysed variables were leaf area, dry matter, net assimilation rate (NAR), ratio of leaf area (LAR), specific leaf area (SLA), absolute growth rate (AGR) and relative growth rate (RGR). The growth of coffee plants increased with the solar radiation increment. However, the irradiance increment starting from 70% practically did not change the accumulation of the coffee plants’ above-ground dry mass. The plants at lower availability of solar radiation had morpho-physiological changes such as, SLA and LAR, which could guarantee their survival in such conditions, however, there was quite low growth with very low dry matter.

Below -ground microbial diversity as influenced by a coffee agroforestry ecosystem in Kodagu, Western India

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Preferred session A1. Multistrata agroforestry systems with perennial crops
Abstract

There is increasing evidence that below-ground biodiversity is strongly influenced by the diversity of above ground biota. Soil is the habitat of a diverse array of soil organisms and vertebrate animals the activities of which contribute to the maintenance and productivity of agro-ecosystems by their influence on soil fertility. Soil micro-organisms contribute a wide range of essential services to the sustainable functions of ecosystems such as nutrient cycling, carbon sequestration, plant health etc. In coffee ecosystems, different shade managements occur. In this investigation, the effect of three different typologies/shade managements . i) coffee with one species of shade tree, ii) coffee with two different shade tree species, and iii) multi-storey coffee ecosystems with three or more shade tree species on soil micro-organisms was investigated at Kodagu region of the Western Ghats in India. Arabica and Robusta were the two coffee types under deciduous and evergreen vegetation with three types of shade typologies. Robusta significantly enhanced the actinomycete population while bacteria and fungi were not much affected by the type of coffee. Evergreen vegetation supported a higher population of actinomycetes and bacteria compared to deciduous vegetation. Amongst the three shade typologies, coffee with one shade tree, C. robusta, increased the actinomycete population but its effect on fungi was not significant. Robusta harboured higher spore numbers of AM fungi compared to Arabica, and evergreen vegetation also supported higher numbers of AM spores and AM root colonization. Coffee plantation with C. robusta as single shade tree species harboured higher numbers of AM spores. The cellulose-decomposing organisms were considerably higher in Arabica coffee, and also under deciduous vegetation. Coffee with two shade tree species harboured a higher population of cellulose-decomposing micro-organisms compared to the other two typologies. Studies on nitrogen fixers, phosphate solubilizers and antagonistic organisms against plant pathogens are underway.

Development of RAMPT models for year-round diversified production in roadside, farmland, homestead and other slopeland agroforestry

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Preferred session A1. Multistrata agroforestry systems with perennial crops
Abstract

The necessity of improving food security, livelihoods and the environment of an overpopulated country such as Bangladesh demands judicious usage of every inch of land through sustainable multistrata production technologies for maximum yield compared to the existing production systems of farm and forest lands. There is also the presence of huge fallow and wastelands along the sides and slopeland of the network of roads, highways, railways, irrigation canals, embankments, farm and homestead boundaries, etc., in plainlands, and also in the riparian and hilly areas of Bangladesh. With a view to bringing these fallow lands under planned development and cultivation along with soil conservation, landscape development and environmental benefits, the three different models
of Roadside Agroforest Multistoried Production Technologies (RAMPT) have been established at
Bangladesh Agricultural University Campus, Mymensingh, Bangladesh. These are: RAMPT-1,
Single Step Single Slope RAMPT [(SS)2 RAMPT]; RAMPT-2, Double Steps Double Slope RAMPT
[(DS)2 RAMPT]; and RAMPT-3 Triple Steps Triple Slopes RAMPT [(TS)2 RAMPT]. The models are
also replicable to other similar slope lands such as raised farmland, homestead, office premises
or institutional boundary slopes, embankment and hill slopes, etc., and pond, lake, canal or river
sides. The results of on-going experiments both on MPTS and herbaceous species including crops
and medicinal plants under the above models have been observed to be effective and encouraging
with a 100% success in tree plantation. Neem (Azadirachta indica),
Mehogini (Swietenia spp.)
and Bakphul (Sesbania grandiflora)-based multisrata production systems have been established
with understoried shrubby and herbaceous species such as Jatropha, lemon, Eryngium, sunflower
turmeric, stem amaranth, chilli, lady’s finger (okra), sweet gourd, etc. The development and
establishment of these models with diversified production systems are described.

Cola fruit/nut traits, variability and relationship within and among non-planted trees
in the forest and savannah zones of Camero

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Preferred session  
B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract  
Cola is among the priority species for domestication in Cameroon; unfortunately most of the trees
are old and low yielding and farmers are reluctant to plant new trees due to their long reproductive
maturity phase and dioecy. Thus, a study to characterize and identify plus trees from natural
stands of Cola for multiplication via vegetative propagation techniques. Five fruit and nut traits
were assessed in 416 fruits from 145 non-planted Cola trees in two sites in Cameroon. A strong
correlation was observed between fruit weight and other fruit traits (e.g. fruit diameter \(r^2 = 0.77,\)
P < 0.001) and fruit length \(r^2 = 0.83, P < 0.001\)). In contrast, the correlation between fruit
weight and nut traits (e.g. number of nuts, weight of testa and number of cotyledons) was found
to be weak \(r^2 = 0.2651, P = 0.001\), with the exception of nut weight \(r^2 = 0.84, P < 0.001\) and
weight of testa \(r^2 = 0.8089\) in Cola anaomala. Results of this study also indicate that fruit and
nut parameters of Cola vary significantly (P< 0.001) with the variation higher between sites than
between trees. Tree-to-tree variation was found to be continuous in all fruit traits. Mean fruit weight
in C. anomala ranged from 103.6 g ± 2.21 to 484.64 g ± 97.13 while in C. acuminata it varied
from 33.04 g ± 79.07 to 82.14 g ± 37.18. These results suggest that domestication through the
selection and vegetative propagation of multiple-trait superior phenotypes is unlikely to be able to
combine good fruit characteristics and good nut characteristics within plus trees. Consequently,
domestication activities should independently focus on ideotypes representing Cola fruit and nut
traits that combine high values of the different fruit and nut characteristics respectively.

Do land tenure systems play a role in conserving tree diversity? A case study from
coffee agroforestry systems of Kodagu, India

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Preferred session  
A3. Role of agroforestry in landscape-scale conservation strategies

Abstract  
The Kodagu district in South India is located in the central part of Western Ghats, one of the world
hot spots of biodiversity. This region was densely forested up to the mid-Nineteenth Century and is
one of the major areas of coffee cultivation in India. The coffee-based agroforestry systems (AFS) of
Kodagu are good examples of human-managed forests that contain a good stocking of diverse tree
species. Hence, these farms can be called coffee agroforests. The management of vegetation or
canopy cover in these coffee AFS is mainly regulated by the rights given to the planters. The trees
in the coffee AFS could be owned either by the forest department or the plantation owner. Though
there are 32 distinct tenure systems, they can be broadly grouped into two major categories, redeemed and unredeemed lands. These complex land tenures determine timber extraction and in turn their structure and diversity. The present study indicates that density and basal area of trees were not significantly different among the redeemed and unredeemed plantations, which could be attributed to the replacement of harvested trees by the farmers. On the other hand, the diversity of trees was higher in unredeemed plantations compared to plantations under redeemed tenure. As coffee AFS under unredeemed tenure are more diverse, they in turn provide better ecological and economic benefits to planters such as better quality coffee, lesser insect pest damage, and additional returns from timber and pepper for which tree standards are essential. These coffee agroforests also serve as corridors for unique fauna such as elephants and birds. Hence the tenure of the land is a major factor that regulates the type of trees and in turn the biodiversity present in coffee plantations and at the landscape level.

**Evaluation of land use systems in the East Usambaras, Tanzania**

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**Preferred session** E5. Rewards for the environmental services of agroforestry  
**Abstract** The East Usambara Mountains in northeast Tanzania are a region renowned for their high biodiversity. Increased rural commercialization of cardamom over the past few decades has led to rapid rates of deforestation and conversion to agricultural land. Deforestation is driven by multiple underlying factors that occur at multiple scales, including the household level and the wider environment. This paper evaluates land-use systems from a socioeconomic perspective in order to understand how opportunities and constraints operate at multiple scales and subsequently impact decision making at the household level. Forests provide private-use values in addition to regional and global ecosystem services. Therefore, policies that integrate conservation and rural livelihood development require an understanding of local conditions. Two hundred household surveys conducted in July and August 2008 reveal that significant variation exists between villages with respect to cardamom production and land-use systems. Understanding the reasons for these differences is imperative in creating sustainable policies that fulfil multiple objectives of local and international stakeholders. Three common land-use management systems are identified based on interviews with district agricultural officers and local farmers. Each system describes land-use changes in crop composition over a twenty-five-year period. Analysis and comparison of these systems leads to a better understanding of profits, trade-offs, and the competitive advantages of prevalent land-use management strategies in the East Usambaras. Payments for environmental services and improved agroforestry systems are mechanisms to provide incentives that support for forests and biodiversity, but only in so far as these alternatives are competitive and perceived as opportunities by poor rural farmers. This study contributes to understanding the impacts of diverse socioeconomic factors upon households and the future adoptability of best-bet land-use systems based on an approach that considers farmers’ opportunities and constraints.

**Towards a sustainable land use option in the Bamenda highlands, Cameroon: implications for climate change mitigation and income generation**

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**Preferred session** C2. Carbon sequestration in agroforestry  
**Abstract** A land use option that can contribute to climate change mitigation and welfare improvement of poor smallholder farmers who cannot integrate with traditional markets, but need alternatives for income generation remains a challenge for researchers and policy makers in the Bamenda highlands. In such a degraded agricultural landscape, where traditional cultivation and pasture have released quantities of greenhouse gases that are today significant in terms of their current impact and potential for long-term contribution to global warming, carbon sequestration projects,
such as agroforestry, can be an alternative. To verify this hypothesis, a cost benefit analysis was employed. To estimate opportunity cost of land-use change, the net present value of agroforestry was compared with those of pasture and traditional cultivation. Some indicators of profitability and cash-flow viability (net present value, pay back, etc.), were used. Sensitivity analysis was used to simulate some salient conditions such as interest rates, establishment costs and carbon prices. To complement these results, a rapid ecological services assessment was undertaken. This was to determine the relative contributions of the different options to environmental ‘viability’. All the options were found to be economically viable. However, agroforestry (NPV = $1361/ha, IRR=30%, payback 4.5 years), though not as profitable as the pasture (NPV = $6829/ha, IRR=63%, payback 2 years), appears to be the only option that can meet the current challenges. Opportunity cost is less ($2.09/ha) for a change from traditional cultivation to agroforestry than from pasture to agroforestry ($12.16/ha). However, land suitability analysis, education and precise silvicultural practices would be an asset.

Key words: cost benefit analysis; opportunity cost; environmental viability.

Coffee and vineyard agroforestry: what lessons on agroforestry with perennial plants can be shared?

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Coffee and vine are both perennial plants that are cultivated for their fruits on large areas in tropical and Mediterranean areas respectively. They are very similar in their structure with significant areas of bare soil. Coffee is mostly grown in agroforestry systems, while vineyards are grown mostly as pure crops. Heavy pesticide use, soil degradation and loss of biodiversity are problems faced by both systems. Therefore, the use of trees in both systems may target some common problems, such as water contamination or pest control. In this paper we address two questions: 1) What lessons could be learned from coffee systems regarding the use of trees?; and 2) What are the differences in light competition with trees at different latitudes (Mediterranean versus tropical)? Shade is sought for coffee production in the tropics, but light competition by trees is considered detrimental for vine growing. However, vine was originally grown as an agroforestry system. The dynamic prediction of radiation patterns below the canopy of wide-spaced trees is essential to predict the outcome of agroforestry systems. A light competition model was used to calculate the impact of various tree canopy sizes and tree-row orientations on the distribution of the light at the coffee or vine level. For a given tree density and tree leaf area, the influence of the shape of the tree crown on the light availability for the crop is discussed. Surprisingly, erected and flat canopies were equivalent in the Mediterranean zone, but induced very different light patterns for the crop in the tropics. Tree-row direction was essential in Mediterranean latitudes and important in tropical latitudes to obtain a homogeneous radiation on the crop, which is counter-intuitive. Practical consequences for the choice and the management of shade trees with perennial crops are discussed.

Agroforestry for enhancing biodiversity and productivity of tropical smallholder homegardens

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Smallholder homegardens are vital for the sustenance of farm families in the rural regions of Asia, where soils are degraded and returns to investments are low. Thus, agroforestry systems using trees could help enhance productivity of these units by modifying these ecosystems. Studies were
Trees help increase productivity and provide biofuel for smallholder tropical farmers

Authors D.B. Wijesinghe, D.K.N.G. Pushpakumara, U.R. Sangakkara and P. Stamp

Abstract

Agroforestry has been identified as a means of increasing productivity and sustainability of tropical smallholder farms, especially those sited on degraded lands. This is due to the ability of these systems to provide green manure for enhancing soil quality over time and also adding nutrients to crops, while protecting the soil from erosion. In the recent past, the potential of agroforestry systems was enhanced due to their ability to provide biomass for fuel energy through periodic lopping. Due to the lack of comparative studies on the usefulness of these systems adopted by farmers on different terrains, a field study determined the benefits of using *Gliricidia sepium* trees to develop agroforestry systems in homegardens for these units and adjacent fields located on sloping, moderate and flat terrain in the hilly regions of Sri Lanka. The yields of maize (*Zea mays*) and mungbean (*Vigna radiata*) planted in the major and minor seasons, respectively were higher with the use of *Gliricidia* leaves obtained from the agroforestry systems. The benefit of increased yields was higher in the steep and moderate slopes where the soils were degraded to a greater extent. The tree numbers were lowest in the steep terrain where the biomass of fuelwood yield was also lower. The trees in the improved agroforestry systems on steep, moderate and flat terrain could provide approximately 2 010 960, 7 797 860 and 7 122 150 kcal units of energy, respectively per farming unit per annum for use as fuelwood or for potential dendothermal projects. The prospects of greater productivity of smallholder farms in the hill country regions of Asia and the potential of producing fuelwood as a source of energy is presented on the basis of this study.

Enabling innovation: gender and agroforestry in Sunyani, Ghana

Authors Lucy Debre, Olivia Agbenyega and Helen Hambly Odame

Abstract

The analysis of gender relations in agroforestry systems in sub-Saharan Africa is longstanding. Thirty years of scholarship have emphasized the ecological, socio-cultural and economic benefits and challenges of agroforestry, initially from a development perspective on women (WID) and later, on gender (GAD). Yet, contemporary agroforestry interventions still have to be reminded of persistent and dynamic gender roles and relations in natural resource management. This paper examines the conceptual and practical implications of gender issues in agroforestry, grounding the discussion with current action research being undertaken in Sunyani District located in the agriculturally important area of Brong-Ahafo Region, Ghana. As expressed through their farm labour and decision-making related to land and capital, women’s agency juxtaposes the structural
resistance they encounter as major actors in agroforestry systems. In Sunyani, key demographic, economic and socio-cultural shifts demand innovation in agroforestry research and development. Keeping the notion of technological and institutional innovation in mind, the paper highlights the need for gender issues at the local level to be articulated to the level of national policy. Highlighting the results of fieldwork undertaken in 2008 involving 849 households in three communities, the authors conclude the paper with a discussion of future opportunities for addressing gendered power relations in agroforestry and rural development.

**Integration of smallholder farmers in carbon markets in western Kenya: the institutional dimension of growing trees**

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Preferred session C4. Mitigation and adaptation to climate change

Abstract

The integration of smallholder farmers in carbon markets targeting carbon sequestration projects is currently highly debated, though institutional design and implementation is far from being established on a broader scale. This refers in particular to so-called ‘Small-scale Afforestation / Reforestation Clean Development Mechanism’ project activities of the Kyoto Protocol. In this study important local-level institutional arrangements were surveyed focusing on tree growing activities within the Nyando and Yala catchment areas in western Kenya. In each of the areas farmer groups and individuals were approached in informal group meetings or in semi-structured in-depth interviews. Additionally, a case study on group by-laws was organised. Looking at major results, it has to be noted that growing trees is increasing in scale and intensity. Primarily trees are planted and managed on individual land by individual smallholders, whereas establishment and management of nurseries as well as consultation of training and extension, are preferably initiated and carried out within the groups. Thus farmer groups have an important role in transferring and multiplying skills and knowledge, which result in mobilizing and empowering individual farmers. This refers also to effective group compositions and processes as well as provision of external support, which are major drivers for decision making, carrying out of work, and willingness to take over responsibilities. Other important drivers are common group by-laws as well as skills and knowledge in proposal writing, addressing donors and funds, and realizing development activities – something that has been incorporated already by some of the groups. When discussing the success of carbon sequestration projects, mitigating climate change and enhancing sustainable development, focusing on distributing benefits is another important matter. In Nyando and Yala smallholders mostly prefer benefits given in cash or in kind, given in advance or bit-by-bit, exclusively to the group.

**Domestication of Phyllanthus emblica l. (Nelli, Amla) in Sri Lanka for food and nutrient security**

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Preferred session E1. Hot or cold: the role of underutilised crops for AF

Abstract

*Phyllanthus emblica* L. (*Nelli* or *Amla*) of the family Euphorbiaceae is a medicinal fruit tree which grows naturally in the dry deciduous and savannah forests of India and Sri Lanka. The economic part of Nelli is the fruit, with high nutritive and therapeutic values. It is one of the sources of highest vitamin C. The fruit is used for many ayurvedic preparations. Although Nelli has a wide range of domestic and industrial uses, it is currently neglected in Sri Lanka and its uses are not properly exploited. Multidisciplinary, multistakeholder research has been undertaken with the objective of domestication of Nelli in Sri Lanka in collaboration with the University of Peradeniya, the Sri
Relevance of local knowledge in conserving biodiversity and sustaining production of coffee in Kodagu, South India

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Preferred session: D4. Incorporating local knowledge in agroforestry science

Abstract

Coffee is grown in an area of about 350,000 hectares across the Western Ghats, one of the three global hotspots of biodiversity in India. The coffee-agroforestry systems (AFS) in this region harbour an enormous amount of biodiversity and provide crucial ecosystem services and livelihood opportunities for some 180,000 farmers. However, intensification of coffee AFS has resulted in loss of biodiversity, fragmentation of forest habitat and loss of landscape connectivity, which in turn have contributed to environmental degradation. This warrants conservation, promotion and sustainable management of diversity of these unique ecosystems. Therefore, we developed methodologies (under the CAFNET project) to assess biodiversity and other ecosystem services both at farm and landscape levels in a participatory mode with stakeholders, with the ultimate aim of linking sustainable management with the payment for environmental services at local, national and international levels. It is increasingly realized that local knowledge-based decisions are crucial in sustainable management of agro-ecosystems. Hence, this study developed agro-ecological knowledge bases to assess the extent and relevance of local knowledge in maintaining biodiversity and sustaining ecosystem services, and their possible role in enhancing value chains. For this, we employed the agro-ecological knowledge toolkit (AKT) methodology of the University of Wales, Bangor, UK (http://akt.bangor.ac.uk/). The study was conducted in evergreen and moist deciduous coffee AFS of the Kodagu district. We gathered and analysed agro-ecological knowledge on four specific issues, floral diversity, faunal diversity, tree interactions, and by-products of these systems. Under each issue, we collated information from various strata such as vegetation types, plantations with native and exotic trees, and from personnel such as planters, labourers, supervisors and traders. Various components of these agro-ecological knowledge bases are presented as well as results of the weighted-score analysis for prioritization of trees species in different vegetation types based on knowledge bases.
Abstract
The Western Ghats, one of the three global hotspots of biodiversity in India, is also known for its biodiversity-rich coffee agroforestry systems especially in the Kodagu district of Karnataka state. Coffee is grown under partial shade of innumerable shade trees with a multitude of utilitarian values. However, in recent years, the floristic diversity of this system has rapidly decreased with a concurrent increase in planting of exotic and fast-growing shade trees such as Grevillea robusta. This has been attributed to the slow growth rate of native species, coupled with legal obstacles for their harvest by the owners of the plantations. Moreover, Grevillea robusta offers a good standard for pepper inter-cultivation inside the plantations. Even with a spectrum of ecosystem services derived out of native trees, these are often neglected. With a view to assess the utility of the native and other shade trees for biodiversity conservation and ecosystem services, we embarked on collating local knowledge of the various stakeholders such as planters, supervisors and labourers, about the floristic diversity present in the plantations. The information on topics such as native and exotic tree species, their suitability for coffee plantations and their influence on coffee yield, interaction with other trees, soil, light and other factors, and use for various purposes, has been gathered, in addition to details of epiphytes and parasites, from various strata of stakeholders. This information is built in to a knowledge base using the agro-ecological knowledge toolkit (AKT) methodology developed at the University of Wales, Bangor, UK (http://akt.bangor.ac.uk/). In this poster, we depict our efforts in information collection, building the knowledge base and analysis of issues in biodiversity conservation vis-à-vis floristic diversity of the plantations.

Faunal diversity in coffee agroforestry systems in Kodagu, Western Ghats India: implications of local knowledge in conservation

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Preferred session: C1. AF, climate change, biodiversity conservation

Abstract
Coffee agro-forestry systems especially in the Western Ghats are known for their rich floristic diversity, which in turn supports an innumerable number of birds and animals. This is because the plantations adjoin the forest areas and they provide food and shelter in various seasons. However, with the dwindling floristic diversity due to intensification of coffee cultivation, there is a decline in the faunal diversity. Further, there has been an increase in incidence of human animal conflicts especially with elephants. With this as a background, we wanted to know how traditional farming systems have supported rich faunal diversity. Specifically, was our focus was an assessment of local knowledge of the stakeholders in conserving faunal diversity. For this we embarked on collating information on bird and animal species, beneficial and conflicting interactions, seasonal variations, and the role of plantations in conserving faunal diversity etc. Some of the specific issues covered include above-ground and below-ground fauna and their interaction with coffee, honey bees and their role in coffee yield, effect of management of coffee on the number and diversity of fauna. This information is built in to a knowledge base using the agro-ecological knowledge toolkit (AKT) methodology developed at the University of Wales, Bangor, UK (http://akt.bangor.ac.uk/). In this poster, we depict our efforts in information collection, building the knowledge base and analysis of issues in biodiversity conservation and local knowledge vis-à-vis faunal diversity of the plantations.

Assessing suitability of agroforestry as an alternative farming practice in the Chittagong Hill Tracts (CHTs) of Bangladesh

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Preferred session: B6. Agroforestry as a tool for landscape restoration
Abstract
Chittagong Hill Tracts CHTs, constituting about 10% of Bangladesh, houses around 1.34 million of people who are mostly ethnic communities and only a few are in-migrant lowland peoples. They practise mostly (90%) jhum as their main livelihood activity. But this century-old traditional farming practice is no longer suitable for the CHTs due to the steady population growth which has led to the reduction of the jhum fallow period from 10 15 years to 3 5 years. This has resulted in the loss of productivity and environmental degradation. In these circumstances, the livelihood and food security of the poor hill people are threatened, and it has become very urgent to find a suitable farming practice. Throughout the world, agroforestry is found to be the suitable farming practice for upland areas. This study is aimed at assessing the suitability of agroforestry farming systems in the context of CHTs. The study reveals that among the existing five major farming practices (jhum, annual cash crops, horticulture, timber plantation, and agroforestry), agroforestry is found to be comparatively suitable in terms of financial, environmental and social aspects. Although it is a suitable practice, there is a series of examples showing the failure of different agroforestry projects implemented in CHTs of Bangladesh. This study determined the causes (e.g. land tenure security, marketing constraints, technical complexities, bureaucratic red tape etc.) of this failure and concludes with some necessary suggestions including policy issues.

Tree resources outside forests. to what extent can their full potential be harnessed?
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Preferred session C1. AF, climate change, biodiversity conservation
Abstract
This study assessed the potential of tree resources outside forests (TROFS) planted in the Rimbi communal area in the South-Eastern Lowveld of Zimbabwe. Environmental degradation and climate change resulting from deforestation are best managed through the conservation of natural forests. However, the rapid rate of natural forest degradation calls for alternative counter responses such as agroforestry practices and community forestry, which offer limited functions compared to the natural forests. Whilst forest deforestation is non-selective, TROF establishment is preferential. A survey was carried out to assess the availability, establishment, diversity and functions of TROFS in the community through biophysical and socioeconomic approaches. The study area was stratified into institutional groups and an inventory of tree and shrub species was done in each stratum. TROFS were classified according to use, establishment, origin, age and height. Data were analysed using one-way ANOVA (SPSS Version 10) and mean differences tested through LSD post hoc tests at the 5% level. Results indicated that 21 plant families, dominated by Fabaceae and Euphobiaceae mostly of exotic origin, were observed. Overall there was a total of 39 species. Of these 18, 27, 12, and 39 species were planted in the business centres, schools, health centres and villages, respectively. It was observed that most plants in all strata were below 5 years and this was attributed to the recent and increasing environmental and climate change awareness. Among the TROFS, fruit trees had the highest priority, followed by fuelwood and lastly, fertility enhancing and fodder species. It was concluded that although TROFS play a positive role in the provision of environmental services, their full potential has not yet been harnessed, making them deficient in matching natural forests.

Key words TROFS, climate change, environmental degradation, deforestation

Relationships between invertebrates communities, litter quality and soil properties under different cocoa agroforestry systems in Bahia, Brazil
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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems
Abstract Cacao agroforestry systems adopted in the southern region of Bahia, Brazil, have beneficial effects
on the faunal soil and litter communities, and such systems can be considered to be conservation systems for soil fauna. This study aimed to evaluate the relationship between soil and litter attributes and faunal communities in cacao agroforestry systems (AFS) in the south of Bahia. Soil and litter samples were collected in September 2003 and February and August 2004, in five cacao agroforestry systems (cacao renewed under *Erythrina* sp., (CRE); cacao renewed under natural forest (Cabruca) (CRF); an old cacao system under *Erythrina* sp. (OCE); an old cacao system under a natural forest system (Cabruca) (OCF); and a cacao germplasm collection area (CGC)) and a natural forest (NF) (the reference). The organisms were extracted over a Berlese-Tüllgren funnel. Soil and litter attributes were analysed and a multivariate analysis was performed (redundancy analysis, RDA). In soil, RDA showed a positive correlation between carbon content with Diplopoda and Pseudoscorpionida; between nitrogen content with Formicidae, Pscoptera and Diplura; between clay content with Isopoda and a negative correlation between soil bulk density and Coleoptera. In litter, the RDA showed Oligochaeta positively correlated with polyphenol content; Coleoptera larvae with carbon content; Diptera larvae with nitrogen content and Pseudoscorpionida with lignin content. Redundancy analysis revealed that in the cacao AFS studied, the attributes that positively affected the composition of the soil community were carbon, nitrogen and clay content, and that bulk density had negative effects. In litter, the attributes which had positive effect were carbon, nitrogen, polyphenol and lignin content.

**Agroforestry as a mitigation-cum-adaptation strategy to meet the challenges of climate change and food security**

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**Preferred session** C1. AF, climate change, biodiversity conservation  
**Abstract** Agroforestry has emerged as a potential adaptation-cum-mitigation strategy to meet the challenges of climate change, which continues to be the greatest challenge for all policy makers. Adoption of Agroforestry also offers protection to natural forests as the fast-growing demand for wood products is met from on farm-wood production. Such land-use systems help in sequestering carbon as well as in conservation of naturally rich carbon sinks. The CDM, A&R projects also promote community involvement, which is seen as a means of encouraging small landholders and cultivators in developing countries to adopt agroforestry. Agroforestry is also a potentially effective option for adaptation to sustaining and improving livelihoods of farmers, due to decreasing agricultural output as a consequence of climate change. Decreasing or fluctuating agricultural output is a potential threat to food security, causing regional disparities and imbalance in demand and supply. Policy makers have to recognize the huge potential of agroforestry in carbon markets and improving rural livelihoods by incorporating useful trees in their farms. This paper analyses the potential of agroforestry as a mitigation and adaptation option. Successful eucalyptus and poplar-based agroforestry models under wheat and paddy-based systems from North India are highlighted. The Kyoto Protocol, CDM, Carbon trading, etc. offer new challenges and opportunities for recognition and reward for environmental services. Policy options for promotion of agroforestry in meeting challenges of climate change and food security and its role as a mitigation-cum-adaptation strategy are suggested.

**Agroforestry curriculum development case study: Sudan University of Science & Technology**

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**Preferred session** D2. Integrating disciplines through agroforestry education  
**Abstract** At the Sudan University of Science & Technology a course named Principles of Agroforestry...
has been developed for the B.Sc. level. Five specializations at the Sudan University have been
taught this course, namely, Forestry, Range, Agricultural Extension, Plants Protection and Crops
Production. The programme was launched in 2001. It covered 3 credit hours in a semester, and
8 for all specializations. At the end of the course, we expect the students to be able to: i)
Explain the concept of integrating trees with crops and/or animals; ii) Recognize the potentials and
limitations of agroforestry; iii) Identify agroforestry problems in the field and communicate them to
the professionals and researchers; and iv) help in execution of different agroforestry programmes
and activities. This paper reflects the following items: introduction, justification and problem
statement, research questions and methodology, course objectives, conceptual framework, in
addition to course evaluation and updating, conclusions and recommendations. The course
outlines the included topics and sub-topics, with their own learning objectives, teaching materials
and learning methods. The main areas and topics covered include: relevant definitions and needs
for agroforestry; agroforestry benefits and constraints; classification of agroforestry Systems; some
silvicultural aspects of agroforestry; some agronomical aspects of agroforestry; animal production
in agroforestry; components interactions in agroforestry; soil management and nutrient balance in
agroforestry; some social aspects in agroforestry; some economic aspects in agroforestry and some
selected traditional agroforestry systems in Sudan including windbreaks and shelterbelts and the
Taungya System.

An overview of progress on the use of tree crops in rehabilitation of degraded mining
areas in Zambia
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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands
Abstract Zambia’s economy is dependant on mining. Mining started in the 1920s and the main minerals
mined are copper, zinc, lead, and emeralds. This sector has contributed to the country’s economic
development. However, mining has caused widespread land degradation in the major mining
provinces of Central, North Western and Copperbelt. Mining activities involve vegetation removal,
excavations, processing of ore and disposal of waste rock, tailings and sludge. The mining waste
is usually deposited in undisturbed low-lying environments resulting in extensive environmental
degradation. An estimated 250 000 hectares country-wide is covered by mining waste. Mining
waste impacts negatively on biodiversity and ecosystem productivity, especially wildlife, aquatic
life and forests. Human communities are also affected by poor air, water and soil quality resulting
in reduced agricultural productivity and general well-being. Generally, degraded mining areas
exhibit surface compaction, high erodability, absence of vegetation, low nutrient status, uniform
aggregates on tailings and large boulders on waste rock dumps. To address these environmental
problems, remedial action has included: (a) improving water permeability and nutrient status by
spreading the surface of tailings with laterite, household degradable waste, and other organic
matter; (b) improving biological productivity by encouraging plant colonization of these sites and
artificially regenerating the degraded areas using direct seeding and planting seedlings of grass
and trees; and (c) conducting environmental education in settlements around degraded mining
areas. This paper therefore, presents a general overview of revegetation of degraded mining areas
using trees in the Copperbelt mining province, the extent of area covered, species regenerated,
methods employed, experiences gained from various natural and artificial vegetation regeneration
exercises. The paper also examines principles behind species selection, productivity, community
participation and general silvicultural practices. In addition, it highlights methodological and data
deficiencies that may have affected the success of revegetation programmes.

Revue du modèle politico- institutionnel pour la gestion durable des écosystèmes
forestiers du bassin du Congo
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Les arrangements institutionnels jouent un rôle déterminant dans le processus de gestion durable des ressources naturelles. Dans cette perspective, les pays du bassin du Congo mettent depuis plus d’une dizaine d’année un modèle politico-institutionnel sous-régional, fait à la fois de normes juridiques et d’organisations interétatiques, susceptible de leur permettre de relever les divers défis inhérents à la quête de la gestion durable des terres forestières de cette zone géographique. Mais, la revue critique du montage institutionnel qui gouverne les massifs forestiers du bassin Congo fait néanmoins apparaître un bilan assez contrasté en termes de cohérence globale, de fragmentation et de mise en œuvre concrète par les Etats et les autres acteurs des différentes orientations publiques choisies dans ce cadre d’action collective interétatique. Cette tendance assez préoccupante pourrait affecter aussi bien les ressources forestières que les pratiques de gestion des parties prenantes. D’où la nécessité de réorienter cette forme d’action collective multilatérale pour l’avènement d’un système plus opérationnel et adapté au contexte.

Comparative growth and yield responses of rape (*Brassica napus* L) to different soil fertility management amendments.

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Preferred session A7. Biological dinitrogen fixation in AF systems

Abstract Poor soil fertility contributes to low vegetable yields under resource-poor smallholder farming conditions. The growers usually rely solely on organic soil amendments. This study compared growth and yield responses of *B. napus* to the recommended treatment and farmers’ levels of organic amendments. A completely randomized block design with four treatments replicated three times: the recommended treatment comprising poultry manure and inorganic fertilizers (RC); *A. polyacantha* green leaf manure (*A. polyacantha*); and a mixture of decomposing miombo leaf litter and soil (miombo); and the control. The fresh-mass yield of *B. napus* harvested from the whole plot was measured three weeks after transplanting at ten-day intervals. Numbers of shoots and leaves per plant were counted prior to harvesting. Data were subjected to analysis of variance using SPSS for Windows (2003) Version 15.0. Fresh-mass yield results were as follows: RC > *A. polyacantha* > control = miombo, at p=0.05. Generally yield levels did not vary (p>0.05) with harvesting time except for the RC where there was a decline from the first to the last harvest. The RC produced more (p<0.05) shoots than the rest of the treatments except for the last two harvests. For the RC a declining trend in the number of shoots over time was observed. For the other treatments no trends were observable. The RC had significantly more leaves per plant (p<0.05) than the rest of the treatments during the first and third harvests only, with the rest being similar to other treatments (p>0.05). There was a general decline (p<0.05) in the number of leaves per plant from the first to the last harvest for all the treatments. It was concluded that use of biomass alone at current farmers’ practices led to lower growth and yield responses of *B. napus* compared to the RC. Resource-poor farmers should be encouraged to apply biomass manure using the N of P equivalent at agronomic rates.

Traditional agroforestry practices by indigenous communities in northeast Bangladesh: conservation prospects and contribution to livelihoods

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract Forests are critical in the life of indigenous communities because they live in the forests with a mostly or solely forest-based lifestyles and culture. In Bangladesh, there are more than 36 ethnic
groups, many of which still live and depend on forests for a variety of reasons including everyday meals. We conducted an exploratory study in Lawachara National Park a northeast protected area and an exceptionally biodiversity-rich region in the country to explore the traditional agroforestry farming practised by the indigenous communities in the park and its buffer zone area, its socioeconomic significance, probable environmental impacts and conservation prospects. Both questionnaire survey (n = 80) and random plot (10m X 10m) sampling were used. We observed four ethnic communities (Khasia, Tripura, Garo and Manipuri) and identified five different traditional agroforestry practices (i.e. betel-leaf-based agroforestry; upland rice-based shifting cultivation; lemon and jackfruit agroforestry; alley pineapple intercropping) in the locality. Theses were found to play an important role in the livelihoods of ethnic communities through providing them with cash income, food, fuel, medicine and other non-timber forest products. The contribution of different farming practices in the livelihoods of these communities were estimated and found to vary from 45% to 80%, both in the terms of cash generation and market value of consumed goods. For realizing the conservation prospects of each farming practice we considered the cultural practices, pesticide/fertilizer use, soil erosion, nutrient/moisture content in the soil and assessed the plant diversity, canopy coverage, undergrowths, and faunal species richness (avi-fauna and mammals) etc. The study indicated that even though none of these were absolutely perfect for adoption in park management and biodiversity conservation, the betel-leaf based agroforestry practice could provide some basis for both conservation and livelihoods as it generates substantial revenue and retains almost all the old trees (as support) that are suitable for wildlife. Finally, we recommend an effective market chain for agroforestry products and large-scale adoption of suitable agroforestry practices in place of unsustainable one.

Characteristics of muddy water infiltration and distance of edge influence at different vegetation compound boundaries

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Preferred session A10. Dryland agroforestry R & D

Abstract Muddy water is a type of available water resource containing sediment from surface runoff and is used for irrigation of agroforestry systems in semi-arid and arid areas. Infiltration can affect soil water recharge and soil water availability to plants, surface runoff and soil erosion. This study intended i) to compare the infiltration of muddy water with tap water on an agroforestry system, and ii) to understand the impact of different vegetation compound boundaries on soil infiltratability of agroforestry systems in the Loess Plateau in China. The sediment content of muddy water for the infiltration test was 30 g/kg, and physical clay content was 419.0 g/kg for loam at the Chunhua experimental station. Field infiltration was measured with a double ring infiltrometer at the water head (pressure) of 40 mm. A volumetric cylinder with an agitator was used to supply muddy water and the amount of infiltration water was recorded manually. The distance of edge influence was detected by using moving split-window techniques. The results showed that muddy water decreased the infiltration capability of soil with loam, and impaired the role of agroforestry systems in water conservation. The distance of edge influence of compound boundary to soil infiltratability of muddy water varied with the vegetation species at edge belts. These were 6m and 4m for the winter wheat apple compound boundary and the black locust Chinese pine compound boundary, and were 8m and 6m for the grass apple compound boundaries respectively.

Key words: muddy water; infiltratability; distance of edge influence; agroforestry; Loess Plateau

Nitrate leaching and N2O emissions in Coffea arabica systems in Costa Rica according to fertilization and shade management

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Abstract
In optimum growing conditions for coffee in full sunlight and high fertilization in Costa Rica, full-sun coffee plantations were compared with coffee agroforestry systems in order to improve N fertilization and shade management, to optimize the production of coffee and associated trees while reducing nitrate (NO3-) leaching to ground water and N2O emissions. The inclusion of shade trees (Eucalyptus deglupta or Inga densiflora) in highly fertilized coffee plantations (250 kg N ha-1 yr-1) increased N accumulation in litter and permanent biomass, and slightly reduced water drainage, but it also reduced coffee production by 25 33%. As a result, the effect of the shade tree on NO3- leaching varied according to coffee production. These experiments showed a low efficiency of N fertilizer use by both coffee and trees and a large NO3- loss to groundwater, highlighting the need to reduce N fertilization in intensively managed shaded coffee systems. In a full-sun coffee plot, where N fertilizer was only provided in coffee pulp (150 kg N ha-1 yr-1), coffee berry production was very low (0.7 t dry matter [DM] ha-1 yr-1 during three years). Incorporating a legume tree stratum (Erythrina poeppigiana) increased berry production to 3 t DM ha-1 yr-1 for the same period without significant changes in NO3- leaching. Compared to the highly fertilized agroforestry system (250 kg N ha-1 yr-1), mean NO3- concentration in water drainage in this ‘organically’ managed agroforestry system was reduced by three fold. N2O emissions were always insignificant compared to the losses though NO3- leaching. However these emissions were increased by high inputs of mineral N fertilizer and to a lesser extent by leguminous shade trees. Coffee producers should be encouraged to adopt environmentally sound N management, reducing N inputs and refining shade management based on a combination of leguminous and timber tree species.

Implications of agroforestry in rural livelihoods: how does it decrease in southwest Bangladesh?
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Preferred session D3. Policy formulation and stakeholder engagement in NRM
Abstract
The economy of Bangladesh is dominated by rural areas in which at least 65% of the people are engaged in agriculture and the production of agricultural products. Most of the time, rural people are heavily dependent on small trees, shrubs and bushes for their livelihoods. The rate of depletion of the agroforests in southwest parts Bangladesh is also increasing an alarming rate. This is due to a lack of employment opportunities for the rural people, a lot of natural disasters in the coastal areas, the growing demand for fuels and energy to cook with, and as a whole, population pressure. People in the rural community can easily cut shrubs and take them to market to earn cash with minimal effort. On the other hand, the demand for these shrub woods and agroforest items is very high as they are cheaper a means of energy for use in the kitchens of rural households. This paper will focus on some villages that are heavily dependent on agroforest, how these resources are being depleted and how people earn their livelihoods based on these agroforest lands. Sometimes the government introduces policies for some social forestry programmes and some awareness-building programmes to discourage people from cutting the shrub woods and agroforests. But due to the increasing rate of unemployment, people are still cutting this resources and taking it to the local market. Lastly, this paper will cite some policies intended to raise these issues as important ones for the local people and to motivate them to plant more agroforest trees and shrubs in their local community with the assistance of some NGO and government interventions.

Key words: agro-forests, south west zone, Bangladesh, Government.

‘Ecological’ farming and the recent increasing importance of the homegarden involving animal practices in rural areas of Turkey
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Assessment of mycorrhiza diversity in Mabira Forest Reserve, Central Uganda


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Abstract Tropical forests have undergone serious degradation. Mycorrhiza has been recognized as relevant in restoring forest ecosystems. The objective of this study was to assess the abundance and diversity of mycorrhiza in the selected forest regimes. A survey of post-degradation mycorrhiza spore diversity and abundance was done in six different blocks at varying ages (0 3, 10 20, 20 30, 30 40, 40 50 and over 55 years). An experiment using sorghum (Sorghum bicolor) as the host plant to trap mycorrhiza in soils of the different forest blocks was conducted. Each soil was replicated three times. Seven vesicular-arbuscular mycorrhiza genera and 18 species were found in the soils of Mabira Forest Reserve. The abundance of each genera was dependent on forest regime (P<0.05). Glomus clarum was the most abundant species with 302 counts distributed throughout the forest regimes while Gigaspora geosporum and Glomus clarisporum were the least abundant with only one count and only occurring in the 10 20 year and 20 30 year forest regimes respectively. The genus Glomus was significantly higher than the other entire genera except for Scutellospora (P<0.05). The number of mycorrhiza species decreased with forest age from 10 20 up to 40 50; in forest regimes of 0 3 years and above 55 years the number of mycorrhiza species were not different.

Key words: mycorrhiza, land productivity, tropical forest, Lake Victoria Catchment

Plant community succession after human disturbance in the Mabira forest, central Uganda

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Abstract Plant community succession after human disturbance in the Mabira forest, central Uganda

Key words: mycorrhiza, land productivity, tropical forest, Lake Victoria Catchment
The study was undertaken to assess the plant community structure and plant species diversity in disturbed sites in order to develop restoration options for the degraded sites. Irrespective of the previous use of the system (e.g. encroachment and mechanised logging) we identified and assessed plant species diversity in five types of abandoned land: (A) encroached (0-3 years ago), (B) encroached (3-10 years ago), (C) encroached (10-30 years ago), (D) logged (>30 years ago), and (E) essentially undisturbed old-growth forest. Sampling involved over 100 plots where all plant species were identified. The undisturbed old-growth forest generally had the highest species richness for all plant forms (herbs, seedlings, saplings and trees) compared to other sites. An invasive tree species (Broussonetia papyrifera) was most abundant in the more recently disturbed sites with the community showing a tendency towards mono-dominance and an even age. This has suppressed the regeneration of native species. Strategies for restoring severely and recently disturbed forest sites may require the removal of invasive species as a strategy for enhancing the regeneration and succession.

Soil and nutrient losses from Mabira Forest Reserve restoration blocks

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Preferred session B1. Quantifying the role of AF in modifying watershed functions

Abstract The aim of this study was to investigate the effect of forest ecosystem restoration on soil properties and soil and nutrient losses in selected Mabira Forest Reserve restoration blocks. The specific objectives were: to quantify runoff, soil and nutrient losses from selected Mabira Forest blocks; and to determine the effect of age of the forest on some soil physical and chemical properties. The study was carried out in six blocks under different restoration periods namely 0-3 yrs, 10-20 yrs, 20-30 yrs, 30-40 yrs, 40-50 yrs, and >55 yrs. An area measuring 150 x 50 was demarcated in each forest block. Three runoff plots measuring 20x2 m located 50 m apart were installed per block to measure runoff and soil and nutrient losses. Other parameters measured included: bulk density, porosity, rainfall, soil pH, organic matter, percentage nitrogen, available phosphorus, exchangeable bases and soil texture. A pre-calibrated erosion sampler was used to collect runoff from which lost nutrients and soil were measured in the laboratory. Soil loss was highest in the 0-3 yrs block followed by >55 yrs block. Similarly, nutrients, NPK had the greatest loss in the 0-3 yrs forest block. Bulk density was highest in the 30-40 yrs block while porosity was highest in the 0-30 yrs forest block. The textural classes indicated most of the blocks to have clay loamy soils except 40-50 and >55 yrs forest blocks whose soils were sandy clay loams. The chemical properties varied widely between the blocks. Runoff, soil and nutrient losses were highest in 0-3 yrs but there was a gradual increase with increase in forest age. There was low nutrient content in most of the forest blocks indicating that the forest is on poor fertility soil.

Key words: degradation, recovery, soil erosion, infiltration, precipitation

Agroforestry systems as suppliers of domestic and international timber markets in Cameroon.

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Preferred session A2. Agroforests in humid tropical Africa

Abstract Recent assessments suggest that the informal logging sector in Cameroon extracts its timber production, estimated at about 1 million m3, mainly from the non-permanent forest domain (NPFD), that is the land allocated to agriculture and agroforestry land-use development. Indeed, some of the most important commercial timber species (Frake, Ayous, Iroko), are found in shifting cultivation fallows and in traditional multistrata agroforests. However, apart from the potential productivity gains to the main crop and to some non-timber forest products, farmers have little consideration for high-value timber production and the management of timber resources on their agricultural land. At the present, timber extraction escapes any legal control and any management model, which could assure a balanced exploitation and the maintenance of the social, economical,
and ecological services those trees provide to the integrated system they belong to. Drawing on field analysis of agroforestry and shifting cultivation practices, integrated by interviews with key informants (farmers, logging operators, industrial buyers, researchers and ministry officials), this study sets out to make this resources management context explicit in order to assess its sustainability in the long term. We propose new research directions towards the identification of opportunities and risks of timber extraction in the shifting cultivation and multistrata agroforests and the definition of management and organization principles for sustainable/low intensive timber extraction.

**Climate change and agroforestry: recognition of environmental services as mitigation-cum-adaptation strategy**

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**Preferred session** C4. Mitigation and adaptation to climate change

**Abstract**

Deforestation and degradation of forests are important sources of Carbon dioxide emissions, which account for about 35 percent of emissions in developing countries and 65 % in the least developed countries. There is increasing evidence that forests will be profoundly affected by climate change. Forests can play a key role in mitigating climate change. Agroforestry or small-scale forestry is a potential tool as a mitigation-cum-adaptation strategy to meet challenges of climate change. The education of emission through degradation and deforestation (REDD) policy under UNFCCC also recognized the environmental services of forests in meeting challenges of climate change. Adoption of agroforestry also offers protection to natural forests as the fast-growing demand for wood products is met from on-farm wood production. Agroforestry as a land-use system aids in sequestering carbon as well as in conservation of naturally rich carbon sinks. The environmental services rendered by agroforestry systems need due recognition as it is a fact that apart from environmental services agroforestry plays a vital role in ensuring socioeconomic and environmental sustainability. This paper analyses the existing policies, guidelines and tools related to CDM, A&R projects and REDD. Policy options and key barriers for promoting agroforestry for meeting challenges of climate change and recognition of agroforestry’s environmental services are discussed. The Kyoto Protocol, CDM, carbon trading, etc., offer new challenges and opportunities for recognition and environmental services. Policy options for adopting agroforestry are suggested.

**By-products from coffee agroforestry systems: does local knowledge of stakeholders help in conservation of biodiversity?**

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**Preferred session** D4. Incorporating local knowledge in agroforestry science

**Abstract**

Western Ghats, one of the 34 global hotspots in India, is the chain of mountains that run across 6 southern states in India. Coorg district in Karnataka (state), part of the Western Ghats, is known for its rich coffee agroforestry systems. According one estimate there are more than 115 trees grown as shade trees for coffee cultivation. In addition to shade, farmers have been utilizing these trees for various purposes such as timber, fuelwood, medicine, ropes and fibres, implements, oil, fruit, leaf composts, moisture retention, fauna attraction, standards for pepper and nectar yielders. Mostly these are native tree species. However in recent years, farmers are neglecting these trees and instead, they are cultivating exotic trees such as silver oak in pursuit of quick money and to avoid any legal problems in cutting the native trees. This has considerably reduced the by-products availability from the plantations. With this scenario, we wanted to immediately assess the specific kinds of by-products and their importance for maintaining the floral, faunal and soil biodiversity. For this, we collated the local knowledge of the stakeholders and built it in to systematic
knowledge bases utilizing the agro-ecological knowledge toolkit (AKT) methodology developed at the University of Wales, Bangor, UK http://akt.bangor.ac.uk). Essentially the knowledge base contains information such as types, utility, harvesting and processing, season/time of availability, nutritional and economic benefits, role in biodiversity conservation, sustainability and livelihoods, and gender issues. In this poster we would like to present the salient components of our by-products knowledge base from the point of view of biodiversity conservation.

**Threats to on-farm conservation of *Vitellaria paradoxa* (Shea butter) tree in Nakasongola District, Central Uganda**

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**Preferred session** B8. Participatory tree domestication (PTD) for land rehabilitation

**Abstract** An assessment of threats to on-farm conservation of shea tree (*Vitellaria paradoxa*) was carried out in Nakasongola District (Central Uganda) between August 2007 and March 2008. The specific objectives were to document ethno uses and assess on-farm conservation strategies and challenges to conservation of the species on farms. Data were collected through household, focus group and key informant interviews. Questionnaire data were coded, entered in a SPSS computer program and analysed for ethno-uses, local conservation strategies and challenges to conservation of shea and other indigenous trees in the area. Logistic regression analysis was used to show how socio-demographic characteristics influenced local people’s willingness to protect shea on their farms. Less than 50% of the respondents preferred shea for fruit and oil production while over 90% of the respondents preferred it for charcoal. Although most of the respondents were willing to plant shea trees, they were constrained by factors such as tree/land tenure, increased termite attack, lack of shea planting materials and increased level of poverty. The tree is currently an entirely wild resource with great economic potential that needs to be sustainably utilized. Regional programmes should aim at mobilizing the local communities to carry out interventions such as assisted tree regeneration, by encouraging farmers to protect and stimulate the growth of naturally regenerating indigenous trees. This may be an effective avenue that can enhance tree-based rehabilitation of degraded resources while ensuring environmental sustainability. Both local and central governments need to come up with appropriate incentives for promoting on-farm conservation of this very valuable species. This is so, because failure of the government and other relevant organizations to intervene will culminate in complete degradation and loss of shea parkland benefits, leading to ‘the tragedy of the commons’ not only in Nakasongola but in other shea parkland areas.

**Community-based domestication of selected tree and vine species in support of the furniture and handicraft industries**

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**Preferred session** B8. Participatory Tree Domestication (PTD) for land rehabilitation

**Abstract** Two people’s organizations (POs) in northern Philippines and southern Luzon, Philippines, were engaged to domesticate indigenous tree species and vine species for raw material support for the furniture and handicraft industries. The tree species were selected by previous research that examined their potential for furniture and handicraft industries, while the vine species was selected based on a species priority ranking by the PO. The POs were familiar with and skilled in raising common exotic trees, e.g. *Gmelina arborea* and *Swietenia macrophylla* but not the indigenous trees and vine species. The four-year-old research documented how the farmers employed, learned and developed knowledge and skills in domesticating crop and exotic trees. Through annual workshops and ‘writeshop’-facilitated processes, the farmers personally described their experiences, learnings and challenges in the domestication of the species. The significant knowledge gained from the research includes: 1) unfamiliar species with market potential are
of interest for farmers to domesticate; 2) site selection and matching skills of farmers employ their previous domestication experience and application of their indigenous knowledge of forests; 3) there are indigenous trees that have comparable growth rates and performance to popular fast-growing exotic trees, even in degraded lands; and 4) modest support and incentives to POs will enable them to domesticate new species. Challenges or constraints for farmer domestication include: 1) market and product utilization policy constraints are major hindrances for POs to fully engage in plantation establishment of trees and vines; 2) identification and reduction, if not total eradication, of biophysical limitations or stresses that constantly pose a threat to the success of the plantations, e.g. fires, long dry season; and 3) sustaining the inputs particularly for maintenance and protection of these resource-limited POs.

Strategies and tools for restoring degraded tropical forest: options from the FOREAIM Project in Mabira Forest Reserve, Central Uganda

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract Strategies and tools for restoring degraded tropical forests are often unclear and yet there is continued degradation and loss of the few remaining forests. The EU-funded FOREAIM Project (bridging restoration and multi-functionality in degraded forest landscapes of Eastern Africa and Indian Ocean Islands) has implemented an inter- and multi-disciplinary approach to design strategies for restoring the degraded forests, based on the Mabira Forest Reserve. The forest has undergone several decades of encroachment, settlement and uncontrolled harvesting of various forest products. The approach involved seven work packages focusing on different aspects that are vital for a successful restoration programme. The work packages are: WP1) local populations and forest degradation; WP2) impact of degradation and rehabilitation on vegetation; WP3) rehabilitation of forest ecosystems and incomes through planting; WP4) impact of degradation and rehabilitation on soil functioning; WP5) impact of degradation and rehabilitation on erosion; WP6) economic potential of native species used in forest rehabilitation; and WP7) tools for transfer and uptake by stakeholders. The traditional local knowledge of the ecology, species, degradation and restoration has been used to prioritize species for propagation for use in restoration. This together with the knowledge of plant species biology has been used to propagate the priority species for planting by the communities. Information on the physical, chemical and biological properties of the soils will be used to ensure that planting efforts are successful. Ultimately, the various forest products can be marketed to promote their use for restoration. This multi-stakeholder and multi-functional approach has ensured that the best tools are developed for uptake by the local communities around the Mabira Forest Reserve and elsewhere.

Economic, social and ecological impact of tree farming on smallholders on Leyte Island, Philippines

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract In two regions on Leyte Island, Philippines, Baybay and Tabango, three groups of farmers were compared using local indicators for sustainability evaluation. In each area, one group of farmers engaged in an agroforestry project, one group had individually planted exotic timber trees, and one group had no (timber) trees. Indicators were identified with farmers in group discussions and in interviews with other stakeholders, such as representatives from universities, NGOs and local government units. A list of local and externally identified indicators was then ranked by 30 farmers and 18 other stakeholders. For primary data regarding farming systems 71 farmers
were interviewed in Baybay and 77 in Tabango. In Baybay 25 farmers practised ‘rainforestation farming’ (RF), an agro-forestry system using indigenous trees, 14 had exotic timber trees and 32 farmers had no timber trees. In Tabango 40 farmers were associated with the World Agroforestry Centre ICRAF, 16 had individually planted exotic timber trees and 21 had no timber trees. In Baybay RF and other tree farmers were better off than farmers without timber trees. RF farmers had significantly (p<0.05) more land available, were mostly landowners, better educated and reported having higher soil quality. While some of these findings are likely to be a consequence of the farming system practised, i.e. better soil quality, others are probably prerequisites to adopt such a complex system, i.e. landownership or farm size. In Tabango differences between farmers groups were seldom significant. Farmers interested in tree farming more often experienced low soil fertility and erosion, which might explain their interest in tree farming. Since the ICRAF project only started a number of years ago, it is not yet possible to make conclusions about its impact on farmers. But for a higher adoptability rate, the less ambitious ICRAF approach seems to attract a wider range of farmers than the complex RF.

Soil carbon and productivity dynamics of a ferric acrisol under hedgerow intercropping

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Preferred session C2. Carbon sequestration in agroforestry
Abstract
Declining soil productivity of tropical croplands are serious challenges to sustainable food production. Emerging strategies in soil productivity improvement include the adoption of hedgerow intercropping with efficient use of organic materials and mineral fertilizers in arable crop production to enhance plant nutrition and also to improve soil organic matter content, which is important for the sustainable use of tropical soils. A long-term study on a ferric acrisol commenced in the major season of 2005, using seven management strategies: 1) burning of biomass; 2) mulch; 3) mulch + fertilizer (70 40 40, NPK kg/ha); 4) mulch + hedgerow + prunings; 5) mulch + hedgerow + prunings + 0.5 fertilizer; 6) mulch + hedgerow + prunings + fertilizer; and 7) mulch + hedgerow + fertilizer. Maize was used as the test crop. By the end of the sixth season mulch + hedgerow + prunings + fertilizer and mulch + hedgerow + prunings + 0.5 fertilizer gave the highest grain yield of over 4.6 t/ha, whilst low grain yields were obtained from plots with burnt residue or sole mulch. Even though the mulched and fertilized plot showed higher grain yields during the early seasons of the experiment, the trend changed in favour of the hedgerow plots as the years progressed, confirming the resilience of hedgerow intercropping in sustaining the productivity of croplands. Changes in soil carbon during the period showed that mulch + hedgerow + prunings and mulch + hedgerow + prunings + 0.5 fertilizer maintained higher levels of soil carbon of about 2.3 g/kg soil. This showed that a higher dose of inorganic fertilizer application could be detrimental to soil organic carbon maintenance. Thus strategies aimed at enhancing soil carbon sequestration should focus on more organic matter input into the soil with less inorganic fertilizer application.

Local mechanisms to fulfil the local needs as compared to those of the State Forest Department in Azad Kashmir Pakistan

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Preferred session D4. Incorporating local knowledge in agroforestry science
Abstract
Farm forestry, agroforestry and social forestry have become the acceptable terms for any forestry programme that involves local communities in Pakistan. Prescriptions for each ecological zone are readily available, with foresters willing to bring land under tree cultivation for the farmers. This paper analyses the factors that determine the choice of species for farmland planting. It also lists the tree species that are widely planted in the farmlands of the State Forest Department of Azad
Jammu and Kashmir AJK. Qualitative and quantitative survey techniques were applied to collect data on species that are made available for on-farm planting in the study area. Data on farmers’ perceptions, needs and actual practices were correlated with those of the suppliers of planting stock. The results reveal that while the focus of the Forest Department is on watershed, fuelwood and timber production, the primary needs of those whose economy is dependent on trees prefer fodder species; fuelwood ranks second in their choice. The research also reveals that a major part of the winter fodder is collected from naturally growing trees (local name Dhaman), Grewia spp., while none of the forest nurseries grow this species. It was also found that the techniques for raising local fodder species are not known to the forest officials. During field work many natural stands of Dhaman were identified that are protected by the owners for sale of green fodder to the pastoralists. The policy recommendation of this study is that the government must focus on naturally growing local species and develop a mechanism in which the local people have a say in the decision-making processes on farm forestry.

Tools for characterizing agroforestry readiness of research-development institutions

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Preferred session D2. Integrating disciplines through agroforestry education
Abstract This paper describes a tool which seeks to build on ongoing initiatives by providing a framework for the proper identification of and response to institutional challenges and needs for the advancement of agroforestry science, innovation and practice. The framework involves two phases of evaluating agroforestry readiness of research-development institutions, based on the experiences with ongoing tools used by the World Agroforestry Centre  ICRAF and the African Network for Agroforestry, Agriculture and Natural Resources Education-ANAFE. The first phase consists of institutional surveys during which data are collected on the status of agroforestry from various selected institutions in the research education development (RED) continuum. The second phase consists of an analysis of the survey results, during which a selected group of stakeholders meet to analyse the current agroforestry situation and determine institutional challenges and needs that are to be addressed for Agroforestry readiness of research development institutions. For each of these phases the basic principles, process, methods and outputs are presented. As experiences and lessons continue to be documented by the various actors engaged each year in the exercise of strategic plan development for the advancement of AF science, innovation and practice, further improvements to the institutional analysis tools are expected over the years.

Sustainable management of farmer forests – a case study from South India

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Preferred session A5. Ecological sustainability: panacea or Pandora’s box?
Abstract Farmer forests (manure forests) are minor forests allowed by the state for community use as organic support in the central Western Ghats area of Karnataka, South India. Sustainable utilization of these for foliage and fuelwood would ensure farmer independence, prevent him/her from putting undue pressure on the natural forests nearby, and maintaining on-farm biodiversity. Ten hamlets were selected at random; from each of these nearly 10 farmers were interviewed by the participatory rural appraisal technique. One representative forest from each of the 10 hamlets was used for a phyto-sociological survey and the results were compared with a natural forest benchmark selected nearby. Species diversity at all levels was higher in the farmers’ forests than the natural forest. The farmers were found to promote species such as Aporosa lindleyana, Memecylon umbellatum, Syzygium cumini and S. caryophyllum for their foliage requirements. The benefits derived, lopping
patterns, protection and planting attitudes of the farmers were marked with a differentiating scheme, and the relative scores on these four attributes were summed up in a management value index (MVI). The MVI was found to increase with the extent of land holding of the farmers, and optimization of the MVI was observed at land holding size 1: 1.5 for a low, intermediate 1 2 ha, and rich more than 2 ha categories. The average size-class distribution of tree species individuals of the 10 farmers’ forest described the expected L-shaped curve similar to that of the natural forest, but possessed larger number of individuals. Farmers need to be educated on sustainable harvest of leaf, fodder, fuelwood, fruits etc., and provided with relevant extension information in order to diversify the multifunctional farmers’ forests biodiversity and productivity.

Cadre de Référence d’Appui Méthodologique à la Recherche-Action

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract

Sur la base des expériences et des leçons apprises de l’expérimentation d’approches en appui à la recherche –action au Sahel, un cadre de référence est développé pour servir comme un guide pratique d’appui méthodologique à la recherche-action. Ce cadre de référence présente les principes de base, les processus , les méthodes et les résultats attendus à prendre en considération dans l’élaboration et la mise en œuvre d’une approche d’appui à la recherche-action. L’utilisation de ce cadre de référence ne sera effective et grande que lorsque l’impact attendu de l’approche issue des éléments de ce cadre devient évident et visible pour les acteurs notamment les bailleurs et les paysans. Il s’agira d’assurer : une effectivité de l’implication des paysans dans les processus de prise de décisions, avec au final l’adoption des résultats ;un renforcement des capacités notamment des paysans pour l’utilisation durable des résultats de la recherche-action par des outils et stratégies de communication effectifs ;la mise en place d’un partenariat opérationnel entre les différents acteurs en vue de développer une vision et des actions concertées pour l’atteinte des objectifs fixés. Ainsi, le changement souhaité d’un développement agricole évoluant de façon durable sur les ressources et initiatives locales sera une réalité pour le développement économique, et socioculturel dans nos pays en développement

Smallholder rubber agroforestry options for improving livelihood and conservation

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Preferred session E4. Socioeconomics and agroforestry in the Pacific

Abstract

The introduction of para rubber (Hevea brasiliensis) in Southeast Asia over a century ago led to a rapid and spontaneous adaptation by smallholder farmers of their traditional shifting cultivation system. Hevea is now well ‘naturalized in the region. With the global demand for natural rubber increasing steadily, its future prospects appear good, and there is a rapid expansion of rubber in the region. Technologies available for rubber were developed for intensive monoculture settings and these are less suitable for smallholders with resource constraints. Despite several decades of government efforts to promote monoculture rubber in Indonesia, many farmers still practise their traditional system as it requires less resources (capital and labour) for its establishment, provides many important products for subsistence and trade, and is easy to manage. Over the last decade improved rubber agroforestry systems (RAS) were designed and field-tested in three provinces in Indonesia. Productive rubber clones are used instead of less-productive seedlings, but most of the positive characteristics of the traditional system annual crops, less weeding and valuable vegetation are maintained making it more conservation friendly. The long-term participatory trials indicated high variability in growth of rubber trees and production of rubber between plots due to a high diversity in the management styles of farmers. This also reflects diversity in farmers’ abilities, limitations and adaptation of rubber agroforestry options. An ex post analysis of the output identified nine distinct types of rubber agroforestry. Economic analysis (for NPV, IRR, return
to labour and return to land) of these types indicated a wide range between them. Several types were significantly more profitable than the traditional system and monoculture rubber, as well as oil palm plantations. Incorporation of high-value annual and long-term crops with rubber can make these rubber agroforestry options even more profitable.

The influence of agroforestry practices on plant species and implications for feeding-resources availability for fruit bats

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Preferred session A. Role of agroforestry in landscape-scale conservation strategies

Abstract Agroforestry practices in farmed lands surrounding the Biosphere Reserve of Pendjari (BRP) in north-west Benin have preserved mainly woody plants that are socioeconomically important for local human populations. Thus, multipurpose woody plants such as Vitellaria paradoxa (Sapotaceae), Tamarindus indica (Caesalpiniaceae) and Diospyros mespiliformis (Ebenaceae) were found in farmed lands but so too were Sarcoccephalus latifolius (Rubiaceae) and Detarium microcarpum (Caesalpiniaceae), which are less valuable for local populations. The assessment of leaves, flowers and fruits of these plant species revealed higher production of leaves and fruits on T. indica and D. mespiliformis in farmed lands. A similar pattern was observed in fruit production for V. paradoxa whereas S. latifolius and D. microcarpum showed similar leaf, flower and fruit production between farmed lands and the BRP. These results demonstrated that land use impacts on the phenology of woody plants and in turn the feeding-resources availability for fruit bats. Regular bat sampling with standardized methods on permanent plots in these areas from 2004 to 2006 revealed that the fruit bats’ population dynamics showed different trends between farmed lands and BRP but peaks were recorded during high phenological productions. Less-common fruit bats species were also recorded during these periods.

Key words: phenology, fruit bats, farmed lands, protected area, Benin.

Socioeconomic analysis of agroforestry systems in the Andes

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Preferred session C.6. Agroforestry and reconciliation ecology

Abstract In the Peruvian Andes a troubling degradation of natural resources such as soils is observed, due to deforestation and inadequate agricultural practices. In order to stop and reverse this process, various state and non-state institutions are involved in promoting agricultural conservation practices in timber production, which consist of the association of trees or shrubs installed in the taluses of slow-formation terraces (land and stone); the purpose of this is to prevent the erosion and loss of soil nutrients, produce forest products, and protect the annual crops from cold winds; and consequently increase their yields and the economic profitability of the land parcels. In the majority of cases these factors determine the viability and adoption of this technology. The purpose of this study is to analyse and compare the economic profitability of agroforestry and non-agroforestry systems in slow-formation terraces and to determine the biophysical and socioeconomic factors that influence their adoption. In order to determine the economic profitability of both systems experimental parcels were established with, crop potato (Solanum tuberosum) in the terrace on an ongoing basis, with and without the forest component (Polylepis racemose). The crop production costs from planting to harvest were recorded and the direct and indirect benefits of the forest component were determined. The biophysical and socioeconomic variables that influence the adoption of agroforestry systems were determined through statistical analyses, utilizing discriminating methods.
Acacia mangium-based agroforestry practices for livelihood security of rainfed farmers of coastal Orissa.

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Preferred session
D4. Incorporating local knowledge in agroforestry science

Abstract
Acacia mangium Wild. is a very fast-growing, nitrogen fixing, multipurpose tree species adapted to a wide range of acidic (pH 4.5–6.5) soils and soils of low fertility and impeded drainage—a phenomenon which is commonly experienced in moist tropical lowlands of coastal Orissa. It grows to a height of 25–30 m, attains a DBH of over 50 cm with a clear and straight bole to over half of the tree height after 12 years of growth. Participatory research on plantations of Acacia mangium on paddy field bunds at 2 m intervals have been successful with regard to growth parameters (height and dbh). It has proved to be a boon to the rainfed farmers of coastal Orissa who can harvest 25–30 cft of quality log and earn a minimum of Rs. 3000–4000 after 12 years of growth from a single tree species. Paddy yield revolved around 39 to 42 quintals per hectare during the period of tree growth in kharif season, the soil organic carbon increased from 0.44% to 0.52% and availability of phosphorus, potassium, sulphur and zinc showed remarkable improvement over the years due to agroforestry practices involving Acacia mangium. Farmer’s acceptance has increased due to the similarity of A. mangium’s wood’s quality with the most preferred tree Tectona grandis. They have developed their own methodology of harvesting a tree after 4 years of growth, alternatively maintaining a tree-to-tree distance of 4 m for more growth and clear bole and this has yielded satisfactory results. This tree species is now an insurance against frequent crop failure due to floods and drought that hit coastal Orissa in alternate years and is a source of livelihood security for the rainfed farmers of coastal Orissa.

Agroforestry systems on Togo’s coastline: inventory and improvements

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Preferred session
A2. Agroforests in humid tropical Africa

Abstract
This study on the practices of agroforestry on the coastline of Togo is a contribution to the inventory of these systems in the south of the country. The study was conducted at 10 areas. Thirteen plots of 50 m x 50 m were installed in each area. In each plot an inventory of all wood and crops has been achieved. To determine stand structure, the diameter at breast height was measured. Data were entered in an Excel spreadsheet. The Excel tables are subject to a correspondence analysis (CFA). This analysis was conducted using the software for data analysis, Spad version 4.01. Ethnobotanical surveys have been conducted among local populations to assess the possibilities for improving existing systems and to learn about the different uses of agroforestry species which were identified. Indeed, the study permitted the identification of some modern and traditional systems of agroforestry. The traditional systems include homegardens, Dialium guineense parkland, Elaeis guineensis parkland and mixed parklands such as Elaeis guineensis and Cocos nucifera parkland, Elaeis guineensis and Borassus aethiopum parkland and mixed-composites parkland. The modern systems include the taungya systems and corridor farming. The taungya with Tectona grandis, Eucalyptus spp. and Khaya senegalensis have been identified. In order to improve the various systems, Albizia chevalieri, a fertilizing plant has been given to some farmers to enrich their fields. The multifunctional management the practice of Albizia fallow, and the introduction of woody species, etc., are the actions suggested for a better production of the known systems.
Teak plantation in agrosystem land-use areas in the Guinean zone in West Africa: the case of southern Benin

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract
Situated in West Africa on the Gulf of Guinea, Benin is a country of limited forest resources. Land cover in Benin is about 65% wooded vegetation. But this natural vegetation is subject every year to the pressure of bush fires. Moreover, an important area is destroyed every year (100 000 ha per year) for agricultural purposes. To address the deficit of the natural forest resources, degraded surfaces are reforested with tree plantations, mainly with teak (*Tectona grandis* L. F.).

Teak, through its silvicultural and technological qualities, appears to be a species of very high economic value. Thus, the introduction and the promotion of teak in Benin in 1949 encouraged the development of private teak plantations, particularly in southern Benin. Many villagers and farmers were encouraged to cultivate teak on small pieces of farmland. This survey showed the importance of teak plantations in maintaining and/or rehabilitating soil fertility, and in several other roles. These plantations are the subject of several agroforestry techniques because of the desire of the owners to maximize the land use on their farms. The Taungya system is practised on 42% of the area by setting up annual crops (corn in particular) and pineapple in teak plantations, and the mixing of lines of teak with other trees (*Acacia*, palms groves). However, the majority of teak plantations (60%) are monospecific. In this case, teak constitutes the main species (54.3% of the surface) used in plantations within the different agroforestry systems.

Branchwood and foliage productivity of *M. alba* (Linn.) in a hedgerow cropping system.

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Preferred session A1. Multistrata agroforestry systems with perennial crops
Abstract
Trees form an integral part of any agroforestry system. The usefulness of trees cannot be overemphasized. Incorporating trees into farming systems leads to greater prosperity and diversification at the farm level. While trees clearly offer economic and ecological advantages, they often also complicate the biological interactions within the system. Careful selection of trees, alley and companion crops and management practices are important considerations in verifying tree-crop compatibility for the success of agroforestry systems. To optimize the overall productivity and sustainability of any system, management of the dominant component is very important.

Four-year-old *Morus alba* trees, planted in rows 7 m apart in the east west direction at three spacings, 1.5 m, 2.0 m and 2.5 m were maintained as hedgerows at a stem height of 1.5 m. Two medicinal and aromatic plants, *Ocimum basilicum* and *Tagetes minuta*, were raised in the alleys. Three different organic manures were applied to the medicinal and aromatic plants. Significant differences in biomass production were observed as a result of different tree spacing within the hedgerow. Maximum fresh biomass was recorded in trees at the wider spacing of 2.50 m. This could be attributed to less competition among the trees for common resources. As the spacing among the trees reduced, the below-ground and above-ground competition increased, resulting in lesser biomass production. However, exact spacing and management would depend upon the objectives of production.
Use and ecological knowledge of *Adansonia digitata* L. in Malawi

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**Preferred session**
D4. Incorporating local knowledge in agroforestry science

**Abstract**
Domestication and commercialization of indigenous fruit tree are important livelihood options for rural communities in Malawi. A survey of 219 households selected from four sites in Karonga, Salima, Chikwawa and Neno districts was conducted to determine the ethno-ecological knowledge and utilization of *A. digitata* L (Baobab). Results showed significant differences in the use and biological information between sites. Leaves were predominantly used by 71% of respondents as food (spinach). Roots were largely (75%) used for medicinal purposes, followed by leaves (28%); while a few people indicated the use of roots (8%) as source of ropes. The majority of the respondents valued fruits as food (72%) and for sale (16%). The households identified trees based on fruiting traits such as taste and shape; and tree sexes were distinguished based on fruiting habits, i.e., males (tree that do not bare fruits) and females (trees that bare fruits). Tree tenure consisted of communal tree ownership (45%) and individual tree ownership (42%). Flowering phenology spanned from September to December across all the sites with insects (30%) as the major pollination agents. The change in fruit colour (60%) was the main criterion for deciding when to commence harvesting. This survey has revealed that baobab is extremely important for supporting livelihoods of rural communities in terms of food, income and medicinal purposes. However, there is a need to investigate the sex ratio of plants in the natural populations, and fruit phenology and fruit traits, in order to kick-start tree improvement and domestication programmes. More research is warranted on fruit processing and enterprise development, while also being cognisant of the importance of cultivation to ensure that rural community dwellers who depend on wild collection for meeting their vitamin C diet requirements are not deprived of this nourishment.

Vineyard agroforestry: a new concept for a sustainable vineyard production

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**Preferred session**
A1. Multistrata agroforestry systems with perennial crops

**Abstract**
Grape vines are one of the few crops in the world that is cropped only as a pure crop system. Vineyards face severe environmental concerns such as soil degradation, heavy loads of pesticides and pests attacks. In Roman times, vineyard cultivation was performed as an agroforestry system called Arbustra, with vines growing on living trees used as trellises. Scattered trees such as peach, almond or olive trees were also grown in vineyards in Europe until recently. These trees have been destroyed to allow easy mechanisation of the vineyard management, including mechanical harvesting of grapes. New vineyard agroforestry plots were set up in 1996 in the south of France, and have been monitored since then for grape production and tree growth. Various tree species were introduced into vineyards, at a density of 222 trees/ha, on shallow rocky soils prone to drought. Both evergreen resinous and broadleaved deciduous tree species were introduced, with *Sorbus domestica* (Service tree) and *Pinus pinea* (Stone pine) as the key species. Control plots with pure tree and pure vine plantation were available. After 12 years of cultivation, grape production and tree growth data showed that vineyard agroforestry is possible. Tree growth is enhanced in the agroforestry system, and grape production is not yet reduced by tree competition, except on extremely shallow soils. Competition for water and/or nutrients appears to be the main limiting factor, while light competition seems not to be a problem so far. Root pruning with a sub-soiler was used to limit water competition by the trees on the vines and proved useful. Some preliminary assessments of pest predators in the vineyard system show that mite control may be enhanced by the presence of trees in vineyards. This could allow a reduction in the use of pesticides in vineyards, but more detailed studies are needed to confirm this hypothesis.
Agroforestry systems in Brazilian Amazon: socioeconomic and geo-environment aspects in the Ariquemes region, state of Rondônia

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
This research was located in the Amazon, in the northern region of Brazil. Field research was carried out on 2595 hectares in 7 municipalities of the Ariquemes micro-region, in the state of Rondônia. Thirty five properties were surveyed, which are located in rural settlements established from 1970 to 1990. Almost all of the producers are migrants from other Brazilian states, mainly from the south and northeast, motivated by the search for land, income and employment. In the properties visited, 60% of the families have 1 to 5 members, and 26% have 6 to 10 members. Technical assistance was inadequate in the AFS implementation phase but families still maintained AFS. The properties' natural landscape is much degraded by agriculture and livestock and half did not reach 50% of their legal reserve. These activities, which are more profitable, threaten the continuity of AFS. In general, the properties have 30 to 100 hectares and there are 3 AFS classes: agrisilvicultural, silvipastoral and agrisilvipastoral. The main products generated are consumed by households and marketed regionally. The monopoly on purchasing products in each municipality, however, results in low profits to rural producers. The soils were characterized as poor, most soils are dystrophic, alic and mesotrophic, reflecting, from the producers' point of view, the declining productivity of the AFS in the last 3 years. Most of the AFS were planted in plain relief to soft-wavy, and rarely strong wavy, such as that of Monte Negro city. There was no surface erosion in any of the AFS. It was proved consequently that AFS with soil protection, productive, sociocultural, habitat maintenance functions, causing products and income generation, family's subsistence. Based on these results it is suggested that soil correction be used to increase AFS productivity, also suggested is the expansion of legal reserves, production diversification, political support and economic subsidies for permanent maintenance of the AFS.

Agroforestry, climate change and forest regeneration

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract
Agroforestry is a practice that is helping solve the problem of global climate change and has been adopted and implemented in Africa by the World Agroforestry Centre (ICRAF) and other NGOs and community-based organisations involved in this practice. The activity of humans has created a negative impact on the environment as far as carbon dioxide production from deforestation and poor agricultural techniques such as slash and burn is concerned, and the release of massive quantities of Carbon dioxide in the atmosphere from both agricultural practices and industrial zones. The planting of trees which is an exercise carried out by Governments and councils, both local and urban, in Africa especially in Cameroon, will help remedy this situation of global climate change; and the implementation of the agroforestry techniques in land use will go a long way to restore the vegetation loss by indiscriminate logging. The conservation of biodiversity such as species of high economic and nutritive value and non timber forest products, can only be successful through the domestication of these species using techniques such as vegetative propagation so that high quality germplasm can be multiplied to replace the lost vegetation and this will assist the problem of carbon sequestration. The absorption of this atmospheric carbon dioxide will help solve the alarming changes in our climatic conditions which have also negatively affected agricultural production, hence the world food crisis. When trees are planted they create a microclimate which aids the the interaction of the organisms and their environment which will be a positive interaction making the habitat more productive in terms of soil fertility, and restoring favourable climatic conditions. Forest regeneration will create a diversity of our highly valued species such as Prunus and Gnetum Africana.
Farmer’s strategies for the domestication of *Prunus africana* (hook F.) Kalkam around the kilum-Ijim mountain forest, Cameroon: I

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**Preferred session**
B8. Participatory Tree Domestication (PTD) for land rehabilitation

**Abstract**
Throughout its restricted distribution range, farmers are involved in the domestication of *Prunus africana*, a threatened afromontane medicinal tree species. The approach under consideration was proposed for more sustainable management, where the overexploitation of the species’ products could be balanced with the conservation of its natural resources as well as the livelihood of producing farmers. This study was conducted with the main aim of assessing the contribution of the domestication of this species by local farmers to its conservation in the highlands region of northwest Cameroon. Specifically, the objectives of the study were to characterize the farming systems where the species is integrated, to analyse the structure of *P. africana* populations and the management practices of trees in these systems, and thirdly, to evaluate the contribution of the species to farmers’ household incomes. The methods used were structured interviews and questionnaires administered to 160 households, a detailed survey, inventory and characterization of *Prunus africana* trees in 170 farms distributed within 16 villages all around the mountain. From the results obtained, 94.3% of the farmers in the study zone have introduced or protected *P. africana* trees in their farms using mainly wildlings (44%) and seedlings (26%). The species was found in almost all the existing farming systems of the study zone, although homegardens (36.5%) and cash crop farms (27.3%) were the most common types. From the morphometric parameters, only 1.7% of these planted stands are readily exploitable (dbh > 30 cm). However, more than 60% of trees found on-farm are exploited using ‘wrong’ 1/2 and 2/4 techniques. The contribution of income generated from bark commercialization to the overall household revenue varied from 19.6% in Belo to 32.4% in Jakiri zone. The implication of these farmer’s strategies of domestication and management for *P. africana* conservation and their livelihood improvement is discussed.

Integrating biodiversity-friendly land-use and environmental service rewards to sustain ecosystems and livelihoods under climate change

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**Preferred session**
A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**
The Sierra Madre de Chiapas is both a chain of key biodiversity areas and one of the most important coffee production areas of Mexico. Its three biosphere reserves, El Triunfo, La Frailesca and La Sepultura, provide water for several municipalities and are an important tourist attraction. Much of the forest cover outside the core protected areas is in fact coffee grown under traditional forest shade. Unless this (agro) forest cover can be sustained, the biodiversity of the Sierra Madre and the environmental services it provides are at great risk. Threats include the increasing population, the risk of land-use change driven by unstable coffee markets, and climate change. Significant areas of forest and occasionally coffee are destroyed every year by wildfires, and this problem is bound to increase in a drier climate. Widespread landslides and inundations, including on coffee farms, have recently been caused by hurricanes whose intensity is also predicted to increase. A drier, hotter climate will be less favourable to the production of quality coffee and lower profitability may compel farmers to convert shade coffee into land uses of less biodiversity value or resort to irrigation with its negative impacts on aquatic biodiversity. A comprehensive programme to sustain the biodiversity, ecosystem services and livelihoods of the Sierra Madre, elements of which are being implemented by an alliance of stakeholders, includes: the promotion of biodiversity-friendly coffee growing and processing practices including complex shade, which has been shown to offer some hurricane protection; payments for forest conservation and restoration from existing government programmes complemented by private initiatives; diversification of income...
sources as a risk-mitigation strategy; integrated fire management; the development of markets that reward sustainable land use practices and forest conservation; crop insurance programmes that are accessible to smallholders; and the strengthening of local capacity for adaptive resource management.

Using agroforestry to reduce deforestation, mass poverty and environmental degradation in Nigeria: potential for accomplishing the MDGs

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Preferred session D3. Policy formulation and stakeholder engagement in NRM
Abstract Reports (in 2008) that the world’s 10 most rapidly deforesting countries are poverty-stricken African and shunned by advanced nations that are unwilling to fulfil their promises for assistance that were made before the most recent financial crisis, confirms Kofi Annan’s charge that the world lacks environmental leadership. Nigeria’s potential for achieving an agroforestry revolution to achieve some MDGs (environmental sustainability, poverty reduction and gender equity) includes: being the most rapidly deforesting nation worldwide; presenting the most paradoxical peasant poverty (70.2 90.8% of her 2006 total population; over 140 million, i.e. one fifth of sub-Saharan Africa’s 2005 total population); and recording one of the lowest per capita agricultural productivities worldwide. Using a descriptive case study, comparative analysis and a survey, this study analysed multiple-source datasets to report that Nigeria could more rapidly achieve MDGs (environmental sustainability, poverty reduction and gender equity) if drastic innovative strategies, e.g. cooperative agroforestry, are adopted. This involves mobilization of Nigeria’s peasant majority; financial institutions (recapitalized banks) for macro and micro-financing; drawing lessons from recent achievements in environmental improvement through increasing good governance and ownership of trees; community-based tree planting and revegetation of desertified parts of Niger as reported by the African Ministerial Conference on Environment, UNEP and partners in 2008. Nigeria also possesses vast underutilized arable land. Most of desertified Nigeria is recoverable by borrowing from Israeli and other environmental technologies that were applied to convert Israeli territories that suffered desertification for about 400 years! Lessons can be drawn from recent investment by banks in rural regional development in Brazil, by capitalizing on Nigeria’s recapitalized banks that have notoriously failed to support agriculture and regional development. The implication of these findings for policy include the urgent and imperative need to rapidly implement cooperative agroforestry as a means to accelerate the achievement of the MDGs relating to environmental sustainability, poverty reduction and gender equity.

Incorporating agroforestry into tertiary agricultural education programmes in West & Central Africa

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Preferred session D2. Integrating disciplines through agroforestry education
Abstract Since 1995, ANAFE has been instrumental in incorporating agroforestry as a science-based discipline in quite a few tertiary agricultural education (TAE) curricula in West and Central Africa (WCA). The objective is to improve the effectiveness of training programmes so that competent and well-equipped graduates are produced, who are capable of solving land-use problems notably severe natural resources degradation, food insecurity and rural poverty WCA. Four basic principles are used for the DACUM process. Firstly, learning needs are identified and the decision is made on the type of training needed to provide these learning needs. Secondly, the training needs are planned carefully so that learning is most likely to take place. Thirdly, the training is delivered in such a way
that learning does take place. Finally, the training will be evaluated so that there is evidence that learning has taken place. In addition to adhering to these basic principles, the DACUM process has five steps. The first step is the planning phase of the curriculum development project during which situation analysis and training needs are determined, among other things. This planning phase is followed by the implementation phase of the DACUM workshop, during which guidance and direction for training and learning is provided. Following the DACUM workshop, the last three steps are, respectively: the course programme formulation, the curriculum implementation, and the monitoring and evaluation. The paper presents the DACUM process, adopted and adapted for executing the initiative, emphasizes the need for various stakeholders to support AF curricula both financially and technically, and highlights some guidelines for achieving this. If developed and supported properly, AF in curricula has the potential to transform lives and landscapes for sustainable human development.

Coffee productivity, ecosystem services provision and adaptation to climate change: how useful can a model be?

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Preferred session A1. Multistrata agroforestry systems with perennial crops
Abstract
Due to the lack of a simulation model, predictions of climate change (CC) impact on coffee do not include CO2 fertilization; they include only changes in temperature and rainfall patterns. It is hypothesized that temperature, rainfall and CO2 will have interacting effects on coffee productivity in agroforestry systems and on the environmental services they provide to society. The aim of this presentation is to include CO2 fertilization in the predictions of CC impacts using CAF2007, a coffee simulation model developed during the EU-funded CASCA project by Van Oijen et al. The model considers, for shaded and sunlit coffee plants separately, how carbon and nitrogen content, leaf area and phenology change over time. Simulations were done for three locations at contrasted altitudes in Chiapas, Mexico. The model calculated a very significant CO2 fertilization effect on coffee bean production. Production, as calculated by the model, increased with altitude, irrespective of the climate considered. When CO2 fertilization was not considered, temperature increase and modification of rainfall pattern reduced bean production. This reduction was worse at higher than at lower altitudes. When CO2 fertilization was included, the model calculated a positive effect of CC on bean production, and this effect was higher at intermediate altitude. Simulations were made to show the possible use of CAF2007 to test shade management effects on coffee production and on environmental services provision. Management modified all performances, and these effects were modified by CC. The CAF2007 model has not been thoroughly validated so far; the results have to be considered with care, and used for discussion more than predictions of the future of coffee productivity. The model is being validated in 2009. Nevertheless, fertilization is a well known effect, and these results showed that it must be taken into account to determine possible impacts of CC on coffee.

Integrating human and environmental health education in Haiti

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Preferred session D2. Integrating disciplines through agroforestry education
Abstract
With 98% of its lands deforested and more than 50% of its population illiterate and struggling to feed themselves, Haiti is the poorest country in the western hemisphere. Because of those indicators, Haiti is also one of the Caribbean islands with the most non-governmental organizations working on it. It is common to see three or four organizations working in the same community delivering different messages, which the local people have trouble understanding. These efforts do not have lasting impact because the recipients do not have the capacity to pass them on. Their lack of education is not only a barrier to improving their quality of life, it is also a contributing factor
to the environmental and health problems of the country. I will present an integrated approach to education in human and environmental health that will effectively generate behavioural changes. This method was developed through a partnership between Hospital Albert Schweitzer, Haiti’s Community Health Division and the Haiti Timber Re-Introduction Project. This programme will be focused on children and young adults in order to generate behavioural changes to improve their health (family planning, immunizations, and other public health messages) and to improve local agricultural practices and encourage agroforestry. Educational messages will be given in local centres in an image and discussion-based format that is accessible to the illiterate. Literacy will be introduced through this same format, and the literacy lessons will be centred on health and educational themes. Therefore the behaviour-changing messages are embedded in the practical education (literacy). Supervised group activities will reinforce the messages. Finally, once the participants are literate they will be given books to read that will encourage behaviours that support public health in the broadest sense, human and environmental.

**Soil conservation tillage on alley-cropping systems in Mexico’s temperate climate**

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**Preferred session**

C3. Agroforestry, water quality and environmental amelioration

**Abstract**

The soil conservation tillage in alley-cropping systems can improve physical and chemical soil properties, which results in better soil productivity, increased crop yield and enhanced environmental effects. The objective of this study was to evaluate the effect of ‘no tillage’ and ‘minimum tillage’ on the soil properties, crop yield and production costs of corn and frijol, in order to compare them with ‘conventional tillage’, within alleys delimited by peach trees. The research was carried out in a Latin square experimental design on an irrigated Mollisol and rained Inceptisol located in the experimental fields of Chapingo University, during the eighth and ninth year of treatment in the temperate region of Mexico. The physical and chemical soil characteristics were evaluated to 0 3, 15 18 and 30 33cm depth. The physical and chemical soil characteristics, as well as grain maize and grain frijol yield did not show consistent significant statistical differences (P= 0.05) from the effect of tillage systems in both soil types and studied years. Bulk density, phosphorus, and potassium, show statistically significant differences in some soils and years at the 0 3cm depth. Organic carbon and total nitrogen of the 0 3cm soil depth were statistically greater in ‘no tillage’ and ‘minimum tillage’ than under ‘conventional tillage’ in frijol after maize cultivation in both soils. These differences indicate stratification of the chemical elements and sequestration of organic carbon in the soil, reducing rate of return of the CO2 to the atmosphere. No and minimum tillage systems, show the smallest production costs with respect to conventional tillage in maize and frijol, in both soils, and are therefore more profitable.

**Land-use policy and agroforestry potential on non-wood forest production and marketing by forest villagers (Case study: Köprülü Kanyon National Park)**

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**Preferred session**

A3. Role of agroforestry in landscape-scale conservation strategies

**Abstract**

In the study area, an annual average of 600 tones of carob fruit is produced every year. This income is about 14% of the total income of the stakeholders in these villages. The price of the fodder income was three and half times higher than the raw material of carob. Basically, the cost of living of villagers in KKNP was supplied by animal husbandry and agricultural activities. Fodder cost was an important input. Oregano production is very important for the villagers in Köprülü Kanyon National Park (KKNP). The major part of the income of Çaltepe village, its production is 300 tons per year, was generated by oregano production. Oregano is utilized in two ways. The first way is selling raw oregano. However, in this activity the economic value of oregano is very limited. Tobacco production, particularly in Aegean and Mediterranean Region of Turkey, is
permitted based on a certain quota, hence oregano production is increased. Oregano production has become widespread, dozens of areas are under production in Izmir, Manisa, Aydin and Denizli provinces. The increase in oregano production from its natural habitats shows that oregano producers will encounter marketing difficulties in the near future (within following 5-8 years). Marketing difficulties in oregano production pose a serious threat for the income of villagers in Köprülü Kanyon. Consequently, sustainable use of oregano is important and thus oregano should be domesticated and cultivated. Oregano honey production should be encouraged as a new source of income generation. The aim of this study was to assess the effects of land-use policy on non-wood forest production and marketing potentials of forest villagers in KKNP.

**Fractions of organic soils under cocoa agroforestry systems in the south of the Bahia**

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**Preferred session**
C5. Soil organic matter and nutrient cycling in multi-strata AF systems

**Abstract**
The agroforestry systems, promoting large deposits of plant material on the ground, become an important source of organic matter for the soil, and thus are considered conservationist. This study aimed to evaluate the contribution of cocoa agroforestry systems to the carbon and nitrogen content of organic soil fractions (free light fraction, intra-aggregate light and heavy fractions, sand, silt, and clay). This study was conducted in agrosystems: cocoa (Theobroma cacao); cocoa-cabruca; and cocoa with Erythrina shadow trees (Erythrina spp). The natural forest is considered the benchmark system. In each area of study, four samples were collected from simple soil, which were assembled into one composite. Were opened minitrinheiras depth of 0-10 cm, in-between, on a random basis, for the simple collection of each sample. The light and heavy fractions of soil organic matter were obtained in accordance with the procedure adopted by Sohi et al. (2001). The light fractions were: a) free light fraction not associated with the organic fraction of soil mineral components; and b) intra-aggregate light fraction organic fraction of soil is physically protected within the household. After extraction of the material lighter soil, in the same sample, the fraction organomineral (heavy fraction) was separated by size. Cocoa agroforestry systems were shown to be important in the supply of carbon and nitrogen for light fractions. The soil under cocoa-cabra contributed to the higher carbon content of the light fraction and soil under cocoa-eritrina proved to be important for the supply of carbon and nitrogen to light fractions, not unlike the cocoa-cabra. Already in heavy fractions no significant differences in the content of carbon and nitrogen from the roof. Therefore, the lighter fractions may be important early indicators for assessing the system.

**Reducing poverty through agroforestry: policy and institutional constraints in the Philippines’ Community-Based Management Program**

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**Preferred session**
E4. Socioeconomics and agroforestry in the Pacific

**Abstract**
As an appropriate land-use practice, agroforestry has the potential to help reduce rural poverty due to its capacity to offer multiple benefits to smallholders to enhance farm production and income, while protecting the environment. The growing food insecurity brought about by the global financial crisis, the threat of climate change, the deteriorating environmental situation, and increasingly scarce livelihood opportunities in many rural areas of most developing countries require governments and other supporting institutions to take advantage of the high socioeconomic and environmental potential of agroforestry. However, enabling policies and appropriate institutional support systems are needed for the adoption of agroforestry technologies to effectively improve livelihoods of rural
communities and contribute to the overall efforts of poverty reduction (El-Lankany 2004). Using the case of the Philippines, this paper explores some of the policy and institutional factors that limit the potential of agroforestry technologies from contributing to poverty reduction in upland areas in the context of Community-Based Forest Management (CBFM) Program. These include: 1) unstable policy and resource-use rights, especially of timber; 2) overly bureaucratic regulatory procedures and requirements; 3) inadequate institutional support systems; 4) poor market access and opportunities; and 5) limited capacity of local communities to organize themselves and act collectively, mobilize local and external resources towards a common end, and build their capital assets (i.e., natural, social, financial, physical and human). Measures to address these constraints are also elaborated on in the paper.

Fuelwood demand by smallholder farmers in Rwanda: relating on-farm tree planting to socioeconomic characteristics of farmers.

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract

This study combines socioeconomic surveys and biophysical data from farms to determine which factors explain best on-farm tree planting and woodlot management for fuelwood supply by farmers in Rwanda. Using Rwanda as a case study, growing trees for fuelwood in comparison to other uses is presented, against the background of the contribution of agroforestry systems to meet household-level fuelwood demand in densely populated countries and with small firewood plantations. Given the current area under forest in Rwanda, and based on a fuelwood demand of 0.85 m³ per capita per year, sustainable forest use and forest conservation is only possible when a large part of the fuelwood demand (>85%) is met by trees and woodlots on agricultural lands. In the case of small-scale farmers as in Rwanda, with the majority of the farms being less than 0.5 hectare in size, this calls for agroforestry systems where competition between trees and crops is minimized.

Challenges in locally adapting AM fungal technology to enhance agroforestry in rainfed agro-ecosystems in Karnataka, South India.

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Preferred session A8. Integrating Genomics in Agroforestry
Abstract

Agroforestry as traditionally practised in the semi-arid regions of South India includes various tree species grown in different planting niches on and off farms depending on ecological and socioeconomic factors. The farmer’s choice of tree species does not necessarily correlate with commercially promoted species. In general, trees that are not commercially promoted by mainstream institutions do not have the scientific and technical support required to promote their widespread use. Here we report on a 3-year effort to adopt lab-based arbuscular mycorhizae (AM) fungi technology to field conditions among small rainfed farmers in south India. This included identifying the farmer’s choice of tree species for their farms and matching this list with available technology for AM fungal enhancement of seedling establishment. We then worked with farmers in developing field methods to culture crude AM fungal inoculum so the technology would become accessible to poor farmers. We worked with farmers in participatory field trials to learn together about the benefits of AM fungi for seedling growth. We demonstrated the utility of farmer-friendly AM fungi technology by incorporating inoculated native tree seedlings in conventional and introduced farming systems. In this paper we discuss the challenges and lessons learned in developing appropriate farmer-friendly AM fungal technology for native trees in traditional agroforestry systems among poor rainfed farmers in Karnataka, South India.
Recuperation of soil fertility in a chronosequence of fallows in dry forests of the Araçá Indigenous Land, Roraima, Brazil

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Preferred session: C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract: The State of Roraima, Brazil, has the largest continuous area of Amazonian savannahs, known locally as the ‘Lavrado’. Common in this region are forest islands, generally associated with soils of higher fertility, which is the reason why they are used for agriculture by the indigenous inhabitants. However, declines in crop productivity following several years of agricultural use lead farmers to abandon fields to fallow under secondary forest. In order to study the effects of this practice on soil characteristics, areas under fallow of different ages (2, 5, 10 and 20 years) as well as primary forest were selected for sampling in three villages of Araçá Indigenous Land; these areas represented randomized blocks with five treatments and three repetitions. In each area sampled, a 50 x 45 m plot was set up, subdivided in three subplots, with soil collected at the following depths: 0 10, 10 20 and 20 30 cm. The soils of the forest islands ranged from acceptably acid to weakly acid. All fallow ages showed low exchangeable Al and a high availability of Ca, Mg, Cu, Zn, Mn and Fe. Levels of organic C varied from medium to high, and in general, the higher levels were found in older fallows and forest. Levels of P and K were low, often below critical levels, indicating that these could be the principal nutrients limiting crop production in these areas. Results show that fallows can contribute to an increment in levels of P, but not to increases in levels of K.

Limitation of post-harvest losses due to weevils (Sitophilus zeamais (Motsh.) by using biopesticides in agroforestry systems northern Cameroon

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Preferred session: A6. Ecophysiological bases of agroforestry-system design

Abstract: Zea mays L. is the traditional cereal in northern Cameroon. During storage, Sitophilus zeamais causes substantial losses of this cereal. To control the pest, farmers use chemical pesticides despite their harmful effects on the environment and humans. This study aimed to find alternative methods of pest control using aromatic plants locally known for their bioactivity. Two trials were conducted in the laboratory to evaluate the damage caused by S. zeamais and the effect of essential oils on these insects. For the first trial, 20 insects were introduced to 200 g of each of the two varieties of maize (local and improved) for a period of two weeks. After inoculation, the insects were removed, whereas the maize remained in an incubator and was accessed periodically to evaluate the bore dust produced and the rate of insects’ growth, the percentage of weight lost, and extent of attack. For the second trial, essential oils from Lippia rugosa (Verb.) Hyptis spicigera (Lam.) and Xylopia aethiopica (Ann.) were tested (contact, inhalation). Thiacloprid, an industrial molecule was used as a control. The results reveal that the production of the bore dust (1.17±0.37 g) and the growth rate of insects (45.2%) were low for the local maize compared to the improved one. The same trend was observed for the weight lost (0.58%) and the attack (23.43%) on the same variety. The sensitivity of the different generations of insects to essential oils was significant different (p < 0.0001). The mortality rate ranged from 35% (L. rugosa) to 80% (X. aethiopica) and essential oils significantly affected the insect reproduction. This study has demonstrated that essential oils from local plants are a good alternative to control S. zeamais. The use of biopesticides should be recommended in sustainable agriculture.

Keywords: cereals, Sitophilus zeamais, depredation, essential oils, sensitivity
Potential for Clean Development Mechanisms (CDM) and reduced emissions from deforestation and degradation (REDD) forestry projects

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Preferred session C2. Carbon sequestration in agroforestry

Abstract
Forests in Sri Lanka have been subjected to deforestation, fragmentation, conversion to other land uses and over-extraction. These forests have higher biological diversity and sequester a large quantity of atmospheric carbon, acting as carbon sinks. Dense natural forest cover of the country is estimated to be around 23%. The majority of the lands in the hilly regions are deforested for tea and vegetable cultivation, while shifting cultivation is being practised to a greater extent in the intermediate and dry zone regions of the country. It is estimated that around 10% of the country’s land area is already degraded due to deforestation and the use of inappropriate land-use systems. Lands under plantation crops of mainly tea and rubber have also been degraded due to poor soil conservation practices. A greater proportion of the country’s land is becoming marginal and unproductive while decreasing carbon storage potential in vegetation. To protect these lands from further degradation, they should be reforested with fast-growing high-value tree species to increase land productivity and conservation potential, while enhancing the carbon stocks in vegetation. Carbon sequestered through afforestation, reforestation, and other agreed land uses, land-use change and forestry (LULUCF) projects, could be traded with developed countries (Annex I) as Clean Development Mechanisms (CDM) projects with non-annex developing countries. Recent developments are underway to introduce reduced emission from deforestation and degradation (REDD) in existing forests as well for carbon trading. Investigation reveals that Sri Lanka has a great potential to sequester carbon by developing its degraded lands into small-scale CDM forestry (sinks) projects, and reducing emissions by conserving existing natural forests from deforestation and degradation as REDD projects, where the sequestered and saved carbon could be traded, earning economic benefits that could be invested in the sustainable development of the country.

Some promising grasses for agroforestry systems and sustainable land use in Maharashtra, India

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
In India forests were ruthlessly exploited to meet the increasing demand of fuel, fodder and timber. The forest cover is about 675 538 km2. The state of Maharashtra has 26 027 km2 forest cover which is 20.13%, less than the national average of 23.41%. The existing land-use systems, with separate allocations for agriculture and forest, are inadequate not only to meet demands for food, fuel, fodder and timber but also to check land degradation, soil erosion and water conservation. The erosion control potential of agroforestry systems such as alley cropping, silvopasture and riparian buffer is well recognized. The grasses play a significant role in controlling soil erosion and water conservation. The state of Maharashtra harbours 413 species of grasses belonging to 123 genera. During this survey of grasses of Maharashtra over the last 10 years, some wild grasses, which have potential to control soil erosion, land slides, maintain water quality and soil fertility, are recorded. This paper reviews some promising wild grass species for agroforestry systems. Some of the important grasses are Dichanthium jainii Deshpande, Dichanthium odoratum Jain & Deshpande, Eulalia trispicata Henr., Ophiuros exaltatus Ktze., Panicum notatum Retz., Panicum repens L., Pennisetum hohenackeri Steud., Phragmites vallataria Veldk., Sehima sulcatum Camus, Sorghum halepense Pers., Pseudanthistria heteroclita Hook.f. and Vetivieria lawsonii Blatt.
McC. These grasses can be used with other suitable shrubs and trees for landscape restoration, forage production, to control soil erosion and landslides, soil fertility restoration, water quality improvement, to reduce damage due to flooding, enhance wildlife habitat and improve biodiversity. Theses grasses will also play a significant role in preserving the ecological balance, increasing agricultural productivity and speeding up social development.

**Effects of human pressure and climatic factors on leaf traits of baobab (Adansonia digitata L.) in Mali, West Africa**

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**Preferred session**
A6. Ecophysiological bases of agroforestry-system design

**Abstract**
Baobab (Adansonia digitata L.) is a multi-purpose tree used daily by rural African communities. The present study aimed at investigating the level of morphometric variation of leaves within and between baobab populations in Mali, West Africa. The main objective of this study is to examine if human utilization and/or other environmental factors are associated with the expressed leaf traits. In total, leaf traits of 224 adult baobab individuals, grown under different climatic conditions and under different levels of human pressure, were measured. Measured leaf variables included: number of leaflets, length and diameter of petiole, length and width of largest leaflet, specific leaf area (SLA), hairiness, colour and leaf shape. Statistical analysis revealed a significant diversity of leaf traits within and among the baobab populations. Human utilization of trees by leaf harvesting is of significant influence on the specific leaf area of baobab leaves: strongly mutilated trees produced much thinner leaves than trees which were less mutilated. Surprisingly, mutilation however has no influence on other leaf traits. Apart from human utilization, it is obvious that other (environmental) factors are of influence on baobab leaf traits. The way these factors influence baobab leaf traits is not clear, however, and further research is needed to examine the existing relationships.

**Traditional homegardening for sustainable livelihood and biodiversity conservation in Mizoram, northeast India**

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**Preferred session**
A1. Multistrata agroforestry systems with perennial crops

**Abstract**
Homegardening is a traditional agroforestry system practice in northeast India which is believed to enhance agricultural sustainability due to their diverse species composition. Despite their importance they are poorly understood as far as their structural diversity and functional dynamism in relation to livelihood support in northeast India is concerned. This study was conducted to develop an inventory on the floristic and structural characteristic of 58 homegardens randomly selected in the highlands of Champhai and lowlands of Mamit in northeast India. A total of 277 plants were recorded from the homegardens of which 90 were herbs, 28 woody non-woody climbers, 29 shrubs and 130 trees. The mean garden size was higher in highlands (4293 m²) than in lowlands (3331 m²). Eighty-one species were common to both the altitudes while 199 species was recorded in the highland and 167 species in the lowlands with an average of 39 and 29 species per garden, respectively. The Shannon-Weaver index revealed higher species diversity in the highlands (H=3.60) compared to the lowlands. Food plants constituted 80% of the species in the highlands against 45.65% in the lowlands, where more medicinal plants were recorded. Characteristically there were 3 4 layers of vegetation in the homegardens. In the highlands, the top stratum (10 16m) was dominated by Parkia timoriana while Tectona grandis and Areca catechu dominated the lowlands. The mean financial value of the homegarden was higher (USD 1435.82) in the highlands than in the lowlands, and income from the sale of the products contributed
37.96% of total household income in the former and only 16.55% in the latter. Our results suggest that homegardens are a promising system not only for livelihood improvement and empowerment of rural poor but also for conservation of plant biodiversity in northeast India.

**Performance of some medicinal plants under eucalyptus: a case study from Dehradun Valley, India**

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**Preferred session** A1. Multistrata agroforestry systems with perennial crops  
**Abstract**  
Agroforestry has proved itself as an integral element not only of the farming system, but also as a key component of sustainable agriculture. Many agroforestry systems have been in existence in the different regions of India since time immemorial. Technical and scientific innovations have enabled the development of modern agroforestry models which ensure high income to the farmers. Some of these models incorporate poplar and eucalyptus plantations with agriculture and are practised by farmers in the states of Punjab, Haryana, Uttar Pradesh and Himachal Pradesh in India. Apart from commercial farming in the initial years of plantations, cultivation of medicinal plants as intercrops can be viable alternatives among the farming community at the later stages of plantations. Keeping this in mind, an agroforestry-based experiment was conducted at the Forest Research Institute, Dehradun (India) during the year 2003-04 to assess the performance of some medicinal plants, kalmegh (*Andrographis paniculata*), tulsi (*Ocimum sanctum*), akarkara (*Spilanthes acmella*) and chitrak (*Plumbago zeylanica*) under 12-year-old plantation of eucalyptus hybrid (*Eucalyptus citriodora* and *Eucalyptus torellina*) grown at a spacing of 3x3m. The medicinal plants were raised through seeds in the month of April in a nursery and then transferred to the eucalyptus plantation in the third week of June. No inorganic fertilizers were applied to under crops, keeping in mind their medicinal uses. All three medicinal crops were harvested in the month of September to October 2003 and 2004 being short duration crops. However, chitrak (perennial crop) was harvested in the month of October 2004. Morphological parameters such as survival percentage, plant height, collar diameter, leaf area, fresh and dry biomass yield were studied along with plants grown in open field conditions simultaneously. Thus, this paper will discuss the scope of introduction and cultivation of medicinal plants as under-crops with commercial eucalyptus plantations.

**Intensification of cacao agroforestry systems in Central Sulawesi, Indonesia**

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**Preferred session** B1. Quantifying the role of AF in modifying watershed functions  
**Abstract**  
The ‘cocoa boom’ in Indonesia during the 1990s resulted not only in a strong increase in cropping area but also in a noticeable intensification of cocoa agroforestry systems in the area of the Lore Lindu National Park (LLNP) in Central Sulawesi. New plantations installed under natural forest cover are incrementally converted into sun-grown cocoa plots by simplifying shade tree covers, thereby reducing biodiversity and ecosystem functioning significantly. As a systematic characterization of cocoa production is still missing in this region, we conducted a detailed socioeconomic study on cocoa agroforestry systems covering the entire intensification gradient. A sample of 144 cocoa-producing households in 12 villages was chosen, with cocoa plots representing a gradient in shade tree cover. For one year, farmers prepared weekly reports on yields and several yield-determining factors (input of labour, agrochemicals, management). Plot structure parameters were surveyed (intercrops, shade tree species, canopy closure). Cocoa plots showed a high variability in structure and species composition. Average plot size was 0.61 ha, average yield in 2007 was 579 kg/ha, and harvests displayed a strong seasonality. In many plots, the amount of shading was notably reduced: from 64.3% in 2007, canopy closure decreased to a mere 42.3% in 2008. Canopy closure (r=0.379; p<0.001, Pearson) and number of intercrops (r=-0.266; p=0.01, Pearson) reduce...
cacao yield most significantly, also shade tree diversity is negatively related to 2007 yields. In summary, extensively managed cocoa plots with a canopy closure of 40-80% have a gross margin of only 310 €/ha/year on average in contrast to intensively cultivated plots with a canopy closures below 40% which deliver 551 €/ha/year. This difference is equivalent to a minimum compensation payment of 0.49 € per kg dry cocoa beans which would suffice for a substantial stabilization of high-shading cacao agroforestry systems within a potential certification scheme.

Contribution of smallholder farm forest plantations to rural livelihood enhancement: the case of households in the Offinso District

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract

Smallholder farm forest plantation development as an alternative land-use option has a great potential to contribute to the enhancement of livelihood of rural households in Ghana, due to its ability to provide multiple products for the farm families. In this regard, this study critically analysed the contribution of farm forest plantations to improve the socioeconomic well-being of rural households in the Offinso District of Ghana. In addition, the study identified and analysed the underlying endogenous and exogenous factors that have influenced rural households to engage in farm forest plantations over the years. The research is rooted in the case study approach for data collection and analysis and applies the principle of co-adaptation and livelihood diversification as a theoretical framework. A total of 150 households in five villages that are engaged in smallholder farm forest plantation development were surveyed. These consisted of households from different wealth groups identified through focus group discussions. Results from the study revealed that low agricultural productivity and output prices in the last decades vis-à-vis limited economic opportunities in the study area have induced households to diversify their traditional farming practices by continuously integrating trees into their farmland. Increased access to market for forest plantation products over the years has also created a favourable condition for households to intensify farm forest plantation development. Smallholder farm forest plantation development has brought changes to the income spectrum of the households. Analysis of cash income from farm forest plantation revealed that on average the households received an amount of US D274.95 per year. This amount accounted for 17.67% of total household income and represented the second most important source of household income after agriculture. This is an indication that farm forest plantation has the potential to enhance farm production and income of rural households.

Keywords: smallholder farm forest plantation, co-adaptation, livelihood diversification

Carbon sequestration of Kandyan Homegarden systems in Sri Lanka

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Preferred session C1. AF, climate change, biodiversity conservation

Abstract

According to the reports of the Intergovernmental Panel on Climate Change (IPCC), CO2 concentration of the atmosphere at present is 360 ppm as against 280 ppm in 1750. It has been predicted that by the year 2100, CO2 concentration will be in the range 540–970 ppm. As a consequence, the global average temperature is projected to increase by 1.4 to 5.80 °C over the period 1990 to 2100. Two major approaches have been recommended to face climate change successfully, i.e. mitigation and adaptation. An important activity in promoting sinks is to maintain vegetative cover. The objective of this study was to investigate the carbon sequestration potential of Kandyan homegardens located in the Central Province, Sri Lanka, predominantly in Kandy, Matale and Kurunegala districts, having a high species diversity and a close relationship with its owner. Three gardens were selected from each district for the study. In each garden, a vegetation
survey was conducted to assess the biodiversity status. According to diversity, gardens were divided into plots of 20x20 m. Trees of individual species were divided into diameter classes, and stem volume was measured in each class. This was extrapolated to other trees of the same species and same diameter class. The total above-ground volume was taken as a sum of stem volume and canopy volume. Using the published equations, the volume was converted to biomass. Using the published root/shoot ratios for trees of similar ages and similar species, root biomass was estimated. Using the litterfall studies, the total turnover of carbon in the below-ground system was estimated. By converting the biomass into carbon the total carbon sequestration (above-ground and below-ground) in the homegarden was determined and this was generalized to other gardens having similar species composition and density.

Large area forest inventories to meet the data and information needs of climate change adaptation projects

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Preferred session C4. Mitigation and adaptation to climate change

Abstract Informed decision making requires information, obviously. This holds for small-area decisions (such as for stands, community forests or forest enterprises) as well as for national and international policy processes. Forest inventories are projects that collect relevant data and help convert them into useful information. They have a long history and have undergone a dynamic methodological development over the past decades. Results of National Forest Inventories, for example, enter on a default basis into national reporting to the international conventions. In the context of a GTZ-funded collaborative project on climate change adaptation in Burkina Faso, we needed a broad range of data to feed the climate models. We decided to go for a data collection approach that carries multiple methodological elements of large-area forest inventories. In this paper we focus on introducing and discussing the methodological approach that we implemented to gather relevant data for a series of indicators that include land use, land cover, structure and diversity of forests, woody vegetation and pastures, and their uses. The study took place in Burkina Faso and the data collection employed an integrated remote sensing and field sampling approach that extends over all land cover classes. Preliminary results are presented, in particular those related to the remote sensing phase of the data collection procedure, as the field survey is still ongoing. The initial experiences show that many elements of large-area forest inventory methodology are suitable for adaptation to the information-gathering challenges in a climate change adaptation project.

Analysis of genetic diversity of Mauritanian date palm with microsatellite markers

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Preferred session A8. Integrating genomics in Agroforestry

Abstract Although huge quantities of date palm are yearly consumed in Senegal, their cultivation plays a marginal role in the country. Date palm production in Senegal is confronted with a lot of barriers, among which is the coincidence of their maturation period with the rainy season and therefore poor quality fruit yields, a situation that constitutes the main obstacle to the development of phoeniciculture. To overcome this problem a survey was undertaken on early and late date palm varieties from Mauritania that are potential candidates for cultivation in Senegal, to gather information on their genetic features. The analysis of the genetic diversity concerned 6 cultivars grouped in 92 samples originating from 5 localities (or oasis) with the use of 16 microsatellite markers. DNA amplification has been obtained with 14 microsatellite markers for all samples. The 2 remaining markers failed to amplify the DNA from a part of the samples. The genetic analysis of the whole population showed a 100% loci polymorphism for Ahmar, Medina and Tijib, the only cultivars with sufficient samples for the analysis of intra-cultivar genetic diversity. For the cultivars Emacine,
Edaghed and Tiguidert this polymorphism varied between 78.57% and 94.05%. In contrast to the cultivars Medina and Tijib, Ahmar showed a low variability with almost all individuals genetically similar throughout the sampling sites. The dendrogram obtained showed a clear separation of all cultivars, despite different levels of similarity. The cultivars Emacine and Edaghed are genetically very close whereas Ahmar and Tiguidert showed the greatest dissimilarity.

Key words: genetic diversity, microsatellites markers, Phoenix dactylifera, cultivars, Mauritania, Senegal.

The impact of integrated rural development projects in biodiversity and rehabilitation of the degraded areas of Semen (Northern)

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Abstract
An integrated rural development project including Tree Gudifecha (adoption or tree sponsoring scheme), water harvesting and zoning of communal lands for conservation and sustainable utilization was introduced in Talaq Amba, Basona Worena Woreda and North Shoa Zone of the Amhara regional states. The area is one of the districts most seriously affected by poverty, shortage of food supplies, malnutrition and a lack of clean water. An assessment of the impact of the project on the biodiversity and conservation status of the area over 10 years was conducted using appropriate tools and methodologies. An attempt was also made to evaluate the socioeconomic impact and the perceptions of the local communities about the project. It was found that a number of annual and perennial species that have ethnobotanical, economic and cultural importance have started to re-colonize the formerly degraded areas. Species diversity was found to be higher in the managed areas (p<0.05) than the unmanaged areas. Farmers are now able to harvest some of the rare medicinal plants in a sustainable way from their communal protected area, which is managed by the community members themselves. Survival of trees planted for enrichment plantation (indigenous) and economically important introduced species was found to be 60-95%. The high rate of survival could be due the creative tree sponsoring scheme that pays farmers if trees survive. In addition, it creates an emotional attachment between the farmer and the tree seedlings. Farmers that were included in the first part of the project have 1000-6000 trees/person that are ready for harvest. The conservative monetary estimates, if trees were currently to be harvested, ranges between 1000-6000 USD/person. This is contrary to previous reports on ‘The tragedy of the commons’. The implication rehabilitating the land in relation to wood deficit and its relevance for women and children will be discussed.

Amelioration of a degraded Ultisol agroforestry shrub species

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Abstract
The restoration ability of agroforestry shrub species (Calliandra calothyrsus, Tithonia diversifolia and Tephrosia vogelii) applied alone or combined with TSP was studied on a degraded Ultisol at Rubona, a southern province of Rwanda. Compared to the control treatment that was continuously cropped for 4 seasons, the organic materials applied alone or combined with TSP significantly (P<0.05) improved maize yields from 24 to 508%. Compared to the above species applied alone or combined with TSP, lime consistently increased pH across the seasons compared to all other treatments followed by Tithonia. TSP compared to other treatments, seemed to increase less pH. Lime and organic materials reduced exchangeable acidity and aluminium significantly (P<0.05) relative to the control. Among the different species tested, there was no significant difference in their abilities to reduce exchangeable acidity and aluminium. Concerning soil organic carbon (SOC), organic materials combined with TSP at 50 kg P ha-1 increased SOC significantly (P<0.05) compared to all other treatments. For microbial properties, microbial biomass carbon (MBC) and
Assessing the role of agroforestry in multifunctional agriculture mosaics: lessons launched from eco-agriculture landscapes

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract
An eco-agriculture landscape is managed with the goals of biodiversity and ecosystem service conservation, sustainable agricultural production and livelihood security. Agroforestry land use is anticipated to contribute significantly to the multiple functions that enable the successful performance of eco-agriculture landscapes. The diverse dimensions of eco-agriculture analysis, however, impose methodological and institutional challenges to developing and evaluating landscape management plans by the stakeholders, sectors and disciplines concerned. To support the coordinated action required to design and locate agroforestry systems and incentives in ways that optimize eco-agriculture performance, frameworks of knowledge and learning are needed that engage a spectrum of perspectives and knowledge resources. This need was addressed by some 20 international science, development and donor organizations representing a variety of sectors and geographies which collaborated to create an interactive, internet-based Landscape Measures Resource Center (LMRC). The LMRC offers guidance to farming communities, technical and regulatory advisers, and scientists in ways of using measurement to support collaborative planning and management of conservation, production and livelihood activity at the landscape scale. Pilot tests of selections of social learning and spatial analysis tools conveyed by the LMRC have been launched with partners in ‘learning landscapes’. The experience gained was found to enrich the content of the LMRC, expand the networks of users, and contribute to eco-agriculture thinking and practice. We anticipate that over time trend analyses will emerge that lend critical insight to the roles of agroforestry in the performance of eco-agriculture landscapes, as well as the roles of measurement in the collaborative management of eco-agriculture.

Loblolly Pine (Pinus taeda L.) tree growth under different thinning regimes

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Preferred session A11. on silvopastoral systems
Abstract
Loblolly pine (Pinus taeda L.) is the most common and commercially important pine species in southeast U.S.A and the majority of the nation’s timber products are supplied by this region. A mid-rotation loblolly pine plantation (18 years old) that was established on an agricultural field at a spacing of 1.83 m x 3.05 m was thinned from a basal area (BA) of 38 m² ha⁻¹ to two residual densities in the summer of 2002: 464 TPH and 17.83 m² ha⁻¹ BA (conventional 5th row thinning = traditional plantation); and 225 TPH and 9.81 m² ha⁻¹ BA (two silvopasture configurations = in 4th row conventional thinning and the double-row set of trees). Tree growth parameters and the foliar nutrient status were examined after a forestry operation. Results indicated that trees in silvopastoral systems increased growth faster than trees under traditional plantation in most of the tree characteristics. Mean tree diameter at breast height, live crown lengths and individual tree volume were similar in silvopastoral systems, but generally higher compared to the traditional...
plantation. Average tree height and height to first live branch were generally higher in the traditional plantation. The high residual stand density in the traditional plantation resulted in higher stand volumes compared to silvopasture systems. Foliar nutritional status of pines was not limiting, and was the same in all treatments. Thinning into silvopasture achieved specific product objectives in reallocating and concentrating of a site’s growth potential on fewer stems, although it does not increase total stand volume.

Phosphorus dynamics in soils after land conversion from silvopastoral to arable land in northeast Germany

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Preferred session A9 Agroforestry in Northern Europe
Abstract
Soil phosphorus is a major nutrient that controls plant growth and development in agricultural ecosystems. Its availability to plants is mainly caused by absorption and desorption of phosphate by Al- and Fe-(hydro) oxides. It is expected that changes of land use modify the distribution of soil P among the various P-pools (P-total, P-labile, P-organic). The aim of the study was to measure the different soil P-pools and the phosphate desorption kinetics under different land-use systems. Four different land-use systems were studied: silvopastoral and arable land cultivated for more than 30 years, and silvopastoral land converted to grassland and to arable land 5 years ago. The study was carried out in northeast of Brandenburg in Germany. Samples were taken from two layers: 0 10 cm and 10 20 cm soil depth. Different P forms were determined by a fractionation procedure and the P desorption kinetics were measured by the flow-through reactor technique over a long term. Total P content for all study sites was comparable; however the highest value was measured in the 30-year-old silvopastoral system with 685 mg kg⁻¹ and 728 mg kg⁻¹ at 0 10 cm and 10 20 cm depth, respectively. The labile pool of phosphorus was higher for the silvopastoral system than for arable land cultivated for more than 30 years and for silvopastoral land after 5 years of conversion. The results have shown that the 30-year-old silvopastoral system contained larger amounts of labile P. The P desorption kinetics considered as a dynamic measurement are described by a first-order-reaction model to distinguish between varying P pools in soils.

Improved jojoba management for rehabilitation of marginal degraded areas

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract
Marginal degraded lands in Kenya play host to over 50% of the livestock and wildlife. These lands, which form a high proportion of over 80% of Kenya which is arid and semi-arid, are mainly communally owned. The pastoralists migrate seasonally in search of water and fodder due to drought, and overgrazing is rampant. This encourages soil erosion and degradation. Overstocking leads to mass deaths of the livestock, making this production enterprise unsustainable. Jojoba can rehabilitate marginal fragile lands as well as provide the local communities with extra income to purchase food during drought. Jojoba is a desert shrub which can grow in poor and saline soils with little rainfall and can tolerate high temperatures. It is highly valued for its high quality oil and products, which are used as automobile lubricants and cosmetics. The following study was initiated to evaluate the morphological characteristics of local jojoba clones and to determine appropriate management regimes on performance of jojoba in southern Kenya. A survey was carried out in 2 locations using a questionnaire and visual observations. It was found that the soils in the areas with jojoba plants were preserved and not degraded. The farmers were enthusiastic about growing the shrub for commercial and household purposes, and jojoba plants with bigger crowns had
higher yields. This can be used as a selection criterion for vegetative propagation of the shrub. Factorial experiments with two factors (weeded and non-weeded) and seven management levels replicated three times were set up and are on-going in Maungu in southern Kenya to document the effectiveness of jojoba in rehabilitating soils in marginal areas and improving rural livelihoods.

**Agroforestry as a sustainable land use in mountains: Indian Himalayas**

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**Preferred session** A5. Ecological sustainability: panacea or Pandora’s box?  
**Abstract**  
The state of Himachal Pradesh represents fragile ecosystems of the north Indian Himalayan Region where the rural inhabitants depend on forest resources for their livelihoods and food security. Over the years, degrading forest resources have led to a complete ban on green felling by the state government in the pursuit of conserving and managing the dwindling resources. In this process of resource conservation, the rural people are facing the problem of meeting their requirements for timber, fuelwood, fodder and other cash needs. The forest department conducted a scientific field-based survey on the availability of timber, catechu, charcoal, resin and other forest-based produce, to address this problem through a proper understanding of the demand for timber for different purposes. A well-designed statistical module was used to estimate the yield of agroforestry trees in terms of timber and other products. The capacity of 3 existing licensed wood-based industries was estimated to be 32 100 m³ per annum. There were 3323 registered saw mills in the state and their sawing capacity was 387 600 m³ per annum. Thus the total annual timber requirement of existing licensed wood-based industries including saw mills was worked out to be 419 700 m³, whereas total annual availability of timber was 483 000 m³. Thus there was net surplus of 63 300 m³. Findings were submitted to central empowered committee constituted by the Supreme Court. These findings helped the state Government to allow the operation of 319 closed saw mills and also paved the way for establishing wood-based industries in the state. Thousands of people have been given employment by opening of these units. The analysis of the demand and supply led to the conclusion that the encouragement of agroforestry is needed as a viable land-use system for the welfare of the rural people. The mountain people have traditionally been practising agroforestry with traditional crop and tree species. This system needs to be recognized for further research and developmental input so that the rural ecosystems are protected on a sustainable basis besides meeting the requirements of the rural inhabitants. The entire problems, challenges and opportunities associated with agroforestry will be dealt in the study.

**Increase in soil fertility along a chronosequence of homegardens in Araçá Indigenous Land, in savannahs of Roraima, Brazil**

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**Preferred session** C5. Soil organic matter and nutrient cycling in multi-strata AF systems  
**Abstract**  
Chronosequences of homegardens were studied in Araçá Indigenous Land in the Lavrado region of Roraima, Brazil, in order to compare changes in soil fertility under homegardens with soils of the surrounding savannah environment. Fifteen homegardens were stratified by age of establishment as ‘new’ (0 10 years), ‘established’ (15 35 years) and ‘old’ (older than 40 years). In each of five communities, one homegarden was chosen randomly for each of these three classes. Soils were sampled in the homegarden and in adjacent savannah at 0 10, 10 20 and 20 30 cm depth. The levels of all macronutrients increased with the age of the homegardens. For potassium and magnesium, this occurred at all three depths, while for phosphorus and calcium, this occurred at only two depths, as was the case for zinc, the only micronutrient to present a significant increase
with homegarden age. Even in cases where there was not a significant relationship with homegarden age, the level of nutrients in homegarden soil was significantly higher than in surrounding savannah. Carbon increased significantly with age only in the surface horizon, with values ranging from 3.4 to 8.1 g/kg in new homegardens, reaching 50.6 g/km in an old homegarden. Aluminium levels were significantly lower in many homegardens, although this was not related to homegarden age. Nutrient accumulation and cycling in these homegardens is related to their diversified structure and composition as well as the domestic environment, associated with management practices that increase soil fertility, such as deposition of organic residues, small-scale burning of some plant wastes and maintenance of plant cover, among others. These practices and their results, permitting fruit production in the otherwise poor savannah soils, represent concepts that could be employed in agroforestry extension to further expand homegardens and increase their productivity.

Assisted natural regeneration as a method of preserving biological diversity in the Sahel

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Preferred session C1. AF, climate change, biodiversity conservation

Abstract In Burkina Faso, plans and strategies aiming for preserving various forest species have been adopted and implemented. Despite all efforts made, the conservation of the genetic resources has not entirely been secured. The plantation of trees in the rainy season is the method most used. However, this method is expensive. Given this situation, ring fencing areas of vegetation represents an alternative. This method has been tested in the field by the NGO newTree since 2003 in the rural areas of central and north in Burkina Faso. This article is based on an evaluation of the growth within the ring-fenced sites, compared to the surrounding area in terms of recovery of the vegetation. The results show that the fencing represents a method of in situ conservation of the phytogenetic resources. At the end of 2007, a total of about 165 675 trees and shrubs benefited from the protection of ring fencing, thus ensuring their growth. Eighty-seven species were preserved in the central zone and 39 species were counted in the north, pertaining to 29 families in the centre and 27 families in the North. A comparison of the vegetation in the fenced sites with the surrounding area shows a higher average density in the fenced areas after four years of protection. The number of trees per hectare in the sites fenced in 2003 is 2.3 times higher in the centre and 8.7 times higher in the north. In terms of numbers of species, the protected sites are 2.2 times richer than their surroundings in the centre, while in the north, the fenced areas are 2.1 times richer. Although the ring fencing of sites is a simple and effective option of natural regeneration, to ensure sustainability it must be accompanied by measures such as recovery of the soils and the implementation of income-generating activities.

Watershed sediment measurement and sediment transport modelling techniques: a case study to quantify the impact of converting cropland along streams to forested stream buffers

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Preferred session B1. Quantifying the role of AF in modifying watershed functions

Abstract Watershed models such as the Soil and Water Assessment Tool (SWAT) have been widely used to simulate watershed hydrologic processes and the effect of management, such as agroforestry, on soil and water resources. In order to use model outputs for tasks ranging from aiding policy decision making to research, models should be scientifically sound, well calibrated and validated, and hence defensible. Lack of good quality hydrologic and water quality data for model calibration and validation is one of the main weaknesses in watershed modelling. Therefore, it is important that quality model calibration and validation data be collected if the results of this branch of science in
Aiding policy making and research are to be more trusted. The goals of this study were to: 1) give a brief description of a rapid watershed erosion and reservoir sedimentation measurement technique using an acoustic profiling system to provide long-term reservoir sedimentation rate information and the sediment data needed for model calibration and validation; 2) present SWAT model case study results of the impact of converting cropland along streams to forested stream buffers on soil loss and water quality at Cobb Creek, one of the three main sub-watersheds within the Fort Cobb Reservoir Watershed (FCRW) (830 km²) located in Oklahoma, USA. Currently, there is an existing twinning pilot project between FCRW and Thika River Watershed located in Kenya, to which these technologies are intended to be transferred. The long-term goal is to get funding for a project that will create a regional or continental rapid watershed and reservoir sedimentation assessment laboratory in Africa. These techniques will complement the goals of bodies such as ICRAF, UNEP, and FAO, and governments whose overarching goal is to ensure food security under a sustainable environment, and institutions of higher learning that endeavour to build capacity.

Forest species growth and soil characterization in agroforestry systems of Rondônia northwest of the Brazilian Amazon: a case study

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract Agroforestry systems are natural resources systems that combine the cultivation of forest species with agricultural species and/or animals in the same area. In these soil use systems, during longer periods the soil quality study of soil chemistry and plant growth of thirty-five agroforestry systems with ten or more years of age after planting in seven municipalities in the state of Rondônia, Brazilian Amazon. The soil characterization for each agroforestry system evaluated total height, diameter at breast height (DBH) of timber species components of the systems, and their growth was related with the soil chemical properties. The results showed that there are several forest species of commercial value in these systems such as Cordia sp, Schizolobium parahyba var. amazonicum, Cedrella sp, Tabebuia sp., Tectona grandis, Hevea brasiliensis and Tabebuia sp. The chemical analysis of the study showed that differences in soil fertility and growth of these species differ with soil characteristics. The soils more frequently found were Red Yellow and Yellow Latosols (Oxisols), and also Red Yellow and Red Argisols (Ultisols).

Indigenous knowledge on non-timber forest product in northern Benin

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract Natural ecosystems have historically been managed independently, or sometimes in collaboration with government agencies. Traditional forest knowledge and innovative forest management practices developed over centuries have contributed significantly to Africa’s natural and cultural heritage, while helping to sustain production of multiple goods and services that enhance livelihood security and quality of life. This study assessed non-timber forest product (NTFP) utilization in surrounding villages of W National Park (northern Benin). The aim of the study was to document NTFP importance in local communities’ livelihoods in order to highlight their potentials as key species to be improved and extended in traditional agroforestry systems. The data were obtained using semi-structured interviews and questionnaires. The random number tables were used to select 148 households among those who engage in NTFP extraction. Data were collected (for the year 2007) through personal interviews using individual questionnaires for the different stakeholders identified as those who gain utilitarian value from plants. Analyses have been made using EXCEL ordination statistical packages. This work showed that 172 species of
Assessing land use impact on the structure of five fodder trees species at W National Park and its surrounding area in Benin

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Preferred session  A3. Role of agroforestry in landscape-scale conservation strategies
Abstract  Land use based on fodder trees was studied at the W National Park and its surrounding area. A quantitative ethnobotanical method based on structured interviews was used to evaluate the local preference, the local use and the local abundance/rarity of fodder trees in the region. Sixty-eight cattle breeders in 5 neighbouring villages were interviewed. Tree measurement and pruning assessment of the five most preferred fodder trees was performed along 16 linear transects (length = 48 km and width = 100 m). Among the 14 fodder trees used locally, the five most preferred are, according to their rank: Afzelia Africana, Pterocarpus erincaeus, Khaya senegalensis, Stereospermum kunthianum and Lonchocarpus laxiflorus. Significant difference existed between the densities of trees in the agroforestry system and protected area. Moreover, the pruning assessment of the five fodder trees and their size class distributions revealed that in the agroforestry system, the viability of the fodder trees is compromised. Therefore, specific measures for sustainable use of fodder trees and their conservation in the agroforestry system have been defined.

Resistance and susceptibility of Ceiba pentandra to stem dieback disease

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Preferred session  A8. Integrating genomics in Agroforestry
Abstract  Ceiba pentandra (L.) Gaertn, of the family Bombacaceae, is one of the most important timber species in Ghana and in recent times demand for it has been rising daily. Due to its numerous uses, Ceiba is now being exploited above its annual allowable harvest and this has seriously threatened its economic potential within the next ten years. In Ghana, it is in the IUCN Red Star Species class and is an endangered species in the Amazon forest. To counter this, Ceiba has been considered for large-scale plantation establishment by the Government of the Republic of Ghana because of its desirable silvicultural traits including fast growth, quality wood, short rotation and its ability to grow under diverse site conditions. As a result, demand for planting materials is on the ascendancy and collections are being made from the wild. However, the occurrence of dieback in Ceiba at both the nursery and plantations has seriously prevented the successful establishment of this species. The pathogen affects the leaves and young stems on immature Ceiba seedlings causing stem dieback throughout the year. Hence, the questions of what and where to collect remains unanswered. This study has identified progenies and provenances of Ceiba that are resistance to dieback disease. This will be complemented with the use of molecular marker analysis, RAPDS and microsatellites, to identify DNA markers linked with dieback resistance. The genetic diversity within and among populations of Ceiba will also be studied. Other economic traits such as collar diameter, stem height, number of live leaves and number of attacked leaves were also studied. The results obtained by preliminary screening showed that 18 out of 80 progenies and 40 out of the 60 progenies screened were found to have varied levels of resistance to Ceiba dieback disease during the major and minor rainy seasons respectively. Analysis of variance showed that the mean number of leaves and mean height were significant at 5% confidence level in both seasons. While
Impact of shade on coffee production and quality in the Lake Kivu region of Rwanda

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Preferred session: A1. Multistrata agroforestry systems with perennial crops

Abstract: Coffee in Rwanda is an important smallholder crop generating over 50% of national export earnings in the late 1990s. Among Rwanda’s coffee regions, the Lake Kivu area is in a good position to address the demand for superior coffee quality: its cup quality is high, renowned and attracts international buyers. However, the region faces challenges including a decline in soil fertility, pressure on fuelwood supplies and land degradation, with one of the highest population densities in East Africa. Shade is purported to positively influence coffee production in suboptimal ecological conditions and to enhance coffee quality. Integrating shade trees into coffee systems also promotes farm diversification, risk reduction linked to coffee price fluctuations, and the sustenance of environmental services supporting farm production. However, a lack of consensus and/or conflicting information exists on the conditions in East Africa, and Rwanda in particular, in which these benefits are experienced. A 3-year survey monitoring coffee performance in shaded and unshaded conditions was conducted in two Lake Kivu districts of Western Rwanda to assess the influence of tree shade on coffee productivity and cup quality. Comparisons were conducted in paired plots made up of four contiguous coffee trees randomly selected under and outside tree shade with otherwise similar characteristics within the same farm. Fifty plots, selected from 90 initially identified farms according to tree shade intensity to provide maximum contrast, were monitored. Harvested ripe coffee berries were measured weekly in standard measuring cups by farmers during the coffee harvesting season and transported to a local washing station where samples were subject to a uniform processing treatment. Cup testing of samples grouped at the plot level was conducted with local cup assessors. The paper presents production and cup quality results of three consecutive seasons as well as farmer perceptions on the tree-crop interface.

Tree growing objectives of smallholder farmers in Claveria, northern Mindanao, Philippines

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Preferred session: E4. Socioeconomics and agroforestry in the Pacific

Abstract: This study aimed to capture the underlying motives of smallholders for planting trees in their farms. Specifically, it aimed to identify the farm and household characteristics that might explain the underlying tree-growing objectives of smallholder farmers, and draw policy implications for enhancing tree growing among farmers. The study was conducted in Claveria, northern Mindanao, Philippines. It made use of 192 farmer-respondents who practised tree-based farming systems with corn being the dominant crop. Empirical evidence from the principal component analysis indicated that smallholder farm forestry is an investment with multiple objectives, primarily focusing on monetary and other economic objectives. The first component represents an employment, economic security and asset motive of tree growing was related to labour income and self-employment, increased income from timber sales, asset motives, security in old age and the speculative motive, etc. The second component, interpreted to represent a
'recreation and aesthetic objective', was characterized by non-timber use of tree growing such as outdoor recreation, solitude and meditation, aesthetic value, and improved healthy residential environment. The variables relating to the objectives of restoring farm fertility and productivity, erosion control measures, nature protection, and making the environment cooler, represented the third component, as ‘environmental protection and restoration objective’. Tree planting for monetary and economic objectives was significantly and positively influenced by farm distance from the centre of the barangay, and inversely related to gender and education of household heads, household size, total annual cash income and average farm distance from the nearest road. Similar variables were associated with recreation and aesthetic objectives of tree planting, except on civil status. The environmental and restoration motive was negatively associated with farming experience of households. However, it was uniquely related to the age of household heads and knowledge level regarding tree-based systems. This finding has significant implications on agricultural technology adoption in general, and tree farming in particular.

Ecological Restoration of tsunami-affected lands in Sri Lanka: the case of Kalmunai

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract Of all beach vegetation, the town of Kalmunai in Ampara District experienced the full force of the waves from the 2004 tsunami. Along with the lost loved ones and all worldly possessions, the tsunami also destroyed livelihoods and means of survival. The most distressed were the farmers who not only lost crops but also their soils, which were rendered saline, and their water sources, which were contaminated. In January 2005, the Neo Synthesis Research Centre (NSRC) initiated relief work in Kalmunai distributing food and drinking water, constructing and cleaning wells, building toilets and assisting schools in serving survivors. Livelihood assistance, in terms of tools and supplies, was also provided to carpenters, masons, weavers and male tailors. Those that benefited were 8616 adults and 8009 children. While it was relatively easy to address the material needs of the people, the greater challenge was to heal the ravaged land. In 2006, NSRC accepted the challenge and established a 3 km conservation forest along the coast; and planted phytoremediation plots around 1001 drinking-water wells; and established 165 plots agriculture use. Faced with soils with a very high sand content, organic materials were of critical importance in producing vegetable and tree crops that provide food, fuelwood, timber, green manure, fodder, and medicine, plus a littoral forest that could withstand an imminent rise in sea level. After two years, the beneficiaries are more food secure; their soils have regained their arability; wells are potable; and the coastline is protected by a wall of native vegetation. Healing the land occurred more quickly than anticipated due to the enthusiastic participation of the surviving community.

The restoration of forest cover in the Paradeke Oya Watershed:

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract In order to maintain the productivity of upland areas and provide dependable water supplies, forest restoration and management offers a range of practical solutions. Forests can be designed for the protection of soils, enhancement of water yields, reduction in risks of landslides and flooding and re-establishment of habitats to protect existing biodiversity. Within such a design, the sustainable development of rural communities can be and, in some cases, must be included. Where poor water management has resulted in outbreaks of waterborne diseases, corrective actions can be taken through the design of forest vegetation and changes in community practices. To serve these and other ends, a watershed management perspective is required in the planning, implementation, and monitoring of forest, water resources, agriculture and urban development programmes. The planning now underway for Gampola and the towns south of Kandy Water Supply Project offers
exciting possibilities about the practicality of a watershed approach in yielding multiple benefits to communities. In 2007, communities within the Paradeke Oya watershed were affected by an outbreak of Hepatitis A caused by poor health and sanitation conditions. In a bid to examine the causes of this disease, the National Water Supply and Drainage Board initiated a comprehensive study. Early findings reveal amongst other problems, that almost no forest cover remained resulting in low water quality, reduced flows during critical times of the year, and a loss of soils. The research includes the detailed description of the few remaining natural forest patches to serve as models to guide the reforestation by copying their architectural structures and ecological functions. The intervention strategy based upon this research will guide the re-establishment of forest cover in the Paradeke Oya watershed to ensure a sustainable water supply and, through improved sanitation, reduce the likelihood of outbreaks of waterborne diseases.

Estimating the carbon sequestration potential of short rotation coppice on marginal sites: a model approach

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Preferred session C2. Carbon sequestration in agroforestry

Abstract In the temperate zone, the increasing need to replace fossil fuels by renewable energy resources, taking into account the general limiting conditions of climate change, has resulted in alternative land-use systems coming to the fore. Short rotation coppice (SRC) of fast-growing trees such as poplar or black locust offers an approach for the sustainable production of biomass and a prolonged fixation of carbon in the plants and the soil with positive effects on soil humus and general fertility of marginal agricultural sites. In the open-cast mining area of Lusatia in northeast Germany, reclaimed mine sites provide a large area of marginal land. To estimate the benefits for carbon sequestration in the above-ground and below-ground biomass as well as in the soil of a poplar and a black locust SRC, results of several field experiments conducted in that region were evaluated. In addition, the empirical carbon model shortcar was used to simulate the carbon cycle of SRC and to estimate the net primary production, net ecosystem and net biome production of the tree plantations. The results demonstrate that SRC can form an effective carbon sink at least for the considered time period. If the effect of replacing fossil energy fuels by regrowing biomass is taken into account, SRC can be considered to be a permanent carbon sink and may provide a promising alternative for future land use in the temperate zone.

Improved fallows as a means for conservation and sustainable medicinal plant production in the Gambia.

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Preferred session B1. Quantifying the role of AF in modifying watershed functions

Abstract Local and international markets of medicinal plants have in recent years received attention due to the conservation benefits of harvesting non-wood forest products and for their income generating potential for the poor. The bulk of the material traded is still harvested from wild sources with a very small number of species cultivated, and an even smaller number domesticated. The expanding trade has serious implications on the survival of several species. The clearance of forests for agriculture, increased urbanization and other economic developments make domestication of many high-value forest resources imperative. The agroforestry of West Africa is less diverse and many species are underutilized compared to the highly complex agroforestry systems of Southeast Asia. This suggests that there is considerable potential for development of these systems in West Africa. Crop management without fertilizer input, which is commonly practised by most farmers in West Africa, requires soil fertility replenishment during a fallow period. Population increase, deforestation and land tenure issues are the main causes of increasingly shortened fallow periods. Planted tree
A conceptual modelling approach for tropical agroforestry systems: a case study on coffee agroforests in ‘Guinée forestière’

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Preferred session
A2. Agroforests in humid tropical Africa

Abstract
Coffee agroforests in ‘Guinée forestière’ are complex cropping systems, with a multistrata structure and a high specific biodiversity (perennial and annual). They play an important role in local farmers’ incomes, and thus for local development and for biodiversity preservation. Nevertheless, interactions between the different components are complex and not well understood. Moreover, farmer’s practices, which build and drive these systems, are barely known. This lack of knowledge on the biophysical and technical characteristics of these systems results in a lack of tools adapted to their assessment and design. More specifically there is a need for models which can be used to: (i) describe and simulate the dynamics of these systems; (ii) assess the influence of farmer’s practices on their dynamics and performance; and (iii) evaluate their sustainability. A conceptual modelling approach that represents the main components of these complex systems and their interaction is a prerequisite to the development of simulation models. Based on knowledge obtained from the literature, and field studies about structure, composition, production, farmer’s practices and their impacts, in 60 plots settled in ‘Guinée forestière’, with different agro-ecological and socioeconomic contexts, we propose a conceptual model of coffee agroforests representing their main components at key stages of the life cycle of the system. We aim to identify the interactions between the main components (economic species such as coffee, cola, forest trees and others) at different dynamic stages: (i) their competition (for space, light and nutrients); and (ii) their influence on system performance in terms of diversity of products (coffee, cola, wood) and ecological services (biodiversity). At plot scale, shade management influences dynamics, composition and performance of coffee agroforest, while farmers’ practices influence coffee architecture, allowing a sustainable coffee production. This conceptualization is the first step before calibrating existing agroforestry models, or building new simulation models reproducing the dynamics of coffee agroforests.

West African safety nets

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Preferred session
A2. Agroforests in humid tropical Africa

Abstract
Many studies have shown that rural people in Africa and elsewhere turn to the forest with greater intensity when they experience mishaps. When crops fail or when sudden needs for cash arise, households often increase the amount of goods they take from the forest. The forest acts as a safety net. In this study, we estimate the insurance value of the forest by assessing the extra value people extract from the forest when faced with shocks that affect themselves, their households, or their villages. We hypothesized that households with access to credit or other forms of insurance (e.g., labour markets) will not depend on the forest in times of need. Households without access to these forms of self-insurance will increase their reliance on the forest when mishaps strike.
We estimated the economic value of the forest as a safety net for 45 rural households in six villages with access to credit, and another 45 households without access to credit. This research, funded by the Smithsonian’s Center for Tropical Forest Sciences, examines interactions among environmental management, subsistence strategies of the local population, and access to informal and formal individual credit in Africa’s oldest intact rainforest, the Korup National Forest, in southwest Cameroon. Specifically, the original research proposed to examine the range of impacts of economic and environmental shocks on rural farmers’ use of forest products in the context of previous work on natural resource management and forest use. Additionally, in the context of these two bodies of work, this research examines the nexus of issues relating to the access to formal and informal credit and its relationship to forest use and conservation within the various models of park management. This is a significant link that has been left relatively unexplored in the current literature.

Maya Nut, an ecological, social and economical option for healthy forests and families in Mesoamerica

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Preferred session D4. Incorporating local knowledge in agroforestry science

Abstract
Maya Nut is a neotropical non-timber tree that produces high quantities of nutritious seeds for human consumption and wildlife, and its seeds and leaves provide high-quality forage for cattle. Maya Nut trees protect watersheds and soils and fix more carbon than many other forest tree species. Maya Nut in agroforestry is an environmental, social, and economic alternative to both pastureland and traditional crop systems. The highly profitable Maya Nut forests produce 5 times more food and 10 times more protein per ha than corn crops. It is more productive, resistant and much higher in many vital nutrients, including antioxidants, than foods grown on farmed soils. Because they protect biodiversity, Maya Nut agroforestry systems provide an excellent opportunity to create natural corridors among forests. Maya Nut has been a food source during famine for many Mesoamerican cultures in the past but its traditional use has eroded due to sociocultural reasons and to globalization. Once abundant in the forests, it is now threatened as it is also an excellent source of fuelwood. The innovative programme of the NGO The Equilibrium Fund has used the Maya Nut to create educational, conservation and income-generating opportunities for women in rural communities in Central America and Mexico since 2001. We teach a simple one-day workshop about the nutrition, processing, recipes, value-added products and agroforestry use of Maya Nut. Our efforts have resulted in 10 000 women trained, 800 000 Maya Nut trees planted and the creation of 15 cooperatives that market Maya Nut products in Guatemala, Nicaragua, Honduras, El Salvador and Mexico. Our ongoing projects include the establishment of demonstration agroforestry plots that incorporate scientific research and the combined local practices from the 5 countries to serve as a model for landowners and policy makers in the countries we work in and others in tropical America.

Financial and economic analysis of agro-silvo-pastoral systems: the role of Acacia senegal in the livelihoods of households

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Preferred session A.11. on silvopastoral systems

Abstract
This study involved the financial and economic analysis of agro-silvo-pastoral system components and the role of Acacia senegal in the livelihoods of households in En-Nuhud Province, West Kordofan Region. It was focused on the profitability of trees, mainly Acacia senegal and other non-timber forest products, with comparative benefits to important crops and animals in the area. This was carried out by calculating the net revenue of trees with agricultural crops and animal
husbandry dominant in the area. The study also determined the income generated by the best land-use alternative mix of agro-silvo-pastoral system of the farm enterprises activities. It also examined the severe constraints faced while practising this system in the area. The study highlighted the net revenue of the system components using families’ farming income sheets, in order to assess the adequacy of their returns concerning the continuity of agro-silvo-pastoral system components in the area. The revenues and costs were calculated per hectare. The market prices were applied in all the study scenarios including to activities such as tree establishment, crop production, and animal husbandry. A sensitivity analysis was conducted to test the effects of some assumptions concerning increases in tree product establishment costs and reduction in tree product prices. The results showed that within three zones, animals-related activities dominated and acquired higher net revenue when compared to other components of the agro-silvo-pastoral system. Regarding the comparison between zones, the findings reveal that ASPS was dominant in En-Nuhud Province.

Cassava with trees: an agroforestry method for restoration of riparian forest in settlements of agrarian reform in the Brazil

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Preferred session C3. Agroforestry, water quality and environmental amelioration
Abstract The Institute Centro de Vida - ICV, through the project, ‘Protection and restoration of riparian forest and springs in the sub-basin of Rio Manissauá-micu - BR 163, Mato Grosso, Brazilian Amazon’, conducted research to develop and improve methodologies for the protection and restoration of degraded riparian forest. In the present work the methodology of cassava plantation was evaluated with trees in the initi

Economic and ecological opportunities for improved management of two NTFPs in estuarine forests of the Brazilian Amazon

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Preferred session E2. AF-based livelihood strategies for smallholders in the Amazon
Abstract Non-timber forest products play a major role in livelihood strategies and the creation of economic opportunities for small landowners in many tropical countries. However, markets can create perverse incentives for forest degradation in order to enhance the production of particular species, presenting a trade-off between biodiversity conservation and greater income generation for traditional populations in forests of varying management intensities. An emblematic example is provided in the palm-dominated forests of the Brazilian Amazon estuary, through the contrasting management of açaí (Euterpe oleracea) and buriti (Mauritia flexuosa). Açaí fruit constitutes the primary source of income and a heavily consumed dietary staple for a growing number of families in the region, however, another major forest resource for smallholder subsistence and income is the buriti palm, which is an arguably more versatile species; the fruits, trunk, and leaves serve a variety of purposes, including pulp for consumption, household and structural uses, and handicrafts. Despite this fact, buriti-based production has become less lucrative in recent years and a low priority has been given to its sustainable management in the Eastern Brazilian Amazon. Meanwhile, market forces, coupled with government incentives for açaí management, have favoured the creation of açaí-dominated forests, leading to a uniform and, thus, economically
and environmentally vulnerable production system. In addition, agronomic research has been carried out to domesticate açaí, contributing to the increase in areas intensively managed or devoted to monocultures of the species. Results suggest a need for policy shifts favouring greater diversification of smallholder production systems in forest areas, including greater investment in resources and technical assistance to promote diversification and use of other forest products. Finally, future research related to cultivated palm forests should not neglect the potential benefits of the development of multi-strata agroforests.

**Farmers perceptions and economic constraints in the implementation of legal framework and voluntary certification systems influencing coffee agroforestry**

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**Preferred session** E5. Rewards for the environmental services of agroforestry  
**Abstract** The success in the construction and implementation of public policies on natural resources management requires an active participation and understanding of all actors involved. This research looks into different stakeholders’ (producers and government officials) perceptions of the legal framework and the voluntary coffee certification schemes, and how this perception could favour or limit the implementation of coffee SAF. Small-scale and large-scale farmers with three main coffee certification schemes (organic, fair trade and Rainforest Alliance) were interviewed in 4 different Costa Rican coffee regions. The legal frame works tested were those related to price differentiation, coffee quality and timber tree management. Data showed a limited understanding of the certification standards and legal framework, especially for small-scale farmers, with the consequent misunderstanding of the objectives, processes and impacts of the legislation. This situation has caused a limited participation of the small-scale farmers in an open consultation process of the national legislation, drastically reducing its political impact on the coffee sector. The study also analysed the cost of implementing the regulation, using 10 cases studies in 4 coffee regions. Some of the costs farmers have to face to comply with national regulations are the price stabilization rule ($2.75/qq if price goes over $100), minimum legal wages and social guaranties (additional 37% of salary) and permits for timber extraction. For certification the additional costs were mainly infrastructure improvement (housing for workers), and direct certification costs. In all scenarios, profitability was reduced with compliance with legal requirements. Due to the small-scale farmers’ organization, certification costs impacted fewer small-scale than large-scale farmers, while compliance with legal frameworks was more difficult for small-scale than large-scale farmers. Strategies are proposed to improve communication channels and participation of all stakeholders, so the legal framework is not perceived only as an imposition but as a tool of rural development.

**Reshaping lives and landscapes in Loboc Watershed Forest Reserve, Bohol, Philippines**

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**Preferred session** D3. Policy formulation and stakeholder engagement in NRM  
**Abstract** The island of Bohol, Philippines, was stripped of its original forests during more than 400 years of colonization by foreign powers from 1500 to the middle of the 20th Century. The remnant bigger trees were logged and exported as the economy struggled with its newfound independence in 1945. Half a century later, vast tracts of forest lands have been placed under the protected areas system affecting thousands of forest-dependent families. This study examined how the forests, the people and their farms have changed over the years with the interplay of economic struggle, stricter forest laws, changing land uses and the insurgency years (1975 1988). The ecological and socioeconomic impacts of protected areas policies after two decades of implementation were analysed. Forest resource utilization was also characterized to depict forest dependency. More than 50 cultivations inside the forests in six villages covering two municipalities were studied, and
trending was carried out. Research methodologies included series of floral and faunal inventories, characterization of forest farms, interviews using semi-structured questionnaires, focus group discussions, secondary data analysis. Findings showed a remaining 4% of the original forest cover from 1900. The 10-year insurgency period created dramatic changes in the lives of the forest-cultivator families who had to abandon their farms. Timber poaching has lessened during the last 10 years while cultivation inside forest lands remains unabated. Wildlife hunting has insignificantly toned down despite the protecting policies. The biggest challenge the forest reserves face are the increasing population of landless tillers, and how to ensure the sustained status of the remnant forest faced with the climate change problems. This paper also presents a suggested model of sustainable land uses in forest-cultivated areas with dense community populations.

Applying a landscape agroforestry conceptual framework: agroforestry land-use patterns and opportunities for polycultural production, habitat enhancement, and environmental services along an altitudinal gradient in Veracruz State, Mexico

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract National economic restructuring and agrarian reform are often cited as principal agents of contemporary Mexican deforestation. Throughout the 1990s, for instance, Mexican forest cover decreased by approximately 631 000 ha annually, the fifth largest amount of forest removal globally during this time period. Land conversion from forest to specialized agricultural production was most intense in Veracruz State where the deforestation rate surpassed the national average. It was therefore hypothesized in my graduate thesis (2003) that agroforestry can ameliorate the negative impacts of deforestation by simultaneously increasing opportunities for polycultural production, habitat enhancement, and environmental services. Furthermore, I conceptualized landscape agroforestry, the integration of agroforestry and landscape ecology principles, as a nascent framework for the diagnosis and design of holistic land-use systems across multiple geographic scales. Accordingly, this research employed an innovative altitudinal transect sampling methodology to determine the extent and character of agroforestry land use in Veracruz State. Transect climatic data were used to delineate natural vegetative associations based on the universally recognized Holdridge life zone classification model. Consequently, the 145 km transect passed through nine life zones from the Gulf of Mexico to 2870 m asl. Using a 30% sampling intensity, a land-use classification inventory identified 110 total land uses, of which 44% were designated as agroforestry systems, 36% as monocrop systems, 11% as human settlements, and 9% as forest remnants. Furthermore, three dominant agroforestry practices, boundary planting around sugar cane, shade trees over coffee, and trees in maize cropland, were considered landscape specific, whereas silvopastoral practices existed across the entire altitudinal gradient. A subsequent ethnobotanical and production ecology investigation of four farm sites within each of the three dominant practices constituted a baseline for agroforestry best management. Collectively, these results substantiated the research hypothesis and provided preliminary information for the dissemination of agroforestry technologies in the region.

Potential and limitation of para-rubber and oil palm plantations in northeast Thailand

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract Thailand, covering 51.3 million ha, is in the Southeast Asia region. Agriculturally, the country is
divided into 4 regions, namely Northern, Northeast, Central and Southern. In 2006, the country had 20.85 million ha (40.64%) of farm holding lands, 16.76 million ha (32.66%) of forests and 13.71 million ha (26.72%) of unclassified lands. The main land uses are agricultural crops, forestry, and built up areas. Para-rubber and oil palm plantations are confined to the humid regions in the Southern region, while lowland rice and upland crops are dominant in the Central, Northeast and Northern regions. The Northeast region comprises of 16.89 million ha (32.92% of the country), with 9.24 million ha of farm holding lands, 2.81 million ha of forests and 4.84 million ha of unclassified lands. The Northeast region was once covered with dense natural forests, but was converted into agriculture, mainly rice and upland crops. Due to the high demand of latex and alternative energy and the attractive prices of para-rubber and oil palm, government policy wants to introduce para-rubber and oil palm to other parts of the country, particularly the Northeast. A GIS and satellite remote sensing analysis by Biotec found that there are high potential lands suitable for para-rubber, but few areas for oil palm plantations. There are many limitations due to high competition of rice, sugarcane and cassava growing areas, social acceptance, bioenergy production as well market prices. Environmental suitability and infrastructure factors are the main limiting factors, particularly for oil palm plantation.

Modelling the behaviour of litter mixtures with chemical diversity

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Preferred session A6. Ecophysiological bases of agroforestry-system design

Abstract Many studies have explored the manipulation of plant residues to synchronize N and P delivery with crop demand by mixing residues of differing quality. Their largely empirical approach has been necessary due to the heretofore unpredictable nature of the strength and direction of mixed-litter interactions. We present recent findings on a promising new conceptual and management tool, the chemical diversity index (CDQ), a quantitative descriptor of the chemical heterogeneity of the species in a mixture, based on Rao’s quadratic entropy. In a controlled laboratory incubation study, the decomposition pattern of 21 litter pairs, founded on 10 tropical forest species, was followed for 12 weeks, during which microbial respiration was measured at regular intervals. Using the initial chemistry of one litter constituent and the chemical diversity of the mixture as predictor variables in a multiple linear regression model, as much as 77% of the variation in the carbon mineralization rates of the 21 pairs was explained. When the 21 litter pair treatments were subdivided into three groups according to the presence of a ‘key’ species (n=7), regression of the initial chemistry of the ‘companion’ species and the chemical diversity of the mixture explained 98% of the variation in the resultant mineralization rates, as well as the magnitude and direction of litter interactions. While this study was focused solely on carbon mineralization, carbon dynamics are a critical component to N and P cycling. These results suggest the possibility of designing litter mixtures with particular decomposition behaviors based on the knowledge of initial litter chemistries and decomposition patterns of individual members.

Incorporating agroforestry practices into multifunctional landscapes for water quality and storage benefits

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract Agroforestry practices and principles have the potential to improve the functionality of landscapes for the production of goods and environmental services. Agricultural landscapes in the Upper Mississippi River Basin in the United States have suffered a loss of diversity, biodiversity and
water storage capacity resulting in highly productive agricultural landscapes that are contributing sediments and chemicals to surface waters and ultimately contributing to hypoxia in the Gulf of Mexico. Agronomic studies, hydrology research and modelling carried out since 2002 has demonstrated that implementing targeted agroforestry practices and perennial cropping alternatives in the Minnesota River Basin can improve both water quality and water storage in the Basin. Benefits include reductions in sediment and chemicals in surface waters, reductions in flooding with associated economic, environmental and social benefits. The research has been carried out by an interdisciplinary team involving agronomists, hydrologists, economists and social scientists, non-governmental organizations, and public and private sector partners. With the recent interest in biofuels, there exist opportunities to introduce agroforestry and perennial cropping alternatives for biomass production which could have significant impacts at the landscape level. This presentation will present results of the interdisciplinary research effort carried out in the Minnesota River Basin and recent efforts to move that research and application to the landscape level linked to growing renewable energy markets.

Improving the curriculum on teaching ‘Markets for Agroforestry Tree Products’ in universities in Southeast Asia

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract Since December 2007, the Southeast Asian Network for Agroforestry Education (SEANAFE) has awarded grants to ten of its member universities in the Philippines, Indonesia, Laos, and Viet Nam to mainstream its curriculum framework and teaching materials on ‘Markets for Agroforestry Tree Products (MAFTP)’. The MAFTP is a 2-year project of SEANAFE launched in 2004, aimed at enhancing the content of agroforestry education programmes, the teaching capacity of lecturers, and the quality of graduates among its 86 member institutions. The grants were generally meant to undertake curriculum reviews and similar activities (e.g., stakeholders’ dialogue/consultation meetings, seminars, etc.) to determine where the project outputs can be incorporated in existing agroforestry courses and/or programmes. Specifically, the mainstreaming activities were aimed at accomplishing one of the following objectives: 1) institutionalize the use of the SEANAFE MAFTP case studies as teaching materials in any existing marketing and related agroforestry courses; 2) incorporate the topics/key themes of MAFTP in existing agroforestry courses where possible using the SEANAFE curriculum framework and case study materials; and 3) offer an entire MAFTP course within an existing BSc Agriculture/ Forestry/ Agroforestry and related programmes with the case studies as major teaching materials. This mainstreaming activity was also SEANAFE’s way of validating the relevance of the project outputs and experiences. This paper will discuss the experiences and lessons learned from mainstreaming MAFTP in SEANAFE’s member universities. It will also share the results of the post MAFTP survey conducted with the concerned universities and the workshop among mainstreaming project coordinators indicating a) the relevance and comprehensiveness of the curricular framework to enhance marketability of graduates, and b) the applicability of the whole curricular framework and case studies for teaching within current programme offerings in the concerned universities.

Keywords: curriculum improvement, agroforestry education, agroforestry marketing, Southeast Asia

Succession management through fallow enrichment in the Brazilian Amazon: the effect of canopy opening and plant dominance on the establishment and growth of native species species

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Preferred session  E2. AF-based livelihood strategies for smallholders in the Amazon

Abstract

Traditional Amazonian agroforestry systems comprise several forms of management of secondary succession, including fallow enrichment through planting of selected forest species. A participatory project with smallholders of the Brazilian Amazon examined growth responses of eight Amazonian forest species planted on fallows with different ages (ranging from 2 to 25 years), land-use histories and light incidence. Selected species were three fruit species (bacaba Oenocarpus bacaba, cacau Theobroma cacao, castanha Bertholletia excelsa), four oleaginous species (cumaru Dipteryx odorata, andiroba Carapa guianensis, pau-rosa Aniba roseodora, copaiba Copaifera multijuga) and one wood specie (mogno Swietenia macrophylla). In 11 smallholding fallows, we established two 20 x 20 m plots (with 40 seedlings planted in each), being one control and one treatment plot, where around 40% of the basal area was removed in order to increase light incidence. Five of these experimental fallows were heavily used in the past (resulting in a Vismia spp. dominated fallow), and the other six had a less-intensive use and were dominated by Cecropia spp. One year after planting, the mortality rate of the seedlings was 8% and there was no difference between treatment plots neither between fallow types. All species have shown a higher height relative growth rate (HRGR) on the treatment plots, but this difference was significant only for species with faster growth: Carapa guianensis, Dipteryx odorata, Swietenia macrophylla and Aniba roseodora. Considering only the control plots, we observed a significant interaction between age and type of fallow on the HRGR. In Cecropia-dominated fallows the HRGR of most seedlings has diminished as fallows got older, while on Vismia-dominated fallows no effect was observed. These results show that the success of fallow enrichment planting can be highly influenced by canopy management and by the type of fallow.

Key-words: second-growth management, relative growth rate, agroforestry, smallholders, Amazon.

Agroforestry installation within riparian forests by re-educating inmates of the agricultural penitentiary institute (ipa) “Javert de Andrade” – São José Do Rio Preto, São pauloBrazil.

Authors

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Preferred session  E2. AF-based livelihood strategies for smallholders in the Amazon

Abstract

The “Agroforestry Systems for Sustainable Development in Native Forests and Legal Reserves Test and Demonstration Units’ Thematic Group”, involves researchers from São Paulo State’s Environment Secretariat and Agriculture and Supplying Secretariat. Its goal is to establish models of Agroforestry Systems in the damping (up to 10 km radius) around São Paulo’s “Northwest Ecological Station”, an area owned by University of São Paulo, in the municipality of São José do Rio Preto. The group’s intent was to combine the use of agroforestry to restore Permanent Preservation Areas with developing social work, by using the workforce and re-educating inmates of the Agricultural Penitentiary Institute (IPA) “Javert de Andrade”. The group’s first technical activity was an Environmental Restoration Project in the Piedade Stream watershed. Initial fields were lead by a group of re-educating inmates who were sensitized and trained. They
attended classes on legislation, environment, forest restoration and agroforestry systems during the cropping cycle. The mission of the Thematic Group is to provide viable economic models for the future of Agroforestry Systems including for dam conditioning areas and Legal Reserves. In addition, the Group aims to promote the return of re-educating inmates to society as productive people.

Key words: Agroforestry systems, Riparian forest, Re-educating, Forest restoration, Resocialization.

Restoration ecology with agroforestry concepts provide professional specialization for a rural settlement in Brazil

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
Although the environmental public policy in Brazil protects the forest around the rivers by not allowing any land uses in these areas, small-scale land owners are encouraged by the government to plant agricultural land with native trees to restore the riparian forest. The government and the University of Sao Paulo State collaborated to form a group composed of farmer’s sons on a rural settlement to learn how to restore forest with a sustainable model of land use, as a means to improve professional skills. Besides the activities based on technical practices for environmental restoration with agro-ecology concepts and sustainable agriculture, self-development exercises were initiated to build self-esteem of these young people. The activities were conducted in a variety of ways such as field practices, lectures, video, oral presentation, visits to others projects and art sensitiveness, generating in each participant a sense of their being a potential actor in local transformation. Thus, a group that called themselves ‘The Pioneers’ has changed the landscape of Sumare through new job opportunities. These services are paid for by initiatives such as social responsibility projects of private enterprises, volunteer carbon market and environmental penalties. Nowadays, after 5 years, ‘The Pioneers’ are considered by a rich social web as a professional group that offers an environmental service on forest restoration and agroforestry implantation. As a result, the group restored 25 ha of a riverside forest, has multiplied the forest cover in the region, and provides remuneration for 15 young rural people. The group has been improving their planting methodology steadily, for example in areas such as organic soil management and the combinations of species. The results of this project are a sign that the involvement of young agriculturists in participative actions of ecological restoration is an efficient way of changing their perceptions and practices for a real sustainable use of natural resources.

Effect of agroforestry on soil quality, fertilizer-use efficiency and maize yield in the costal savannah zone

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract
A study was conducted in southern Togo in order to evaluate the potential of agroforestry in improving soil nutrient supply capacity, fertilizer-use efficiency and crop yield. The agroforestry systems consisted of alley farming of \textit{Leucaena leucocephala} (from 1991 to 1995). In 1995 half of the alley-farming system was transformed into a parkland through partial removal of the trees of the alleys. A fertilizer trial consisting of four treatments (control, control+ fertilizer, alley farming, alley farming + fertilizer, parkland and parkland + fertilizer) was conducted in order to study the effect of the alley farming and parkland on fertilizer recovery (2001 to 2003). Applications rates in Kg/ha were 90 for nitrogen (N), 30 for Phosphorus (P) and 60 for potassium. In 2004 a nutrient omission trial which consisted of PK, NP, NK and NPK treatments was conducted under the parkland and the control land (without agroforestry) in order to evaluate the contribution of agroforestry to the nutrient supply capacity of the soil. N, P K were applied at the rates of 90,
The results of the first trial showed that the control field without alleys and without fertilizers produced an average 1.4 t/ha of maize grain, with alleys and without fertilizers, the average production was 2.2 t/ha. The field without alleys but with fertilizers had an average yield of 3.4 t/ha; with alleys this became 4.0 t/ha. The omission trials established that agroforestry cannot provide enough nutrients to sustain maize production but improves soil quality, fertilizer-use efficiency and therefore provides incentive for fertilizer use. The findings suggest that agroforestry should not be promoted as an alternative for inorganic fertilizers for smallholder farmers but as tools to increase returns of investment in fertilizer and soil quality.

Assessment of the ecological and productive effects of Dehesa encroachment

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract Dehesas, a multipurpose open woodland in the Iberian Peninsula, is the most widespread agroforestry system in Europe, where it covers 3.1 million hectares. Dehesas are considered to be an example of sustainable use, though several threats to their conservation have arisen in the last few decades. Soil compaction, the failure of natural tree regeneration, dieback in ageing oak stands, and lost of biodiversity are some of the most outstanding threats. Several studies have pointed out the positive role that shrubby vegetation can play in the restoration/conservation of soil quality, biodiversity and tree regeneration. However, shrubs could also act competitively with trees and herbaceous plants, and then negatively affect the productivity of both strata. Here, we analyse the consequences of dehesa encroachment on the functioning of productivity of the system, comparing adjacent wooded plots with and without a shrubby layer. The variables studied are in five groups: (i) forage resources (amount, quality and phenomenology of pasture, shrubs and acorns); (ii) physiological status of trees (leaf nutrients and water potential); (iii) inter-specific competence for below-ground resources (rooting system); and (iv) natural regeneration. Integrating this information will help us to interpret the plant-to-plant relations –positive, negative and neutral occurring among three strata, tree, shrub and herbaceous plants. Finally, the information is used in order to optimize the productivity and conservation through the maintenance of a mosaic-type structure of dehesa with the combination of a variety of grazed, shrubby and cultivated open woodlands and close forests.

Agricultural policy reactions to climate change in Zambia

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Preferred session C4. Mitigation and adaptation to climate change
Abstract Maize is the major crop grown by most farmers in Zambia, and is the staple food for the majority of Zambians. The continued successful cultivation of this crop is, however, dependent on favourable climatic conditions which have not been stable in the recent past. Climate change can no longer be avoided. So far, the global mean temperature has increased by an estimated 0.3 to 0.6 °C since the late 19th Century, and by about 0.2 to 0.3°C over the last 40 years, though the warming is not globally uniform (Climate Ark, 2007). For Zambia specifically, it has been indicated that temperature is increasing at the rate of 0.6 °C per decade, which is ten times higher than the global or the southern African rate. Nevertheless, in terms of rainfall, there would be both a regional increase and decrease over land areas in the low latitudes (IPCC, 2001). This paper, therefore, highlights how agricultural policy is evolving to take into account the expected future changes in climatic conditions in order to ensure continued livelihoods for the rural poor as well as food security for the nation. The paper will analyse the impact of climate change that has been noticed so far, the policy intervention that the country has put in place to mitigate the effects of these impacts, and the role that agroforestry is playing in addressing some of the challenges that are arising from the impact of climate change.
Pratiques culturales anciennes et conservation d’espèces ligneuses chez les peuples Baoulé du Centre-Est de la Côte d’Ivoire

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Preferred session
A2. Agroforests in Humid Tropical Africa

Abstract
Les Baoulé du Centre-Est de la Côte d’Ivoire ont longtemps adopté des pratiques culturales qui leur ont permis de conserver plusieurs essences des forêts de cette localité. Plus que pour des objectifs de conservation, ce sont les pratiques culturelles et des besoins d’alimentation, qui ont permis à ces peuples d’épargner certaines espèces comme Milicia excelsa (Welw.) CC Berg, Vitellaria paradoxa Gaertn. C.F., Parkia biglobosa (Jacq.) Benth., etc. Ces espèces cohabitaient avec les cultures et ont fini par devenir de véritables essences des forêts et savanes de cette région. Ils jouent un important rôle écologique en même temps qu’ils pourraient contribuer à la lutte contre la pauvreté dans cette région qui constitue aujourd’hui l’une des plus pauvres de la Côte d’Ivoire. Malheureusement, ces espèces, comme bien d’autres nos forêts, sont aujourd’hui menacées de disparition à cause de leurs exploitations abusives pour les unes et de l’amélioration des techniques culturales actuelles qui commandent généralement que l’on débarrasse le sol de toute sa couverture végétale. Pour éviter d’aboutir à cette situation qui serait désastreuses pour nos populations rurales, et pour la communauté entière à cause des problèmes écologiques et de la paupérisation, que leur disparition peut engendrer, il est indispensable de rechercher les moyens les moyens d’intégration de ces deux techniques (ancienne et nouvelles) culturales pour une conservation durable de ces plantes.

Biomass and carbon accumulation in land-use systems of Claveria, the Philippines

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Preferred session
C2. Carbon sequestration in agroforestry

Abstract
This study was undertaken to assess standing biomass and carbon accumulation in smallholder farming systems in Claveria, the Philippines. The land was categorized into 19 different land-use types, and age and standing biomass was assessed by field measurement and use of allometric equations. The above-ground carbon stock varied between 2.9 to 234 Mg C ha-1. The highest carbon stock was observed in preserved forests followed by homegardens, whereas the lowest was observed in the grasslands. The highest rate of carbon accumulation was found in mango plantation (17.9 Mg C ha-1 year-1) followed by banana intercropped with fruit trees (13.6 Mg C ha-1 year-1). Low (<1 Mg C ha-1 year-1) rates of carbon accumulation were calculated in coconut plantation, coconut intercropped with banana, bush fallow and grasslands. The highest above-ground carbon stock was found in the land-use systems with high tree diversity, but the land-use systems with a high number of species were observed to have a low annual carbon accumulation rate. However, homegardens and corn intercropped with timber and fruit trees contained a high number of tree species and have a high rate of carbon accumulation.

Agroforestry and other soil and water conservation technologies for sustained productivity of the banana system, Southwest Uganda

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
The focus on agriculture in development is necessary for sixty per cent of the poor in developing countries whose livelihood is agriculture-based (Ehui & Pender, 2005). Improved natural resource management techniques and government policy interventions have seen recent developments in rural agroforestry and soil and water conservation (SWC) technologies. Innovative technologies such as those discussed in the study (e.g. incorporating trees into farming systems, maintaining contour bunds for water flow and improved mulching techniques) are crucial to such development interventions. The purpose of this study was to determine the impacts of agricultural change on society and environment at a local scale and explore how the introduction of improved technologies is perceived by the end-users, and the influence of national government policy interventions on these local community systems. Research was conducted to ascertain key agricultural practices that address issues of environmental management, with particular reference to agroforestry systems and SWC technologies in Southwest Uganda. Tradeoffs between society and the environment were also explored; perceptions, adaptations and actions undertaken by households were determined to assess the role of government programmes and policies. A triangulation method was used to approach these aims and objectives. The Ibanda case study provided a comprehensive view on people’s perceptions and responses to sustainable agriculture and related technologies. The combination of quantitative and qualitative methods made this possible. In addition, the study provided a vivid overview of the importance of sustainable agriculture towards the development of livelihoods in Ibanda. This study highlighted the importance of key management initiatives at the local level to ensure sufficient sustainable agricultural initiatives are executed to achieve national and international development goals, such as the MDGs. Considering government limitations, such as financial constraints, appropriate measures in the future will be necessary to combine the environment-poverty-agriculture narrative and achieve effective development progress in Uganda.

The role of fuelwood production in landscape conservation in rural and peri-urban areas of southern Africa

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Abstract
Rural and peri-urban communities in southern Africa are faced with energy challenges. The majority of these areas, by virtue of being rural, are not electrified and the escalating electricity tariffs in electrified peri-urban communities compel the people to use fuelwood for their daily needs. The rapid increase in population entails an upward shift in fuelwood needs therefore exerting pressure leading to landscape degradation. The loss of southern African woodlands has been widely documented. Deforestation of the main regional woodlands the Miombo has resulted in a decrease of woodland products for fuelwood. The high demand for fuelwood has resulted in substantial amounts of forests being cleared for charcoal. Trade in charcoal and fuelwood contributes to household income of both the manufacturers and traders. The adoption of agroforestry technologies by communities has reported an improvement not only in rural people’s well-being but also in the landscape. The improved agroforestry systems (AFS) such as improved fallows that mimic shifting cultivation and other AFS provide benefits that contribute to rural livelihoods, improved socioeconomic status and ecosystem functioning of land-use systems. This paper presents how the various agroforestry tree species that are useful for fuelwood are also being used for landscape conservation in southern Africa.

Keywords: fuel wood agroforestry systems, biodiversity, ecosystem, livelihoods

Do market opportunities threaten tree species diversity in rural homegardens of Central Sulawesi, Indonesia?

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Abstract

Keywords: fuel wood agroforestry systems, biodiversity, ecosystem, livelihoods
Shifting from subsistence towards market-oriented production is generally said to threaten agrobiodiversity. Homegardens are regarded as a sustainable agroforestry system, based on their high plant diversity. Commercialization of homegardens is mostly related to increasing dominance of annual cash crops at the expense of trees. Integrating commercial trees may offer a more sustainable intensification of homegardens. However, little is known about the dynamics of tree diversity during such a transformation process. This study aimed to answer the following questions: (i) does the integration of commercial tree species negatively affect overall tree species diversity in homegardens; and (ii) which type of homegarden harbours high tree species diversity? In 30 homegardens randomly selected from three villages in Central Sulawesi, diversity parameters of all woody plants (including trees, shrubs and vines) were assessed in 2001, 2004 and 2007; and in 20 homegardens from two additional villages in 2004 and 2007. Socioeconomic farm and household data were gathered through individual interviews of the gardeners. From 2001 to 2007, the abundance of the commercial crops cacao and vanilla markedly increased in the homegardens, but decreased for arabica coffee, reflecting the world market price fluctuations of the same commodities during this time. Although the overall number of woody individuals per garden decreased from 2001 to 2007, significant increase was found for average woody species richness (15-19), Shannon diversity (1.71-2.12) and evenness indices (0.65-0.73). Homegardens rated as commercial harboured higher numbers of woody individuals per garden, similar species richness, but lower Shannon diversity and evenness as compared to subsistence gardens. Highest species richness was found in large gardens of non-migrant farmers, who were less dependent on their gardens for income generation than migrant farmers. In conclusion, a modest tree crop-based commercialization of homegardens did not threaten the overall tree species richness, but reduced the evenness of species abundances.

The role of the species in the central valley of Tarija Bolivia and its biodiversity was studied. The study found that there is a large use of different species (exotic and native), not only for energy but also for other activities such as construction, food, medicine, which permit the diversified use of these species. People of this study area gave a high value to these species, but there is a downward trend in the number of uses because of the competitiveness between native and exotic species, and the lack of training in conserving those native tree qualities. We found also that changing in the rainfall would affect native trees, but few of the exotic trees.

It is commonly acknowledged that the risk of insect pest outbreaks in annual crops may be different in agroforestry systems to that in annual crops grown alone; this mainly because of: i) difference in resource availability trees and herbaceous bands at their bottom may restrain the pest population expansion; ii) micro-climate alteration radiation and therefore temperature modification due to trees may change the insect development ratio; and iii) altered prey predator equilibrium according the ‘natural enemies’ hypothesis, the enhanced vegetal diversity associated
with trees may provide nutrients and protection for natural enemies of insect pests, and thus help keep them in the field, contributing to the prevention of pest outbreaks. Little data however are available to corroborate these hypotheses in temperate agroforestry systems. We conducted field experiments to test these hypotheses in a walnut winter wheat agroforestry system in southern France in two consecutive years. We monitored populations of cereal aphids, specific predators such as ladybirds (Coccinellidae),hoverflies (Syrphidae) and lacewings (Chrysopidae) and evidence of parasitism (mummified aphids), in adjacent plots of winter wheat alone and walnut wheat. Moreover, half of the agroforestry plots had lower specific richness due to weed destruction at the bottom of trees, and the other half were enriched by flower sowing in herbaceous bands. No clear differences were found in aphid or natural biocontrol agent development, neither between ‘classical’ and agroforestry plots, nor between enriched and poor agroforestry plots. The effect of temperature reduction alone on the development of cereal aphids was also tested in winter wheat by simulating tree shadow cast on the crop. Again no differences were found between ‘shaded’ and ‘normal’ wheat plots, in spite of a significant difference in temperature. These results are discussed in relation to experimental context and their significance for further investigations in pest management in agroforestry systems.

Climate change and household vulnerability: implications on sustainable land management in Ondo State, Nigeria

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Preferred session A3. Role of agroforestry in landscape-scale conservation strategies
Abstract

The objective of this study is to analyse climate change, land-use change and household vulnerability in Ondo State, Nigeria, and how these factors have affected cropping patterns and land-use and land management practices. Apart from human resources, land is the greatest single asset of Nigeria. Nigeria has 92.4 million hectares or 924 000 km² of land. About 57% of this is suitable for a variety of arable and tree crop and pastures. The changing patterns of the climate over the years have made farmers adopt different coping strategies, ranging from variation in farming systems and crop growing periods to land management practices. Questions have therefore been raised as to how land-use sustainability can be achieved under the present changing climatic and sociocultural as well as demographic conditions. Such questions are based on the fact that sustainable land-use measures that will prevent further degradation of agricultural landscape and mutilation of forest reserves in the face of climatic change are necessary. This study involved the use of a questionnaire to collect primary data on socioeconomic, demographic and other relevant factors from households in the study area. Climatic and other biophysical data were also collected. Analysis was done mainly using descriptive and inferential statistics. Preliminary results of analysis show that the changing patterns of climate in the study region have a great influence on farmers’ decisions to adopt certain farming systems and cropping patterns. It also has a link with farmers’ decisions to adopt certain land management practices. The study also shows that households in the study area have different vulnerability levels to climatic change. Finally, the study has clearly shown that socioeconomic and demographic factors are important drivers of land use and land-use change in the study area.

Morphological variability of Adansonia digitata in the parklands in Mali

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Preferred session A6. Ecophysiological bases of agroforestry-system design
Abstract

Adansonia digitata L. (Baobab tree) is one of the species characteristic of the parklands in Mali. In spite of its great potential, varieties of improved A. digitata are not available. This work aims at
evaluating the morphological variability of A. digitata in the parklands according to agro-ecological diversity in Mali. The morphological evaluation concerned a sample of 8 morphotypes and 40 trees per morphotype. The measurements concerned the fruit (length, diameter, weight, length of peduncle, thickness of the capsule after crushing, weight of 100 seeds before and after steaming at 105 °C for 18 hours and weight of pulp) and the leaf dimensions (diameter, length of the pedicel and number of lobes). Multivariate analyses (principal component analysis, correlations) were applied to the data. The results showed that the all group do not follow their geographical origin, except the group composed by Kodjuguni and Kerela. Taking into consideration correlation, the discriminating morphological descriptors are the length, the width and weight of the fruits, the thickness of the pericarp, the weight of the pulp, the ratio of fruit length to fruit width, the weight of the seeds, the length of the pedicel, the diameter of leaves and the circumference at 1.30 m above the soil. These descriptors constitute tools of decision making in the field of the genetic improvement and the domestication of A. digitata.

Institutionalization of INAFE on emerging roles of ICT on distance e-learning of agroforestry in Indonesia

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Preferred session D2. Integrating disciplines through agroforestry education

Abstract INHERENT is an internet backbone network which connects 32 universities all over Indonesia, including Gajah Mada University (UGM), Lampung University (UniLa) and Lambung Mangkurat University (UnLam), all members of INAFE (Indonesia Network for Agroforestry Education). Distance learning on agroforestry in Indonesia is needed because forest and agricultural resources are scattered and generally located in remote areas. Being an archipelago, most agriculturists and foresters are also located in various areas, specifically in the different universities all over the country. However, some universities outside Java are still lacking in expertise of agroforestry lecturers. Thus, ICT is found as an appropriate solution to address this gap. In so doing, students will benefit more in improving their knowledge on various agroforestry systems practised in different sites in Indonesia from various experts other than their lecturers. It has been three years since INAFE introduced ICT in its working environment. There are several achievements and obstacles which are investigated in this paper, particularly the network’s experiences in implementing a distance education programme in 2008 to teach a basic agroforestry course commonly offered in UGM, UniLa, and UnLam. Several indicators are presented to illustrate the passage of the e-learning and e-working environment in these INAFE institutions. These indicators include hardware, human resources, and learning management, and the policy regarding the application of ICT in the learning processes. However, there is a bigger challenge for ICT application in agroforestry education in the future, i.e. to extend the significance of ICT in agroforestry education processes not only in the national level but also at regional and international levels.

Terrace risers: a niche for producing Alnus nepalensis green manure and stakes for bean production in Gicumbi district, Rwanda.

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems

Abstract Agroforestry has always struggled to find its niche in the broader issues of agriculture and ensuring sustainable food supplies with a shrinking land base. In many African farming systems, organic manures are the primary source of nutrients for crops, and the production of climbing beans has often been constrained by the shortage of stakes. The quantity and quality of such material that can be produced on-farm are therefore important issues. In this study, Alnus nepalensis was analysed for leaf nutrient contents, and the production of leaf dry matter and stakes on the terrace risers
quantified with different pruning frequencies per year. Three cropping treatments were tested in a complete randomized block design using climbing beans (Phaseolus vulgaris) as a test crop. The cropping treatments were: 1) beans with green manure; 2) control; and 3) beans with hedgerows of Alnus nepalensis trees. Production of Alnus nepalensis with one pruning was 3.28 t/ha/yr of leaf dry matter and 1191 stakes/ha/yr; and with four prunings only 4.17 t/ha/yr of leaf dry matter. A high crop yield was observed in the treatment with green manure. With both 2.47% of nitrogen and a C:N ratio of 14.7, the study confirmed the initial belief that Alnus nepalensis leaf has high value as a manure.

An assessment of the effectiveness of the forest policy of India in a changing environment

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Preferred session C4. Mitigation and adaptation to climate change
Abstract
Many of the poor, especially the landless depend directly or indirectly on forests for livelihood. Agricultural expansion, water resources development programmes and hydroelectric power projects have destroyed extensive forest areas in the past few decades. Changing seasonality and intensity of rainfall and increase in temperature affect many plant species. India has invested heavily in afforestation and forest protection and has developed a strong forest policy. However, there are some drawbacks in the implementation of the policy that threatens the existence of remaining forests. There is widespread encroachment into the forests for the products and for agriculture. In the present study, an assessment on the effectiveness of the national forest policy is made, in view of the changing climate, increasing population and increasing human impact on land and water resources. Special reference is made to the Western Ghats Mountain region where forest cover is a decisive factor in producing very heavy rainfall. This environmental hotspot has several rare and valuable species facing extinction. Deforestation here reduces summer water flow in the rivers and the storage capacity of dams. Construction of several dams in the Ghats cleared millions of hectares of thick forests. Several mini-hydroelectric projects under consideration may destroy more green cover, including the remaining tropical evergreen forest. Trends in rainfall, susceptibility to droughts and changes in water surpluses and deficiencies in a changing climate have been studied to assess the situation for the near future. Suggestions for the better management and effective implementation of an updated forest policy are presented.

Designing a temperate, multiple use goat fodder forest

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Preferred session A9 Agroforestry in northern Europe
Abstract Economic and climatic conditions are quickly changing in the southern Blue Ridge Mountain Province, in the southeast United States (zone 7a). The expense of ruminant fodder and the recent increasing intensity of warm season drought highlight the need for drought-tolerant, farm-scale production of nutritious fodder. A large percentage of the landscape has been maintained as cleared land for at least 200 years for the cultivation of sun-loving annual crops that have serious pest, disease, and drought issues. Meanwhile, the default ecosystem type is deciduous forest, with many native or acclimated woody species capable of resiliently providing nutritious fodder, human food, high-value timber, and many other services. This paper proposes a highly productive, drought-tolerant forest farm, modelled after the coppice-with-standards approach once common in the United Kingdom, and informed by Yeoman’s key line approach. This system is primarily focused around the perpetual production of coppiced goat fodder species, accompanied by an overstorey harvest cycle of high-value hardwood timber from nut trees, as well as the production of marketable quantities of edible tree crops, including saprobic and mycorrhizal fungi. Excess mast feeds native fauna such as turkey, deer, grouse, groundhog and feral pig that are harvested for meat. An herbaceous plant layer provides high-value native medicinals such as
American Ginseng, Goldenseal, and Blue Cohosh. Other benefits of this system include carbon sequestration (particularly through incorporation of powdered char into soils), as well as bee forage for commercial honey production. Through key lining, swaling, and careful species selection, the system quickly builds topsoil and survives drought in hilly terrain. This design is for a small farm (27 acres), but with a modular format so that it is useful to small or large landholders in similar mountainous, temperate areas.

Consumption and conservation of dryland indigenous fruit trees to improve livelihoods in Kenya: the case of Mwingi district.

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Preferred session E1. Hot or cold: the role of underutilized crops for AF

Abstract

Many indigenous fruit trees (IFTs) exist in Kenya that could be integrated into farming systems to support the nutritional security and income of communities. These fruits are good sources of specific vitamins and other essential micronutrients, and consumption of a range of species could help prevent a wide range of diseases. Despite their wide natural occurrence in dry areas of Kenya, however, the promotion of IFTs has not been adequately fostered by agricultural and forestry institutions and consequently they remain underutilized. Here, we report on a survey that was conducted on IFTs in arid and semi-arid Mwingi District. Our objective was to investigate patterns of consumption, and perspectives and practices of use and cultivation by local communities. Employing a stratified random sampling design, a structured questionnaire was used to interview 104 household members, equally split among women, men, girls and boys in two agro-ecological zones (LM5 and IL6). Fifty-seven species were documented as useful to local people. Average fruit consumption per person per day of these species was low at around 20 g. Children were the main consumers of these fruits although adults consume particular species. A negative attitude to use by adults is a factor that limits consumption. Seasonality appears to be another important factor that limits use, with consumption varying by month in relation to the fruiting seasons of important species. Wild habitats are the main sources of these fruits, with planting in farmland currently rarely practised, although householders will often protect existing wild trees in the agricultural landscape. Poor markets are a major reason for low planting of these species. Other reasons are lack of germplasm, water and awareness of the value of IFTs. We make the case for more attention at national and international levels to these species.

Helping smallholder agroforestry farmers in arid and semi-arid areas in Africa participate in carbon trade: the case of Siakago,

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Preferred session C2. Carbon sequestration in agroforestry

Abstract

The Clean Development Mechanism (CDM) of the Kyoto Protocol has been developed to allow developing countries to contribute to the global effort to stabilize greenhouse gas (GHG) levels in the atmosphere while assisting them to achieve sustainable development. Providing sinks of atmospheric carbon dioxide through carbon sequestration projects in developing countries has been approved as an eligible activity for participation under the CDM. Carbon credits accruing from such projects can be used to offset carbon emissions in industrialized countries whose emission levels have been capped. This paper reports on a research project that was aimed at assessing whether the smallholder agroforestry farmers in semi-arid areas of sub-Saharan Africa
are able to participate in carbon-offset programmes among other tree outputs. Data were collected using actual measurements, an interview schedule, discussions with relevant extension agents and an observation checklist, and then analysed using both excel and SPSS computer packages. The study established that opportunities exist for smallholder farmers to incorporate carbon offset as a tree product for participation under the CDM. Currently farmers have been able to stock 2.08 tons per ha of carbon with a market value of USD 492.

Effect of native trees on coffee yield and on environmental conditions in an agroforestry system in Minas Gerais, Brazil

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Preferred session A1. Multistrata agroforestry systems with perennial crops
Abstract
This experiment aimed to study the effect of the distance and the number of individuals of Schizolobium parahyba (Vell.) Toledo and Senna macranthera (Colladon) Irwin & Barneby, on the coffee yield and on the environmental conditions in an agroforestry system. The research was carried out in a coffee farm. Forty coffee plants were marked and concentric circles were established around each one at three, five and seven meters distance. The number of trees inside each circle was counted. The coffee yield was recorded in both 2005 and 2006 years. The shade, litterfall, soil moisture and P and K soil content were determined next to the coffee plants. Data were analysed by Path analysis. There was a positive effect of the soil moisture during the dry season on the coffee yield. The increase of the number of individuals of S. parahyba between zero and three metres increased phosphorus soil content, but this species affected yield negatively in all the distances. The number of individuals of S. macranthera between three and five meters increased soil moisture through shading, and positively affected the coffee yield. S. macranthera between zero and seven meters increase K soil content without affecting coffee yield. These results suggested that water availability during the dry season determines yield under experimental conditions. The presence of S. macranthera between three to five meters increased coffee yield, while the presence of S. parahyba at least at seven metres of distance reduces coffee yield under the local conditions.

Investigation of genetic diversity of Moringa oleifera provenances and other Moringa species in selected coastal areas of Tanzania

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Preferred session C6. Agroforestry and reconciliation ecology
Abstract
Knowledge of population genetic diversity is one of the prerequisites for development of conservation strategies. It is also fundamental to the understanding of the ecology and evolutionary forces that affect a population. In the case of wild species that represent the genetic resources for cultivated plants, the knowledge of their genetic diversity is essential for selecting plants for crosses with elite varieties. This study was conducted to investigate the morphological and genetic variations between and within cultivated and non-cultivated provenances of M. oleifera and to explore the possible existence of other Moringa species in selected coastal areas of Tanzania. Ninety individuals from cultivated and non-cultivated populations were assessed for morphological variation using a descriptors list of fifteen characteristics, and ninety-six individuals were assessed for molecular analysis including two individuals of M. stenopetala. The morphological and genetic relationships were analysed using NTSYS-pc and UPGMA program. Morphological analysis revealed six clusters with similarity ranging from 0.66 to 1.00 while Genetic analysis using 12 selected RAPD primers revealed five clusters with similarity ranging from 0.54 to 0.96. Genetic distance within
the M. oleifera group ranged from 0.95 for most related individuals to 0.65 for most divergent individuals. The genetic distance within the majority of plants cultivated ranged from 0.76 to 0.93 and the genetic distance within the majority of non-cultivated plants ranged from 0.80 to 0.96. Both morphology and molecular data separated individuals based on cultivated or non-cultivated status. Furthermore, genetic separation between M. oleifera and M. stenopetala at 0.54 similarity coefficient supports the occurrence of two species of Moringa in Tanzania.

An organic agroforestry model for small islands in eastern Indonesia

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Preferred session
A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
Indonesia consists of 17 500 islands and has the second longest coastline in the world at 81 000 km. Currently the destruction of forests in Indonesia is causing deforestation at an average rate of 2 million ha per year causing on-going environmental disasters in many places. Agroforestry represents systems of land use combining forest plants, agriculture and animal husbandry as well as fisheries in certain areas. This model, which has already been in practice for a long time in accordance with local conditions, includes a top structure of forest or long living plants, a middle structure and, underneath, agricultural plants and fodder for livestock. In coastal, river and lake areas a fishery can be developed as one of the elements of agroforestry. The organic agroforestry model represents the integration of all of the elements in an ecosystem without the use of any chemical input to maintain the viability of crops, plants, biodiversity as well as the fertility of the soil. The organic model will protect and conserve the small island ecology and guarantee the economic and social well-being of its communities. Biodiversity of land and sea will be maintained and reduction of emission gasses will be achieved. Local governments, industry and education institutions will work together to bring about changes in agricultural and forestry practices. The trial projects currently happening in North Halmahera, Maluku and Seram involves the development of an organic agroforestry model, and local community members, students and university graduates are currently being trained to work and manage the model. The Model will change land use in small islands.

Importance de la biodiversité dans l’aménagement des sytèmes agroforestiers du Bassin arachidier et des Niayes au Sénégal

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Preferred session
B6. Agroforestry as a tool for landscape restoration

Abstract
Une caractérisation de la biodiversité des systèmes agroforestiers du Nord-Ouest et du Centre Sénégal a été effectuée à travers 288 relevés de végétation et des enquêtes réalisés dans six terroirs villageois en tenant compte des systèmes d’utilisation des terres, des microvariations topographiques et des ethnies. Les relevés floristiques réalisés dans les différents terroirs villageois retenus ont conduit à la construction d’une matrice globale de 336 espèces et 288 relevés et les enquêtes à une matrice de 9 catégories (conservation, bois de chauffe, bois de service, arbres champêtres, fruits comestibles, sauce, pharmacopée, commerce, Fourrage) et 216 personnes. Les données floristiques ont été organisées en quatre tableaux floristique, phytogéographique, biologique et types de dissémination et analysées. Ces espèces sont réparties en 67 familles 228 genres. Pour chaque famille, le nombre de genres et d’espèces représentées ainsi que leurs fréquences respectives sont représentées. Les Poaceae et les Fabaceae-Faboidea sont les familles dominantes. Les Poaceae sont représentés par le plus grand nombre de genres suivis des Faboidea qui sont les plus diversifiées. Les Euphorbiaceae, les Asteraceae et Rubiaceae, Malvaceae et Convolvulaceae sont le deuxième lot de familles les plus riches malgré le nombre limité de genres. Les populations locales ont marquée leur priorisation à la conservation des espèces ligneuses, rencontrées dans
Mycorrhiza as ‘bio-organic’ fertilizer for the agroforestry systems in Indonesia: librarian roles for promoting and successful dissemination of online information for the forestry sector.

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Preferred session: A7. Biological dinitrogen fixation in AF systems
Abstract: Most tropical countries, including Indonesia, face two major problems: increasing over-exploitation of their forest resources for timber or fuelwood and diminishing soil fertility for agricultural production. On the other hand, forests play an important role in water conservation, prevention of land erosion or land slides and air pollution, as well as supplying forest products. Successful regeneration of logged moist forest in Southeast Asia, especially Indonesia, depends largely on the population of young seedlings. Mycorrhizae will play an important role in growing young trees. It increases nutrient absorption, helps them with biological deterrence of pathogenic root infection, and in the production of growth hormones and regulating substances. Under the financial assistance of the government of Indonesia, the Faculty of Forestry of Bogor Agricultural University has successfully collected and inventoried mycorrhizal fungi, as well as tested its effectiveness and compatibility, as a contribution to solving part of the problems encountered by the Indonesian government in maintaining its forest conservation programmes. The value of information on forestry development, especially agroforestry to the development and management of the Indonesian forests is essential. The role of this information in this context for decision-makers is presented. Strategies are proposed for improving access to and dissemination of online information for forestry sector. These include improving the publication, management and dissemination of information produced by Indonesian scientists and providing access to regional and global information. The usefulness of a portal in making it possible to identify and locate sources of information in agroforestry, with special interest on mycorrhizae is analysed. The remarkable potential of electronic media to store and manipulate information is emphasized.

Linkages between environment and food and security in northern Ethiopia

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Preferred session: D3. Policy formulation and stakeholder engagement in NRM
Abstract: This paper shall analyse the different rules and actors involved in linking environmental protection concerns with food security issues in Ethiopia and the existing perceptions about it. Mainstreaming food security issues into programmes for biodiversity and land conservation poverty is a vital part of the CCD and the CBD. Programmes focusing on poverty reduction and food security are also included in environmental activities; examples include the World Food Programme, the UN Millennium Project and poverty reductions strategies. Instruments of these programmes show a broad and partly contradictory variety, varying from bottom-up to top-down approaches. Indigenous people and other locals may be involved, while at the same time experts and foreign NGO’s may be involved. As a consequence, within the various international agreements, there exist synergies as well as trade-offs between environment and food security issues concerning their goals and also their processes of implementation. These are reflected accordingly by the implementing institutions from a national level down to the local level in Ethiopia. To analyse these,
Adapting forest management to the impact of climate change in the Congo Basin

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract: In the Congo Basin, pressures such as forest fragmentation, reduction in habitat, loss of biodiversity and the resulting adverse effects on forest-based communities are already proving difficult to manage. Climate change constitutes an additional burden that will limit development in countries in this region from realizing major global targets such as the eradication of extreme poverty and hunger and ensuring environmental sustainability as well as to promoting gender equality and empowerment of women. The Congo Basin forests are one of the two remaining vegetation towers for global climate management containing at least 25–30 billion tones of carbon in their vegetation alone. However, though not currently a large global source of carbon emissions, estimates of carbon emissions from deforestation and forest degradation for Central Africa range from 20 to 60 million tones per year, with DRC accounting for 47–56% of the total carbon emissions from land-use change for the region. Incidentally, climate change is not currently considered in decisions and long-term forest management plans in this region. Climate change is notably absent in both the academic forest-based policy literature and within current national forest policies themselves. This paper highlights the importance of sustainably managing the Congo Basin Forests along with the protection of the biodiversity contained in them. To achieve this, the paper recommends: 1) an increase in resources for basic climate change impacts and adaptation science; 2) a review of forest policies, forest planning, forest management approaches and institutions, to assess our ability to achieve social objectives under climate change; 3) develop an enhanced adaptation capacity of local communities; and 4) maintain or improve our capacity for communications and networking.

Key words: climate change, adaptive forest management, livelihoods, Congo Basin

Forest farming in temperate climates with non-timber forest products: opportunities, challenges and solutions

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Preferred session: A9 Agroforestry in northern Europe

Abstract: Non-timber forest products (NTFPs) have long been collected for food, medicine, income and pleasure, and play an important role in rural households. Some have well-established domestic and international markets. Peoples from around the world have been nurturing native plants found in their forest lands for these products. In recent years, concerns have been raised about
the sustainability of these resources due to reduced habitat and possible over-harvesting. Today, forest farming is promoted and recommended for ecological and economic reasons, to provide alternative income sources while conserving forested landscapes. This session will explore research and extension activities that promote opportunities and address challenges in producing NTFPs through forest farming in temperate climates. Researchers and technology transfer agents working in temperate environments around the world will benefit greatly from participation in this session.

**Existing legislation and policies on agroforestry land use and institutional capacities for promotion in Zimbabwe.**

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**Preferred session** D3. Policy formulation and stakeholder engagement in NRM

**Abstract**  
Zimbabwe has relatively well developed environmental and agricultural policies and institutional frameworks but legislation and institutional capacities for promotion are not clear enough. This paper provides a review of existing legislation and policy related to agroforestry in Zimbabwe. Issues of strengths and weaknesses in the legislation and policies as well as the challenges being faced in the implementation and management of agroforestry in both smallholder and commercial agriculture are indicated and discussed together with ways by which capacity of the various governmental and non-governmental institutions can be strengthened. The study shows that the potential that agroforestry systems provide, however, is being threatened by many problems related to lack of effective coordination of legislation and policies, lack of incentives in smallholder agriculture coupled with a lack of adequate and meaningful research funding support in institutions of higher learning.

**Ecosystems dynamics and climate change adaptations in miombo vegetation found in semi-arid areas on granite in Zimbabwe.**

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**Preferred session** C4. Mitigation and adaptation to climate change

**Abstract**  
In semi-arid areas Zimbabwe, the miombo ecosystem occupies at least sixty percent of the granitic landscapes with characteristic vegetation structure and species composition. This ecosystem is being utilized for subsistence crop farming and grazing by most small-scale farmers in communal areas. As a result, much of the natural or semi-natural vegetation has been substantially modified. The objectives of the study were to explore ecosystem dynamics and determine mechanisms that have been developed by smallholder farmers in order to cope with ecosystem micro variability and climate change. Methods used involved selection of naturally vegetated and ostensibly undisturbed sites with the aid of existing natural resources survey maps and imagery. This was followed by air photo interpretation coupled with field checking and vegetation enumeration and measurements together with soil sampling. The data analysis was done using a detrended correspondence analysis (DCA) technique to explore vegetational variance, species distribution patterns and to extract ecological gradients. Results show that while vegetation distribution patterns
appeared to be landscape dependent, variance of vegetation data could be explainable in terms of land quality and ecological gradients related mainly to soil fertility, drainage status and erosion intensity of the soil on the landscape; factors that are influenced by climate variability and change. It was concluded that the ecological gradients that exist are a microcosm of a common pattern in savannah vegetation types on granite. As a result, smallholder farmers have exploited this ecosystem micro variability by developing appropriate farming systems and coping mechanisms to avert food shortages during periods of climatic hardship.

**Poverty and agroforestry adoption: the cases of *Mucuna pruriens* and *Acacia auriculiformis* in Godohou village (southern Benin)**

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**Preferred session** B6. Agroforestry as a tool for landscape restoration

**Abstract**

Agricultural activities are responsible of the greatest amount (76.1 percent) of environment degradation in the Benin Republic (Adegbidi and Biaou, 1995; Tovo, 1995). Environment degradation by agriculture is exacerbated by the shortening (and even suppression) of the fallow period in the southern Benin in general, because of demographic effects. Some improved fallow technologies (IFT) have been promoted in order to fix this problem. This study was implemented in Godohou village in the Adja plateau (southern Benin), a zone recognized for having the highest poverty indices (incidence, poverty gap, squared poverty gap) in Benin, after Borgou Department (MAEP, 2001). Two IFTs of high agronomic and environmental potential were studied: *Mucuna pruriens* and *Acacia auriculiformis*. The goal was to determine with a qualitative approach the influence of the farmers' welfare on the farming systems in general and on the adoption of these two IFT in the village. The data, analysed with the participatory wealth ranking technique of Grandin (1988), revealed that: i) there is no significant difference between the farmers' knowledge of the agronomic and ecological value of *Mucuna pruriens* and *Acacia auriculiformis* from one wealth level to another in the village; ii) poverty is the main obstacle to *Mucuna pruriens* and *Acacia auriculiformis* adoption in this village; iii) the adoption rate of *Mucuna pruriens* and *Acacia auriculiformis* falls, although globally weak, increases from the poorest class (Ayatonon class) to the wealthiest one (Hotonon class).

**Les représentations forestières des paysans et les pratiques de gestion de l’arbre : le cas des Betsimisaraka, sur la côte Est d**

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**Preferred session** B6. Agroforestry as a tool for landscape restoration

**Abstract**

Les paysans utilisant l’abattis brûlis sont mondialement accusés d’être responsables de pertes en biodiversité. L’ethnie betsimisaraka, du corridor de la forêt dense humide de la façade orientale malgache, n’y échappe pas. Mais jusqu’à présent, leurs représentations forestières et leurs pratiques de gestion de l’arbre n’ont guère retenu l’attention des autorités, des chercheurs et des développeurs. La recherche vise à comprendre les représentations sociales sur la forêt et les arbres des paysans et leurs pratiques de gestion de l’arbre, en vue d’une restauration forestière. De 2006 à 2008, des entretiens semi-directifs individuels (1061) et en groupe (12) ont été menés auprès des paysans pour comprendre les relations qu’ils établissent entre leurs représentations sociales et leurs pratiques de gestion des ressources arborées. Par ailleurs, des relevés écologiques ont été réalisés afin d’évaluer l’état général des espèces forestières et des arbres cités par les paysans. Le travail montre que l’expression « dégradation des ressources naturelles » ne prend de sens que par rapport aux fonctions attribuées aux ressources considérées. Si les représentations sociales des paysans concernant l’arbre sont homogènes chez les Betsimisaraka, en revanche, celles de
Biomass sourcing concept for 1 000 000 million bone-dry tons for the BTL Plant in northeast Germany

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Preferred session A9 Agroforestry in northern Europe
Abstract Short introduction of company and product - biomass sources for BTL production - biomass logistics - supply curve calculation for the Schwedt site - preferred biomass portfolio – medium-term and long-term biomass sourcing strategy for BTL prod

Abstract incomplete at time of going to press

Earthworm and management effects on soil organic matter and N dynamics in hill-slope agro-ecosystems of western Honduras

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Preferred session C5. Soil organic matter and nutrient cycling in multi-strata AF systems
Abstract The Quesungual slash-and-mulch agroforestry system of western Honduras has emerged as an alternative to traditional slash-and-burn agriculture in the mountainous, tropical dry forest regions across Central America. The system forgoes burning and utilizes native trees interspersed with annual crops to stabilize hillsides, promote soil biological activity and fertility, improve crop yields, and conserve vital soil moisture. The research presented here sought to elucidate mechanisms behind the system’s success by examining the role of agroecosystem management and earthworms on soil organic matter and nitrogen fertilizer dynamics. Earthworm populations were manipulated using microcosms (with and without worms) installed within a replicated field trial comparing land management systems (Quesungual vs. slash-and-burn vs. secondary forest). The Quesungual and slash-and-burn treatments were further divided into sub-plots receiving no inorganic nutrient additions or standard fertilizer applications (N-P-K), with 15N labeled fertilizer applied in the microcosms. At the end of the growing season soils were fractionated by wet-sieving into macroaggregates (>250 μm), microaggregates (53-250 μm), and the silt and clay fraction (<53 μm). Macroparticles were further separated into coarse particulate organic matter (> 250 μm), microaggregate within macroaggregate (53-250 μm), and macroaggregate-occluded silt and clay (<53 μm). All fractions and bulk soils were analyzed for total C, N and 15N. Preliminary results indicate that soil structure and aggregate-associated C and N are impacted by cropping, relative to uncultivated secondary forest. However, the form of agricultural management employed (Quesungual vs. slash and burn) does not appear to affect aggregation or SOM dynamics. Although earthworms do not influence aggregation or SOM dynamics, they significantly decrease the recovery of added fertilizer 15N from the bulk soil and aggregate fractions. Early results from this research suggest that short-term direct impacts of agroforestry systems on soil processes may be less important than indirect effects on soil fauna.
Contract tree farming and smallholders: drivers of adoption and livelihood impacts in Thailand

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Preferred session E4. Socioeconomics and agroforestry in the Pacific
Abstract Contract tree farming by smallholders is of increasing importance to many forest industries, paralleling the rise in contract farming of other crops. Contract tree farming is focused on developing and emerging economies in the tropics, where tree plantations have a comparative advantage, and where smallholders have an interest in enhancing their livelihoods. Contract tree farming has many sponsors, including forestry companies, national governments, and development agencies. However, there are also concerns about the impacts of contract farming on adopters’ livelihoods, which have been discussed for at least two decades. However, there have been few studies. This paper focuses on the smallholders’ perspectives and investigates the drivers of adoption of contract tree farming, and the impacts on adopters’ livelihoods. Both qualitative and quantitative methods and analyses were employed, and the research was conducted as a case study in four eucalypt-growing regions of Thailand. This research aimed to provide a comprehensive analysis of the adoption and the impacts of contract tree farming by smallholders. From January to March 2008, over 800 eucalypt tree farmers and non-farmers were randomly selected and surveyed in four different regions of Thailand, using door-to-door household surveys. Focus groups and key informant interviews were also used to gain an in-depth understanding of the issues. Eucalypt tree farming in Thailand contributes to the livelihoods of smallholders by offering a comparatively attractive land use for sites of poor productivity, with low labour requirements and low investment requirements. Contracts for tree farming positively impact on adopters’ livelihoods in several ways: they increase profit made from tree farming in block planting, and offer a way to transfer companies’ technical knowledge to farmers, who benefit from companies’ economies of scale for things such as research in tree improvement and commercial production of high-yielding clonal cuttings.

How the geographic origin of all agricultural commodities can be traced back: first results from a stable isotope analysis in Prunus africana

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Preferred session A8. Integrating genomics in agroforestry
Abstract One of the recent scientific tools used to trace back agricultural commodities is the stable isotope analysis. Many of the elements occur in slightly different forms, i.e. they are a mixture of isotopes. While the chemical characteristics are identical, isotopes differ only in the number of neutrons in their nucleus. This phenomenon is the backbone of a universal, non-radioactive analytical tool to differentiate the geographical origin of biological material. All biological material including agricultural goods including timber should have a unique isotope fingerprint. Taking into account the geographical pattern of D/H and 18O/16O in meteoric water as well as in ground water should differentiate the origin of biological material. The pattern of D/H and 18O/16O in meteoric water depends mainly on the temperature, the landscape altitude and the distance from the oceans. By adding the remaining stable isotopes of the elements of life (especially nitrogen and sulphur), a geographical fine tuning is likely. Soils show different isotope ratios of 15N/14N and 34S/32S depending firstly on the natural geological composition and secondly on the anthropogenic influences such as cultivation and fallout. The isotope approach is explained as a universal method to trace back the geographical origin of biological plant material, and first results from different geographical bark sources of Prunus africana collected in Cameroon, Equatorial Guinea, Kenya, Madagascar, South Africa, Tanzania and Uganda will be presented. The ratio 18O/16O and D/H were almost linearly correlated and when all isotopes are considered, a clear geographical pattern was obtained.
Local perspectives of priority plant species in communal areas of sub-tropical thicket: implications for restoration in the Eastern Cape

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract

The thicket biome supports a diversity of plant and animal species and also plays an important role in supporting local livelihoods. The significant dependence on thicket ecosystems by locals contributes to the current widespread landscape degradation. Opportunities to restore thicket ecosystems in the Eastern Cape while simultaneously enhancing people's livelihoods are provided by the carbon trade market through funding. One of the aims of this project was to determine how local knowledge may contribute to thicket restoration projects. An ethnobotanical study was carried out in Pikoli, a Xhosa village in the thicket biome of the Eastern Cape. Data relating to the use and importance of 37 plant species found within the communal lands surrounding the village were collected using the informant consensus method. A total of 50 community members were interviewed. Both male and female respondents were sought between the ages of 9 and 65 years. An attempt was made to obtain responses from people across different user groups; mainly livestock owners, medicinal plant collectors, women and children. Species found to have the highest use values included *Ptaeroxylon obliquum* (Sneezewood), *Acacia karoo* (Sweet Thorn), *Aloe ferox* (iKhala/ Bitter Aloe), and *Carissa bispinosa* (L.) Desf. ex Brenan (iNcumNcum). There were eight use categories; some of the most prominent being fuelwood, medicine, cultural events and livestock feed. Species that were perceived as being of the greatest importance were unanimously those that were also of cultural significance. Perceptions of decreases or increases in species abundance over time differed; with the majority of culturally important species perceived to be threatened. The implications of local people's perceptions and priority plants for restoration efforts in the region are discussed and the importance of local stakeholder involvement is highlighted.

Climate change mitigation through agroforestry in South Sorong District-Papua

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Preferred session: C4. Mitigation and adaptation to climate change

Abstract

Agroforestry practices could be used in developing adaptation and mitigation strategies for climate change. In Papua, agroforestry has been developed for social/community forest purposes, to increase income of the local community, ensure environment sustainability and opportunities to access international funding. However, very little research has been conducted regarding agroforestry practices particularly endemic species choice for climate change mitigation (carbon sequestration) and for income generation for local people. The objective of this study was to develop a mitigation effort in the forestry sector by establishing agroforestry-based community forest management. Evaluation of mitigation potential of selected endemic species and community income was also examined in South Sorong District. A COMAP (comprehensive mitigation analysis process) model was used for data analysis. Three categories of community forestry were used: Agroforestry system (patterns 1-4), Complex Agroforestry system-1 (pattern 5) and Complex Agroforestry system-2 (patterns 6 and 7). The results show that the agroforestry systems gave mitigation potential value at ~500 tC/ha, complex agroforestry-1 system had ~550 tC/ha, and complex agroforestry-2 system had ~700 tC/ha. Both the Agroforestry system and the complex agroforestry systems produced a positive financial impact with a range from USD 16 752 to USD 62 775 per ha/rotation. The benefit from the agroforestry system was double that of the monoculture system (forest plantation). Total area available for agroforestry system implementation approximately 226 259 ha in South Sorong District alone.
Marketing of African Walnut: opportunity and drivers of agroforestry practices in southwest Nigeria

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Preferred session
E1. Hot or cold: the role of underutilized crops for AF

Abstract
Tetracarpidium conophorum Mull. (Arg), family Euphorbiaceae, commonly called the African walnut and conophor, is a perennial climbing shrub found in the moist forest zones of sub-Saharan Africa. Five states (Ekiti, Oyo, Ogun, Ondo, and Osun) in the southwest geopolitical zone of Nigeria were selected for this study on the production and marketing of the walnut. A multistage random sampling technique was used to select 30 study sites (3 LGAs and two villages from each LGA) in each state. The respondents include walnut producers, traders and consumers. In all, 180 respondents/State (totalling 900 respondents) were sampled. Structured questionnaires and focus group discussions were designed for each category of the respondents. A purposive sampling method was used to select local markets where the walnuts were sold. The result indicated that the plant is cultivated principally for its highly nutritious and medicinal nuts which are cooked and consumed as snacks. In southwest Nigeria, marketing of walnut started with agroforestry farmers (85%) who planted the perennial climber on their plantation of cocoa, kolanut, oilpalm, etc. under indigenous trees. At the household level, the process of gathering and processing the fruit, and selling the nuts created social interaction between the young and the old within the communities. Beyond the family level, the excess nuts were sold to the village merchant who then transported them to wholesalers in the city for onward distribution to retailers. The producer sold the bag, basin and bowl of the raw nuts for N 4500 ($37.50), N 1750 ($14.58), and N 150 ($1.25) respectively. A bag, basin, and bowl of the raw nuts were sold for the average prices of N 7000 ($58.33), N 3500 ($29.17), and N 400 ($3.33) by the village merchant, while the wholesaler sold the same quantity for N 9000 ($75.00), N 5000 ($41.67), and N 1250 ($10.42) respectively. In comparison with selected NTFPs such as Irvingia spp, Garcinia kola, and Parkia biglobosa, T. conophora generated the highest income to the marketers. Engaging in the marketing of the walnut therefore directly generated high income to the various intermediaries and thereby facilitated involvement of more agroforestry farmers in the production process.

Vulnerability to climate change in Sri Lanka: adaptation strategies and layers of resilience

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Preferred session
C4. Mitigation and adaptation to climate change

Abstract
Sri Lanka is vulnerable to climate change. As in other countries, the impacts of climate change are visible in human health, agriculture, water, ecosystems, wildlife, sea-level rise and extreme weather conditions. This paper reviews the current situation on vulnerability to climatic change in relation to the agricultural sector of the country. An agro-ecological map which was developed in 1975 was revised in 2003. This indicates the seriousness of the issues. The country’s staple crop production has been continuously affected by drought, floods, temperature rise, and sea water intrusion etc. Other important plantation crops such as tea, rubber and coconut, and other agricultural export crops such as cinnamon, pepper, cloves and cardamom etc. will be positively or negatively affected by climate change. Other subsidiary food crops also may be affected. Possible impacts of these increased frequencies of these climate changes include declining agricultural production and decreases in real incomes as current food prices go up. Rural sector paddy farmers have shifted from farming, resulting in about 63% of their mean household income coming from non-agricultural activities. As a consequences of all these impacts, the country has faced a food scarcity, and a decrease in real incomes as food prices go up rapidly. For the small marginal farmer, vulnerability to climate change can mean indebtedness, loss of land, etc. Women farmers will be adversely affected because of their traditional role as collectors of water, fodder and fuel.
Controlled ectomycorrhization of an exotic legume tree species *Acacia holosericea* affects root nodule bacteria diversity

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Preferred session
A3. Role of agroforestry in landscape-scale conservation strategies

Abstract
In the 400-700 mm rainfall zone, *Acacia holosericea* was found to be one of the best-adapted exotic trees showing excellent survival rate and rapid early growth (Harwood, 1994). In addition to rhizobial symbiosis, this tree species can form arbuscular mycorrhiza (AM) and/or ectomycorrhiza (De La Cruz and Garcia 1991, Founoune et al. 2002), and controlled mycorrhizal inoculation could improve its performance in glasshouse conditions (Duponnois et al., 2000a, 2001, 2003) and also after outplanting into the field (Duponnois et al., 2005, 2007). The impact of the establishment of exotic plants on the structure and function of native microbial communities was mainly unknown. Hence a study was conducted in a field experiment carried out in Senegal with *A. holosericea*, inoculated or not inoculated with an ectomycorrhizal strain *Pisolithus albus* IR 100 (Duponnois et al., 2005, 2007) in order to evaluate the influence of this exotic fast growing leguminous tree on the native soil microbiota and the potential consequences on soil revegetalization with native plant species. Among the targeted native species, the leguminous tree *Faidherbia albida* has been selected since it plays a major role in the agro-sylvo-pastoral balance of the Sahelian regions of Africa. Our study shows that exotic plant species can drastically affect the genotypic and symbiotic effectiveness of native bradyrhizobia populations which could limit the natural regeneration of endemic plant species such as *F. albida*. But this field-based experimental research highlights the role of mycorrhizal symbiosis in afforestation programmes with exotic tree species that target preservation of native plants.

Key words: *Acacia holosericea*, ectomycorrhizal, inoculation, bacteria diversity, afforestation

Nutrient and non-nutrient resource interactions in agroforestry systems:

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Preferred session
A6. Ecophysiological bases of agroforestry-system design

Abstract
The dominant agro-ecological goal of perennial-based agroforestry systems is typically to maximize target species performance. However, lacking is a management support system that focuses on target species performance through the diagnosis of nutrient and non-nutrient resource effects, as well as providing recommendations and prescriptions for facilitative interactions at the farm level. Although various methods exist for nutrient diagnosis (critical levels and DRIS techniques), no current model provides an inherently comparative analysis thus increasing site-specificity and independent plant analysis. Here, we present vector analysis as a diagnostic tool based on nutrient supply and biomass production; growth response to progressively available nutrients is curvilinear in form where increasing the availability of a limiting nutrient will induce a corresponding increase in growth, to the point of nutrient sufficiency, followed by luxury consumption and then toxicity. Vector analysis, an integrated multi-parameter graphic model, combines biomass production, nutrient concentration and content in relation to a normalized reference point, the control, typically a competitive-free state (monoculture). Vector analysis has recently been employed in agroforestry studies, in tropical and temperate systems. However, such models of growth in relation to nutrient uptake do not take into consideration non-nutrient resource limitations (such as light or moisture) on growth, which can be particularly active in agroforestry systems. If facilitative effects on local resources occur, accelerated growth will presumably follow, demonstrating a biomass response in the absence of external nutrient supply. Therefore, we also propose an advancement to vector analysis, specifically for agroforestry systems, that incorporates effects of non-nutrient resources. This advancement will allow for diagnosis and classification of plant response to intercropping, predict mechanisms driving interactions and provide appropriate management prescriptions.
Current status of non-edible oil production and research in Kenya

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation
Abstract Biofuel is globally much discussed non-edible oil-producing crops as *Jatropha curcas* especially, and also *Croton megalocarpus* and castor (*Ricinus communis*) are receiving new and renewed interest. These species have in common that they are underutilized crops and peer-reviewed publications relating to them are not widely available. It is recognized that there is a potential for smallholder farmers in Africa and other parts of the world to raise a new source of income by implementing oilseed production. The oil produced can be used in multifunctional platforms that can generate electric and motive power and improve rural livelihood (Messemaker 2008). Domestication has just begun, there are no varieties available that have proven and published qualities to fit particular agro-ecological zones for *Jatropha* (Jongschaap, et al. 2007), and collection of Croton seeds for biofuel purposes is a very recent development. Many people have recently started to grow these species and collect oil seeds. Information and facts on the Kenyan activities were collected earlier this year in ‘The oilseed base line study’ and the current status will be disseminated. To obtain more basic information on *Jatropha* cultivation, agronomy trials in different agro-ecological environments will be initiated in the first half this year; the basic recommended agro-management practices will be tested (Gour 2007). Nationally and internationally available provenances will be tested of both *Jatropha* and castor. This project is in cooperation with World Vision International’s area development programmes, *Jatropha* growers as well as Kenyan national research institutions. Hard data on those oil-producing species are much wanted for different kinds of analysis and models that are able to predict the species’ impact and potential (Achten, et al. 2008).

Tree seeds for farmers: an exploration of informal tree seed supply systems in Nairobi, Meru and western Kenya

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation
Abstract The supply of germplasm in sufficient quantities and quality at the small-scale farmer level is a limiting factor to agroforestry development. While the past trend has been to put more emphasis on central supply systems such as national tree seed centres and government nurseries, policies are now being adopted to encourage decentralized supply of seeds, seedlings or vegetative propagules. This study was therefore carried out to investigate the mechanisms of supply and quality of the seeds supplied by the informal supply systems; the species and amounts supplied by these systems in selected parts of Kenya. The study involved a survey of the nursery operators and seed dealers in the districts, and seed tests and nursery experiments at ICRAF to compare seed quality and early seedling vigour. The seed tests at the laboratory followed the International Seed Testing Association (ISTA) rules on seed testing, while the nursery experiment was on a completely randomized design to analyse seed quality and seedling vigour issues. Results revealed that informal suppliers were supplying more seeds at the farm level than formal systems with many seed dealers having joined the business after working with the formal sector. They, however, mainly supplied seeds of orthodox exotic species that were easy to handle (collect, process and store). Many nursery operators considered physiological quality factors in their choice of tree seeds and thus the seed dealers’ seeds were of similar physiological quality (purity and germination potential) as the seeds from the formal sector. This was also confirmed by the results of seed tests in the laboratory and seedling heights in the nursery experiment. These results were found to agree with others observed with supply of agricultural crops in different parts of the world. The genetic quality of the informally supplied seeds was found to be low as revealed by a low number
of closely spaced mother trees the seeds were harvested from. Results were similar even for seed dealers who had undergone some training or had some level of experience in seed handling.

Climate change adaptation through agroforestry in Orissa: issues and strategies

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Preferred session C4. Mitigation and adaptation to climate change
Abstract Climate change has the potential to alter the ability of the earth’s physical and biological systems. Observations over Indian states such as Orissa, show that substantial adverse impacts of climate change are going to affect humanity in the form of extreme climatic events. Increasing demand for food and other agricultural goods will aggravate the pressure on agricultural lands. Farmers in Orissa, principally relying on marginalized rainfed mixed crop livestock systems, are likely to be the most severely impacted. This situation has been further aggravated with massive soil erosion, triggered by deforestation. With mangrove forests being cleared, more areas of Orissa have come under the effect of cyclones. There is an agreement that farmers in the agroforestry sector are learning to adapt to projected or actual changes of climate by making adjustments in cultural practices, processes, or structures of systems. All these adaptation strategies are of unplanned adaptation strategies and are subsistence in nature. Therefore, this paper aims at identifying appropriate long-term adaptation strategies in the agroforestry sector, by fostering the adaptive capacity of rural communities through adopting appropriate techniques and adapting their livelihoods, which will increase the resilience of agro-landscapes and improve capabilities to cope with future climate stress. It is expected that the work will also provide a possible roadmap and insights for the policy makers for adopting an appropriate policy for agroforestry and rural development with less energy-intensive strategies. It is also envisioned that the paper will bring out a few ‘models of climate change adaptation in the forestry and agriculture sector’, which could be effective in enabling the vulnerable rural communities of India to fight against climate change.

A comparative study to linking charcoal commodity chains and agroforestry systems in Kenya, Madagascar and Uganda

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Preferred session B7. The role of degraded lands in biofuel production in SE Asia
Abstract Climate change has the potential to alter the ability of the earth’s physical and biological systems. Observations over Indian states such as Orissa, show that substantial adverse impacts of climate change are going to affect humanity in the form of extreme climatic events. Increasing demand for food and other agricultural goods will aggravate the pressure on agricultural lands. Farmers in Orissa, principally relying on marginalized rainfed mixed crop livestock systems, are likely to be the most severely impacted. This situation has been further aggravated with massive soil erosion, triggered by deforestation. With mangrove forests being cleared, more areas of Orissa have come under the effect of cyclones. There is an agreement that farmers in the agroforestry sector are learning to adapt to projected or actual changes of climate by making adjustments in cultural practices, processes, or structures of systems. All these adaptation strategies are of unplanned adaptation strategies and are subsistence in nature. Therefore, this paper aims at identifying appropriate long-term adaptation strategies in the agroforestry sector, by fostering the adaptive capacity of rural communities through adopting appropriate techniques and adapting their livelihoods, which will increase the resilience of agro-landscapes and improve capabilities to cope with future climate stress. It is expected that the work will also provide a possible roadmap and insights for the policy makers for adopting an appropriate policy for agroforestry and rural development with less energy-intensive strategies. It is also envisioned that the paper will bring out a few ‘models of climate change adaptation in the forestry and agriculture sector’, which could be
The roles of apiculture in vegetation characterization and conservation in Central Ethiopia

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract: Honeybees and flowering plants have a well-developed system of interdependence. Beekeeping fits in well alongside many other livelihood endeavours because it uses the same natural resources as, for example, forestry, agriculture and conservation activities. The significance of apiculture in vegetation characterization and sustainable livelihoods was studied in Walmara district in western Oromia, Central Ethiopia. The study was designed to investigate the complementarity of apiculture and vegetation conservation, to study the possible use of honey pollen and bee pollen nutritional analysis for vegetation characterization. In this study, a total of thirty-one beekeeper and thirty-one non-beekeeper households were taken from 21 villages of eight PAs of the district and socioeconomic studies were undertaken. Along with this, on-farm botanical inventories, melissopalynological analysis (honey pollen analysis) and bee pollen collection, bee pollen protein as well as N, P and K minerals analysis were carried out. The socioeconomic survey indicated that the majority of the beekeeper households (84%) grow and conserving plants for their honeybees and other economic uses. Although 16% of the beekeeper households grow plants in their backyards, its priority is not for beekeeping. There were highly significant (P<0.001) differences between beekeeper and non-beekeeper households in different on-farm tree and shrub-growing practices, plant diversity and species richness within homegardens. There is a higher plant diversity and species richness within beekeepers’ on-farm tree and shrub-growing practices than in those of non-beekeepers. From the melissopalynological and bee pollen pellets analysis, forty-one and twenty-two plant species were identified, respectively. This reveals that pollen grains in honey and in bee pollen pellets reflect the floral composition (flowering and certain cone-producing plants) of the local vegetation. The protein and mineral content analysis of bee pollen for seventeen plant species was undertaken. The analysis showed the variations among plant species in their nutritive value as bee forage and a human food source. Eucalyptus spp., Croton macrostachys, Justicia shimeriana, Cynotes barbata and Andropogon abyssinicus are the dominant nutritional sources in the area. In conclusion, apiculture strongly complements on-farm vegetation conservation, plays a significant role in vegetation description and hence in the sustainability of household livelihoods.

Effect of soil moisture on the productivity of a cotton jujube ecosystem under drip irrigation in Central Asia

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Preferred session: C3. Agroforestry, water quality and environmental amelioration

Abstract: The ecological adaptability of growth of cotton roots and shoots with different moisture conditions was studied by field experiments under drip irrigation in a cotton jujube ecological system. The results indicate that moisture affected the cotton root growth and distribution, which are directly related to the growth of the shoot. In four different water treatments mainly distributed under film, the proportion of root dry weight is 60.65%, 73.45% and 39.35%/26.55% under bare land. Water stress increased root depth and root dry weight of deep layers, and expanded the scope of the horizontal distribution of cotton root in the soil. There was a significant difference between cotton biological characteristics/dry matter accumulation and partitioning of different water treatments; excessive moisture increased the height/width of inverse fourth leaf/branches and squares accelerated the dry matter accumulation rate, increased ratio of root/shoot and proportion of vegetative organs dry
weight, improved biomass, at the same time, increased rate of fruit abscission and reduced yield. The results also indicate that spatial distribution characteristics of cotton root length density for all water treatments were basically consistent. Horizontally, the cotton root length densities are similar between wide and narrow rows, but are significantly higher than bare land; vertically, root length density of cotton increased with soil depth. But the distribution of cotton root length density has a significant difference under different water treatments. Excessive water increased cotton root length density for bare land, but decreased for wide and narrow cotton rows. Root length density of cotton increased with increasing irrigation amounts. Water stress increased root length density for the deep layer. There was a significant correlation between root length density and yields of cotton. The regression between irrigation amounts and yields of cotton are $y=-0.0026x^2+18.015x-24845$ ($R^2=0.959$). The regression showed that the irrigation amounts of 3464.4 m³ hm⁻² can achieve appropriate root length density and yields of 6360.8 kg hm⁻².

Role of carbon finance in promoting sustainable land use and livelihoods: the case of Plan Vivo projects

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Preferred session C2. Carbon sequestration in agroforestry

Abstract The objective of this presentation is to provide an overview of how Plan Vivo carbon standard can enhance environmental sustainability and promote sustainable livelihoods of rural communities through the creation of carbon assets in smallholder farming units. The Plan Vivo standard has been developed to enable the participation of smallholder farmers and rural communities in emerging voluntary carbon markets. Carbon finance may be derived from land-use activities including afforestation, reforestation, agroforestry, forest restoration and REDD (reduced emissions from deforestation and degradation). Plan Vivo also provides a suitable vehicle to aggregate the carbon assets from multiple locations to allow for effective carbon sales to outside markets and feed the benefits of carbon sales through to smallholder farmers and rural communities. Through Plan Vivo rural people can efficiently produce sustainable charcoal and increase their returns while maintaining and enhancing the integrity of the environment. There is high potential to use the Plan Vivo System in Kenya in management and rehabilitation of Prosopis species, P. juliflora and P. chilensis, which were introduced into Kenya in the last twenty years. Due to poor silvicultural management, these species have become invasive in some ASAL (arid and semi-arid lands) areas such as Turkana, Garissa and Baringo. However with proper silvicultural management which involves thinning and pruning for eco-charcoal, Prosopis can realize benefits for communities through enhanced livelihoods and the conservation of the environment. A tailored Plan Vivo system can gradually phase out Prosopis species for eco-charcoal and introduce

Factors influencing slow climate change coping mechanisms in range lands surrounding the Amboseli ecosystem, Kenya

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Preferred session C4. Mitigation and adaptation to climate change

Abstract The Amboseli National Park is a major tourist destination in Kenya due to high populations of numerous wild species found in the park. The Masai community that live in the park’s riparian areas are predominantly pastoralists. This study evaluated factors that influence climate change coping strategies among the Masai community. The study indicated a diverse range of climate change coping strategies. The results showed that about 60% of the population is aware that the region’s climate pattern has changed for the worse and therefore grazing areas have shrunk by
about 47% in the last 10 years. Forty percent of the population has adopted some form of coping mechanism. The most common form of coping mechanism is increased land privatization and increased privatization of livestock grazing areas. About 70% of the population is apprehensive about the success of this coping mechanism. The most commonly indicated reason that has resulted in privatization is associated with ‘tragedy of the commons’. Institutional coping mechanisms that have been adopted in some of the commonly owned rangelands include alternation in grazing areas and adoption of grazing banks. A coping mechanism institutionally practised is the creation of woodlots. However, this is greatly hampered by weak institutional support, weak enforcement measures, legislation, poverty and illiteracy cultural lifestyles and traditional livelihood practices.

Key words: Amboseli, arid-semi arid, climate change, coping strategy

Estimating the carbon sequestration potential of improved fallows and woodlots in eastern Zambia using the CO2Fix model

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Preferred session C2. Carbon sequestration in agroforestry
Abstract The link between increasing atmospheric CO2 concentrations and an increase in the earth’s average surface temperature has generated intense interest in measuring and monitoring carbon pools and fluxes to predict changes in carbon concentration. However, a major challenge in measuring and monitoring tree and soil C pools is measuring plant biomass and soil carbon turnover. The CO2Fix model, which calculates carbon balance and turnover in terrestrial ecosystems, consists of biomass, soil, woody products, financial and carbon accounting modules. Although the model has been tested and validated for various temperate and tropical ecosystems, it has not been widely tested using data from southern Africa. The objectives of this study are to: (i) test and validate the CO2Fix model for estimation of carbon pools in improved fallows and woodlots using data from eastern Zambia; (ii) estimate carbon sequestration potential of improved fallows and woodlots in eastern Zambia; and (iii) assess the impact of conversion of an agricultural ecosystem to improved fallows. The study will utilize data collected at three sites in eastern Zambia as part of carbon studies. Accurate estimates of carbon stocks and turnover in agroforestry systems are needed for implementation of carbon sequestration strategies in compliance with the Kyoto Protocol and alternative carbon crediting schemes.

Key words: carbon sequestration potential, soil, tree, carbon pools, CO2Fix model, woodlots, improved fallows

Alternative energy, food and livelihood sources for forest conservation and climate change mitigation

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Preferred session C4. Mitigation and adaptation to climate change
Abstract The usual energy source for cooking (fuelwood), usual food sources (corn, upland rice, fresh root crops) and usual crops farmed (corn, upland rice) of upland settlers all involve activities that require cutting trees, clearing and cultivation, and thus the consequent destruction of forested or wooded areas. The testing of and development of alternatives to these will prevent this tree-cutting and clearing, thus resulting in forest conservation and climate change mitigation, inasmuch as 20% of all global carbon dioxide emissions is caused by deforestation. This testing was done in one upland village in the southern Philippines. A solar panel cooker was tested as an alternative
to fuelwood-fueled stoves; the solar-dried root crop chips were tested for their length of storage life and as alternative food; and a food vine (yam) was tested for its productivity when grown alongside trees, thus not requiring clearing of a wooded area. These alternatives proved to be feasible.

Simple but effective: low-input domestication strategies for large-scale deployment of improved agroforestry species


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Preferred session  B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract  Throughout the tropics, farmers have integrated many tree species within their farming systems. Many of these farmland species are grown from undomesticated varieties, whereas traditional tree breeding approaches are challenged by the large number of important species, lack of financial support, large environmental heterogeneity between planting sites and the common lack of input supply systems that ensure deployment of best plant material. Also, the expected impact of climate change challenges the traditional breeding approaches. Based on experiences from Asia, Africa and Latin America, we argue that tree genetic potential can be released to the benefit of rural people by properly matching species and seed sources to planting sites, and by brining the species into a domestication process. Examples are presented for species grown for fodder, edible fruits, oils, medicine, farmland timber – or combinations of these uses – and we discuss what we can learn from these past/present programmes. We argue that improved tree growth, product quality and ecological adaptation can be achieved by supporting identification and use of the best seed sources and robust, effective (but unsophisticated) improvement activities that do not rely overly on continuous input of external resources. We suggest a new seed source classification system suitable for agroforestry species in a farmland. We put special emphasis on the Breeding Seed Orchard (BSO) and argue that the concept is suitable to meet some of the challenges for domestication of tropical agroforestry species mentioned above. We also discuss experience with deployment of improved clones through grafting and compare this approach with seed-based approaches for different specific contexts. Finally, we discuss two key challenges of institutional nature: how can we ensure that the improved varieties get into the hands of the farmers?; and how can financial sustainability and cash flow be maintained ensuring the domestication programmes continue to develop?

Enhancing smallholder timber practices around Meru, Kenya

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Preferred session  B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract  Smallholder timber farming offer farmers a unique pathway to complement efforts to stabilize household incomes and even accumulate capital in the longer term. In this context, tree and agricultural crop cultivation are not mutually exclusive activities in meeting household
Diversity of agroforestry practices in mixed crop livestock smallholder farming systems of Kenya

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Preferred session: A3. Role of agroforestry in landscape-scale conservation strategies

Abstract:
Smallholder farming in the Kenyan highlands is characterized by poor farm productivity due to several constraints. Substantial research has focused on understanding constraints on the livelihoods of smallholder farmers, and identifying approaches, including agroforestry, to improve farm productivity on smallholder farms. Given the complexity and heterogeneity of smallholder farms in the Kenyan highlands, there is a need to explore the role of agroforestry technologies within integrated mixed crop/livestock farms to better understand the potential of these technologies and enhance their adoption. We made an inventory of existing agroforestry practices in the western and central highlands of Kenya. Farm surveys were conducted on existing agroforestry technologies in relation to farmers’ production objectives, other uses, and other ecosystem services. The study was carried out on 300 farms in Kirege, Murugi and Machanga (central Kenya) and Emuhaya, Shinyalu and Teso (western Kenya) on sites of diverse agro-ecological and socioeconomic conditions. We found that most farmers plant trees on cropland (scattered trees within cropland and homestead, boundary planting) and woodlots. The main tree products identified by farmers were wood (for timber, fuelwood and poles), fruits and fodder. The predominant planted tree species in central Kenya was *Grevillea robusta* within cropland (on boundaries and scattered within cropland) while *Eucalyptus saligna* was commonly planted in western Kenya in woodlots or along external farm boundaries. *Calliandra carlothyrsus* was mainly planted by farmers along contour hedges for fodder and fuelwood production. Few farmers planted improved fallows with legume trees in western Kenya but none did in central Kenya. Agroforestry practices were found to be diverse and depend on the needs of the farmer, hence the need to consider farmers’ objectives when designing agroforestry technologies that fit well into their farming systems.

Key words: agroforestry, livelihoods, diversity, smallholder, crop, livestock
component. Farmers usually grow teak from seedlings originating from natural regeneration, without any attempt at selection for growth rate, wood quality or form. A baseline study of tree gardens was carried out in Gunung Kidul district, Yogyakarta, Java, to establish the importance of teak to farmers and the silviculture practices currently used in the production system. Farmer visits to government research sites and the gardens of other farmers were used to initiate discussion of ways in which smallholders could become producers of quality teak, and what support they would require in the process. The baseline survey showed that because of farmers’ reliance on natural regeneration, teak tree spacing and density is sub-optimal. Furthermore, few farmers practise any form of silvicultural management. As a result of poor planning and poor management, teak timber production in smallholder systems of Gunung Kidul is of limited quantity and poor quality. Smallholder management practices, together with limited market knowledge and restrictive timber regulation policy, impede the profitability of smallholder teak systems. Adopting improved silvicultural practices is a first step toward improving returns from smallholder teak systems. These practices have to be integrated into existing farming systems. A subsequent challenge is to build smallholders’ market linkages and reduce restrictive regulation practices.

**Challenges and successes of using *Faidherbia albida* as an agroforestry species in rural Malawi**

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**Preferred session** A6. Ecophysiological bases of agroforestry-system design

**Abstract** *Faidherbia albida* is a traditional agroforestry species used in rural Malawi. These trees are native, nitrogen fixing, they coppice well and lose their leaves during the rainy season thus not competing with crops for light. These characteristics make it a favourable species for agroforestry and it is selectively weeded around in fields when found growing naturally. However, when propagating *F. albida* in a nursery, the greater inputs of care and knowledge compared to other agroforestry species must be taken into consideration. Several community groups living near Mulanje Mountain, where *F. albida* is now scarce, found some difficulty successfully propagating and out-planting these seedlings. There was little information about growing *F. albida* and groups often treated them the same as other species, resulting in low germination rates and poor seedling survival. Groups faced difficulties with proper seed treatment, avoiding root pruning and protecting trees that are widely spaced from fire, weeds and grazing. These problems caused a higher failure rate of *F. albida* offsetting its benefits. Most other agroforestry species planted in the area such as *Gliricidia sepium*, *Leucaena leucocephala*, and *Sesbina sesban* are easier to propagate and are planted closer together, making them easier to care for. However, *F. albida* is a well known species and can commonly be seen in Malawian fields; its impact is apparent. As a result, farmers show greater interest in planting these trees over other agroforestry species and practices. *F. albida*, once grown, is also low maintenance and does not compete with crops for water. *F. albida* is an important agroforestry species in Malawi and the proper care and knowledge for its propagation should be stressed so that it can be grown successfully.

**MSc programme Agroforestry and Soil Management at NUR**

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**Preferred session** D2. Integrating disciplines through agroforestry education

**Abstract** Agroforestry, by definition, is multidisciplinary and integrates knowledge from a range of disciplines. Agroforestry, i.e. the cultivation of trees on farms, focuses on productivity of woody perennials, while improving or at least conserving soil resources. In academic education, both disciplinary knowledge and integrative systems approaches need to be considered. At the National University of Rwanda, a new MSc programme in Agroforestry and Soil Management has been developed in close collaboration with Wageningen University. The MSc programme starts out with a general analysis of agroforestry systems and their potential for smallholder farmers; by defining information
needs within a farming systems approach, students are motivated to subsequently increase their
disciplinary knowledge, which is finally brought together in a synthesis at the farm and landscape
level. While doing so, students are stimulated to analyse agroforestry systems in view of farmers’
needs, development opportunities, local site conditions and economic constraints, and learn to
identify limiting factors and key issues that need to be addressed to improve productivity and
farmers’ livelihoods. The MSc programme and the systems approach it is based on are described
in the poster, and information for student applications is provided.

An analysis of some components of the nitrogen cycle as affected by land-use adjacent
to the riparian zone of a southern Ontario creek

Authors F. O. Plascencia-Escalante, A. M. Gordon, P. K. Sibley, J. Buttle and N. Thevathasan

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Preferred session B3. Riparian system effects on soil and water quality

Abstract
To assess components of the N cycle such as ammonification, nitrification and net nitrogen
mineralization, as well as extractable nitrate and ammonium (NH4+-N) pools, a study was
conducted at Washington Creek, southwest Ontario. Four different land-use systems were studied:
natural forest (NF), agricultural land + grass buffer (AP), livestock land (LS), and agriculture +
rehabilitated buffer (RA). Soil net N-mineralization rates were calculated from ammonification
and nitrification rates using the buried polyethylene bag method. Extractable nitrate and
ammonium concentrations were obtained from samples taken as part of the sampling protocol
for N-mineralization fluxes. Groundwater was also sampled from wells installed in the four land
systems, and periphyton was sampled in stream waters associated with each land-use system. Net
soil N-mineralization rates were generally significantly higher (p<0.05) in the RA (81 mg m-2 d-1)
and AP (40 mg m-2 d-1) systems compared to the NF (24 mg m-2 d-1) and LS (18 mg m-2 d-1)
systems, particularly in the fall. The same pattern was observed for extractable NO3--N over all
seasons. However, for extractable NH4+-N, higher concentrations were found in the NF system
in the fall of both 2003 and 2004; no differences were noted between land uses in other seasons.
Chlorophyll a and ash-free dry mass (AFDM) of periphyton were significantly higher (p<0.05) in
the LS system. Chlorophyll a and AFDM were poorly correlated with aqueous concentrations of
nutrients, but were positively correlated with canopy openness.

Initial landscape restoration in an area modified by livestock activity in the Eastern
Amazon

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract
The aim of this paper was to provide information on initial lanscape change using Amazonian
native tree species: sobrasil (Colubrina glandulosa Perkins), ipê amarelo (Tabebuia sp.), jatobá
(Hymenaea reticulata), bandarra (Schizolobium amazonicum (Vell)), and pau sangue in areas
previously used with intensive livestock activity. The study area was located at Presidente Medici
municipality, 400 km from the capital of Rondonia State, Eastern Amazon. The method consisted
of adapting conventional agroforestry techniques with native tree species spaced in three different
arrangements according to its ecological group and existing number of nurseries. At the end of
five months preliminary evaluation revealed that all the native species had a 95% survival rate,
showing a favourable potential for recovering soils covered by cultivated grasslands, mainly
bandarra (Schizolobium amazonicum) and sobrasil (Colubrina sp). The first soil analysis results,
at the end of the rainy season, in Areas 1 and 3 (March-April) showed similar values to those
found in the nearby forest fragment in the same period. For two months, water quality in the main
stream of the area was also monitored, the results of which showed important changes in water
characteristics. The future goals with this initiative are to keep monitoring native tree species growth, and establish an observation unit for local farmers to deal with the environmental impacts caused by livestock activity in this portion of the Amazon.

Agroforestry-induced land cover change supporting livelihoods in Andhra Pradesh

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract Andhra Pradesh is the fifth largest Indian state both in terms of geographical area and population. Its agriculture adds about 30% to the state’s GDP and provides employment to 65% of the state’s population. Out of the total geographical area nearly 60% is put to other uses than agriculture, including 23% under forests and 39% under wastelands. In the past 25 years the land use and land cover

Économie d’énergie du bois de chauffe pour la lutte

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Preferred session B9. Collective action for tree based rehabilitation of degraded lands
Abstract Le développement durable de toute société humaine et de tout peuple passe par la maîtrise de l’énergie dont les besoins pour l’homme sont multiformes et très variés. Dans les milieux ruraux des pays pauvres en général et particulièrement ceux de l’Afrique au sud du Sahara, l’énergie domestique représente plus de 90% des formes d’énergies utilisées. La principale source de cette énergie rurale est le bois de chauffe. Son utilisation dans les foyers est effectuée par les femmes qui s’en procurent à partir du bois mort mais surtout à partir des arbres des savanes et forêts, abattus et laissés se sécher. Au Togo la situation est très préoccupante à cause de l’extrême pauvreté du pays. Les habitudes séculaires d’utilisation de cette source d’énergie domestique que ce soit en dans les milieux urbains ou ruraux sont à l’origine de gaspillage par ignorance à la fin des préparations d’aliments à la cuisine. La braise finale produite après que le tison soit retiré du feu est laissée pour poursuivre inutilement sa combustion jusqu’à devenir de la cendre (gaspillage d’énergie d’origine forestière) qui une fois récupérée est déversée sur les dépotoirs (source de pollution terrestre). Ce comportement contribue à la déforestation. Des deux problèmes environnementaux (pollution et déforestation) résultant de cette pratique d’utilisation du bois d’énergie que constitue le bois de chauffe, c’est le dernier qui fait l’objet de l’étude projetée dans la présente communication.

Le rôle de l’agroforesterie dans la vie des populations et la lutte contre les problèmes environnementaux en Afrique subsaharien

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract L’humanité toute entière a aujourd’hui l’obligation morale d’assurer un environnement durable. Pour y parvenir, l’une des approches réside dans le développement de l’agroforesterie où l’Afrique subsaharienne a des défis à relever tant pour le bien-être des populations que pour résoudre les
problèmes environnementaux. En Afrique, la pauvreté dans toute la région s’est traduite par la disparition des forêts et d’autres ressources écologiques précieuses. En Afrique subsaharienne, on estime que la superficie couverte par des forêts a été réduite de 29,3% en 1990 à 27,1% en 2000 (CEA, 2005). A réduction de l’environnement et des sols entraîne certains problèmes : réduction des rendements agricoles due à la baisse de productivité des sols, pollution, épuisements des bassins d’eau douce, réduction de la diversité biologique et perte de recettes provenant du tourisme (CEA, 2005). L’objectif de cette communication est de faire une analyse sur le rôle que peut jouer l’agroforesterie dans la vie des populations et des problèmes environnementaux en Afrique centrale. Le problème s’articule autour de la question de savoir : comment l’agroforesterie pourra avoir un impact positif sur les conditions de vie des populations locales tout en préservant l’environnement ? La méthodologie dans ce travail consiste à exploiter les documents des politiques nationales sur l’agroforesterie et la gestion des terres dans certains pays. Des entretiens avec les cadres de Ministères en charge de la gestion des ressources forestières ainsi que certaines institutions de recherche agronomique seront réalisés.

Mot clés : agroforesterie, ressources forestières, environnement, populations.

Factors Influencing Slow Climate Change Coping Mechanisms In Range Lands Surrounding the Amboseli Ecosystem, Kenya.

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Preferred session C4. Mitigation and adaptation to climate change

Abstract

The Amboseli National Park is a major tourist destination in Kenya due to high populations of numerous wild species found in the park. The Masai community that live in the park’s riparian areas are predominantly pastoralists. This study evaluated factors that influence climate change coping strategies among the Masai community. The study indicated a diverse range of climate change coping strategies. The results showed that about 60% of the population is aware that the region’s climate pattern has changed for the worse and therefore grazing areas have shrunk by about 47% in the last 10 years. Forty percent of the population has adopted some form of coping mechanism. The most common form of coping mechanism is increased land privatization and increased privatization of livestock grazing areas. About 70% of the population is apprehensive about the success of this coping mechanism. The most commonly indicated reason that has resulted in privatization is associated with ‘tragedy of the commons’. Institutional coping mechanisms that have been adopted in some of the commonly owned rangelands include alternation in grazing areas and adoption of grazing banks. A coping mechanism institutionally practised is the creation of woodlots. However, this is greatly hampered by weak institutional support, weak enforcement measures, legislation, poverty and illiteracy cultural lifestyles and traditional livelihood practices.

Key words: Amboseli, arid-semi arid, climate change, coping strategy

Policies affecting agroforestry land use, conservation and management in Mindanao, Philippines

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract

The study provides a comprehensive analysis of policies affecting agroforestry land use, conservation and management in Misamis Occidental landscape in Mindanao, Philippines, as well as the various factors underlying the dynamics of policy implementation among the stakeholders. Specifically, the study assessed the effectiveness of the National Policy in Forestry Reform Code (FRC) and the Local Government Code (LGC). Triangulation was employed in combining rigorous processes in the methodology, findings of the qualitative in-depth interviews of policy implementers, and
findings of the quantitative semi-structured interviews conducted among the local residents in a representative barangay/village. Findings revealed that the policy makers and implementers have shared common views, different and unique perspectives on aspects of agroforestry, conservation and management. With regard to local residents, most are aware of FRC and LGC laws, however some specific provisions of these policies were rated as not implemented effectively, not relevant and not accepted due to the “implementation with a heart” approach when it comes to Indigenous People (IPs). The study was able to determine that the convergence point in the implementation of policies on laws is at the barangay level, and that this is coupled with numerous effects aggravated by sociocultural, economic and political dimensions. Thus, the following recommendations are drawn: a policy on incentive systems for local residents, tenured migrants or IPs to be fully accountable for the management of agroforest land be designed; IEC strategies for agroforest land-use conservation and management be implemented and sustained, as well as development strategies for the area; and a joint conflict resolution committee for other related policies be created at the operational level.

Land Care Programme as policy option and institutional innovation for agroforestry

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract
A National LandCare representative from South Africa will share the opportunities available for using the LandCare approach as the best option for developing sustainable land management policies. This will include the institutional arrangements for the LandCare Programme in addressing land degradation while at the same time serving community needs through the management of natural resources. We are all aware that accelerating land degradation is being influenced by climate change and this has implications for the poverty levels of communities making use of natural resources. These resources are vulnerable to a wide range of negative impacts, some of which are already occurring. These impacts include, amongst others: physical influence effects, such as droughts, floods and veld fires; biological effects, such as increases in insect and disease infestations; shifts in species distribution, and changes in the timing of natural events; and economic and social effects, such as adverse impacts on tourism, infrastructure and other resource uses. Resource managers face several challenges in addressing the observed and potential effects of land degradation. Additionally, the pressure for land use by communities aggravates the situation. The adoption of the LandCare approach within policy and institutional development will ensure: i) ownership sustainability of community development projects supported by the Government and ii) capacity building strengthening local organizations’ capacity for community-based planning, hence enhanced creativity and innovativeness. It is therefore the intention of the presentation to share opportunities available for adopting the LandCare approach to developing sustainable land-use policies.

Policy options, adoption strategies and success of taungya agroforestry land use system in Ondo state, Nigeria

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract
This work focuses on policies, adoption strategies and the contribution of Taungya agroforestry system to the rural economy, biodiversity and environmental conservation, afforestation, wood availability and food production in Ondo State, Nigeria. The success of afforestation through the system is also assessed. Data were collected with questionnaires, and growth data were collected in five equal-sized plots of Tectonia grandis plantations established through Taungya between 1988 and 1999. A set of questionnaires, administered to government officials in charge of Taungya
in the eight forestry administrative zones, collected information on policies and guidelines for adoption, institutional and social problems facing the practice. A second set was administered to 100 taungya farmers. The results show that about 800 farmers are involved in taungya and more than 1000 hectares of Gmelina arborea and Tectona grandis plantations in different parts of the state have been successfully established and maintained by the farmers. The cost of plantation establishment and maintenance is significantly reduced under this system. While 80% of the farmers were allocated 1ha of land annually, 20% got 2 3ha for arable cropping. They vacate the land immediately there is canopy closure. Under this scheme, the farmers have free fertile land for farming, especially the landless and immigrants, there is an increase in food production and their standard of living, and they were given an opportunity to participate in the afforestation programme of the state government. Unfaithfulness and forest encroachment are some of the problems facing this practice. The mean annual increment for the Tectona grandis is 26.09 m³ and the current annual increment is 24.63 m³. The stand density, volume, basal area and mean DBH obtained are 465 trees/ha, 741 m³/ha, 69.25 cm²/ha and 43.36cm respectively. This shows that adequate care was given to the trees by the farmers at their early stage of growth.

Integration of contour hedgerows and conservation tillage in smallholder farming systems of central Kenya

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Preferred session: A.11. On silvopastoral systems

Abstract
An on-farm study was undertaken in the central Kenya highlands to examine the benefit of conservation tillage and soil erosion control practices that can provide multiple benefits for smallholder farmers. Our specific objectives were to: 1) measure hedgerow biomass production and spatial variations in maize crop yields across different tillage and hedgerow systems; and 2) assess implications of hedgerow and tillage effects on management of cropping and livestock systems in different types of smallholder farms. There were two experimental factors: tillage (traditional tillage and no tillage); and cropping system (two contour hedgerow intercrop systems: Napier (Pennisetum purpureum), Leucaena (Leucaena leucocephala) and one mono-crop system). The fodder biomass production was 2.20 and 6.38 Mg ha⁻¹ season⁻¹ for Leucaena and Napier contour hedgerow intercrops respectively across tillage systems. At plot level, the mean maize grain yields were largest in all Leucaena contour hedgerow intercrop systems (6.43 Mg ha⁻¹) and smallest in the mono-crop system under traditional tillage (3.42 Mg ha⁻¹). The spatial variation in row grain yields was described by second order polynomial equations whose root mean squared error ranged from 0.092 to 0.046. From the lower end to the mid-terrace position for all the crop and tillage systems, row grain yields increased steadily; followed by gradual lessening of yields towards the upper end for all the contour hedgerow intercrop systems whereas the mono-crop systems had a progressive increase in grain yields. Leucaena contours under no tillage system can be used to improve maize crop yields in smallholder farms due to minimal competition, reduced soil erosion and provision of fodder for livestock. Napier contours provided more fodder, but were more competitive against the maize crop. Traditional tillage is recommended for the Napier contour hedgerow intercrop system to help control superficial roots from the hedges for improved associated maize crop yields.

Enhancing agricultural and forestry-based productivity for local consumption and domestic market in two contrasting semi-arid environments in eastern Kenya: a proposal

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Eastern Kenya largely lies in a semi-arid region where the increasing population has to utilize the increasingly fragile environment for production of food and income generation. The poverty levels are still high (i.e. 45.2% but in some areas of Kajiado district rising to over 70%) and are worsened by degraded environments (i.e. soil physical and chemical status, surface sealing erosion and salinization) and vegetation (i.e. deforestation) that arise from desertification processes enhanced by human activities. The environment is characterized by dwindling water quantities and qualities, low output per unit land in both livestock (i.e. large low-quality herds) and crop production, and unavailability of credit for facilitation of essential activities. Intervention in the use of appropriate irrigation and moisture enhancement practices would enhance the huge potential for high-value crops whose use as food and for the domestic market (i.e. in the vicinity of the Mombasa highway and highly populated fringes of the central provinces and Nairobi city) has exceptional potential. The stakeholders including inhabitants can be involved from the inception, in classified production, processing and marketing strategies to reduce poverty levels. These interventions would enhance efficient use of water (i.e. drip irrigation), conservation of environment (erosion control, afforestation), generation of additional income (i.e use of high-value crops), and enhancement of inhabitants’ capacities to produce, process and sell, but also plough back, resources (i.e. income, and other materials) for sustainability at household level. Enhanced value chains will include boosting production, encouraging processing and marketing links for generation of extra income. The link between productivity and income generation will be enhanced by value addition while diversification will be achieved through encouragement for growing a combination of both indigenous and exotic agricultural and forestry varieties.

Agroforestry as a means to achieve smallholder coffee production profitability

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract

The Kenya coffee sector was adversely hit in recent years by several factors, among which, the world price crises from 1998 to 2004 and a regular two-figure inflation rate for the last decade, are of major importance. More recently, the dramatic price increase of food and agrochemical products has again lowered coffee farmers’ incomes. Nowadays, Kenyan coffee stakeholders question the crop’s profitability and worry about the future of their well-renowned production. This research project aimed to understand the conditions under which coffee could remain profitable, and the main drivers of production. For this purpose, in 2008, 160 farmers from three cooperatives were interviewed in three different agro-ecological areas of the largest coffee-producing region of Kenya, Kangema, Karatina and Embu districts. Results showed that, in the smallholder context, coffee profitability was low or zero for the majority of farmers. Farm profitability was only maintained through other sources of income such as tree products and horticulture, off-farm revenue and dairy products. This explains why coffee was most frequently associated with other crops and trees. Nevertheless, coffee was still grown for various reasons, mainly as a means to access credit through the cooperative and a hope for future better price. Farmers’ strategies to reach this positive trade-off depended upon the agro-ecological context, the family size and the farmer’s age. They included various options of income diversification and capitalization, where trees play an important role mainly in providing fuelwood, timber or fruit. Our results demonstrate that the revitalization of coffee production in Kenya could only be achieved through an integrated management of the global agroforestry system, and that a more focused approach, limited to coffee support, is likely to fail.
Réhabilitation des terres dégradées par la plantation des arbres

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Preferred session: B9. Collective action for tree-based rehabilitation of degraded lands
Abstract: La présentation se focalise sur les Objectifs, les améliorations voulues, la méthodologie et les zones cibles qui sont: a-) Objectifs 1- Restaurer et réhabiliter les zones dégradées par le reboisement des essences capables d’augmenter le rendement des cultures vivrières ; 2- Appuyer les collectivités locales dans l’identification, la diversification et le développement des Activités Génératrices de Revenu (AGR) afin de diminuer la surexploitation des sols ; 3-) Encourager la conservation des écosystèmes et de diversité biologique pour une meilleure adaptation au changement climatique afin de sécuriser les moyens d’existence des populations défavorisées. b-) Améliorations voulues Les mesures proposées pour réhabiliter les terres dégradées reposent sur la plantation des arbres et le changement de comportement basés sur : - La création de nouvelles sources de revenu (AGR). Ce qui se traduit par une amélioration du cadre et des conditions de vie des bénéficiaires ; réduisant ainsi la pauvreté dans les zones ciblées. - La protection et la conservation des terres et ses fonctions agricoles puis l’élargissement de la superficie des formations naturelles et artificielles à travers la régénération et le reboisement. - L’augmentation de la conscience écologique à travers l’éducation et la sensibilisation des différents intervenants. - La promotion de l’agroforesterie et l’utilisation de la gestion durable des ressources naturelles (terre, eau, forêt...). c-) Méthodologie et zones cibles La réalisation de ces objectifs mérite la stratégie de partenariat, de gestion participative, de l’approche intégrée multisectorielle, de l’intégration du genre, de la recherche de transparence et du consensus aussi bien dans la phase diagnostique que dans les solutions retenues. Ce faisant l’organisation syndicale gère au mieux la réhabilitation des terres dégradées par l’acceptation et l’appropriation effective de cette initiative dans les milieux arides de YOTO, VO et ZIO de la Région Maritime du TOGO.

Économie d’énergie du bois de chauffe pour la lutte contre la déforestation au Togo

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Preferred session: B9. Collective action for tree based rehabilitation of degraded lands
Abstract: Abattract ie dend by “attachehed doc”

Addressing climate change and poverty through reforestation in rural landscapes in Togo

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Preferred session: C4. Mitigation and adaptation to climate change
Abstract: Climate change, the main cause of global warming, is a scourge that aggravates poverty, especially in rural areas through its impact on agriculture. With the participatory involvement of communities in approaches to finding solutions to this scourge, GASD/ ADD-TOGO initiated a project called
Plan of Action perpetual Adequacy Environment and Development’ (PAAED). The first plan is for the benefit of the people of 8 villages in southern Togo, bordering the Togodo national park. Ten students from Togo had their capacities strengthened on the theme ‘Integration of ethics in biodiversity in development projects in rural areas’. These students then made people aware of the importance of forests and reforestation in the fight against climate change and poverty. Semi-structured survey questionnaires were used to evaluate local potential, needs and proposed solutions for populations whose ranking has led to the development of this project: ‘Tree planting in rural areas for the fight against climate change and poverty in Togo’. The work has resulted in: the establishment of 24 groups of 9 members each (3 women and 6 men) to coordinate local activities; capacity building of the 216 members of reforestation groups as a means to fight against climate change, and choice of teak (Tectona grandis) species for planting; reforestation of 54.12 hectares with 86,585 teak plants provided free to farmers in 2007 and 2008; an estimated FCFA 860,000,000 net income from the sale of teak after 10 years, representing the contribution of SADD-TOGO to reducing poverty in these villages. The unmet demand is 85 ha and the potential for teak reforestation is estimated at 360 ha. Collaborations and multidimensional partnerships will be welcome.

Domestication of NTFPs in agroforestry systems

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Preferred session  A1. Multistrata agroforestry systems with perennial crops

Abstract  Non-timber forest products (NTFP) make up an integral part of the livelihoods of the people living in tropical forests. However, there are very few examples of domestication of such NTFPs in cultivation. This paper documents the experiences of domestication of a few NTFP species available in tropical forests in multilayered, perennial agroforestry systems in Western Ghats, a global biodiversity hot spot of the world. About 15 such NTFPs of the 140 NTFPs species collected from the forest are domesticated effectively by local people. Benefits of such systems will be shared.

Successional agroforestry systems: principles, research and application by small-scale farmers in the Alto Beni Region of Bolivia

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Preferred session  A1. Multistrata agroforestry systems with perennial crops

Abstract  The creation of agroforestal succession systems means, in the first place, imitation of the local ecosystem's vegetation, and then, in each successional phase, the crops that are of interest for the farmer. These systems are highly productive and auto-dynamic and need no external inputs to maintain their productivity. The contexts shown in this work indicate that living systems cannot arbitrarily be reduced in complexity or managed by technologies without having their stability compromised in the long term. In this regard, the results of research on soil development using the development of natural fallow woodland were shown in comparison with successional agroforestry systems in Brazil, along with field studies of fruit fly infestation and soil fertility in orange plantations in Bolivia, both in successional agroforestry systems and monoculture. The research results described, show that the approach towards solving this complex problem, and that of disease and pest infestation, and also in relation to soil fertility, could lie in the application of the principles of successional agroforestry systems. Our experience with small-scale farmers in the Alto Beni region of Bolivia indicate that agriculture using the principles of successional agroforestry systems could represent a long-term perspective for land use in these areas, with the emphasis on more than short-term economic, social or structural objectives.
A case study of annual cropping systems in tropical zones employing natural processes in species succession

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Preferred session E2. AF-based livelihood strategies for smallholders in the Amazon
Abstract

Based on the principles of natural succession, it is possible to establish more sustainable systems for cultivating annual crops in the tropics. The major problem with common slash and burn agriculture is that burning frees the energy of the biomass which would otherwise be used by soil micro-organisms to perform their beneficial function of supporting soil fertility. The innovative successive agroforestry system described here does not involve burning, and builds upon the recycling of organic matter, mimicking nature. Experiments show that yield in these systems is higher and labour necessary for weeding is reduced. This innovation is particularly useful for small-scale farms that often only have a small amount of forest left on their land. ECOTOP, a consulting company in Bolivia, approached the problem of how dry rice and other annual crops could be cultivated without a previous slash and burn technique. A 4-year experiment in Alto Beni, Bolivia, showed that it is possible to cultivate dry rice and to sustain the yield on the same piece of land (not needing rotation). After this experiment, plantations were established in cooperation with 18 small-scale farmers. As well as establishing plantations without previous burning of biomass, other plantations were also established on fields that had only been burned once before. Another successful experiment was conducted on a 7000 m² (1 Manzana) field in Honduras. Even after one rotation period, the agroforestry cultivation system reduced labour time necessary for weed control by 70%, reduced nitrogen fertilizer by 50% and increased productivity by 65% compared to monocultures.

Enhancing negotiation support for effective natural resource management: lessons from the East African highlands

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Preferred session D3. Policy formulation and stakeholder engagement in NRM
Abstract

Management and use of natural resources often give rise to conflicts between those benefiting and the losers, making collective decision making a vital precondition for successful and effective natural resource management. Our experience in the highlands of East Africa show that where dialogue between the two groups is facilitated and supported by empirical evidence including information on what is actually taking place, who is losing and who is gaining, what the alternatives are and what the long-term scenario is, has the potential to resolve long-standing conflicts in effective NRM. Using focus group discussions, key informant interviews, historical trends analysis and case studies, the paper presents lessons and experiences of negotiated support in promoting sustainable NRM and peace for improved livelihoods in the humid highlands of East Africa. Through the interventions of the African Highlands Initiative (AHI), a long-standing dispute on boundary trees between neighbouring communities in Tanzania, stalemates in addressing a common pest in Ethiopia, and conflicts between local communities and protected areas in Uganda, were resolved using negotiated support. A stepwise approach in negotiation support enriched with lessons and experiences from the three countries is presented. The paper argues that negotiation support is not a substitute for technological innovation but complementary to it, whereby it enables solutions that address system-wide problems while avoiding appreciable harm to any land user.
Study of growth and development of maize on soil enriched with tree-prunings and Foliage

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Preferred session  
A6. Ecophysiological bases of agroforestry-system design

Abstract  
A study was carried out to evaluate the growth and development of maize on soil enriched with foliage from *Parkia biglobosa*, *Vitellaria paradoxa*, *Tectona grandis* and *Gliricidia sepium*. Green leaves and prunings were collected from the mature trees of these species which were air dried and ground into powdery form after fifteen days. The prepared leaf samples were mixed with river-washed sand at the ratio of 1:7. The soil mixtures were packed into ten-litre buckets laid out in a completely randomized design. An analysis of variance test showed that prunings from *Gliricidia sepium* has the best performance in terms of plant height, leaf area, leaf number and total plant biomass. The soil mixture also had high organic carbon and nitrogen content. *Vitellaria paradoxa* showed the least value for all the parameters that were investigated.

Plantains in agroforestry farming systems in the humid forests of the southwest region of Cameroon

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Preferred session  
A2. Agroforests in humid tropical Africa

Abstract  
A survival issue in plantains production has been observed in tree crop production systems in humid forest areas. This was common between tree rows and in multi-cropped farms. The area under investigation is within the humid forest of the southwest region of Cameroon in the Gulf of Guinea, West Africa. This area is characterised by several farm types ranging from small-scale farm holdings with mostly food crops (banana, plantain, cocoyam, cassava, yam, maize, etc.), industrial plantations for the production of export crops (oil palm, Hevea, cocoa, coffee, etc.), and intercropped farms having various combinations of perennial and food crops. Long-term processes affecting sustainability are involved and studies were therefore conducted to better understand management practices in such cropping systems and to identify factors contributing to this. Collected data were put in tables and analysed using a statistical package. Results showed that trees planted with plantains favourably improved the production of plantains and even suppressed weeds. Planting densities were at times very high especially when plantains served as shade crops at early growth of perennial crops like cocoa. Trees in the farming systems adopted played key roles in improving the overall production of plantains. Selectively, hedgerows with leguminous trees such as *Calliandra*, *Leucaena* and *Gliricidia* were more favourable in suppressing plantain pests and diseases and in improving production alongside non-leguminous trees such as *Senna* or *Cassia*. Biophysical factors in the production milieu were therefore modified. This study shows that plantain was amongst the most intercropped annual crops in perennial crop systems and between planted rows of trees. In effect, with cassava, plantains accounted for more than 50% of observed intercropped frequencies.

Key words: agroforestry, humid forests, plantains, trees
**Simarouba glauca - a potential tree species for drought prone areas**

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**Preferred session**  
A10. Dryland agroforestry R&D

**Abstract**  
Simarouba glauca also known as the Paradise tree, a native of El Salvador, Brazil, was introduced to India during late 1960s. Pioneering research work was conducted on various aspects of this species at Forest College and Research Institute, Mettupalayam. The species was tested in different agroclimatic zones of Tamil Nadu and was found suitable for all the tracts. Being a highly drought tolerant species, it could also be grown in shallow soils with low fertility status. It yielded around 20-25 kg of seeds/tree at ten years. Studies on oil content and spacing were also conducted and standardized. The oil was found to resemble groundnut oil in terms of stearic and oleic acid composition. The species had a male to female ratio of 60:40 and this created problems in commercial planting programmes. To overcome this problem, vegetative propagation studies were conducted and softwood cleft grafting was found to give maximum success (80%) which in turn helped to grow male and female trees in the desired ratio of 1:6. Studies on the economic viability of raising this species in wastelands and rural areas were carried out and the results were promising. Given the positive results obtained from intensive research conducted on this species, Simarouba glauca was released (introduced) as a new tree species in Tamil Nadu in 2000. The species has become popular in many southern states of India.

**Grain amaranth: a nutritious crop suitable for arid zones**

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**Preferred session**  
E1. Hot or cold: the role of underutilized crops for AF

**Abstract**  
Humans have been utilizing nearly 3000 plant species for food and economic purposes. Grain Amaranths, highlighted as “prince feather”, is a non-conventional food crop but has great potential that could be exploited as a nutritious food crop in the near future. It contains 12-19% protein with 5-8% essential amino acids. The lysine content of this crop is twice that of wheat, thrice that of rice and maize and in fact has as much as is found in milk, which is considered to be the standard for nutritional excellence. The grains also contain 6-9% oil content, which in turn is a source of squalene. Grain Amaranth is distributed throughout the temperate and tropical regions of the world and could be considered as a cosmopolitan crop. It comes up well up to 3000 m above sea level. In Amaranth, four species namely A. hypocondriacus, A. cruentas, A. caudatus and A. edulis are in cultivation and among them A. hypocondriacus is popular and widely grown. Grain Amaranth is cultivated in tropical and sub-tropical regions of India. Gujarat is the state where the crop is cultivated over thousands of acres and it is one of the cash crops of the state. In Tamil Nadu it is a staple food crop of the tribal people of Western Ghats, particularly in Nilgiris and Anamalais. Ann All India Research Network programme on underutilized crops funded by the Indian Council of Agricultural Research has been in progress since 1982. Under this programme, more than 15 underutilized crops are identified for research and popularization and grain Amaranth comes in the front. This programme has so far released 4 varieties, Annapoorna, Suvarna, GA1 and GA2 for various parts of the country and the yield of which is around 1.5 to 2 tonnes per hectare.
Nitrogen fixation in Puerto Rico coffee agro-ecosystems

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Preferred session A7. Biological dinitrogen fixation in AF systems
Abstract
Coffee in Puerto Rico is produced mainly in small and medium farms with limited resources, on acid and highly erodable soils. Agro-ecological zoning (AEZ) analysis showed areas that could be more productive, and the results could be used to assess the impact of global climate change. A census indicated that almost 60% of the area is used to produce coffee under sun. The remaining 40% shaded coffee was studied and the predominant species found were Inga vera, Andira inermis and Citrus sp. More than 30 species of legume trees were evaluated for growth and N fixation under greenhouse conditions in two soils and without inoculation. Inga vera and Inga spectabilis showed the highest nodule number among Mimosoideae, whereas Clitoria fairchildiana and Flemingia macrophylla were the species with the highest nodulation among Papilionoideae. Several species (Adenanthera pavonina, Anadenanthera peregrina and Parkia pedunculata) lacked nodules. Nitrogenase activity was highest in Flemingia macrophylla, Clororia fairchildiana and Erythrina variegata. Shaded coffee soils had higher N mineralization rates and free-living N fixation was low under field conditions.

Impact of agroforestry interventions on farm income under subsistence farming systems of Himacahl Himalays

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Preferred session A5. Ecological sustainability: panacea or Pandora's box?
Abstract
Practices that minimizes the rate of soil degradation, increases crop yield and raise farm income are the keys to sustaining agriculture productivity in the hills of Himacahl Himalys. The use of farm land is undergoing rapid changes in response to increasing population pressure deforestation and subsistence need. This agroforestry has a great potential for enhancing food production of farmers.

Sustainable models of seed and seedling supply for agroforestry tree species

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation
Abstract
Smallholder tree farming systems are major contributors to local livelihoods and land rehabilitation. These systems also hold potential for biodiversity conservation, carbon sequestration and combating climate change. Quality germplasm is an essential innovation for smallholder tree farming systems, determining the upper limit of yield and productivity (citations from Koffa & Roshetko). Unfortunately, quality germplasm is of limited quantity and often restricted to the formal seed sector. Most smallholders are unaware of the importance of germplasm quality. They frequently source germplasm from natural regeneration or informal local supply systems that do not include quality germplasm. ICRAF, Winrock International and partners have been involved in many efforts to provide communities of smallholder farmers with the foundation stocks of quality germplasm and develop models of germplasm supply required to sustain their tree farming systems. Examples of successful models of germplasm supply come from Asia, Africa and South America. They may include collaboration with the formal seed sector or primarily focus on the development of independent local germplasm sources. Although models vary greatly, they
Successful species combinations in the Sahelian baobab gardens are threatened by destructive nematodes

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Preferred session
B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract
Baobab leaves form an important part of the local diet in Sahel countries and elsewhere in Africa. In the Sahel, the baobab functions as an agroforestry tree in cultivated fields, and farmers recognize different varieties. It is also planted and managed around villages and in vegetable gardens, where the trees are typically maintained in stunted form to maximize leaf yield and accessibility. With the exception of regularly watered gardens, baobab Adansonia digitata sheds its leaves during the dry season hence reducing the availability of fresh leaves for human consumption. The introduction of other Adansonia species from the centre of diversity in Madagascar and from Australia, show potential in enhancing food security as their leaves are very rich in the mineral contents and B1 and B2 vitamin levels. However, the local species normally used in the vegetable food banks far outperformed the introduced species in survival, growth and resistance to termites. Results from grafting as a way of harnessing the vigour of well-adapted local baobab varieties to the superior nutritional profiles of introduced baobabs were very successful with more than 80% survival 1.5 years after planting. Such cross-species grafting tests in Adansonia are creating new agroforestry possibilities with different scion/rootstock combinations in the baobab nutritional banks. But baobab has been reported as a host for several species of plant parasitic nematodes. As such gardens are frequently watered for fresh leaf production throughout the year, nematodes attacks become a real threat. Various nematodes, including the destructive Pratylenchus species and Helicotylenchus have been identified associated with baobab gardens in Mali. As nematodes can be a serious threat to the extension of this successful agroforestry technology, an extensive survey is needed in order to develop a better knowledge of this threat.

Effect of initial planting spacing regimes on growth of Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia and Acacia crassicarpa at Kongowe, Tanzania

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Preferred session
A6. Ecophysiological bases of agroforestry-system design

Abstract
A study was conducted to evaluate growth performance of Acacia mangium, Acacia auriculiformis, Casuarina equisetifolia and Acacia crassicarpa planted at four spacing regimes (a) 2.0x2.0 (b) 2.5x2.5 (c) 3.0x3.0 and (d) 4.0x4.0 at Kongowe, Kibaha, Tanzania. Annual rainfall ranged from 700 1000 mm. There are short rains between November and December and long rains from January to May, followed by a dry season (June October). Mean annual temperature for the coldest and hottest months are 18°C and 30°C respectively. The soils of Kibaha vary from place to place within short distances. A large part of the area is endowed with sandy loams with high permeability. Loam clay soils are common in valley bottoms. The natural vegetation consists of open savannah woodland with islands of thickets. The main species found are typically miombo. They include: Dalbergia melanoxylon, Milicia excelsa, Pterocarpus angolensis, Newtonia spp and Combretum spp. The grasses found in the area are Pennisetum purpurcum, Panicum maximum, Panicum trichioclachum, Andropogon and Cymbopogon spp. The tree species studied are grown
on farms for the purpose of fuelwood, pole and timber production. This reduces exploitation pressure on coastal forests which are next to the Eastern Arc in species richness, both in flora and fauna. Assessments were carried out at 3, 29, 42 and 58 months after planting on a range of variables. At age of 58 months, the results showed that the basal area for all species, crown diameter and height to live branch for *A. crassicarpa* and *C. equisetifolia* were significantly affected by spacing, while survival, total height, root collar diameter, diameter at breast height (DBH), crown depth for all species and crown diameter and height to live branch for *A. auriculiformis* and *A. crassicarpa* were not significantly affected by spacing. It is recommended that for fuelwood and pole production spacing of 2.0x2.0 m is appropriate, while for big logs a regime of 3.0x4.0 m is appropriate. Increased planting of these trees on farms leads to soil enrichment through nitrogen fixation and this influences food security. This further influences the reduction of the incidence of mining forests by charcoal burning in search of food and money.

**Soil nutrient restoration during five years growth of *Faidherbia albida* trees in degraded lands of semi-arid Baringo District, Kenya.**

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**Preferred session** C5. Soil organic matter and nutrient cycling in multi-strata AF systems  
**Abstract** Farmers throughout Africa have long used *Faidherbia albida* for improving soil fertility and crop yields. Increases in yield from crops grown below the trees have been attributed to increased nutrients. Sixteen provenances of *F. albida* were planted in a randomized complete block design (RCBD) with five replications in April 1997 at Noiweit sub-location in the semi-arid Baringo district of Kenya. The objectives were: 1) to investigate the pattern of genetic variation and performance among the 16 provenances to determine their suitability for introduction to this environment; and 2) to assess the soil fertility development under *F. albida*. Assessments of growth variables and soil properties were done in October 1997 (six months after planting) and March 2002 (five years after planting). There were significant differences in height and diameter growth among provenances at six months but not at five years. Survival percentage was higher among the eastern and southern African provenances, while four of the five West African provenances had 0% survival at five years. Soil data showed significant increase in soil pH, organic C, total N, available Olsen P and exchangeable Na and K; a significant decrease in exchangeable Ca and Mg; and no significant difference in exchangeable Al in five years. Eastern and southern African provenances were found to be suitable for introduction, and *F albida* has proved to be effective in soil fertility restoration and improvement in this region.

**Integrated oil palm-based agroforestry systems in Southeast Asia: production and environmental sustainability**

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**Preferred session** A.11. On silvopastoral systems  
**Abstract** Increased efficiency in natural resource management and environmental sustainability is justified by the need for improved land-use systems and total factor productivity. The latter is reflected by serious inadequate animal protein production throughout Asia, where available supplies cannot match current and projected human requirements up to 2020. Integrated oil palm-based systems, largely underestimated, are an important pathway for development in which ruminants (buffaloes, cattle, goats and sheep) can provide the entry point. The stratification of the systems, production options, use of forage legumes, and potential for enhanced productivity are indicated in the paper. The advances in research and development in Southeast Asia highlight demonstrably increased productivity of animals and meat off-takes, value addition to the oil palm crop, sustainable development, and distinct economic impacts. The results from 21 case studies over the past three
decades showed increased yield and measures of 0.49–3.52 mt of fresh fruit bunches (FFB)/ha/yr; increased income by about 30%; savings in weeding costs by 47–62% equivalent to 2–62 RM/ha/yr; and an internal rate of return of 19% based on actual field data. These provide important socioeconomic benefits for resource-poor small-scale farmers. Potential increased off-takes and income exist with the integration of goats. The reasons for low adoption are poor awareness of the potential of integrated systems, resistance by the crop-oriented plantation sector, and inadequate technology application. Promoting wider adoption in the future is linked directly with coherent policy, institutional commitment, investments, private sector involvement, and a stimulus package of incentives.

Trees as an integral part of coffee systems to cope with coffee wilt disease: the case of smallholders in Mukono District, Uganda

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Preferred session A1. Multistrata agroforestry systems with perennial crops

Abstract

For more than 50 years, coffee has been the dominant commodity in Uganda’s economy and the main cash crop for farmers. This sector employs more than 2.5 million smallholders. However, coffee wilt disease (CWD) has become the major setback to coffee production. It has destroyed around 50% of Robusta coffee trees and almost 90% of Ugandan farms are affected. Today, waiting for resistant coffee materials, farmers don’t have any means of controlling the disease. This research aimed to determine the role of trees in farmers’ strategies to maintain their incomes in the face of the CWD crisis. This survey was carried out in 2008, in Mukono District, the first coffee area of the country. Fifty semi-structured interviews of farmers, discussion with farmer groups, local experts, and key informants involved with the coffee sector were conducted. Coffee always grows under shade trees and is intercropped mostly with banana plants and other food crops. Agroforestry has been part of the farming system for at least three generations of respondents in Uganda. The various trees are important to farmers for their services, products and functions. Some, such as Ficus, Albizia and fruit trees, are voluntarily planted by farmers to get shade, fuelwood and fruit. Others, such as as *Markhamia lutea* and *Meopsis eminiis* grow naturally in their gardens. In response to CWD, farmers have diversified their crops, and they still maintain their shade trees in the hope to replant new coffee trees. Currently, no other crop’s revenue can compare with coffee. Thus, farmers are replanting coffee seedlings even if these trees are vulnerable to CWD. Farmers maintain trees within their farm even if they are not considered to be a valuable source of cash. This study showed a close link between trees and coffee; agroforestry systems give resilience during a crisis period.

Technologies and conditions for participation and empowerment of rural people in restoring degraded sites: the case of Mabira Forest Reserve, Central Uganda

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Preferred session B6. Agroforestry as a tool for landscape restoration

Abstract

Forests and allied tree resources form part of the natural environment and contribute to many livelihoods worldwide. In Uganda, forests and allied tree resources are important for the rural poor and degradation is partly accelerated by inadequate technologies that can be locally promoted to sustain or restore degraded sites. Mabira Central Forest Reserve (MCFR) has been affected by degradation and efforts to restore degraded sites are necessary. The research aimed to assess benefits of locally proposed technologies, conditions for participation and empowerment of the forest communities in restoration of degraded forest sites. The objectives were to: i) identify technologies that can be locally accepted and promote restoration of degraded forest sites; and ii) determine the conditions for local people’s participation in restoration practices of degraded sites. The study
was conducted in MCFR between 2007 and 2008. Data were collected using 156 individual semi-structured interviews and 12 focus group discussions. Results show that eight technologies are possible. The most recommended ones include: promoting on-farm tree planting; large-scale nursery establishment, and enrichment planting in the forest; and mycorhizal inoculation of soils for tree planting, soil erosion and invasive species control. The major conditions for local participation include more access rights, strengthening institutional capacity for collaborative forest management (CFM), awareness creation and capacity building among the local people, continuous monitoring of new technologies and collaboration between research and management institutions. Technologies can be transformed to meet local standards so that they can support the local population strategies and innovative abilities.

Forest and on-farm tree use by farmers, and implications for forest restoration, Mau Forest, Kenya

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract
Deforestation and degradation of forest ecosystems are widely reported, especially in humid and sub-humid zones. Crop agriculture and human pressure are among the main factors driving degradation. Despite the expanding degradation, little information is available on forest use to guide sustainable use of forests involving local population. This study assessed stakeholders’ forest and tree management uses with the aim of supporting people’s ability to restore forests and manage trees outside forests. Commencing in 2005, research was conducted in 17 villages bordering Mau Forest, Kenya. Socioeconomic data were collected using structured and semi-structured questionnaires. Results showed that the farmers’ main source of tree products is public forests (52%) and their own farms (40%). Harvested products included fuelwood, timber, poles, herbal medicine, thatching grass, honey and charcoal; they also grazed their animals in the forest. Farmers in the eastern part are more dependent on the forest for cash income and there is a growing commercialization of some wood products such as charcoal and fuelwood. The extent of forest use differs depending on the type of use (subsistence, commercial or a combination of both) and on availability of alternative income opportunities. Charcoal making was identified as the main destructive use of the forest because the indigenous species used take longer to mature, and the alternative tree species on farms are limited or not available at all. The use of the forest for grazing is intensive and the presence of animals is a constraint to forest rehabilitation. The promotion of agroforestry and multiple-purpose trees is a priority for most households. The only way to cultivate a positive working relationship with the local people is to allow controlled grazing or harvesting of fodder in areas where tree planting is taking place. Because most households have small land holdings, it is desirable that trees incorporated into farming system should be compatible with current land use.

Payments for Environmental Services (PES) approach as potential to develop agroforestry and reduce land degradation in Albania

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Preferred session B6. Agroforestry as a tool for landscape restoration
Abstract
Payments for environmental services (PES) are one type of economic incentive for those that manage ecosystems to improve the flow of environmental services that they provide. Paying for the provision of environmental services is an environmental policy tool attracting much attention in both developed and developing countries, but not yet applicable in Albania. This paper discusses the potential for implementation of PES by communities located in Drini’s Microcatchment where Albanian’s biggest hydropower plants of Fierza, Komani and Vau i Dejës
are established. Overharvesting, fires and overgrazing in forest areas within the Drini watershed are proportionally correlated with land degradation and increased erosion and flooding, causing the overload of hydropower reservoirs, thus increasing the need for public investments for national road maintenance, and building dams for erosion control around the hydropower plants. The participation of local communities in forest management in the last decade has demonstrated that sound natural ecosystems perform critical life-support services, which are beneficial for both local communities and the general public; but not all environmental uses generate financial returns to local communities. One of the most important reasons is that forest is considered as a public good, owned by the state, and many environmental services fall into the category of positive externalities or public goods because of their non-excludability and non-rivalry. Taking into consideration the impact of extraction or conservation on the natural resources as ‘natural capital’, we contrast two scenarios and try to measure how the quantity of each service would change as a result of forest extraction or conservation, compared to their quantity without the extraction or conservation; as well as using the degraded non-crop land for grazing or its protection. This study needs to be followed by detailed studies on the impact of farm and forest conservation in decreasing erosion and extending the economic life of hydropower plants, and recommendations are given on improvements of the legal framework.

Réhabilitation des terres dégradées par la plantation des arbres

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation
Abstract
Au Togo, le paysage agricole est composé de petites exploitations morcelées et caractérisé par une surexploitation des surfaces cultivables. Le problème de disponibilité en terre ne se pose pas encore à l’échelle nationale en terme d’espace exploitable. Toutefois, les difficultés d’accès à la terre sont réelles et on note dans certaines zones, l’existence d’une pression foncière croissante, d’une dégradation de la fertilité des sols et de poches de pauvreté rurale. C’est le cas entre autre de l’Est de la Région Maritime, du Centre Est de la Région de la Kara et de l’Ouest de la Région des Savanes. Dans ces zones, on constate des rendements bas dus à la monoculture des vivriers sur plusieurs années ; une disparition du couvert forestier et des indicateurs sociaux particulièrement alarmants (malnutrition, bas taux de scolarisation, etc…). Ces zones connaissent une agriculture avec des contraintes comme la faible capacité d’organisation des acteurs, une dégradation des ressources naturelles (feux de brousse, déboisement accéléré, une mauvaise pratique culturale…). Suite à cette dégradation des terres et de son couvert végétal due à la production du bois d’œuvre, d’énergie et des activités agricoles ; ces zones, bien que n’êtant pas un milieu sahélien connaissent déjà des signes forts de désertification. Eu égard à cette situation, SY.TRE.BACT s’engage à réhabiliter certaines terres arides et fortement dégradées à partir de la plantation des arbres, de la restauration de la flore, de la cohabitation et de la diversification des cultures vivrières dans une franche collaboration avec les populations riveraines qui ont déjà manifesté leurs intérêts comme alternative inversant actuellement l’état du rendement des terres.

Indigenous lac production strategies of the monga-stricken people in rural Bangladesh: a study on agroforestry

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Preferred session E1. Hot or cold: the role of underutilized crops for AF
Abstract
This paper intends to portray the traditional strategies of lac production that the monga-stricken community people of northern Bangladesh formulate and undertake in order to reduce the monga situation that has caused a food crisis and employment crisis that have affected their livelihoods during two lean agricultural seasons. The adverse environmental situation and lean agricultural seasons induce ‘monga’ for the poor people here in this region of the country, and this fact is
addressed in the paper which explores the economic difficulties associated such crises that the community people have to face twice in a calendar year. Empirical data were collected from the monga-stricken people of two Nilphamari villages through observation, case studies and focus group discussions (FGDs). The findings are presented in a qualitative fashion in association with quantitative analysis. The paper explored how many indigenous host plants are planted in homesteads and agricultural land and used by the respondents for raising lac. The traditional methods and techniques of extracting matured lac from the branches of these host plants are also detailed in this paper. The paper aims to explain the contribution made by this non-wood product of indigenous host plants to the reduction of economic crises and other consequent crises caused by monga in this region. It is evident that the indigenous knowledge of the lac farmers needs to be incorporated into scientific knowledge so that the lac production and its management can be more effective in reducing the monga situation. Finally, the paper suggests some policy interventions based on the findings for alleviating the monga situation for consideration by the government and non-government organizations with an emphasis on the incorporation of indigenous lac production knowledge into scientific knowledge for their future development contents.

Soil carbon sequestration in fruit tree orchards

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Preferred session
C4. Mitigation and adaptation to climate change

Abstract
Plant cover and tree plantation can have fundamental effects on soil organic matter (SOM) dynamics. In recent years, apple and peach production in the North China Plain region rapidly increased, but the knowledge about the potential of C sequestration and aggregate stability in this special vegetation is very scarce. The objective of this research was to evaluate the distribution of SOM fractions in apple and peach orchards established in 1995, 1987 and 1977 in Pinggu and Changping, Beijing, China. Soil samples collected from one metre soil depth (0 10, 10 20, 20 40, 40 70, 70 100 cm) were fractionated after wet sieving into four aggregate size classes (>2000 µm; 250 2000 µm; 53 250 µm and <53 µm) and concentrations of organic carbon (OC), inorganic carbon (IC) total carbon (TC) and total nitrogen (TN) in each fraction were determined. Large amounts of aggregates were accumulated in the 250 2000 µm size class and the smallest amount was found in the macro-aggregate size (>2000 µm). Total organic carbon and nitrogen decreased with increasing soil depth and increased with age of tree plantation. Higher OC and TN were more strongly associated with the sieved fraction (<53 µm) than with other aggregate sizes, indicating that the proportion of aggregates with diameter <53 µm may be a suitable indicator of organic matter accumulation. Total organic carbon and TN were significantly higher (P<0.05) in Changping than in Pinggu plots, probably due to the difference in soil parent material, as well as management practices. Our data also supported the hypothesis that the recovery of SOM becomes more distinct with increasing age of plantation. The dynamics of SOC and SIC sequestered within apple and peach soils differed significantly. Thus, soil developed in different vegetation types, different parent materials and management may have different modes of soil organic matter stabilization.

Characterization of Vitellaria paradoxa subsp. nilotica (the shea butter tree) populations in the agroforestry parklands of Lira District, northern Uganda

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Preferred session
B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract
The population structures of Vitellaria paradoxa subsp. nilotica (the shea butter tree) were characterized in Otuke County, Lira district, northern Uganda. Eight hundred Vitellaria individuals were assessed in eight plots established using a plotless sampling method. The dbh, height, nearest
neighbour and crown diameters were recorded and data processed for each sampled *Vitellaria* tree and combined populations. The populations of subspecies nilotica consisted of high numbers of larger trees (>30 cm) and relatively few small ones (< 0.01) indicating undomesticated, non-standardized management of *Vitellaria* canopy and genetic variation. Due to cattle rustling and the Lords Resistance Army (LRA) wars people resorted to cutting of *Vitellaria* trees for burning char ≤30 cm dbh. Falling *Vitellaria* stocking is indicated with about 8 trees/ha of ≥ 10 cm dbh with very few *Vitellaria* seedlings/coppice shoots reaching reproductive age. Such larger trees are always retained because of *Vitellaria*’s resource value. Although the community expects to harvest a lot of fruit from these already mature trees, *V. paradoxa* stands have been decreasing due to reduced regeneration in the periphery where farming is practised. *Vitellaria* canopies significantly vary in size (DF=799, F=30.57, Pcoal and excavating mortars. Together with unattended severe, destructive fires and drought, reduced regeneration is causing the *V. paradoxa* populations to change in structure. The charcoal burners, craftsmen, local community and district authorities are highly aware of the diminishing stands, but are uncertain as to whose responsibility it is to identify and implement sustainable management options. A deliberate attempt to enhance shea regeneration has to be designed and implemented. Future research on population characterization of *V. paradoxa* should also include monitoring of young individuals in the main land-use types, assessment of seed production, care and germination together with potential for vegetative propagation.

**Reboisement en milieu rural pour la lutte contre les changements climatiques et la pauvreté au Togo**

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**Preferred session** B6. Agroforestry as a tool for landscape restoration

**Abstract**

Climate change, the main cause of global warming, is a scourge that aggravates poverty, especially in rural areas through its impact on agriculture. With the participatory involvement of communities in approaches to finding solutions to this scourge, GASD/ ADD-TOGO initiated a project called ‘Plan of Action perpetual Adequacy Environment and Development’ (PAAED). The first plan is for the benefit of the people of 8 villages in southern Togo, bordering the Togodo national park. Ten students from Togo in late cycles had their capacities strengthened on the theme ‘Integration of ethics in biodiversity in development projects in rural areas’. These students then made people aware of the importance of forests and reforestation in the fight against climate change and poverty. Semi-structured survey questionnaires were used to evaluate local potential, needs and proposed solutions for populations whose ranking has led to the development of this project: ‘Tree planting in rural areas for the fight against climate change and poverty in Togo’. The work has resulted in: the establishment of 24 groups of 9 members each (3 women and 6 men) to coordinate local activities; capacity building of the 216 members of reforestation groups as a means to fight against climate change, and choice of teak (*Tectona grandis*) species for planting; reforestation of 54.12 hectares with 86 585 teak plants provided free to farmers in 2007 and 2008; an estimated FCFA 860 000 000 net income from the sale of teak after 10 years, representing the contribution of SADD-TOGO to reducing poverty in these villages. The unmet demand is 85 ha and the potential for teak reforestation is estimated at 360 ha. Collaborations and multidimensional partnerships will be welcome.

**De l’agriculture à l’agroforesterie : la technique traditionnelle du zaï comme moyen d’adaptation endogène au Changement Climatique au Yatenga (Burkina Faso)**

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**Preferred session** C4. Mitigation and adaptation to climate change

**Abstract**

La menace que représente le changement climatique, constitue le principal, sinon le fondement de l’adoption et de la pratique de la technique du zaï comme moyen d’adaptation au changement
climatique et à la disparition de la forêt. Le zaï est un système complexe de restauration de la productivité des terres faisant appel à un apport localisé de matières organiques, aux termites pour perforer la croûte de battance, à la capture de limons éoliens, à l’infiltration localisée du ruissellement, au travail profond du sol et à la culture en poquets du mil ou du sorgho, suivant que les sols sont perméables ou limono-argileux. Les cuvettes ou zaï étaient utilisées dans le Yatenga mais à une très petite échelle. Elles ont été abandonnées pendant la période de bonne pluviométrie des années 50 pendant laquelle on en avait plus besoin, du moins partiellement. Les sécheresses récurrentes depuis la fin des années 60 ont provoqué la misère des populations et la relance du zaï fut une réaction d’adaptation à cette situation. Dans cette perspective, la technique du zaï constitue un moyen d’adaptation très important, dans la mesure où elle permet, en prenant un chemin inverse, de partir d’une surface dénudée pour reconstituer l’écosystème forestier. C’est l’une des pratiques culturales qui font de l’agriculture non pas une cause de déforestation mais un moyen de reforestation. C’est cela qui constitue l’originalité de cette technique endogène, apparue en pays moaga dans les années 1970-80 en réponse aux périodes successives de sécheresses qui contribuait à accroître la vulnérabilité des sociétés paysannes et à menacer sérieusement leur survie.

Integrating Calliandra calothyrsus trees in smallholder crop-livestock farming systems: effect on milk yield and household income

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Preferred session A.11. On silvo-pastoral systems
Abstract

Napier grass (Pennisetum purpureum) provides over 80 percent of the fodder in intensive smallholder dairy cattle systems in Uganda. However, its low fodder dry matter (DM) yield and crude protein (CP) content during the dry season result in poor animal performance and reduced income. A study was conducted on 48 smallholder dairy farms in Masaka district to assess the response and profitability of dairy cows fed maize stover lablab residues (MSL) or Napier grass desmodium forages (NGD) supplemented with Calliandra calothyrsus (calliandra) leaf hay (CLH) and/or Lablab purpureus (lablab) hay (LH) and a concentrate. The results of the study showed that crossbred cows fed MSL in addition to Napier grass fodder supplemented with 1 kg/day of CLH and 4 kg/day of a concentrate produced a higher (p<0.05) milk yield (14.0 litres/cow/day) and gross margin (Ushs 1 641 180) than cows fed NGD forages with LH and a HMC (9.7 litres/cow/day and Ushs 918 000). Additional supplementation of CLH to NGD + LH basal diet improved milk yield by over 7% when compared to NGD + LH (9.0+0.04 litres/cow/day). More women (>80%) than men (<75%) mentioned improved milk yield and household income, soil fertility; supply of fuelwood and a means of conserving the environment as positive impacts from integrating calliandra trees in crop livestock farming systems.

A comparison of different artificial substrates for the cultivation of shiitake mushrooms

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Preferred session A6. Ecophysiological bases of agroforestry-system design
Abstract

The Shiitake mushroom (Lentinus edodes) is an edible wood-rotting fungus belonging to the family Tricholomataceae. The mushroom species is used in folk medicine to treat various ailments such as cancer; it lowers cholesterol levels and it boosts the immune system and has anti-oxidant activities. It tastes good either fresh or dried and is a dietary source of protein and essential amino acids, carbohydrates, vitamins B and D, and minerals. Cultivation of shiitake is generally on natural hardwood logs. However, there is a challenge to develop reliable artificial substrates for cultivation particularly in developing countries. Therefore the objective of this study was to compare different artificial substrates for the cultivation of shiitake mushroom. Three independent trials were conducted to evaluate the performance of different substrates on shiitake mushroom cultivation. The experiment was conducted within the growing chamber at the Agricultural Research
Council-Institute of Tropical And Subtropical Crops (ARC-ITSC). The trials were arranged with the randomized complete block design (RCBD) with four replications. In the first trial, substrates from oak, pine and eucalyptus sawdust without supplements were used. The results showed that eucalyptus substrate performed better followed by oak and pine. The biological efficiency (BE %) was 59%, 45.8% and 20.5% respectively. In the second trial, eucalyptus with woodchips (2:1) and pine with woodchips (2:1) substrates with supplements (wheat bran, gypsum) were evaluated. The eucalyptus substrate gave a BE of 138% and the pine substrate yielded a BE of 38%. In the third trial, a substrate made of wheat straw and pine (7:2) with supplements (sucrose, caso4, caco3 and citric acid) and from wheat straw and eucalyptus (7:2) with supplements were investigated. Results showed that wheat straw and pine substrate performed better than wheat straw and eucalyptus substrate. The former had a BE (%) of 35.7% while the latter yielded a BE (%) of 14.4%. In conclusion, eucalyptus substrate with or without supplements provided better results.

**Promoting carbon sequestration through participatory land-use planning by poor resource farmers in arid communal areas of Zimbabwe: a case study.**

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**Preferred session**  
C2. Carbon sequestration in agroforestry

**Abstract**  
Participatory extension approaches are needed to promote the adoption of key farming programmes and systems that enhance carbon sequestration and increased yields in arid communal areas of Zimbabwe. Participatory rural appraisal meetings and field assessments were employed to gather data on resource potential and key agricultural processes affecting soil carbon dynamics in Tagwira village, Mwenezi District. Results indicated that 14% of farmers in the village practise reduced-tillage farming, while (88%) practise residue mulching in their gardens. Only 4.7% use cover crops in arable lands, while 24% have poorly maintained woodlots. Grazing land is adequate to meet the current needs of livestock. No energy crops are grown in the village but almost 88% of the farmers practise crop rotation. Maps and action plans were produced indicating community plans for improved food security. Incidentally, all the action plans also contribute to carbon sequestration. It was proposed that there should be sustainable utilization of existing resources to promote carbon storage in the soil. The study recommended the documentation and promotion of technologies that would result in both carbon sequestration and increased yield as the latter will reduce greenhouse gas emission. This is the initial survey on carbon sequestration through proper land management. Financial support is required to analyse the amount of carbon in the soil together with yields obtained under each land management technique to enable farmers to appreciate benefits derived. This will enable easier adoption of the technologies by other farmers.

**The establishment of agroforestry parks containing shea trees in southwest Burkina Faso, a strategy of survival and a mechanism for mitigating climate change impact: the case of Iolonioro in the province of Bougouriba**

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**Preferred session**  
C4. Mitigation and adaptation to climate change

**Abstract**  
In southwest Burkino Faso the constitution of the agroforestry parks on the basis of shea tree has become important enough to attract the attention of researchers. This tree, appreciated for its fruits and its numerous virtues, is selected and left the fields, the fallow, and spare zones, etc. Estimates show that its rate of production will increase and produce more income for the country. The origin of the practice of agroforestry with this species is related to the variations of the climate and degradation of natural resources. The establishment of the agroforestry parks of Shea tree results from an awareness of the socioeconomic, sociocultural and agro-ecological contribution of the species. Today this practice is a means of coping with the shocks of the climate change, and when better developed, an instrument of adaptation. According to the studies, 90% of surveyed farmers announced that the constant variations of the climate, which are accentuating dryness and...
reducing the fertility of the ground, are the source of bad harvests. Regarding the persistent food insecurity resulting from the variations of the climate, the Shea tree contributes to people’s survival during times of famine or dry seasons by compensating for deficit in cereals. This explains why people’s initiatives are encouraged by institutional measures and research institutes proposing seedlings with fast growth and better productivity. Regarding this climatic crisis, local people took the initiative to protect the species that they considered essential to their existence. What benefit do people get from these agroforestry parks? What is the contribution of this practice to the mechanisms of mitigation and adaptation to climate change? These questions will be examined in the article.

Community consultations on use and management of preferred NTFPs: a case study of the four ecological zones of Swaziland

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Preferred session D1. Forest farming of non-timber forest products in N America

Abstract Traditional forest management systems were part of daily life in the natural forest and woodland resources in the olden days of Swaziland. The objective of this study was to embark on community consultations to collect information on the communities’ perception of preferred edible and medicinal NTFPs, their direct uses, the existing management strategies, the threats to forest biodiversity, and the domestication and commercialization initiatives. The findings indicated that local communities lack knowledge of the existing policies and legislation that safeguard the sustainable use of NTFPs in the adjacent natural forests and woodlands, and further indicated that there are no existing traditional local-level NTFP management systems. This is confirmed by the ongoing over-exploitation and unsustainable use of NTFPs leading to the current accelerated rate of deforestation and forest degradation. Uncontrolled trade in NTFPs by non-resident collectors in Swaziland has been seen to be one of the predominant threats to forest biodiversity. This reaffirms the weak and ineffective national policies and legislation, and shows that the existing policies and legislation are not able to be implemented. Proper and innovative policies and legislation need to be put in place to cope with the current challenges. The positive side is that local communities have identified potential threats to forest biodiversity. Though some of them may not be aware of the opportunity cost of the adjacent natural forests, all local communities are willing to participate in the conservation and sustainable use of the adjacent natural forests and woodlands. Most local communities already have initiatives encouraging the selection of top priority species for domestication and commercialization, and these are opportunities for sustainable NTFP management and development. The institutional, cultural, socioeconomic, ecological, environmental and policy issues raised by local communities in this study are crucial and essential elements for the formulation and development of guidelines for local-level sustainable management and development of NTFPs.

Dipterocarp trees in rubber agroforestry: interplanting strategies for high-value timber production in Sumatra

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Preferred session B1. Quantifying the role of AF in modifying watershed functions

Abstract Rubber (Hevea brasiliensis)-based agroforestry systems or rubber agroforests (RAF) in Sumatra and Kalimantan usually consist of many other tree species that regenerate spontaneously. RAF, provide sustainable productive and protective forest and agricultural functions. Farmer interest in planting timber trees is increasing as the value of timber is rising and availability of timber trees in forests is decreasing. The current reforestation programme of the Government of Indonesia also
encourages the planting of dipterocarp trees inside rubber plantations. Although deliberate planting of timber trees inside rubber plantations is not common, many smallholder RAF farmers plant and manage trees that will benefit them in the future. However, farmers’ interest may be hindered by several constraints, such as limited access and availability of quality planting materials, lack of management skills and government regulations on the sale of timber by smallholder farmers. On the technical front, our on-farm experiments showed RAF provided a suitable environment for dipterocarps trees. \textit{Shorea lamellata} and \textit{Shorea selanica} adapted well under open canopy and could be used as tree options for enrichment planting. In Sumatra there was no soil biological constraint on enrichment planting with dipterocarps in RAF and other land use types. Suitable ectomycorrhizal inoculum persists in the soils after forest change to other types of land use. Inoculation with symbiont fungi in the nursery is, at least in our test sites in Jambi, not necessary to accelerate growth of dipterocarp seedlings. Contrary to earlier belief, high-value dipterocarp trees can be planted in landscape restoration without much difficulty. It is however important to have nursery technology that is simple so that local communities can produce dipterocarp seedlings locally. Spatially Explicit Individual-based Forest Simulator (SExI-FS) is a computer model that can simulate growth of trees inside mixed plots. Different stocking density, planting pattern and time of enrichment planting can be tested and optimized. Example outputs of tree growth simulation in RAF with rubber and dipterocarps and practical recommendations are discussed in this paper.

Rubber agroforests – how to define?

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Preferred session: B1. Quantifying the role of AF in modifying watershed functions

Abstract

‘Kebun Karet’, or traditional rubber agroforests of lowland Sumatra in Indonesia, are well known to contain a large share of the original forest plant and animal species. As remaining natural forests continue to be destroyed, the rubber agroforests are becoming the only alternative habitat for these species. Attempts are underway to enable these species-rich agroforests to receive market recognition for their conservation role and other environmental services similar to those from forests. However, any form of eco-certification requires an operational definition of species-rich rubber agroforests. Although biodiversity-rich ‘jungle rubber’ is quite distinct from ‘rubber monoculture’, there is a continuum of management intensities and species richness between these two systems. Definitions of different rubber agroforests have been developed that use quantitative criteria that are easy to understand, easy to measure and reliable. The criteria are based on datasets collected over the years, and consist of tree species including presence of ‘large’ trees and saplings, diameter and relative basal area of rubber. A sampling methodology for such assessment is also proposed.

The importance of forests for environmental safety in Central Asia

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Preferred session: B2. AF for salinity control and land rehabilitation in Central Asia

Abstract

Forests are one of the major components of the biosphere. They play a large role in erosion control, conservation of water resources and water quality, and prevention of air pollution from dust and industrial emissions. Forest plantations have been established in Central Asia since the 1890s for protective purposes. Plantations in the mountains of Uzbekistan date back to interventions from national, but also Russian and German foresters over 100 years ago. The possibility of reforesting degraded mountainous slopes has been demonstrated in various sites, partially using fruit tree species, over a total of 2000 ha. This has been achieved with specific efforts, e.g. terracing and artificial irrigation for kick-starting the plantations. This presentation will introduce some of the experimental sites and present data on biomass production, water and air protection and erosion control of these sites. Experimental data on the role of artificial forests on water saving and regulation will be discussed. The role of artificial forests in improving microclimate, regulating snow melting and improving soil quality will be highlighted. Results will be presented on the
status and composition of artificial forestry in the river basins of Aktash and Sukok. Among a large number of tree species tested, several were identified as suitable for mountainous conditions for production of higher biomass. Higher biomass production from forest could help meet other social needs, besides improving environment safety. Among the tree species tested, oak, walnut, ash tree, pine and acacia were more suitable than others for biomass production. The results from our studies underline the importance of artificial forestry on many important aspects of environment safety. These findings are useful for other parts in Central Asia as well as for other regions of the world where forest management is critical for improving environmental safety.

Lessons and challenges of participatory nursery management in Galessa watershed, Western Shewa zone of Oromia Regional State, Ethiopia

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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract Forest clearing is continuing all over the tropics and is resulting in the loss of crop productivity, shortages of forest products, declining potential of springs, and land degradation. This study was carried out in Galessa watershed, which is located in the central highlands of Ethiopia, with an altitude range of 2820-3100 metres above sea level. The initial watershed problem identification survey was done in 2004 and identified the loss of indigenous tree species and the shortage of wood resources as two of the 18 prioritized watershed problems of this watershed. Following this, a participatory nursery management study was conducted at Galessa watershed in the Western Shewa zone of the Oromia Region, Ethiopia, from 2004 to 2007. On the basis of these problems, three tree nurseries were established in the watershed in order to contribute to solving these problems. Some of the lessons learnt include: participatory nursery management enabled farmers to raise tree and shrub seedlings in their vicinity; it benefited those farmers who didn’t have land near the watering points; and it enabled farmers to learn from each other how to raise and manage tree seedlings in the nursery. The major problems associated with the management of community nursery include improper fencing of the nursery site, difficulties in implementing local nursery by-laws, poor implementation of nursery activities, and differences in level of participation. Participatory nursery management can be more effective as long as incentive mechanisms are designed for facilitators within the community.

Estimation the economic efficiency of cashew nut production in Benin

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract This study contributes to the debate regarding the competitiveness of developing countries in the context of globalization. To take advantage of this trend, developing countries will have to position themselves properly through new policies and efficiency in production. In Benin, new orientation of agricultural policy concerns the diversification of exported products. Therefore and due to the decrease of the international price of cotton as the main exported crop, cashew nut, the second most important exported crop, becomes more interesting for government policy. This study examines the production efficiency of cashew nut farmers using a stochastic production frontier based on data collected from a stratified random sample of 262 farmers in Benin. Using numerical classification, we distinguished three overall classes of cashew nut producers, whose average plantation areas are respectively 3.6, 8.9 and 20 hectares. The results show the large farms are not more effective than the small ones. The results show an average of 39% and 61% of the cashew nut farmers are not, respectively, technically and economically efficient. The study also shows that the farmers who are technically and economically inefficient have less experience in
The role of *Faidherbia albida* land use for poverty alleviation in drylands of Ethiopia.

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**Preferred session**  
A10. Dryland agroforestry R&D

**Abstract**

Poverty is most acute in Ethiopia, particularly in rural areas where 85% of the total population directly depend on agriculture. Of all rural areas, it is the drylands that experience destitution the most mainly because of low productivity. For these reasons, poverty alleviation, by increasing agricultural productivity, has to focus primarily on conservation-based agricultural production, such as agroforestry land use systems. It is because of this that the potential of *Faidherbia* (acacia) *albida* (Del.) A. Chev. in croplands was assessed to improve soil fertility and enhance productivity in Tigray, northern Ethiopia. In Tigray, soil fertility and crop productivity (barley yield) were assessed at field and landscape scales for different distances (1, 25 and 50 metres) from *F. albida* trunk with different *F. albida* land uses: *F. albida* standing alone (AA), *F. albida* visited by livestock (AL), and *F. albida* growing adjacent to Eucalyptus (AE). Significantly higher barley yield (P < 0.05), soil moisture (P < 0.001), total N (P < 0.01), available P (P < 0.01) and soil OM (P < 0.01) were observed at closer distances to *F. albida* trunk as compared to further away from the trunk. This is so because of *F. albida*’s N fixing capabilities and its lower water demand, by shedding its leaves during the cropping season and reducing crop wilting during the dry periods. In the AL land-use system, higher available P was contributed from *F. albida* and the effect of manure from the livestock visiting *F. albida* for fodder and shade. In contrast, results from the AE land-use system indicated that barley yields and soil fertility under *F. albida* trees did not differ from those in the open field. The study also demonstrated that with higher ecosystem services, added barley yield can be gained at high *F. albida* density within croplands.

Enhancing sustainable productivity and agro-biodiversity in smallholder farming systems in dryland areas: a multi-scale case study in Tigray, Ethiopia.

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**Preferred session**  
A10. Dryland agroforestry R&D

**Abstract**

Land degradation and loss of agrobiodiversity affects smallholder farmers in dryland regions by decreasing the buffering capacity of agro-ecosystems and increasing susceptibility to yield variability including crop failure due to weather extremes. A better understanding of the underlying processes such as land-use dynamics, agrobiodiversity and agricultural productivity are necessary, especially in developing countries such as Ethiopia where 85% of the population directly depends on agriculture. The overall objective of this research was to assess land-use/land-cover (LULC) dynamics, agrobiodiversity, agricultural productivity and sustainability, and their relationship at different spatial and temporal scales in Tigray, northern Ethiopia. A multiscale approach was adopted to carry out the research. Classified maps from remotely sensed data indicated that significant changes in LULC (vegetation decline in natural habitats and decrease in trees/shrubs from croplands) were accompanied by loss of agrobiodiversity and intensification of agricultural production. A survey of 151 farms in Tigray indicated that a higher number of species of trees and shrubs in croplands (agroforestry land use), along with cultivation of land races was associated with traditional farming practices of smallholders in 2000 and 2005. At the same time, overall caloric crop yields were highest and soil erosion was lowest in sparsely cultivated cashew nut production, less contact with the extension structure and are not members of a farmers’ association. The results of this study suggest that, farmers could increase output and household income through better use of available resources.
areas (agroforestry land-use type) with high biodiversity, where traditional farming practices still dominate. At the field scale, it was shown that *Faidherbia albida* trees contribute significantly to higher soil fertility and barley yield. Results of this research may assist policy development on agrobiodiversity and agroforestry restoration by providing information on long-term historical trends, insight into their drivers, and their consequences on food security among resource-poor smallholders in the region. Finally, the study can stimulate new directions for improving resource-use utilization in complementary ways between agrobiodiversity/agroforestry conservation and agricultural production to promote sustainable agricultural production.

**Genetic structure of *Albizia gummifera* and its local adaptation to the associated arbuscular mycorrhizae in East Africa and Madagascar**

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**Preferred session** A8. Integrating genomics in agroforestry

**Abstract**  
*Albizia gummifera* is an indigenous fast-growing tree species with potential for restoration. It has the ability to form both mycorrhizal and rhizobial symbiotic associations. The aim of this study was to assess the genetic structure and local adaptation of *A. gummifera* to associated mycorrhiza among populations from Uganda, Kenya, and Madagascar. Using variation in chloroplast DNA sequences, estimates of genetic diversity/differentiation were obtained. Local adaptation of *A. gummifera* to the associated mycorrhiza was investigated by planting seed from different *A. gummifera* provenances into soils inoculated with microbial samples from respective local sites. Mycorrhizae in the soil inoculum were identified using direct microscopic observation, and genetic data were analysed using GENALEX. *A. gummifera* was found to be genetically diverse with 14 cpDNA haplotypes identified (hTOT = 0.803). Uganda showed the highest diversity (h = 0.813) and Kenya the least (h = 0.398). Although the majority of variation was distributed within populations (75%), significant population differentiation was observed (\( \delta^2P = 0.249, p > 0.01 \)). Each population contained private haplotypes: Uganda (5), Madagascar (3), and Kenya (1). The greatest genetic distance was observed between Kenya and Madagascar (2.711) and lowest distance was observed between Uganda and Kenya (0.298). The diversity of the mycorrhizal community varied between sites with Ugandan fresh soils being more diverse than Kenyan fresh soils. Based on the growth performance measurements, there was no evidence of adaptation of *A. gummifera* provenances to local mycorrhiza. It appears that the specific kind of fungi the *A. gummifera* plants are exposed to is not important, although they can benefit from the exposure. Since the populations are significantly differentiated, transferring propagules to sites outside their own for restoration purposes may pose a genetic threat. More research is however needed to ascertain adaptive differences of *A. gummifera* to abiotic, other biotic factors and the exact mycorrhizae that can colonize them.

**Hybrid poplar production in the semi-arid intermountain western United States**

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**Abstract**  
Temperate region agroforestry includes tree planting for soil conservation and production for timber, fuelwood, cellulosic ethanol feedstock, and carbon sequestration. The rapid growth rates of hybrid poplar (*Populus* spp.) enable rotations of 10–15 years to obtain merchantable timber, or 5–10 years for biofuels. Given adequate water for irrigation in arid and semi-arid regions of the Intermountain West, hybrid poplar could be produced as a biofuel feedstock in addition to providing environmental benefits such as erosion control and carbon sequestration. A 1995 Oregon study demonstrated that clone OP-367 (*P. deltoids* x *P. nigra*) was the only clone performing well on alkaline soils in this trial and tests in Colorado and New Mexico confirmed the adaptation of this
clone. To assess adaptability of a larger gene pool growing in alkaline soils, a trial was established in 2003 at Farmington, New Mexico and Ontario, Oregon. Trees were planted at 1.5 x 1.5 m spacing and irrigated by surface drip irrigation. Diameter at breast height (DBH) and tree height were recorded annually (2003-2006); wood volume (WVol) and total above-ground biomass (TAB) were calculated from these measurements. Of the 25 clones tested, 19 were common to both sites. Mean height was greater at the Ontario site through the first three years (2003-2005). By the end of four seasons, the tallest Farmington entry was OP-367 at 9.4 m with 72 Mg ha⁻¹ TAB while the tallest Ontario entry was Malheur-3 at 8.9 m with 79 Mg ha⁻¹ TAB. Although OP-367 was the most productive entry at Farmington, it was not statistically different from the mean at Ontario in height, DBH, TAB, and WVol. Given the growth and productivity range at these two sites, it is difficult to make generalizations across wide areas, but it appears feasible to identify clones suited to alkaline soils.

**eLearning for agriculture, agroforestry and natural resources management**

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**Preferred session** D2. Integrating disciplines through agroforestry education

**Abstract**

As providers of international public goods (IPGs) based on research for development on agriculture and natural resources management in sub-Saharan Africa (SSA), CGIAR centres and UN agencies are well positioned to develop original high-quality learning content, and many of them have started to explore eLearning as a means to disseminate information. National and regional learning institutions and networks as well are taking an interest in eLearning, not only as end users of information but also as contributors. Rapid developments in internet, mobile access and technologies nowadays favour widespread adoption of eLearning. To avoid the ‘one-size-fits-all’ approach to eLearning, more attention needs to be paid to ‘meLearning’ and personalized learning environments (PLEs) allowing individual learners to tailor learning content and learning strategies in a way that best fits their personal characteristics. This approach is especially relevant for multidisciplinary and complex learning areas with diverse learning audiences, such as agroforestry, climate change, risk and vulnerability. This paper presents an overview of the efforts of several CGIAR Centres and their national and regional partners in the use of open and distance learning (ODL) approaches and technologies. It is based on a study using survey design and the decomposed Theory of Planned Behaviour to assess the readiness and willingness of national partners in agricultural higher education in SSA to develop and deliver eLearning. Ordinal regression analysis has been applied to provide initial results about the usefulness, security and ease of use of eLearning, institutional influence, self-efficacy, computing experience, computer anxiety and technological facilities. The findings will help to identify core issues underlying the introduction of e-learning in African learning institutions. The results will have implications for eLearning policy and practices for the institutions. They will further help the CGIAR to better target its support in assisting national partners to adapt eLearning to their local needs.

**Does Mucuna pruriens’ fallow adoption reduce poverty? a case study in Benin**

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**Preferred session** D2. Integrating disciplines through agroforestry education

**Abstract**

Improving soil fertility has become one of the major preoccupations of developing countries such as Benin. The decrease of soil fertility reduces productivity, contributes to food security problems of households and household poverty. The use of agroforestry systems, such as *Mucuna pruriens’* fallow, was one of the proposed solutions. Since this was introduced in Benin there has been no published analysis on the impact of its adoption by farmers on poverty. Based on data collected from a stratified random sample of 305 households in rural Benin, this paper uses the counterfactual
outcomes framework of modern evaluation theory to estimate the average treatment effect (ATE) of *Mucuna pruriens*’ fallow adoption on household expenditure. Results indicate that the adoption of *Mucuna pruriens*’ fallow has a positive and significant impact on expenditure and consequently food security. The adoption of *Mucuna pruriens*’ fallow increases household expenditure by 57 845 FCFA per adult equivalent per year and it reduces the expenditure deficit ratio of the poor by 21 percent. These findings suggest that the introduction of new farm technologies, including agroforestry systems, can contribute to improving food supply of rural households and thereby to alleviating poverty.

**Adoption and socioeconomic impact of the semi mechanization of the process of transformation of the kernels of the shea tree in butter in north Benin**

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**Preferred session** D3. Policy formulation and stakeholder engagement in NRM

**Abstract**

In order to diversify the sources of incomes of the country, to reduce the financial risks and to improve the farmers’ revenues, the government of Benin decided to promote new agricultural sectors. One of those new sub-sectors is shea tree, which is the subject of this study. Due to the difficulties of certain stages of shea butter processing, semi-mechanization was initiated. The paper uses data from a stratified random sample of 198 shea butter producers to assess the adoption and impact of this semi-mechanization in north Benin. A multinomial probit model was estimated to analyse the factors that explain the adoption of each type of technology. A counterfactual approach drawing from a modern evaluation theory is used to evaluate the impact of this semi-mechanization on producers’ incomes. It was found that that adoption of a crusher was influenced by the presence of electricity in the village and by the availability of family labour. As for the shea nut grinder, the determinants of its adoption are membership to a shea butter producers association, literacy in the local language and the availability of family labour. The results also reveal that the adoption of these technologies increases significantly with the producers’ incomes by 103 914 FCFA per year.

**Native shrubs *Piliostigma reticulatum* and *Guiera senegalensis*: the unrecognized potential to remediate soils and optimize productivity of Sahelian agroecosystems**


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**Preferred session** C5. Soil organic matter and nutrient cycling in multi-strata AF systems

**Abstract**

The Sahel is experiencing landscape and soil degradation that reduces food and economic security of rural people. A proposed solution is intercropped trees, but trees are slow growing and can compete with crops for water and nutrients. Conversely, two native shrubs, *Piliostigma reticulatum* and *Guiera senegalensis*, coexist in farmers’ fields throughout the Sahel and until recently have largely been overlooked. Unfortunately, the current management of spring coppicing and burning prior to cropping is not utilizing this organic matter effectively. There has been very little research on how to ecologically or agronomically manage these shrubs. Therefore, the global objective was to determine the unrecognized ecological function of these shrubs in agro-ecosystems of Senegal that are representative the Sahel. To test these hypotheses, our team over the last 5 years, has conducted extensive field-based investigations in the Peanut Basin of Senegal that included: ground surveys and remote sensing to determine the landscape levels of shrub C and biomass; hydrology and water relations between shrubs and crops; rhizosphere microbiology; residue decomposition; N and P cycling in relation to crops; and crop productivity. The project, funded by the US National Science Foundation, graduated 4 PhD students and 3 post docs. Besides showing
that non-thermal management is possible, other major findings in Senegal are that shrubs: provide significantly more organic matter than any other source in cropped fields; increase soil quality; perform hydraulic lift by moving water from wet sub-soils to dry surface soils and drive microbial processes year around and appear to assist crops through drought periods; recharge groundwater in the rainy season; promote microbial diversity and may harbour beneficial microbes in their rhizospheres; and intercropped, do not compete but stimulate crop growth and yield by >50%.

Climate change and tree genetic resources: maintaining the productivity of agroforestry landscapes in the tropics

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Preferred session A8. Integrating genomics in agroforestry

Abstract
Humans are altering the climate, with significant consequences for the sustainability and productivity of agroforestry ecosystems, upon which millions of people depend. Here, we address the following questions: Why is it important to manage tree genetic resources in these landscapes? What are the consequences of climate change for these resources? And, what interventions can be made to address the emerging challenges presented? Maintaining and enhancing tree genetic variation in farmers’ fields – through improving farmers’ access to a range of planting materials and by devising ‘intelligent markets’ that support diversity – is essential in order to sustain the productivity of individual tree species, of species complexes and of agroforestry ecosystems in the face of current threats from deforestation, land degradation and crop intensification. Climate change reinforces the importance of these interventions and brings additional challenges, as planting domains shift, as completely novel environments are created, and as droughts and floods become more common. At a genetic level, these changes bring particular opportunities for intervention, through the selection and introduction of better-adapted tree provenances to new conditions. To ensure future productivity, key gaps in knowledge must however be addressed: How will climate change impact on the ‘connectivity’ between trees, which influences the level and structure of genetic variation found in farming landscapes? What is the best approach for introducing better-adapted provenances to farmers, and how does this differ from currently favoured decentralized models for delivering germplasm? How can ‘domain mapping’ be carried out effectively at a population level, so that the high adaptive variation found among different provenances of a species is managed efficiently? A better understanding is needed of how to design, undertake and interpret ‘transplantation’ experiments, in which provenances for possible farm planting are tested over a range of conditions, and of the specific characteristics that should be prioritized during selection.

Black cohosh sustainable harvest study

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Preferred session B4. Agroforestry in Europe: land reclamation

Abstract
The USDA Forest Service, U.S. Fish and Wildlife Service and the Garden Club of America, all members of the Medicinal Plant Working Group, started working together on a long-term ecological study with a goal to provide knowledge on the impact of harvesting black cohosh (Actaea racemosa), a valuable medicinal plant from the hardwood forests of the Appalachian Mountains. This study provides data that will help improve the management of this plant resource which is used world-wide to ameliorate the symptoms of menopause. Determining the status is critical since almost 100% of black cohosh is collected from natural forests. Although permits are required to harvest black cohosh in national forests, there are no limits or records of the number of pounds being harvested annually. The American Herbal Products Association reported over 159 tons sold in both 2003 and 2004; however, only 92 tons sold in 2006 which generated over USD
There is growing concern that natural populations are being over-harvested. Data generated by monitoring, mapping and testing different harvest intensities (0%, 33%, 66%) will greatly improve our understanding of black cohosh population dynamics. These data can be used to determine sustainable harvest-level guidelines for future management practices. The economic impact of the loss of this medicinal plant as a crop would be detrimental to local rural populations. To maintain the integrity of the species, monitoring and inventory control is essential.

Phylogeography and population genetic structure of the African endemic *Prunus africana* as revealed by cpSSRs and nSSRs

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**Preferred session**
A8. Integrating genomics in agroforestry

**Abstract**
African governments are faced with the challenge of coming up with sustainable strategies to manage *Prunus africana*, an endangered medicinal evergreen monoecious tree with both international and national significance. This is due to the indiscriminate harvesting of timber and bark, deforestation for farming and human settlement and climate change, among other things. One way of mitigating this decline is to incorporate *P. africana* in agroforestry systems. This will ensure the survival and sustainability of bark harvest, reduce pressure exerted on natural stands and benefit small-scale rural dwellers economically. The development of sound conservation and sustainable utilization strategies would require employing novel tools such as microsatellite markers (SSRs) to assess the phylogeography and population genetic structure of the species. To date, such vital knowledge is lacking for most tropical African tree species. Here, chloroplast and nuclear microsatellites were used to infer phylogeography of the species in 8 countries across the geographical range of the species (Cameroon, Equatorial Guinea, Kenya, Madagascar, South Africa, Tanzania, Uganda and Zimbabwe). Population genetic structure was also determined. The implication of these findings for appropriate approaches to development of international and national conservation strategies for the species within protected areas and managed forests, as well as making a preliminary suggestion on superior germplasm for ex situ conservation, are discussed.

How the geographic origin of all agricultural commodities can be traced back: first results from a stable isotope analysis in *Prunus africana*

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**Preferred session**
C1. AF, climate change, biodiversity conservation

**Abstract**
One of the recent scientific tools used to trace back agricultural commodities is the stable isotope analysis. Many of the elements occur in slightly different forms, i.e. they are a mixture of isotopes. While the chemical characteristics are identical, isotopes differ only in the number of neutrons in their nucleus. This phenomenon is the backbone of a universal, non-radioactive analytical tool to differentiate the geographical origin of biological material. All biological material including agricultural goods including timber should have a unique isotope fingerprint. Taking into account the geographical pattern of D/H and 18O/16O in meteoric water as well as in ground water should differentiate the origin of biological material. The pattern of D/H and 18O/16O in meteoric water depends mainly on the temperature, the landscape altitude and the distance from the oceans. By adding the remaining stable isotopes of the elements of life (especially nitrogen and sulphur), a geographical fine tuning is likely. Soils show different isotope ratios of 15N/14N and 34S/32S depending firstly on the natural geological composition and secondly on the anthropogenic influences such as cultivation and fallout. The isotope approach is explained as a universal method to trace back the geographical origin of biological plant material, and first results from different geographical bark sources of *Prunus africana* collected in Cameroon, Equatorial Guinea, Kenya, and Zimbabwe.
Madagascar, South Africa, Tanzania and Uganda will be presented. The ratio $^{18}O/^{16}O$ and $D/H$ were almost linearly correlated and when all isotopes are considered, a clear geographical pattern was obtained.

**Rangeland rehabilitation: experiences from the desert margins programme (DMP) in Turkana district of northern Kenya**

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**Preferred session** B9. Collective action for tree-based rehabilitation of degraded lands

**Abstract**  
Pastoralism in the Turkana region of Northern Kenya thrived under traditional management practices characterized by delineation of seasonal grazing areas to support nomadism. This facilitated natural resource resilience through periodic relief of grazing pressure between the foraging intervals. However, development interventions have encouraged sedentarization without regard to ecological implications. These settlements, including riparian ecosystems, have become degradation foci. Key factors associated with this trend include overexploitation of resources due to localized increase in human and livestock populations, climatic changes and poverty. The paper highlights the contribution of the DMP in rangeland rehabilitation in Turkana. The programme aimed to arrest land degradation through demonstrations and capacity building. Sensitization meetings, trainings, enrichment plantings of degraded areas with high-value trees, enclosures to enhance natural regeneration and pasture reseeding were undertaken along the Turkwel river ecosystem. Studies on effectiveness of long-term enclosure technology showed a higher density of fodder species in the fenced than in the unfenced areas. *Acacia tortilis* attained a density of 124 trees per hectare in the fenced areas compared to 14 trees in the unfenced area. The average ground cover by *Crysopogon plumulosus* was 36% in the fenced area compared to only 4% in the unfenced area. Technology adoption was high, as evident from fence expansion from the initial 5 hectares established under research and development, to the current area of 23 hectares. Introduction of *Jatropha curcas* showed promising potential with regard to germination, survival and time to maturity. Propagation of highly valued doum palm tree was realized through pre-treatment of seeds thus reducing germination period. Pasture enrichment trials prioritized *Cenchrus ciliaris* and *Entropogon macrostachyus* as good potential grasses in range rehabilitation. Findings indicate the importance of community participation in the project cycle. Up-scaling of best-bet technologies is highly recommended.

**Comparative analysis of agroforestry in Cerro Azul (Brazil) and Shang Qing (China): a base for rural planning and policy making**

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**Preferred session** D3. Policy formulation and stakeholder engagement in NRM

**Abstract**  
Agroforestry is a land-use system which allows a simultaneous combination of perennial trees and/or shrubs with agricultural crops and/or animals. It is a feasible option among the existing sustainable production systems, providing socioeconomic, cultural and environmental values. The aim of this ongoing research is to evaluate agroforestry and its potential in rural communities of Cerro Azul (southern Brazil) and Shang Qing (southwest China). A comparative analysis and evaluation of agroforestry systems (AFSs) in both regions will be carried out in order to support rural planning and establish policies related to agroforestry. Twenty small-scale farmers were interviewed in each region, emphasizing the productive process and agroforestry practices. The farmer groups which have been interviewed in Cerro Azul are currently shifting from conventional agriculture to agro-ecology. Several years ago the region was Brazil’s main citrus supplier. Lately they have faced severe production declines due to strong use of pesticides and herbicides, leading to soil exhaustion. A non-governmental organization introduced these groups to agro-ecology, which avoids use of artificial inputs. One group has a quite well-developed practice and understanding.
of agroforestry. Their AFSs are in an initial phase, but are examples for other groups already. They face lack of governmental support regarding the provision of knowledge and financial incentives for agroforestry. In Shang Qing and its surroundings, few farmers are combining fruit trees to annual food crops by their own experience. The agriculture is conventional relying on heavy chemical inputs. The region is mountainous, arid and faces erosion and water shortage problems. Agroforestry is suitable for the area and has to be developed. The government mainly provides knowledge about growing food and cash crops. It also gives incentives to afforestation practices but not necessarily agroforestry. Both areas face similar problems and agroforestry constraints. They need specific policies/incentives to support agroforestry, and professionals to implement it.

Community forests: an agroforestry approach to rehabilitating forest land degraded by shifting cultivation in southern Cameroon

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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands
Abstract
The new forestry policy adopted by the government of Cameroon in 1995 developed a legal provision for allocation of community forests to village communities in an attempt to stop the further spread of rapidly increasing shifting cultivation and deforestation, and to secure substantial benefits for village communities as well as to motivate them to better protect the forests. A recent study to evaluate the efficiency of five community forests carried out in southern Cameroon indicates that although all begin as shifting cultivation fields, they differ greatly in species composition and richness, in intensity and length of management, in economic orientation, and in adaptation to particular agro-ecological conditions. Agroforests that mimic local ecosystem processes can be used to contribute to farmers well-being while protecting and preserving forest resources and biodiversity. Farmers derive income from tree products with high market value and generally collect other tree products primarily for home consumption. The domestication of the most valuable species, especially food-related or income-generating species, offers considerable scope for enhancing the nutritional and economic security of subsistence farmers. Farmers use a diversity of techniques, many of which fit well in their local conditions, and can lead to conservation and regeneration of the natural resource base, but not all are effective. Therefore, modifications and adaptations are necessary. Such modifications should take into consideration farmer’s rationales and knowledge. This should be based on a thorough knowledge on how farmers use household and field characteristics to make adoption decisions.

Identifyinf fruting problems in *Jatropha curcus* intercropped with Dalbergia sissoo for biofuel production

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Preferred session A6. Ecophysiological bases of agroforestry-system design
Abstract
*Jatropha curcus* has been intercropped under a sissoo plantation at Kharenitar in Tanahu district, Nepal for biodiesel production but it failed to produce good fruit. With the objective of extracting biodiesel from *Jatropha* seed, this species was planted in 22 hectares of forest lands within a sissoo plantation involving local women’s groups; approximately 10 hectares were planted with branch cuttings of *Jatropha* and the rest with seed sown directly in the ground. An oil expeller machine was also established in the area to extract oil and share benefits with the local community. Even with healthy growth most of the plants barely yielded 10 to 20 fruits per year and many had zero production. The plantation area however has poor soil condition, close planting and low exposure to sunlight. Genetic factors could also be a considerable. To identify the problems, different treatments with shade, pruning, space, insecticides and soil nutrients were used in trial
and observation plots in the area. The treatments of spacing and pruning combined with fertilizer are promising better yield. Further analysis will give more authentication. In the meantime this presentation will share ideas in finding more concrete outputs. Parental sources are also being assessed for genetic factors.

Biophysical and socioeconomic studies for the development of a Rwandan Irrigation Master Plan


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Preferred session C3. Agroforestry, water quality and environmental amelioration

Abstract According to the 2007 UNDP Human Development Report, Rwanda is a low-income, food-deficit country that faces significant threats of food insecurity. This is exacerbated by high population growth rates and densities that have led to deforestation, soil erosion, and decreased agricultural productivity. The Government of Rwanda, through the Ministry of Agriculture and Animal Resources (MINAGRI), commissioned a study on the development of an Irrigation Master Plan for the country. In March 2009, the World Agroforestry Centre (ICRAF) signed a Memorandum of Agreement with Ebony Enterprises Ltd., an Israeli development company, to implement this study. ICRAF is using a scientific approach to identify and inform MINAGRI of the potential for irrigation. Biophysical parameters such as slope, soil types, land cover, and climate have been analysed, ranked, and entered into a GIS environment for multicriteria analysis (MCA) using standardized procedures that will guide the selection of potential irrigatable areas. From a large pool of potential sites, the team will carry out detailed spatial analysis to determine the final sites. During this phase, an environmental impact assessment, as well as pedological, hydrological, geotechnical and agronomic analyses will be undertaken to ascertain the suitability of the sites for irrigation and determine appropriate crop, livestock, and agroforestry selections. Finally, financial and socioeconomic analyses will be carried out to determine the viability of these sites for irrigated agriculture. The team has produced a flow chart to illuminate the processes necessary for completion of the IMP, at which time a final report will be used by MINAGRI for tendering and implementation of the planned irrigation projects in Rwanda.

Leucaena: a valuable agroforestry tree for fodder production in semi-arid Kenya

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Preferred session A.11. on silvopastoral systems

Abstract The semi-arid regions of Kenya are characterized by an inadequate quantity and a low quality of livestock feed. Advances have been made in identification of high-yielding and nutritious legumes to offset low-quality feed. Research findings on dry matter yield and nutritive value of Leucaena (Leucaena leucocephala [Lam] de Wit) in semi-arid regions of Kenya is summarized. The benefit of Leucaena as a livestock feed supplement is also presented. Among the germplasm evaluated, the Leucaena hybrids were more productive than the conventionally cultivated Leucaenas. Leucaena contains high crude protein (23.7%), low lignin (8.2%) and is highly digestible (57.3%) and thus a suitable source of protein supplement for livestock. Kenyan goats fed on a basal diet of natural pastures and Napier grass supplemented with Leucaena leaf meal, gained an average of 31.2 g per day while goats fed on basal diet only lost an average 3.8 g per day. Leucaena can be grazed directly in the field by ruminants, conserved as leaf meal or used in cut-and-carry feeding systems in livestock production systems. There is considerable scope for usage of Leucaena as a supplement for ruminants fed on a diet with low crude protein in semi-arid regions of Kenya. The
woody stems, which comprise of about 50% dry matter (at a harvesting height of 1 m), can be a source of fuelwood. Being a legume and fixing nitrogen, Leucaena can be incorporated into a cropping system with gains in overall land productivity. However, despite the positive attributes of Leucaena, its adoption has been low over the years. Consequently there is a need to reactivate research on Leucaena to improve its adoption by providing agronomic practices, information on management and seed to framers.

Challenges in the integration of Macadamia into Kenya’s farming system


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Preferred session B8. Participatory tree domestication (PTD) for land rehabilitation

Abstract

The genus Macadamia belongs to the family Proteaceae. The large evergreen macadamia trees were popular shade trees in Queensland and New South Wales prior to the existence of the commercial industry. Macadamia was introduced into Hawaii in about 1881 for use as an ornamental and in reforestation programmes. Of the ten species, only three, Macadamia integrifolia, M. tetraphylla and M. ternifolia are considered edible. Macadamia was first introduced into Kenya by Bob Harries’ family in 1946, and was introduced to smallholders as a complementary cash crop for coffee in 1964. Macadamia is currently a high-value crop with low labour and production cost requirements once it reaches maturity. The trees contribute to Kenya’s economy by being a foreign exchange earner, creating employment (at nut farm level, tree nurseries, nut collection points, processing factories and in nut vending), raising rural income and providing nutrition. The trees are currently being incorporated in agroforestry programmes to help in the reduction of environmental degradation. Use of legumes and vegetables as intercrops empowers women, as they are able to provide nutritious meals and earn an income. The fact that once a tree is established it can continue bearing for over 80 years with good management makes macadamia a preferred crop in areas where land availability is a problem. The country has established nut processing plants and there is market demand for the nuts in Japan, China, USA and Korea. Moreover, the husks and shells are alternative sources of fuel that prevents the need to cut down trees. To address macadamia production constraints, macadamia root rot, macadamia stink bug, provision of clean planting material of superior cultivars (through tissue culture and marker assisted breeding), and macadamia value addition are on ongoing research activities at KARI-Thika. This will ensure sustainability of the macadamia enterprise in Kenya.

Economics of Melia Volkensii production on smallholdings in the drylands of Kenya

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Preferred session B9. Collective action for tree-based rehabilitation of degraded lands

Abstract

Melia volkensii is being promoted in the drylands of Kenya as a source of wood biomass for domestic and commercial purposes. However, little is known about its profitability in smallholder production systems. Operating behind a background of resource-based constraints, smallholders aim to increase and/or diversify food and cash income from their farms. Existing information on ‘Melia system’ is insufficient to make informed decisions on the profitability of growing Melia as an economic enterprise. The study, therefore, carried out an economic evaluation of the ‘Melia system’ to generate information on its profitability. The study was executed as a field survey covering 92 smallholder farmers and 20 processors/traders of Melia in four dryland districts. Analysis showed that 1 ha of Melia woodlot requires an investment of Ksh. 1 246 836 (USD 15 586) (discounted to 2009 prices) for a 10 year rotation cycle, covering tree establishment to timber production. Harvesting and processing done jointly were the most expensive operations in Melia production, contributing about 85%, i.e. Ksh. 1 054 747 (USD 13 184) of the total cost. Fencing, commonly done using tree branches, was the least expensive operation (0.1% of total cost). Profitability of Melia on smallholdings depended on the extent of integration into existing
farming systems, market outlets and level of value adding. The highest profitability was achieved when intercropped with green gram at the initial stages of establishment, and its value-added products sold. In this scenario, a 1 ha *Melia* stand gave a net present value (NPV) of Ksh. 1 165 754 (USD 14 572) translating to a discounted annual profit margin of Ksh. 158 389 (USD 1 980) for 10 years. The profitability of *Melia* was higher than *Eucalyptus* spp and *Grevillea robusta* in a similar environment. Although the tree has economic and ecological benefits in drylands, product value addition is a prerequisite to realizing good returns. Aggressive marketing of *Melia* products is essential.

**Reaping the benefits of Agroforestry: the experiences of dairy farmers in Kenya in the use of calliandra tree fodder**

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**Preferred session**
A.11. on silvopastoral systems

**Abstract**
Livestock is a major source of livelihoods for smallholder farmers in central Kenya but it use is constrained by a shortage and poor quality of available feed. To overcome this constraint the National Agroforestry Research Project (NAFRP) in Kenya introduced and evaluated through farmer-participatory on-farm trials the use of calliandra (*Calliandra calothyrsus*), a fodder tree, in order to overcome the feed constraint. Integration of calliandra into farms had significant impacts not only on livestock productivity but it also directly translated into increased household incomes. For instance, results from the dairy cattle feeding trials showed that supplementation of the standard basal diets of Napier grass (*Pennisetum purpureum*) with 2 kg calliandra dry matter (DM) resulted in a similar response to that of 1 kg DM commercial dairy meal. The results therefore showed that calliandra could be used to substitute the costly commercial dairy meal without loss of milk yield, thus providing an opportunity for farmers to cut-down on the cost of feeding. Similarly, diets fed to dairy lactating goats containing 80% calliandra and 20% maize stover increased milk yield by 28% over diets containing Napier grass. The results indicate that the efficiency in the use of crop residues could be improved for dry season feeding, stabilizing animal production. A socioeconomic assessment on the contribution of a calliandra-based feeding system indicated higher economic benefits in terms of cash returns and also ability for farmers to meet basic livelihoods items, especially education for their children. Overall, the experiences from the adoption of the calliandra-based feeding systems indicate great potential to spur economic growth and improve livelihoods of smallholder farms in Kenya.

**Integration of crops and livestock for small-scale farmers**

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**Preferred session**
A.11. On silvopastoral systems

**Abstract**
Livestock feed in Kenya accounts for 60–80% of the total livestock production costs. The government aims at promoting diversification of the feed base through the use of alternative sources of both energy and protein and the utilization of crop residues in animal feeds. Grown as hedgerows, multi-purpose leguminous trees do not require much land, and are thus a suitable source of protein-rich fodder where land is limited. The trees remain green through the dry season, serving as a crude protein bank in addition to improving soil fertility through nitrogen fixation, nutrient recycling and stabilizing soil on terraces. Trees inter-planted with bananas are necessary as wind breaks and as a natural method of replenishing soil nutrients and sustaining productivity of farmland. For small-scale mixed crop livestock producers, a major challenge is getting enough feed. Apart from using banana crop residue for livestock feeding, some farmers have started intercropping bananas with forages to cope with the situation. A simulation model has shown that this practice is economically viable. The model assumes 0.4 ha of bananas grown in alleys of *Leucaena diversifolia* and *Calliandra calortheses* with Guinea grass (*Panicum maximum*) as an intercrop. Napier grass (*Pennisetum purpureum*) is planted in holes 60 cm wide and 60 cm deep
in the alleys as a pure stand. Napier, banana residues and leguminous tree trimmings are fed to a dairy cow, which will produce 3000 kg milk in a 300-day lactation period. The simulation model shows that this system can generate up to KES 80 000 a year, aside from the soil conservation and nitrogen fixation benefits. The model is currently being verified on-station at KARI Kitale.

Rangeland rehabilitation: experiences from the desert margins programme (DMP) in Turkana district of northern Kenya

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Preferred session A10. Dryland agroforestry R&D

Abstract Pastoralism in the Turkana region of Northern Kenya thrived under traditional management practices characterized by delineation of seasonal grazing areas to support nomadism. This facilitated natural resource resilience through periodic relief of grazing pressure between the foraging intervals. However, development interventions have encouraged sedentarization without regard to ecological implications. These settlements, including riparian ecosystems, have become degradation foci. Key factors associated with this trend include overexploitation of resources due to localized increase in human and livestock populations, climatic changes and poverty. The paper highlights the contribution of the DMP in rangeland rehabilitation in Turkana. The programme aimed to arrest land degradation through demonstrations and capacity building. Sensitization meetings, trainings, enrichment plantings of degraded areas with high-value trees, enclosures to enhance natural regeneration and pasture reseeding were undertaken along the Turkwel river ecosystem. Studies on effectiveness of long-term enclosure technology showed a higher density of fodder species in the fenced than in the unfenced areas. Acacia tortilis attained a density of 124 trees per hectare in the fenced areas compared to 14 trees in the unfenced area. The average ground cover by Crysopogon plumulosus was 36% in the fenced area compared to only 4% in the unfenced area. Technology adoption was high, as evident from fence expansion from the initial 5 hectares established under research and development, to the current area of 23 hectares. Introduction of Jatropha curcas showed promising potential with regard to germination, survival and time to maturity. Propagation of highly valued doum palm tree was realized through pre-treatment of seeds thus reducing germination period. Pasture enrichment trials prioritized Cenchrus ciliaris and Entropogon macrostachyus as good potential grasses in range rehabilitation. Findings indicate the importance of community participation in the project cycle. Up-scaling of best-bet technologies is highly recommended.

Priority indigenous fruit species in Kenya

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Preferred session E1. Hot or cold: the role of underutilized crops for AF

Abstract Despite various efforts made to develop and promote indigenous fruits in Kenya, no systematic prioritization of species has been carried out. Prioritization attempts have been unsystematic and have often resulted in varied lists of priority indigenous fruits. Species prioritization in Kenya has largely depended upon researchers’ self-interest and/or farmers preferences with minimal attempts to harmonize concerns of all players in the sub-sector. Based on the foregoing, an attempt was made to generate a list of priority indigenous fruits using criteria that reflect diverse interests of key players involved in production, trade and research. The criteria include food potential, commercial value, storage shelf-life, availability, policy framework, other uses and ease of propagation. Fruits were weighted based on viewpoints of producers, traders and researchers captured during field appraisal preceded by discussions with various stakeholders. To be able to score each fruit, the
seven factors were categorized further into attributes that enhance their value, and a score of 2 allocated to each item. The highest ranked indigenous fruit species was *Tamarindus indica* followed by *Adansonia digitata* with a score of 96% and 89%, respectively. The two fruits have high potential as sources of food and income, both scoring 6 points out of a total of 7 points on food value and market demand, respectively. The two fruits have substantial amount of utilizable pulp and their seed kernels are often utilized as food. The other highly ranked indigenous fruits included *Sclerocarya birrea*, *Ziziphus mauritania*, *Balanites aegyptiaca*, *Vitex doniana*, *Dialium orientale*, *Berkamia discolor*, *Azanza garckeana*, *Carissa edulis*, *Landelphia kirkii* and *Saba comorensis*. These are the indigenous fruits with potential as sources of food and commodities of commerce. It was concluded that *T. indica* and *A. digitata* present vast potential for domestication as sources of nutrition as well as commodities of commerce in the drylands.

**Integration of trees, livestock and crop production for sustainable development: lessons and experiences from coastal lowlands of Kenya**

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*Preferred session* E4. Socioeconomics and agroforestry in the Pacific

*Abstract*

Agroforestry is an integral part of the farming system in coastal Kenya. The majority of farmers practise mixed farming of food crops and livestock. Maize (*Zea mays* L.) followed by cassava (*Manihot esculenta* L.) and cowpeas (*Vigna unguiculata* (L.) Walp.) are major staple food crops. The dominant tree crops in CL3 and CL4 agro-ecological zones (AEZs) are coconut (*Cocos nucifera* L.), cashew (*Anacadium occidentale, L.*) and fruit trees, mainly mango (*Mangofera indica, L.*) and citrus. A study in CL3 on a cashew-pasture-dairy complex showed that shade from cashew trees resulted in animals spending longer periods of the day grazing, in addition to the benefits that accrue from an established tree orchard. Unlike under cashew, pasture production under a coconut canopy is influenced mainly by soil moisture and nutrient status, but rarely shade because of better light penetration to the soil surface. Alley farming was introduced in the region in 1989. This is an agroforestry intervention that integrates fodder or food crops with fast-growing leguminous trees. The benefits observed include profitable dairy production by feeding cows on N-rich fodder, while maintaining soil fertility through recycling of nutrients in animal manure. A mixture of grasses like Napier (*Pennisetum purpureum*) or food crops (Maize) grown with leguminous shrubs *Leucaena* (*Leucaena leucocephala, L.*) and/or *Gliricidia* (*Gliricidia sepium, L.*) in the alley farming system provides a quality diet to dairy cows. Total fodder yield increased from 10 t ha-1, when grown as mono-crop, to 16 t when intercropped with fodder trees and applied slurry. The maize bran from maize production is the energy supplement for dairy cattle. Annual milk production of 2000 kg ha-1 yr-1 is achievable from cows fed grass only, compared to 6000 kg ha-1 yr-1 of milk achieved in grass-legume maize bran system. Integration of livestock production in coastal agroforestry systems increases productivity, contributing to improved livelihoods in smallholder mixed-farming systems.

**Lessons and experiences on integrating fruit crops into farming systems in central and eastern provinces**

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*Preferred session* E1. Hot or cold: the role of underutilized crops for AF

*Abstract*

Integration of fruit crops into farming systems is a common practice in Kenya, especially with small-scale farmers. This is the case because small-scale farmers prefer to have several enterprises in the same farm unit as a way of spreading risks and maximizing returns. Use of this system is becoming even more common these days with continued reduction of land size per household. There are many advantages when fruit trees are integrated into a farming system such as prevention...
of soil erosion. On the slopes of the Aberdares ranges in Nyandarua districts, Central Province, for example, temperate fruit crops such as apples and pears are grown together with other fruit crops, and also to prevent soil erosion. Fruit trees also help in maintaining soil structure by reducing the impact of raindrops on the soil. In addition, fruit trees create a micro climate favourable for crop growth especially in very hot areas. Other advantages include wind breaking and nutrient recycling. Mango which is quite a hardy crop, has mitigated against food shortages caused by prolonged drought in districts like Kitui and Makueni in Eastern Province. In these districts, mango trees provide food and income to the affected household during times of drought. In addition, trees of mango, avocado and other fruit crops provide fuelwood when pruned, thus reducing deforestation. There are however some challenges integrated systems including that disease and insect pest management of different crops in the system may become more difficult, and there could be likelihood of chemical drift from one crop to another during chemical application. This is made worse by the fact that the approved chemicals for fruit crops are not necessarily the same as for other crops. Mechanization may also become more difficult to apply with integrated systems considering the small size of the land. Other challenges include competition for nutrients, water and sunlight between fruits and other crops thus reducing the yield potential of individual crops. It can, however, be concluded that the advantages outweigh the disadvantages and therefore farmers should be encouraged to adopt integrated production systems.

Agroforestry as a strategic tool for breaking the policy block in climate change

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Preferred session D3. Policy formulation and stakeholder engagement in NRM

Abstract Indonesia has prepared some policies related to climate change and sustainable forest management. One, P.6/Menhut-II/2009, Developing Forest Management Unit (Ministry of Forestry Decree), deals with forest management units (FMU) that are important for sustainable forest management; another, P. 68/Menhut-II/2008 is about establishing demonstration activities (DA) in terms of reducing emissions from deforestation and forest degradation. The interface of these policies presents the challenge for agroforestry to be a strategic tool for breaking the policy blocks of the climate change ‘Forestry’ mainstream in Indonesia. The demonstration activities, at the site level of management practice in combating climate change, will play an important role due to the following reasons: 1) the high diversity of forest types; 2) the diversity of ecosystems; 3) the high diversity of forest functions; 4) many sociocultural differences; and 5) the many geographic (islands) types that exist in Indonesia. These diverse circumstances will require different methodologies and will give different impacts. For example: the methodology of DA in peat forests will be different to community forests dealing with choosing the right local specific species instead of silviculture treatment. There are some requirements that must be fulfilled by Indonesia in order to implement many methodologies related to combating climate change, such as 1) clearly defined forest borders (for REDD) and community forestry for voluntary carbon market; 2) conflict resolution of land tenure between communities and other stakeholders; 3) household economics; 4) environmental services; 5) reducing emissions. An agroforestry system that will be implemented at the interface of FMUs and DAs has many variables that must be considered, such as landscape area, local specific species, soil type, local institutions, traditional knowledge, structure combination of trees species based on silviculture science, economic value, carbon stock and diagnosis and design (D&D) methodology. Agroforestry could sequester C and prevent further deforestation by providing a wide range of sources of income.
Biodiversity in Agroforestry Systems

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Abstract

Large areas of the agricultural landscapes in the lowlands of Northern Germany are low-structured and monotonous due to a consequent removal of trees, shrubs or other landscape elements within the last decades. The lack of heterogeneity has a drawback on biodiversity. Many species of the open field use hedgerows as refuges when environmental conditions become too harsh. If such refuges do not exist, the population decreases. Furthermore, forest species that usually perceive agricultural landscapes as a barrier, may use hedgerows as corridors connecting different habitats. For these species, hedgerows in the landscape are important to ensure an exchange between different populations.

Alley cropping with strips of short rotation coppice (SRC) offers an opportunity to re-introduce hedgerows into the treeless agricultural landscape. In the presented study five species communities representing different trophic groups in SRC and alley cropping systems were investigated. The results were compared with that from conventionally managed agricultural land and presented for young stands as well as for more than ten years old stands.

The results suggest that alley cropping implies many benefits for an increased biodiversity and may help to sustain or even to increase the number of species in the agricultural landscape. But the effects are manifold and it has to be considered that the benefit for biodiversity depends on the considered group. Species that depend exclusively on open farmland are likely to decrease as a consequence of an increased share of hedgerows in the agricultural landscape. Anyway, a differentiated harvest management of the trees may improve the diversity of many organism groups and benefits many species from the fields as well.