AGROFORESTRY DEVELOPMENT IN THE ASIA-PACIFIC REGION

—Proceedings of the Fourth APFNet Workshop on Forestry and Rural Development

- Asia-Pacific Network for Sustainable Forest Management and Rehabilitation

China Forestry Publishing House

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Nature Conservation Publishing Center · China Forestry Publishing House
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图书在版编目(CIP)数据

亚太区域农林业发展: 亚太森林恢复与可持续管理网络第四届林业和农村发展研讨会论文集 = Agroforestry development in the Asia-Pacific region: 英文/亚太森林恢复与可持续管理组织编. —北京 : 中国林业出版社, 2013. 10
ISBN 978-7-5038-7256-3

Ⅰ. ①亚… Ⅱ. ①亚… Ⅲ. ①区域农业 - 农业经济发展 - 亚太地区 - 国际学术会议 - 文集 - 英文 Ⅳ. ①F33-53

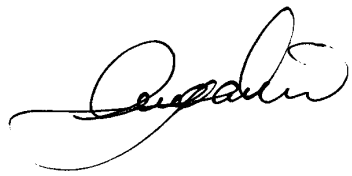
中国版本图书馆 CIP 数据核字(2013)第 257516 号

Preface

As part of its capacity building program, the Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet) sponsored a workshop on agroforestry for rural development. In November 2012, participants from 15 developing economies met in Kunming, China to exchange best practices and lessons learned on how to diversify household incomes, reduce poverty and restore the environment by combining trees with agricultural cash crops and/or animal husbandry.

Agroforestry systems-shifting cultivation, home gardens and trees on farms, for example, are the oldest forms of land use in history. Farmers developed and adapted them over time to meet their specific needs according to prevailing environmental and socio-economic conditions. This adaptation continues to this day, with practitioners devising flexible approaches in response to global change, including climate change. However, agroforestry still faces serious challenges: the absence of domestic legislative and policy frameworks in many cases, the lack of coordination among sectors involved and the insufficient financial/technical support, to name just a few. Despite such obstacles, real progress is being made in the Asia-Pacific region. Rural livelihoods are improving and vast areas of degraded land are being restored.

Workshop attendees provided many valuable insights during discussions which APFNet is pleased to share by making this compilation of reports available. We hope that readers will find the information helpful in terms of enhancing domestic farming practices. Lastly, we would like to thank all participants for their important contributions which made this publication possible.



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Content

Development of Agroforestry Practices in the Asia-Pacific Region

——An Overview of APFNet's Workshop on Agroforestry for Rural Development

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1. Introduction

The Asia-Pacific region is characterized by huge diversity in climate, geography, population, and agricultural and economic development. The livelihoods of a large population in this region are challenged with food insecurity, poverty and malnutrition (World Bank, 2007). Since the most economies of the region are agriculture and/or forestry-based, development of these sectors are necessary to improve livelihood of the rural communities. Agroforestry is a traditional land use system that has been reinvented to meet the needs of modern societies in environmental protection and livelihood improvement. Agroforestry plays a particularly important role in the development of the Asia-Pacific region because it helps conserve indigenous knowledge of the high diversity of ethnicity, increase and diversify sources of income of resource-poor smallholders, conserve soil and water, and the highly diverse yet threatened biodiversity.

APFNet's Workshop on Agroforestry for Rural Development was held on 12th-22nd November, 2012 in Kunming to help promote and improve sustainable forest management through capacity building and information exchange. The workshop brought together officials from related sectors and organizations to review different dimensions of agroforestry, share experience and identify challenges and opportunities faced in promoting and developing sustainable agroforestry. Participants from 15 economies attended the workshop; each of them shared their domestic experience in agroforestry in the form of presentation and participants' report. Resource persons were invited to deliver keynote lectures on agroforestry, but these are not included in this summary.

2. Summary of Participants' Reports

The summary of 15 participants' reports are grouped into five sub-regions: (1) East Asia—China and Mongolia; (2) Southeast Asia—Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand and Viet Nam; (3) South Asia—Bangladesh and Nepal; (4) Oceania—Fiji (representing the Pacific community) and PNG; and (5) Latin America—Peru.

2.1 East Asia

Agroforestry systems are relatively widespread in China while literally inexistent in Mongolia. Chinese agriculture has been developed for more than 10, 000 years (World Bank, 2007); it is widely practiced by the majority of Han people and many of the 55 ethnic minority groups. Due to this long history of development and integration with local cultures, many traditional agroforestry systems have evolved that are still being practiced in China, such as shifting cultivation, rotation, intercropping, home-gardens, tea plantations under natural forest, etc. As the academic researcher in social sciences, the participant presented one of the agroforestry systems, Tsao-ko cultivation, that is practiced by Miao, Yao, Hani and other ethnic groups in Southwest China. This is an example of an introduced crop that becomes an important source of income for the rural communities. Same as many other introduced crop, the increased market demand in recent decades had led to livelihood improvement of the rural communities, but at the same time, the integrity of natural forests and biodiversity had been jeopardized. A pilot program had been successfully implemented to plant Tsao-ko scientifically in a community forest, which showed that with sufficient support and incentives from the government, the conflicts between rural development and nature conservation could be effectively mitigated.

Agroforestry is currently not being exercised in Mongolia because of the harsh conditions and under-developed agricultural sector. The professor of Department of Forest Science, National University of Mongolia shared his project experience in forest rehabilitation and crop cultivation. The case studies reflected the unique condition of the economy that hindered agroforestry development, but these also indicated the potential to develop inter-planting systems of timber trees and perennial crops to produce timber, protect crops from sand and wind, while providing ecosystem services such as sand fixation and water conservation.

2.2 Southeast Asia

As the population in Southeast Asia increased by six times between 1880 and 1980, the area of forest cover had declined by 25%, and the area of cultivated land had rose by almost five times (Lamb, 2011). In response to the common needs and challenges in agroforestry development in the region, the Southeast Asian Network for Agroforestry Education (SEANAFE) was formed to facilitate educational change in the field of agroforestry and integrated natural resources management. It has over 80 member institutions in Indonesia, Lao PDR,

Philippines, Thailand and Viet Nam that are actively involved in the formal and informal teaching, research, promotion, and dissemination of agroforestry techniques. In general, agroforestry is relatively more developed in Indonesia, Malaysia, Philippines, Thailand and Viet Nam, while it is less developed in Cambodia, Lao PDR and Myanmar.

In Cambodia, more than 60% of the population depends on subsistence farming, while the rural communities are generally poverty-ridden and lack proper farming skills. Development of agroforestry, therefore, is urgently needed. As the deputy chief of Forest Administration, the participant shared his experience in designing guidelines for selecting agroforestry system that suits the soil, climate and geography of a site, while meeting the farmers' needs. Certain issues had been brought to attention: (1) environmental and social problems such as the level of flooding or soil erosion, and the status of land use planning and management, etc. must be taken into consideration during agroforestry design to enhance the ecological functions of the system. (2) In respect to the competitive global market of agricultural products, planners must aim for high quality, or even certified farm products, not just for quantity. (3) Agroforestry should be linked or benefit other industries, such as tourism, to diversify source of income.

Agroforestry was introduced to Indonesia in the early 19th century for the establishment of teak plantations. As the senior lecturer of the Bogor Agricultural University, the participant presented an experimental project that was supported by South Korea under the Association of Southeast Asian Nations (ASEAN) Korea Environmental Cooperation Project (AKECOP) . This project demonstrated the engagement of people who had encroached protected forests in establishing agroforestry systems. With this approach, income of local communities could be secured while they learned to practice sustainable and environmentally responsible production. Community involvement and education was critical to sustainable forest management, and scientifically established agroforestry systems were effective means of reducing social conflicts.

Most rural communities in Lao PDR are smallholder farmers, and about 27% of rural population lives below the poverty line. Without knowledge in terms of selecting the right species, planting and managing of agroforests, the rate of forest degradation or loss will remain high and the livelihood of farmers will not be improved. As the deputy head of Forest Technique Standard Development Division, Department of Forestry, the participant described some efforts made in recent years by some international NGOs on promoting agroforestry for rural development. These programs had enhanced the knowledge and skills of some farmers on tree planting, agroforestry models and marketing, but the impacts of these programs were both short-lived and localized. Issues such as land tenure,

under-developed market system, and low level of support from the government remained to be major challenges to the promotion of agroforestry and rural development.

Agroforestry, in the form of inter-planting of timber trees and perennial crops have been developed and promoted by the Forest Department in Peninsular Malaysia (FDPM) to rehabilitate degraded land, while providing income for local communities. As the senior assistant director, the participant gave an overview of the future strategies of FDPM to effectively implement agroforestry models and promote the involvement of smallholders. These strategies included supporting the research and development of agroforestry models and technologies, providing financial support to farmers for adopting agroforestry, and providing market information and different forms of training to smallholders to practice agroforestry. These strategies at the government level were critical to the promotion of agroforestry and sustainable forest management at the local level, and should be incorporated into national forest policies for effective implementation.

Agroforestry has been practiced in some rural areas of Myanmar as traditional customs, but these systems are not wide spread nor appropriate for large-scale adoption. The project officer of the Lutheran World Federation (LWF) has identified a number of agroforestry systems that are being practiced in Myanmar, e. g. trees on farms, homegardens, trees and aquaculture, paddy cultivation in mangrove forests, and various types of inter-planting of trees and crops, etc. LWF's mission was to contribute to the alleviation of poverty through community empowerment for sustainable development, and it sees great potential in agroforestry in this regard. The project activities of LWF included increasing environmental awareness of the communities, establishing community tree nursery, supporting the conversion from traditional to energy-saving stoves, providing funds and loans to farmers, and providing technical support on agroforestry. This case study demonstrated the important role that NGOs playing in mobilizing resources and promoting community involvement in improving farming practices.

In the Philippines, smallholders constitute about 90% of the farming population (Catacutan, 2012) , and many types of agroforestry systems are being practiced, including alley cropping, tree crop and grazing, improved fallows, inter-planting of timber trees and crops, and indigenous rice terraces. Indigenous rice terraces have been established by the Ifugao tribe on steep mountain slopes for more than 2,000 years. As the senior forest management specialist of the Forest Management Bureau, the participant presented five government forestry programs that had been implemented since the 1980s to facilitate the development of agroforestry and sustainable forest management. Through

these programs, the government aimed to reduce slash-and-burn practices, rehabilitate degraded forestland, increase productivity, conserve biodiversity and mitigate the effects of climate change on food security. There was also an agroforestry project by the Department of Environment and Natural Resources to formulate supportive policies for farmers, provide training on agroforestry techniques and empower communities to manage forestland. It had been found that the most effective approach in sustainable forest management was for government and non-government agencies to offer strong support to communities to rehabilitate and manage forestland, from which the communities gained direct benefits.

In Thailand, forest loss and land degradation have been the major agendas of development. The technical forest officer of the Royal Forest Department provided an overview of the development of smallholder forestry and agroforestry in Northeast Thailand to combat these problems. Traditionally, agroforestry had been practiced in Northeast Thailand in the form of mixed gardens, yet many had been transformed to monoculture of cash crops as market expanded. Forestry laws and regulations were enacted in response to the rapid decrease of natural forest cover and associated biodiversity loss. With the introduction of teak and rubber plantations, inter-planting with food crops and fruit trees was established by farmers to earn quick revenue. In the 1970s and 1980s, agroforestry was further promoted by the government to cope with fuelwood shortages and unsustainable land use. And from 1990 onwards, a number of reforestation projects had been implemented using agroforestry to rehabilitate degraded or salted lands.

Viet Nam has achieved a considerable progress in terms of policies and programs in the forestry sector that facilitated investments in agroforestry. It achieved its targeted increase in forest cover by 43% in 2010, by implementing incentive programs for smallholders to plant more trees and integrate the same on farms (Catacutan, 2012). As the researcher from the Vietnamese Academy of Forest Science, the participant gave a detailed account on different types of agroforestry systems in Viet Nam. Agroforestry had been practiced by indigenous people for a long time, yet the study of agroforestry systems was not conducted until the 1980s. The Land Law (2003), the Law on Forest Protection and Development (2004) and the Forest Development Strategy (2006 – 2020) played critical roles in facilitating the establishment of agroforestry, and rural development programs had introduced new techniques of agroforestry to the rural communities in recent years. A high diversity of agroforestry systems could now be found across Viet Nam, such as growing medicinal plants in plantations, incorporating ecotourism in agroforestry development, practicing aquaculture in mangrove forests, growing rice and

practicing aquaculture and beekeeping in seasonally flooded *Melaleuca* forests, and agroforestry on sand dunes, etc. The future of agroforestry in Viet Nam was bright: the government was facilitating adoption with more supportive policies on credit, loans and investments; international NGOs were carrying out on-going projects to encourage the adoption of agroforestry; and research institutes were actively conducting research on agroforestry systems.

2.3 South Asia

Agroforestry has a long tradition in the South Asia. The socio-religious influence in these economies encourages people to raise, care for and respect trees (ICRAF, 1987) . Therefore, trees have been integrated extensively in the crop- and livestock-production systems across the region. As the deputy conservator of forest from the Forest Department, Bangladesh, the participant presented a project that promoted agroforestry specifically for mitigating the effects of climate change. This case study demonstrated the new important role of agroforestry in an economy with large proportions of coastal communities and forests, where climate change might lead to a greater intrusion of saline water, inundation of coastal lands, river erosion, and more intense flooding, *etc.* An agroforestry model had been developed to afforest coastal sites to mitigate the impacts of storm surges, cyclones and rise of sea level, at the same time it produced income and improved food security of rural communities. This model is a good example of multifunctional agroforestry and participatory approach where various stakeholders and sectors were involved.

Agroforestry systems are relative widespread in Nepal. The planning officer at the Department of Forests introduced a successfully agroforestry program in Nepal that was initially funded by international NGOs, and had later led to government initiatives in many other parts of Nepal . The government provided incentives for farmers to establish their agroforestry farms on degraded land previously used for low-production shifting cultivation, and provided training and other forms of support, including the provision of electricity supply. The program required a high level of government input, but it would produce long-term and significant impacts on the livelihoods of rural communities as the farmers became increasingly self-sufficient and knowledgeable.

2.4 Oceania

A great variety of traditional, smallholder agricultural systems have evolved in the Pacific to meet the diverse range of biophysical and social environments

that characterize the region (Craswell, 1998). However, most of these agroforestry systems have not been scientifically studied and a great proportion has been replaced by monoculture. Flatter areas of fertile arable land tend to be used for commercial plantations and urban development. As a result, the use of sloping lands by smallholders is increasing across the region (Craswell, 1998). The majorities of farmers in the Pacific are resource-poor, use few or no external inputs such as fertilizer, and rely on subsistence agriculture for their food and cash. With the intensification in the use of sloping lands in the Pacific, problems associated with declining productivity, soil loss, and land degradation are increasing (Craswell, 1998). Staple food from tree crops are critical to the nutritional wellbeing of Pacific island peoples, replacement of these foods by highly-processed and imported foods has resulted in widespread malnutrition in the region (FAO, 1999). Furthermore, Pacific islands are more prone to land degradation than others because of their particular biophysical attributes (Lamb, 2011).

Recently, the Secretariat of the Pacific Community (SPC) initiated a program to promote agroforestry because of its potentials in protecting coastal areas and improving food security under climate change, as the Agroforestry and Communications technician described. It had been found that even though some agroforestry techniques such as alley cropping were introduced in the 1930s and 1940s, few people still practiced them today. The major reason was the low level of linkages and collaboration among government sectors, institutions and communities. Further, the trend for young people to quit farming also contributed to the loss of traditional knowledge. In this case, SPC played an important role in developing consistent forest policies and coordinating efforts among economies to solve common problems in the region.

The research scientist at the Papua New Guinea (PNG) Forest Research Institute presented a unique case where 97% of land was owned by local communities (clans). Agroforestry was a traditional practice, but it almost vanished in the 1970s and 1980s because of difficulties to commercialize. Since the early 1970s, research and demonstrations had been carried out to identify the most effective agroforestry systems. But because there were no national policies or strategies to promote agroforestry, its application was limited. Due to the characteristics of the land tenure system, agroforestry could only be successfully implemented in PNG through improving public awareness and education, and enacting policies that provided incentives to the farmers.

2.5 Latin America

Agroforestry is a prevalent land use in Latin America, it covers a total of 200-357

million ha. As a result, agroforestry is fully incorporated in national laws, institutions, and policies; and in the practice of farmers (Somarriba *et al.*, 2012). Commercial silvopastoral systems and shaded tree-crop systems are the most prominent examples in the region (Somarriba *et al.*, 2012). Modern agroforestry in Latin America began in the 1970s with the establishment of Centro Agronómico Tropical de Investigacióny Enseñanza (CATIE), a regional organization to promote agroforestry (ICRAF, 1987). Agroforestry exist in Peru in a number of traditional and modern forms. The general director of Forestry and Wildlife of the Ministry of Agriculture introduced a not so successful case of agroforestry development in the Peruvian Amazon Region. A program was designed and implemented to facilitate small holders' accessibility to high quality germplasm for the improvement of silvopasteroal systems, agroforestry systems, multistory systems and improved fallows. The outcome of this program was unsatisfactory mainly because the selected species did not represent those that were most resistant to diseases, most suitable for local soil conditions, or those that were most likely to be planted by farmers. It was suggested that establishing an organization that facilitate and coordinate the involvement of multiple stakeholders was necessary to implement successful agroforestry programs.

3. Challenges and Opportunities for Agroforestry Development in the Asia-Pacific Region

3.1 Challenges

3.1.1 *Lack of or inadequate policies and government infrastructure to promote agroforestry*

The role of government is substantial in promoting agroforestry because it requires appropriate policies and administering agencies to guide land/forest management and provide incentives to farmers. Agroforestry farmers often face problems such as poor soil conditions, unsecure land tenure, and insufficient planting and marketing skills, etc. Any government policy that can relieve farmers of these difficulties would encourage them to adopt and carry on practicing agroforestry. Government incentives can be in the forms of land tenure, tax credits, technical advice, and planting materials, etc.

3. 1. 2 *Lack of information/technology transfer and cooperation among sectors and communities*

Forestry and agricultural institutions generally have different jurisdictions and territories, which limit their abilities to share information and collaborate. Many economies have separate research institutes and university faculties for forestry and agriculture, which hinder any interdisciplinary training and development. Among communities, farmers are typically smallholders, low-resource and widely-dispersed operators. As such, it is difficult for them to interact with their domestic counterparts and let alone their international equivalents, to exchange information and techniques. Therefore, institutional structures are required to facilitate information flow among sectors and communities regarding agroforestry techniques and market development, etc.

3. 1. 3 *Lack of funding for research and development*

Public spending on agriculture is the lowest in agriculture-based counties, while their share of agriculture in Gross Domestic Product (GDP) is highest (World Bank, 2007). Currently, funding for agroforestry research and development are very limited, and it mostly comes from donors. A more efficient way to increase funding for research and development is to attract investments from private sectors with profitable market opportunities. For smallholders, the adoption of agroforestry is both costly and risky. Their capitals need to increase and they need to cope with increased uncertainties in productivity and the markets. Innovations in finance can provide smallholders with better access to credit, savings facilities, money transfer mechanisms, remote payments, and leasing.

3. 1. 4 *Lack of efficient marketing systems and marketing skills*

With increasing domestic and global market demands, trade and marketing of forestry and agroforestry products have penetrated into remote forest areas. Without effective marketing systems and governmental control mechanisms, over-exploitation and irreversible environmental damage could result. Changes in commodity prices or labor costs can make farms uneconomic, which may also cause sites to be overexploited and degraded before being finally abandoned. Thus, efficient marketing systems, coupled with adequate marketing skills of farms, are crucial for sustainable agroforestry development and the development of value-adding processing.

3. 1. 5 *Lack of agroforestry knowledge and models*

Agroforestry requires sectors and farmers to change their perception on what is conventionally regarded as best for forestry or agriculture. For example, the adoption of agroforestry may require replacement of some crops with timber trees that produce slow return. Communities with traditional knowledge and techniques in agroforestry are usually more willing to adopt modern forms of agroforestry. Scientifically-tested agroforestry models ensure the use of appropriate species combinations and management systems. Most smallholders lack resources and knowledge to develop appropriate models on their own.

3. 1. 6 *Problems associated with land tenure*

Secure land tenure is particularly important to encourage long-term investments in trees and land improvements to enhance food production (FAO, 1999). Secure tenure and use rights of farmers will require some policy reorientation, particularly with existing regulations designed to keep people out of the forests. New mechanisms can increase the security of property rights, facilitate land reallocation and facilitate access to land for the landless. Farmers lacking tenure contribute significantly to forest and land degradation as they move to a new site once productivity declines rather than invest in improving productivity (FAO, 1999).

3. 1. 7 *Natural threats such as climate variability, climate change, invasive species, pest and disease*

Agriculture in South and Southeast Asia is particularly vulnerable to weather-related hazards, especially tropical cyclones, storm surges, floods, and droughts (Iglesias, 1996). Changes in the current climate patterns would cause severe impacts on agricultural productivity in these regions. Climate change could also raise the sea level, leading to flooding of low-lying coastal regions that support high populations and extensive agricultural production (e. g. in Bangladesh). Climate change could also increase the risk of insect and disease outbreaks, which subsequently lead to crop failures and income losses. It is thought that agroforestry can help reduce these risks, but the introduction of more productive or fast-growing species in new sites could create new pests. Little progress has been made so far in reducing uninsured risks in smallholder agriculture. State-managed insurance schemes have proven largely ineffective (World Bank, 2007). As a result of natural disasters or other forms of disturbance, farmers are forced to sell their assets; their children are forced out of school, intensifying the problems of poverty and development. Weather-

indexed insurance is a new way proposed to mitigate farmers' risks (World Bank, 2007).

3.2 Opportunities

3.2.1 *Development of international and regional networking to support technology and germplasm exchange*

There are currently a few international and regional organizations that are dedicated to the promotion of agroforestry. The World Agroforestry Centre (WAC) was established in 1977 (formerly known as the International Council for Research in Agroforestry) with the funding from over 50 governments, private foundations, international organizations and regional development banks. Its mission is to generate science-based knowledge about the diverse roles that trees play in agricultural landscapes, and use its research to advance policies and practices that benefit the poor and the environment. To improve agricultural productivity for better lives of rural populations, the Food and Agriculture Organization of the United Nations (FAO) carries out projects and produce publications to promote sustainable production and agroforestry. A regional FAO project supported by the Government of Japan and the United Nations Development Program (UNDP) has established the Asia-Pacific Agroforestry Network (APAN). APAN has facilitated the establishment of a number of national-level agroforestry networks or working groups that are linked to one another for information exchange. It also publishes the Asia-Pacific Agroforestry Newsletter (APA News) online twice a year that provides information on agroforestry research, promotion and development, and education and training to researchers, practitioners and policy-makers in the region. APFNet plays an important role in promoting and improving sustainable forest management and agroforestry through capacity building, information exchange and support for regional policy dialogues and pilot projects. The International Board for Soil Research and Management (IBSRAM) was established in 1983 with the aim of promoting soil management research in developing economies. It creates research networks on common soil and land management issues, and the role of agroforestry in sustainable management of sloping lands is the subject of networks in seven economices in Asia (Asialand) and four economies in the Pacific (Pacific Land). Despite all the efforts made by these organizations, new mechanisms between economies to exchange information and superior germplasm are pressingly needed, and this requires policies on free exchange of agroforestry research results and technology, and open exchange of superior germplasm.

3. 2. 2 *Establishment of national organizations or networks to enhance multidisciplinary research on agroforestry*

Agroforestry has been shown capable of mitigating multiple problems of the society. Its full potential cannot be developed and utilized without information exchange and collaborations among government sectors (agriculture, forestry, fishery, economic development, and environmental protection), research institutes (agriculture, forestry, fishery, biodiversity, and social studies), NGOs and communities.

3. 2. 3 *Facilitation of community participation*

Decentralization holds the potential to deal with the localized and heterogeneous aspects of agriculture, and community-driven development can also harness the potential of their local knowledge, creativity, and social capital of rural communities (World Bank, 2007). A participatory approach also enhances the effectiveness of natural resources management and the ability to resolve conflicts. Smallholders can engage in more effective collective action to access services, achieve economies of scale in markets, and acquire voice in policy making. Enhancing smallholders' participation in agroforestry needs market infrastructure, upgrading farmers' technical capacity, risk management instruments, and collective action through grassroots organizations (World Bank, 2007).

3. 2. 4 *Development of processing enterprises to improve value chain*

High-value markets open new opportunities for the private sector to foster innovation along the value chain. To take advantage of these new opportunities, it often requires partnerships among the public sector, the private sector, farmers and grassroots organizations in financing, developing, and adapting innovation. More developed processing operations can motivate the production of raw agroforestry products. And developing processing operations in the local communities can also improve financial income of farmers, but farmers require technological and market support, as well as financial support such as low-interest loans.

3. 2. 5 *Marketing opportunities*

There is enormous potential for community-based production and marketing of non-wood forest products and agroforestry products for domestic and export

markets. However, developing economies face many barriers and forms of protectionism in the trade of forest products, imposing great burden on small enterprises (FAO, 1999). These barriers can be reduced, and sustainable rural development can be encouraged by adjusting market and trade arrangements. This can be achieved through forums and trade negotiations with the World Trade Organization (WTO), the Asia-Pacific Economic Cooperation (APEC), the Association of Southeast Asian Nations (ASEAN), South Asian Association for Regional Cooperation (SAARC), etc. In addition, government sectors and NGOs should help develop and expand the markets of agroforestry products, or assist the farmers to break into existing market by providing subsidies for product promotion, and exempting agroforestry products from levies, etc. Through systems of certification, consumers can support the development of agroforestry by buying goods from sustainable production systems. Furthermore, the development of carbon trade [e. g. the Clean Development Mechanism (CDM) and the Reduced Emissions from Forest Degradation and Deforestation (REDD+) projects] can also act as incentives for smallholder farmers. CDM and REDD+ offer a range of incentives for smallholders, such as direct payments and capacity building.

4. Commentaries

4.1 Commentary on Agroforestry in the Asia-Pacific Region

Asia-Pacific economies face some common problems and opportunities in environmental protection, economic and social development, only in varying degrees. Most economies in the Asia-Pacific Region are dominated by the tropics, whilst most of the forest losses in the world today occur in the tropics (FAO, 1999). Forests in the Asia-Pacific Region generate a high proportion of income and employment, yet the region has the fastest rate of deforestation, the fastest rate of commercial logging, the highest volumes of fuel wood removed from the forests, and the fastest rates of species extinctions. The economies losing the largest areas of forest are in Southeast Asia, which include Indonesia, Malaysia, Myanmar, Philippines and Thailand (FAO, 1999).

East Asia and South Asia are some of the most densely populated regions of the world, and the population rise in Southeast Asia is insurmountable (it rose by 6-fold between 1880 and 1980) (Lamb, 2011). Due to the rising demand for food, these regions and many other economies in the Asia-Pacific Region are faced with pressing issues of shrinking agricultural land and serious deforestation. And these led to the development of large-scale monocultural

operations in recent decades at the expense of traditional small-scale agroforestry systems, and farmers are forced to cultivate ever steeper slopes and less fertile sites (FAO, 1999). Sloping land constitutes 60%-90% of the land resources in many Southeast Asian economies (Craswell, 1998). Conversion of additional marginal areas is likely to have a net negative effect on food production and food security in the long-term. Therefore, agroforestry in these regions is particularly important for achieving sustainable development, enhancing farming systems on marginal lands, and mitigating soil and water degradation as well as deforestation.

Some of the most poverty-ridden economies are found in Southeast Asia, South Asia and Latin America, where people are highly dependent on forests for food security. Governments of these regions in particular, are struggling to reduce unemployment, produce more export crops for foreign exchange, increase domestic food supply to mitigate upward pressure in wages and prices, and generate domestic sources of investment (FAO, 1999). Forestry in these economies is dominated by family-or community-oriented operations. Thus agroforestry has great potential to contribute substantially to rural development and poverty alleviation in these regions.

Low-lying island and coastal economies are more vulnerable to the effects of climate change due to predictions on sea level rise and increased risk from extreme weather events (IPCC, 2007). The increased incidence of extreme high sea level would lead to decreased freshwater availability due to saltwater intrusion. Coastal ecosystems such as mangroves and salt marshes are particularly affected by climate change due to multiple stresses. Small islands are also more at risk where there is high exposure of population and infrastructure to projected climate change impacts (IPCC, 2007). Apart from various costly adaptation strategies such as relocation and construction of storm surge barriers, agroforestry can be promoted and developed in these regions to prevent coastal erosion, mitigate the effects of flooding, and diversify production of local communities to enhance food and economic security.

Large areas of the warm, humid tropics in Southeast Asia, the Pacific and Latin America are mountainous. An estimated 500 million people practice subsistence agriculture on steeply sloping lands around the world (Craswell, 1998). Continued population growth has led to the intensified cultivation and grazing of large areas of the sloping lands, exacerbating the problem of soil erosion. Soil erosion is a prominent problem in most developing economies such as China, Philippines and PNG. Repeated erosion reduces fertility of the soil, and it can lead to other environmental problems including water degradation and river sedimentation. Although research shows that alley cropping and other contour agroforestry systems can stabilize the sloping lands, these systems have not

been widely adopted by farmers.

All in all, there is a range of policy incentives in the forestry and agriculture sectors at global, national, and local levels that can provide opportunities for smallholder agroforestry. Incentive or support mechanisms should be designed to meet each economy's unique conditions as well as the specific needs of smallholders.

4. 2 Commentary on APFNet's Workshop on Agroforestry for Rural Development

As described above, information exchange is crucial to the development of agroforestry in the Asia-Pacific Region and worldwide. APFNet, as one of a few international organizations that promote information exchange and cooperation in sustainable forest management, should take on a more important role in agroforestry development. APFNet's Workshop on Agroforestry for Rural Development is an invaluable opportunity for key officials from government sectors, research institutes and NGOs to share their experience in agroforestry, identify difficulties and issues, and suggest possible ways to mitigate such issues. At the moment, no follow-up activities are being carried out after APFNet's workshops. The impacts of its workshops can be effectively enhanced by (1) follow-up on the progress of the focal points in disseminating information shared during the workshop, (2) establishing the online forum for discussion and technical support for the focal points, and (3) organizing workshops on agroforestry periodically to monitor and support progresses.

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Agroforestry Case Study in Peninsular Malaysia

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Abstract

The Forestry Department of Peninsular Malaysia (FDPM) first implemented an agroforestry project in the 1950s in the Mata Ayer Forest Reserve, based on Myanmar's taungya system. Local farmers planted and tended both agricultural cash crops and forest timber trees until the trees were ready for harvest. The Forestry Department of Negeri Sembilan adopted this practice to rehabilitate degraded areas in the Permanent Reserved Forests and to implement community forestry so that participating farmers could earn income from the sale of agriculture crops while they cared for the trees.

At present, agroforestry is recognized as an important component of national socio-economic development. However, this approach needs to be modified when establishing forest plantations so that objectives for their management can be met. Given the time it takes for trees to mature and the fact that initial investment is high in terms of the cost and risk to establish forest plantations, agroforestry is a viable option. Other advantages are that it maximizes land use and improves productivity. This paper highlights efforts that FDPM is undertaking with regard to two agroforestry models: planting between rows (inter-row planting) and planting along perimeters (perimeter planting).

1. Introduction

The FDPM implemented its first agroforestry project in the 1950s when it planted alternate rows of teak trees and selected perennial crops such as hill paddy and tobacco at a small scale. The purpose was to rehabilitate degraded areas in Mata Ayer Forest Reserve in Perlis. Local farmers planted and tended both agricultural cash crops and forest timber trees until the trees were ready for harvest. This model is based on Myanmar's taungya system and on Indonesia's tumpangsari system, both of which call for farmers to balance agriculture and forestry in a single area so as to generate higher incomes from these two land uses.

Although the plantation was at a small scale, encouraging results prompted the expansion of the model to the State of Perak where alternate rows of *Gmelina arborea* (a forest timber tree) and tobacco were planted. In the early 1970s, this system was implemented in Kenaboi, Gallah and Setul Forest Reserves in

Negeri Sembilan, mainly to rehabilitate degraded areas. The timber trees were selected from indigenous and exotic species: meranti (*Shorea* spp.), kapur (*Dryobalanops aromatica*), kelempayan (*Anthocephalus chinensis*), *Toona sureni*, mahogany (*Swietenia macrophylla*), *Gmelina arborea*, pine (*Pinus* spp.) and *Araucaria* spp. They were planted with perennial (cash) crops—banana, papaya, pineapple, chili, pumpkin, maize, groundnut, sweet potato, watermelon, yam and ginger.

The FDPM is exploring other agroforestry models which could also be adopted when establishing a forest plantation. Given the time it takes for trees to mature and the fact that initial investment is high in terms of cost and risk, agroforestry is a good option because it can generate early revenue from the sale of agricultural crops. The first two models FDPM explored were inter-row planting and perimeter planting (Table 1). This paper highlights efforts to develop them.

Table 1 Study Sites

Location	Tree species	Area(ha)	Model
Alienated Land, Mukim Pulau Manis, Pekan, Pahang	*Khaya ivorensis*, Pisang Berangan, Tongkat Ali	2.5	Inter-row planting
Rancangan Tanah Berkelompok, Bukit Tarek, Hulu Selangor	Karas, Mahogany, *Khaya ivorensis*, Petai, Tongkat Ali and Agro Crops	20.0	Perimeter planting

2. The Importance of Agroforestry

Agroforestry involves the intentional integration of forest species into agricultural land use systems or *vice versa*—the intentional integration of perennial agricultural crops into forestland. Animal husbandry can also be added to this mix. If these systems are introduced after considering the conditions of the land and the needs of farmers, they play important roles in conserving the forest environment and rehabilitating degraded forestland. If planned, implemented and managed properly, agroforestry is also capable of increasing productivity and profits as well as maintaining ecosystem diversity and processes. As importantly, the Third National Agricultural Policy recognizes agroforestry as a desirable land use system.

3. FDPM Agroforestry Models

3.1 Case Study

FDPM's objectives of the study that it undertook on agroforestry were to:

(1) rehabilitate degraded forest areas;
(2) explore practical, suitable and viable models for commercial production by the private sector and smallholders; and
(3) promote the involvement of local communities.

The State of Pahang was implementing inter-row planting (model 1) and Selangor was testing perimeter planting (model 2). In the first instance, agricultural cash crops were intercropped with trees and medicinal plants to optimize use of the space. In the second instance, forest tree species and medicinal plants were planted along the borders of agricultural crops.

3.2 Model Frameworks

Frameworks for models 1 and 2 are found below, each with its unique strengths and weaknesses (Figures 1 and 2). However, both share a common planting technique where all crops are in rows at specific distances apart to facilitate maintenance and harvesting. The layout and crops are determined by factors such as land tenure, size and fertility of site, farmer preferences, rotation cycle of the timber trees, combination of the perennial (agro) crops and forest species, and silvicultural and management systems.

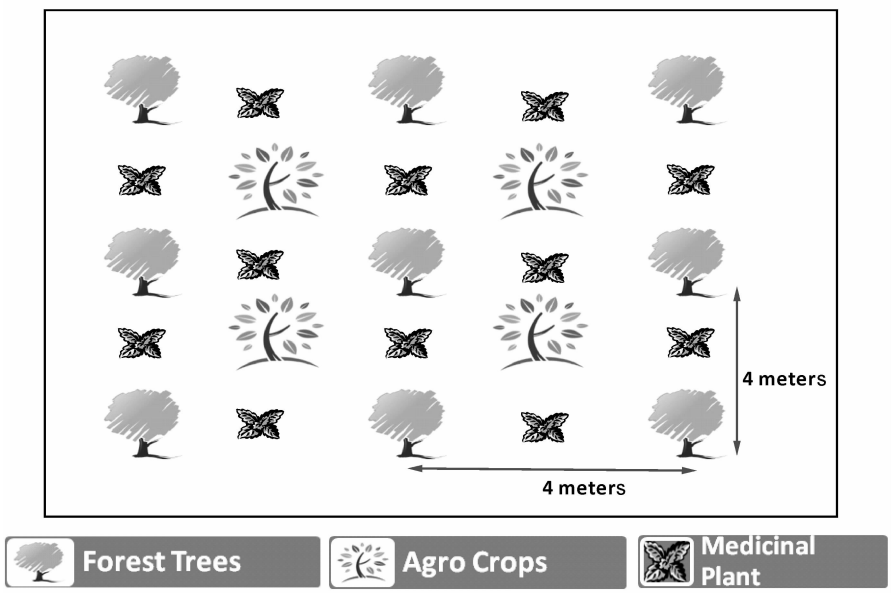

Figure 1 The inter-row model

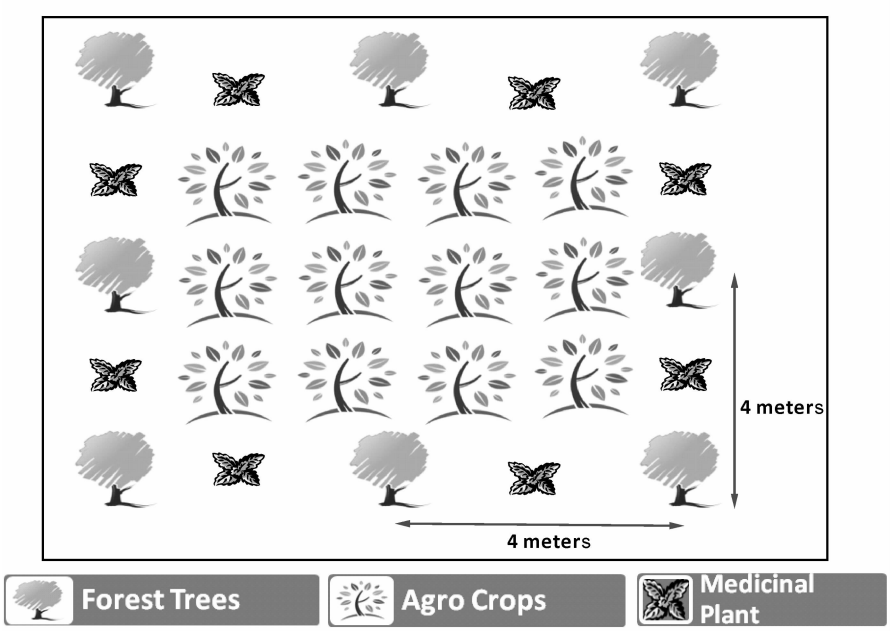

Figure 2 The perimeter model

4. Issues and Challenges

4.1 Organizational issues and challenges

Agroforestry requires close collaboration across sectors and technical input from a range of partners, including agriculture, forestry, veterinary and husbandry, fisheries and research institutions. The Forestry Department's experience in this regard showed that each organization had its own priorities and interests. Therefore, the government should establish a One-stop Agroforestry Centre to deal with issues and to provide advice to farmers on this way of farming.

4.2 Financial issues and challenges

Financial institutions are still reluctant to consider agroforestry as a sound investment because of its close association with the long-term and high risk nature of forestry. Therefore, government should provide funds and incentives to attract both large-scale entrepreneurs and smallholders to invest in and incorporate agroforestry into their estates/plantations. For example, it could reduce the land premium where agroforestry is practiced and subsidize the cost

of tree seedlings and seeds of selected agricultural crops.

4.3 Different models and planting designs

Agroforestry models vary in the way that planting is designed for and it is sometimes difficult to determine the best one when establishing forest plantations because many factors must be taken into account, such as those listed above. However, the final selection should reflect the priorities of participating farmers which is generally based on the model which incurs lower cost relative to the revenue it generates in the short term.

4.4 Research and development

Participants lack the technical knowledge to choose the most appropriate model for site conditions so that more research and development are needed to strengthen this aspect. More often than not, farmers prefer a model that generates early revenue, with minimum cost, short gestation periods and low risk. Therefore, they are reluctant to introduce forest timber trees, instead preferring to plant perennial cash crops. Inputs from relevant and interested agencies on the combination of crops and planting design on a site would be helpful.

4.5 Land tenure

Secure land tenure continues to be one of the most important factors for successful implementation of agroforestry. While high land premiums and other restrictions may hinder its adoption, the availability of large suitable tracts of land is crucial. Tenure was not an issue in the pilot project which was implemented on alienated land but, for the people who are farming in the forest reserve, the state forestry department must issue them permits and they must abide by FDPM rules. Thus, it is essential to strengthen cooperation and promote farmer involvement during the development phase of projects.

4.6 The way forward

Future FDPM strategies to effectively implement agroforestry models and promote the participation of large and small-scale operators call for the following improvements.

4.6.1 *Efficiency and productivity*

Steps will be taken to support and encourage smallholders and farmers to cultivate forest trees, rattan, bamboo, medicinal plants, food crops, rubber and oil palm to maximize land utilization and productivity. The private sector will be encouraged to practice agroforestry on a large scale by adopting inter and mixed cropping on their plantations.

4.6.2 *Competitiveness*

Efforts will be made to identify the best crop mix and production system in different regions, along with the end products downstream, which will yield maximum benefits. In addition, government will collect and disseminate market information to support smallholders and owners of plantations to move into this new area of mixed cropping.

4.6.3 *Economic foundation*

Incentives and financial support will be provided to smallholders and plantation owners to move from monocultures to mixed cropping. In addition, state governments will be encouraged to reduce land premiums and royalties for agroforestry development.

4.6.4 *Integrated research and development*

Efforts will be made to accelerate the development of new technologies for agroforestry and to identify crops and forest tree species that can be integrated for maximum benefit. Further work is needed to identify various agroforestry models which are practical, viable and acceptable to farmers. Collaboration should be strengthened between the research institute and universities to study biological and physical factors, especially the choice of species, their growth requirements and site suitability, control of pests and diseases, as well as silviculture and management systems such as planting direction, spacing, thinning, pruning and fertilizer.

4.6.5 *Capacity building*

Short courses, seminars and consultancies on agroforestry will be given to enhance and diversify the skills and knowledge of smallholders. Moreover, extension services will be upgraded to include mixed cropping and the skills of

department staff will be enhanced to help farmers use new technologies. Handbooks and manuals, based on experience and lessons learned in the trials, will be developed as a further aid to farmers involved in agroforestry.

4.6.6 *Enhancing knowledge and information exchange*

Additional efforts are needed to develop/strengthen networks and linkages with other agencies, research bodies, universities, the private sector and smallholders to exchange information, knowledge and experiences related to agroforestry.

5. Conclusion

The revised National Forest Policy in Peninsular Malaysia provides the basis for a coordinated agroforestry programme which will help to achieve sustainable forest management, maintain a stable environment and provide a continuous supply of forest products in rural areas. The role of FDPM in promoting agroforestry is bringing direct and indirect benefits to society. Its importance to rural livelihoods in terms of adapting to and mitigating the effects of climate change is also better recognized.

Agroforestry in the Philippines

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1. Introduction

The Philippines is an archipelago which consists of more than 1700 islands. Its land area of 30 million ha is legally classified as alienable and disposable land and forestland. Based on 2001–2003 satellite images, forest cover is an estimated 7.168 million ha (24.27% of total area), the breakdown of which is shown in Table 1.

Table 1 Forest cover in the Philippines

Category	Forest area in forestland (ha)	Forest area in A and D lands (ha)	Total forest area (ha)	Percentage of forest area (%)
Closed forest	2,495,833	65,039	2,560,872	35.72
Open forest	3,578,526	452,062	4,030,588	56.23
Mangrove	165,425	81,937	247,362	3.45
Plantation	281,764	47,814	329,578	4.60
Total	6,521,548	646,852	7,168,400	100.00

Source: Philippine Forestry Statistics (2003).

The Philippines, like many other Asian economies over the last century, lost forest cover through heavy logging, upland migration and agricultural expansion. It went from 17.0 million ha in 1934 to 6.461 million ha in 1988. However, forest cover increased by 10.94% between 1988 and 2003, mainly due to regrowth of vegetation, plantation establishment and spontaneous tree planting by farmers and others on public and private lands.

Over the years, government initiatives to rehabilitate degraded forestland have evolved in response to changing socio-economic, environmental and political realities. Early efforts were meant to restore forest cover, provide environmental services and supply timber. More recently, they have been undertaken to improve the socio-economic conditions of communities living in forested areas.

The Philippine government advocated agroforestry as an alternative to the destructive slash-and-burn practices of many upland farmers. As a strategy to rehabilitate degraded forestland, agroforestry was an attempt to deal with both poverty and damage to the environment. Given this potential, it was integrated into community-based forest management as an effective way to increase productivity, address climate change and conserve biodiversity. Some of the programs which combine agroforestry and sustainable forest management are

described below.

Integrated Social Forestry Program (ISFP): this program was initiated in 1982 through Letter of Instruction 1260 to assist upland farmers to turn their lots into permanent and productive agroforestry farms. They are issued a 25-year Certificate of Stewardship Contract (CSC) which is renewable for another 25 years. It is awarded to individuals or families who were occupying or tilling portions of forestland prior to January 1, 1982. The contract allows them to peacefully occupy, cultivate and enjoy all income/proceeds derived from a designated area. One requirement of the program is to farm trees on at least 20% of the land to maintain ecological stability.

Community-based Forest Management (CBFM): in 1995, Presidential Executive Order No. 263 consolidated all people-oriented government forestry programs such as the ISFP. CBFM is the national strategy for sustainable forestry and social justice. Its primary instrument is the Community-based Forest Management Agreement (CBFMA) which is awarded to local communities or People's Organizations. Like the ISFP, the term is 25 years, renewable for another 25. As of 2008, 321, 638 households belonging to 1, 783 People's Organizations were issued about 1, 783 CBFMAs covering 1. 62 million ha. Components are forest rehabilitation including agroforestry, forest protection, development of alternative livelihood opportunities which do not necessarily depend on forest products and forest products utilization.

Upland Agroforestry Program (UAFP): as per Department of Enviroment and Natural Resources (DENR) Administrative Order 2005 – 05, individuals are granted a minimum of 50 ha of open and unproductive forestland to establish and develop agroforestry farms and plantations, including on lands within the CBFMAs and on forestland used for other purposes such as grazing. The program promotes and encourages collaboration between government and the private sector to increase forest cover, productivity and employment; ensure sufficient supply of agricultural and fruit tree crops; and improve the economic well-being of upland communities. Participation in the program requires successful applicants to sign a Joint Venture Agreement or Memorandum of Agreement with DENR.

Upland Development Program (UDP): this program aims to accelerate reforestation and agroforestry development by engaging People's Organizations, small landholders, local government, communities and civil society. Areas targeted include those covered under CBFMA or Protected Area Community-Based Resource Management Agreement, small holdings within the watershed of marginal farmers who are not part of CBFMA, and fragile protected areas.

National Greening Program (NGP): Executive Order No. 26, promulgated in

2011, consolidates all government greening efforts under this program which promotes agroforestry as one of the modes of development within CBFM. The NGP seeks to achieve sustainable development for poverty reduction, food security, biodiversity conservation and climate change mitigation and adaptation. It aims to plant some 1.5 billion trees, including indigenous species and mangroves, on about 1.5 million ha between 2011 and 2016 for timber, fuelwood, coffee, cacao, rubber, bamboo, rattan and fruit.

2. Agroforestry practices

Agroforestry is defined as the management of forestland which increases productivity by properly combining forest trees, agricultural crops (annual, biennial and perennial) and livestock simultaneously or sequentially over time through the application of compatible management practices. In the Philippines, traditional agroforestry has been practiced for generations, including farm-based systems of alley cropping or hedgerow intercropping, multistorey, tree crop/grazing. Agroforestry systems can also be forest-based such as taungya, alley cropping integrated with tree plantations, and terraced rice cultivation in forests.

2.1 Alley cropping

Alley cropping is better known Sloping Agricultural Land Technology (SALT). Trees or shrubs are placed along the contours, usually in double hedgerows. The strips or alleys in-between are planted with annual and/or perennial agricultural crops.

2.2 Multistorey

In this system, mixed species occupy different canopy levels. Trees or other woody perennials form the upper layer to provide partial shade to agricultural crops in the lower layers. Examples are a mix of coconut – coffee – pineapple – banana in Cavite Province, Albizia – coffee/cacao in Mindanao, a mix of coconut – banana – pineapple of the Subic-Cawag Farmers Association (a People's Organization) in Subic, Zambales, and a mix of *Gliricidia* and coffee which is found in many areas. This system can be adapted by interplanting shade-tolerant species under established tree and coconut plantations.

2.3 Home gardens

Home gardens are predominantly coconut-based and are an important land use in the Philippines. The number and type of species vary from garden to garden and province to province. They can have as many as 4 vertical canopy strata—a common structure of individual farm lots under CBFM of the Subic-Cawag Farmers Association.

2.4 Tree crop/grazing

Animals such as cattle, carabao and goats graze freely under mature tree plantations. This system has proven practical and economical because the land is fully utilized while being maintained and protected.

2.5 Trees as farm boundaries

Trees have traditionally been planted around agricultural fields to serve as boundary markers, live fences, firebreaks or windbreaks. When mature, some are harvested to make posts or to use in light construction. Depending on site suitability, preferred species include *Gliricidia*, *Leucaena*, *Alnus* and *Swietenia macrophylla*.

2.6 Trees as live trellis

The tops of trees—mostly *Gliricidia sepium* and *Leucaena leucocephala* —are pruned to serve as live trellis for climbing crops such as beans, peppers, yams and cucumbers. A People's Organization (LUFAMCO) under a CBFM in the municipality of Liliw, Laguna practices this method as its main source of livelihood. After each cropping season, the posts are left in the farm and allowed to coppice and grow. For the following season, the leaves and young branches are removed and placed as mulch at the base of forest trees. Aside from helping to conserve soil moisture, mulches are also rich in organic matter when decomposed. *Gliricidia sepium* does not only serve as trellis but also increase productivity because of its ability to fix nitrogen the soil.

2.7 Fallows

This system is said to be the oldest form of agroforestry, where farmers clear

the land, burn and, without plowing, plant agricultural crops such as corn, cassava and banana. After a few years, the area is left to rejuvenate but it is not abandoned. Rather, the farmer moves from one piece of land to another in a well-defined rotation cycle.

The improved fallow system is similar to traditional shifting cultivation except that selected species of trees, often nitrogen-fixing, are cultivated during the fallow period to enhance and accelerate soil rejuvenation. An example is the naalad system in Naga, Cebu. Native ipil-ipil (*Leucaena* spp.) trees are used during the 5-to 6-year fallow period. They are then cut and the branches are piled along the contours to form a fascine-like structure ("balabag") that traps the eroded soil. In time, natural terraces are formed, thus stabilizing the steep slopes.

2.8 Taungya

Taungya is an agroforestry system in which agricultural crops are planted in newly established reforestation areas. As soon as the tree canopy closes and blocks the light that is required to grow crops, farmers move to another reforestation area and repeat the process. The Family Approach to Reforestation Program of the Department of Environment and Natural Resources was an example of this practice.

2.9 Rice terraces – forest coupled agroforestry

The Ifugao tribe in northern Philippines has practiced this sustainable form of agroforestry for more than 2000 years. Bench terraces are constructed along steep mountain sides and rice is planted throughout the year. A network of canals along dikes which originate from natural springs provides irrigation. This system is also practiced in the province of Bohol where terracing the steep slopes probably accounts for its sustainability. Moreover, the forest stands not only prevent land slippage but also serve as watersheds to irrigate the rice.

3. Issues, Approaches, Lessons and Impacts

The issues, approaches taken, lessons learned, results and impacts of rehabilitation efforts listed below are taken from the report of Center for International Forestry Research (CIFOR) (2006) and from DENR's observations during project monitoring and evaluation.

3.1 Issues

- Improper matching of species to site and species combination;
- Inconsistent or contradictory policies;
- Lack of livelihood opportunities for upland farmers;
- Insufficient marketing support, including road access to markets;
- Apathy of villagers to rehabilitation projects;
- No follow-up after the project ended so that many areas became open again;
- Lack of facilities, support and farmer training for processing to add value;
- Inability of low income upland farmers to compete with corporate farms in terms of quality and price of produce;
- Low productivity; and
- Environmental concerns such as pests and diseases, soil erosion and natural calamities.

3.2 Approaches

- Increasing skills to practice agroforestry through training and visits to successful projects;
- Encouraging communities and farmers to engage in forest rehabilitation through targeted campaigns;
- Organizing, training and empowering communities to effectively manage the forestland and directly benefit from their efforts ;
- Providing additional livelihood support, especially non-wood based alternatives; and
- Formulating stable supportive policies;

The most promising approach, based on the results of the study of CIFOR (2006) , is for government and non-government agencies to offer strong support to communities and farmers so they can rehabilitate and manage the forestland and directly benefit from their efforts.

3.3 Lessons learned

3.3.1 *Physical aspects*

• Species must be matched to site conditions and the proper species combination must be selected to ensure good survival rates, growth and financial returns. The provision of technical guidance and materials by government is also important, as is the availability of quality planting materials of the appropriate species.

• The planting of many species in mixed stands or in mosaics reduces pests and diseases.

• The survival of planted areas involves paying attention to technical and socio-economic issues.

3.3.2 *Socio-economic aspects*

• Government-led community projects should consider livelihood support to ensure their sustainability.

• Both short and long term income generating options are needed for communities to engage in rehabilitating and managing the areas. If only short term benefits are offered, people return to their former activities after the project is over. A promising approach combines employment opportunities, livelihood schemes and long-term benefits from the sale of agroforestry and timber products.

• Community empowerment and capacity building is a must to help manage farms and funds as well as harvest and market products. Because it may take a long time before communities can manage themselves, continued long term assistance and an appropriate financing mechanism are necessary.

3.3.3 *Environmental aspects*

• Impacts of projects on soil and water must be evaluated, particularly given that ①this aspect drives many projects; ②observation of impacts vary widely; and ③ perceived links between forests and large scale flooding and landslides drive forestry policies in the Philippines.

• The planting of many species in agroforestry systems can enhance biodiversity while meeting production and livelihood needs.

3.3.4 *Production and marketing aspects*

• The government and other agencies need to provide market support for products generated by local communities and the private sector in order to sustain efforts and investment in rehabilitation.

• The development, dissemination and implementation of clear and consistent policies are required for managing and harvesting different types of forestland in terms of legal status, conditions of tenure and institutional arrangements. Such policies should be framed following information exchanges and negotiations with stakeholders which are well facilitated. Provisions should be based in legislation to reduce vulnerability to political changes.

• Upland communities need assistance on technical and marketing aspects because fruit and other non-timber crops are an important source of income over the long-term while they maintain tree cover.

3.3.5 *Other lessons*

FAO (1996) cited other lessons learned over the last two decades of agroforestry in the Philippines.

• When project implementers live with the farmers, they develop a closer and more harmonious working relationship and the transfer of technology that occurs in this situation makes farmers feel they are partners in the initiative.

• The bayanihan communal work system strengthens cohesion among group members in performing farm activities.

• The involvement of key leaders and local officials in meetings, special occasions and social activities related to the project helps to motivate farmers.

• The success of community projects depends on how extension officers harmonize indigenous knowledge and technology with research findings.

• The best strategy to mobilize people and encourage self-reliance is to make them partners in development.

• To enhance farmer capability, they must receive on-farm training and be encouraged to become involved in farm planning and development.

• On-site research provides continual technical support to development activities.

• Farmer knowledge should be used when appraising agroforestry technology.

• The establishment of demonstration farms is important to showcase agroforestry technologies and serve as learning laboratories for communities.

• Planting contour hedgerows in areas with slopes of 18% ~30% is economically advantageous and should be extensively promoted.

• The use of tested technologies to minimize soil erosion in agroforestry systems should be adopted as apolicy.

• Technologies developed through experience can strengthen the extension efforts of People's Organizations.

3.4 Results and impacts

The impacts of agroforestry in the Philippines are both environmental and socio-economic.

From 1988 to 2003, reforestation and tree growing had increased forest cover by 0. 7 million ha through the Integrated Social Forestry Program (ISFP) and Community-based Forest Management (CBFM) which established about 185, 497 ha of plantations between 1996 and 2002. Agroforestry also resulted in on-site and off-site environmental benefits such as soil and water conservation and increased soil fertility. Tree hedgerow planting in cultivated hillside led to less soil erosion and surface run-off, and this practice improved soil fertility.

With the recognition of local communities as partners in forest management and development, those which occupied the land had been given secure tenure through CBFM agreements. People's Organizations had been granted the legal right to develop and manage their lands and to use/earn income over the long term from the products they grow such as fruit and agricultural crops.

4. Challenges and Opportunities

• Agroforestry projects require continuing government technical assistance to be sustainable.

• Further research and development are needed to test the applicability and replicability of agroforestry systems in various site conditions and to improve current practices and technologies.

• Direct links to market must be established for agroforestry products.

• Under the National Greening Program (NGP) , areas for agroforestry development must be expanded.

• Policy and regulations must be made consistent and logical through consultations with stakeholders.

• Under the National Convergence Initiative, four agencies (the Department of Environment and Natural Resources, the Department of Agriculture, the Department of Agrarian Reform and the Department of the Interior and Local Government) have formed a partnership to achieve the objectives of the NGP and this collaboration is facilitating implementation.

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A Summary of Agroforestry Systems in Viet Nam

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1. Introduction

Agroforestry systems are a combination of trees and crops and/or animals integrated either in a spatial mixture or temporal sequence. The systems are well known for generating economic and environmental benefits such as supplementing incomes, reducing risks associated with climate change, protecting soil and sequestering carbon.

Agroforestry had been practiced in Viet Nam ever since indigenous people in mountain areas drew on their knowledge and experience to choose and arrange many tree species and crops on fallow land around their homes. In addition, the garden – fishpond – pigen (VAC) model had been widely applied on the plains since the 1960s. Rural development programs in mountainous regions also introduced new techniques to sustainably practice agroforestry on slopes. It had been undertaken both at the household level (several ha of agricultural and forest land) and at the farm level (hundreds or thousands of ha). The former usually provided basic needs for food (e. g. vegetables, meat, eggs) and materials (e. g. timber and resin) or to sell products to earn cash. The latter was often commercial in nature, managed by enterprises or communities.

Viet Nam is divided into 8 agro-ecological zones, according to its tropical monsoon climate and diverse topography (Figure 1): Northeast, Northwest, Red River Delta, North Central Coast, South Central Coast, Central Highlands, Southeast and Mekong River Delta. People in rural areas had long practiced agroforestry in one form or another but models were not documented until the 1980s. Some popular systems had been applied nationwide, while others had been found only in certain areas.

2. Agroforestry Systems in Viet Nam

Decision No. 1828/QD-BNN-TCLN, dated 11/8/2011, notes that Viet Nam had approximately 13.4 million ha of forests in 2010: 10.3 million ha of natural forest and 3.1 million ha of plantation forests, which were divided into 3 types of forests, i. e. forest for special use (2 million ha), protection (4.8 million ha) and production (6.4 million ha).

Figure 1 Agro-ecological zones in Viet Nam
(Source: http://www.jpn-vn-redd.org)

The Land Law (2003), the Law on Forest Protection and Development (2004) and the Forestry Development Strategy (2006–2020) are key documents which regulate the establishment of agroforestry systems in the different types of forests in Viet Nam.

2.1 Agroforestry models

2.1.1 *Description of Agroforestry models*

The list below describes popular agroforestry systems in Viet Nam. No fixed models are in place because farmers in each region tend to modify tree species or crops to meet household or market demand for products (the components in brackets are optional).

(1) Agrisilviculture (trees – crops)

Multipurpose trees – crops

- Cinnamomum cassia – upland rice – cassava;
- Cinnamomum cassia – (pineapple) (*Schizostachyum*) (*Indosasa*);
- Illicium verum – (*Canarium album*) (Shane Tea) (*Tephrosia candida*) (*Annas aquatic*) – cash crops;
- Manglietia conifera – (*Dendrocalamus* sp.) – cash crops;

• Cassia siamea – Leucaena glauca – (cash crops) (*Coffea arabica*);
• Styrax tonkinensis – upland rice;
• Tectona grandis (*Manglieta glauca*) – bamboo – cash crops;
• *Pinus* sp. – (Manglietia confier) (*Eucalyptus* sp.) (*Crotalaria* sp.) (bamboo) – cash crops;
• Vernicia Montana – Manglietia confier –*Crotalaria* sp. –*Tephrosia* candida – tea – cash crops;
• (Erythrophloeum fordii) (*Peltophorum pterocarpum*) (*Ormosia* sp.) – bamboo – cash crops;
• Aquilaria crassana – (Livistona saribus) – cash crops.

Exotic trees – (indigenous trees) – crops
• Acacia auriculiformis – cash crops – (Tephrosia candida);
• Acacia mangium – cash crops;
• Acacia hybrid – (*Erythrophloeum fordii*) (*Cinnamomum obtusifolium*) (*Catanopsis* sp.) (*Canarium album*) (*Tephrosia candida*) (*Dendrocalamus* sp.) – cash crops;
• Eucalyptus camaldulensis – cassava – Tephrosia candida (*Dendrocalamus* sp.).

Trees – crops – fruit trees
• (Eucalyptus camaldulensis) (Acacia auriculiformis) – (litchi) (longan) (Jujube tree) – cash crops – (*Annas aquatica*) (*Dendrocalamus* sp.);
• (*Pinus* sp.) (*Camelia* sp.) (*Vernicia Montana*) – (litchi) (longan) (Jujube tree) – cash crops – (pineapple) (*Dendrocalamus* sp.).

(2) Agrisilvipasture (crops – trees – pasture – animals)
• Natural or plantation forest – crops – livestock (RVAC);
• Forest – tea – cash crops – livestock;
• Acacia – cassava – livestock;
• Manglietia glauca – Guatemala grass – livestock;
• Forest – fruit trees – cash crop – livestock.

(3) Agrihorticulture (fruit trees – crops)
• Pomelo – mango – *Arachis pintoi* ;
• Longan – litchi – Jujube tree – soybean – peanut;
• Jackfruit – (tea) (pepper) – pineapple;
• Multistorey models, including:
  • trees demanding significant light, e. g. durian, coconut, mango, jackfruit;
  • trees demanding medium light, e. g. lanzone, mangosteen, Burmese grape;
  • trees demanding little light, e. g. banana.

[Sources: revised from Nguyen Ngoc Binh (1985); Department of Science and Technology (1987); Nguyen Ngoc Binh and Pham Duc Tuan (2005); Dang Thinh Trieu, Nguyen Huy Son, *et al.* (2005); Bao Huy, Vo Hung, *et al.* (2008); Nguyen Van Chung (2009).]

2.1.2 *Specific agroforestry models*

Multipurpose trees (indigenous trees) – crops: In mountainous areas, land allocated to households is often hilly and farmers apply most agroforestry systems listed above. The planting of multipurpose trees, in combination with crops, is typically done in the northwest and northeast since the 1980s. Trees are the main component, while cash crops are interplanted to provide additional food and material in the first few years, before the canopy closes. The trees in these models differ from location to location due to soil, climate, tree characteristics and local market demand. Table 1 shows the main trees planted and their uses. Cash crops also vary, depending on the needs of households and crop characteristics (e. g. upland rice, corn, peanut, soybean, ginger, rattan, *Amomum loniligulare*). Leguminous trees such as *Tephrosia candida* and *Cassia siamea* are often planted to fertilize the land.

Table 1 Usage of some multipurpose trees in agroforestry models

Vietnamese name	Scientific name	Usage
Quế	*Cinnamomum cassia*	Essential oil is extracted from the bark, branches and leaves which are also used in traditional medicine
Hồi	*Illicium verum*	The timber is consumed by the family. The fruit is eaten, used in traditional medicine and for the extraction of essential oil
Trám trắng	*Canarium album*	The fruit is eaten and can be dried, either sugared or salted. It is also used in traditional medicine. The resin is used to make incense and colophane. The family uses the timber for fuel and furniture, for example
Thông nhựa	*Pinus merkurii*	The resin contains colophane/turpentine oil which is used widely in industry. The essential oil is a traditional medicine. The family uses the timber and sells any surplus
Trẩu	*Vernicia montana*	The essential oil extracted from the seeds is used widely in industry. The residuals can be use as fertilizer or food for cattle after detoxication. The bark can be use for fuel. The timber is used by the family or to make pulp
Trầm hương	*Aquilaria crassna*	The agarwood is a valuable resin used to make incense. The timber is used by the family or for making board
Sở	*Camelia* sp.	The seeds are a rich source of valuable oil which is used for many purposes. The family uses the timber
De ăn hạt	*Catanopsis* sp.	The seeds can be eaten and can also be sold for a high price. The bark contains tannin and the family uses the timber
Cọ bầu	*Livistona saribus*	The leaves are used in roofing and the seeds can be eaten. Many parts of the tree can be used for handicrafts and in other ways

Source: information from the website kiemlamvung1. org. vn.

Fast-growing exotic trees – (indigenous trees) – crops: since the introduction of fast-growing exotic trees such as *Eucalyptus* sp. and *Acacia* sp. (nitrogen-fixing), farmers in many regions have combined them with cash crops (e. g. peanut, corn, soybean and cassava) in the first few years. Many households have also mixed them with indigenous trees such as *Erythrophloeum fordii*, *Cinnamomum obtusifolium*, *Catanopsis* sp., *Canarium album* and *Michelia mediocris*. The exotic trees are often harvested in 5 – 6 years to make pulp, after which time more are planted. This model is popular in northern provinces (Phu Tho, Vinh Phuc and Tuyen Quang) because of their proximity to the Bai Bang paper company which buys the pulp to manufacture paper.

Natural or plantation forests – medicinal plants: trees mixed with *Amomum achinosphaera* or ginger is a recent agroforestry model which has expanded to many provinces because of its high economic value. *Amomum achinosphaera* is a well-known traditional medicine and sells for a high price in markets. However, it requires a certain canopy closure to grow well. Through research, new techniques have been developed to plant *Amomum achinosphaera* under the canopy of both natural and plantation forests.

Fruit trees – crops: the system of planting fruit trees with crops was only developed for commercial purposes after projects introduced improved tree varieties and provided technical assistance to farmers. Litchi from Hai Duong, longan from Hung Yen and plum from Son La are shipped across Viet Nam and their high economic value has helped many farmers to escape poverty.

Fruit trees – crops – ecotourism: the Red and Cuu Long River Delta areas offer favourable conditions for combining fruit trees and crops, usually in 3 layers. The trees are selected based on their requirement for light. Local people developed the ˝Miet Vuon˝ model which adds eco-tourism as a third dimension, an aspect which has proven to be of high economic value.

Trees – crops – animals: in addition to the agrisilviculture systems noted above, agrisilvipasture is practiced in mountainous areas where households raise buffalo, cows, pigs, ducks and chickens, for example, for food and to draw ploughs.

Forest – garden – fishpond – cattle/poultry (RVAC): this system has been practiced in mountainous areas of Viet Nam for a long time. It includes 4 components (Figure 2). The natural or plantation forest is located at the top of mountain or upper hills to protect lower land from soil erosion and to regulate water flow. Multipurpose trees and cash crops or grass to feed the cattle and fish are grown at mid-point of the hill. Fruit trees and vegetables are usually planted at the foot of the hills and around houses. Fishponds are often located close to the garden on the lower land, cattle are released to graze in the mountains and poultry are raised near the house for meat and eggs.

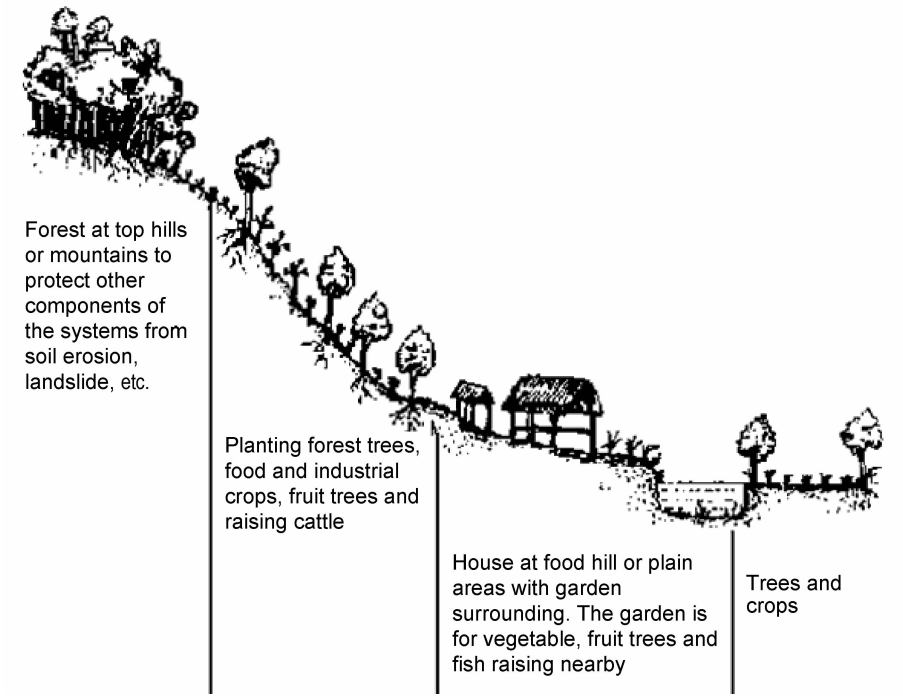

Figure 2 Cross-section of a RVAC system
(Source: Edited from greenstone. org)

2. 2 Agroforestry models in coastal/flooded areas

Aquaculture in mangrove forests: mangrove forests are found in 29 ones of Viet Nam's 64 provinces and perform critical environmental functions in coastal areas. They are the most important source of income for millions of people, providing abundant fish, crab, shrimp, shellfish, mussels, conch, snail and eel. Farmers have been practicing this type of agroforestry for a long time and experience has shown that the ideal proportion of mangroves to total area is between 30% and 60%. Successful models of aquaculture in mangroves are the following:

- integrated shrimp – crab farming in Ca Mau Province;
- aquaculture-silviculture in Fishery and Forestry Company 184, Ca Mau Province;
- ecological shrimp farming in Ngoc Hien District, Ca Mau Province;
- aquaculture in Can Gio District, Ho Chi Minh City;

• alternative extensive greasy-back shrimp farming in Yen Hung District, Quang Ninh Province; and

• farming of crab, rock hind fish (*Epinephelus adsensionis*), blood cockle (*Anadar granosa*) and mud creeper (*Cerithidea obtuse*).

(Source: Ngo Dinh Que, Pham Trong Thinh, *et al.* 2012.)

Melaleuca forests – water rice – aquaculture – beekeeping: according to Nguyen Quang Trung (2009), Viet Nam had about 176, 295 ha of Melaleuca forests in 2006, mainly in the Mekong Delta (Long An, Dong Thap, Kien Giang, Tien Giang, An Giang and Ca Mau Provinces). The forests often tolerate flooding for 6 or more months during the rainy season, are an important part of the ecosystem and provide a major source of income to the local people. Farmers in these areas combine Melaleuca forests with aquaculture, beekeeping and crops such as water rice which is alum-tolerable but requires NPK fertilizer (Figure 3). Between 20, 000 and 30, 000 trees are planted per ha and thinning is done in the 6th year. Flowers of the *Melaleuca* tree are of high quality and can support beekeeping. Where water is deeper than 50 cm and stays longer than 6 months, fish farming is done (Figure 3).

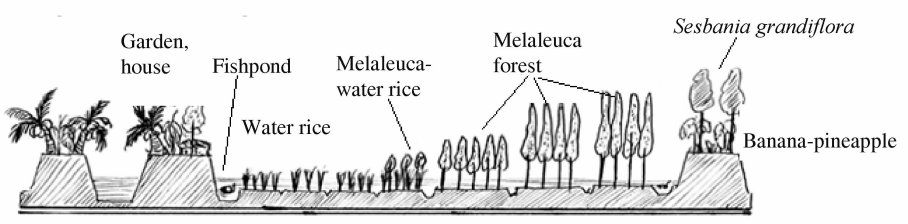

Figure 3 Agroforestry with Melaleuca forest
(Source: Nguyen Viet Khoa, Tran Ngoc Hai. ,*et al*. , 2006)

2.3 Agroforestry in the Central Highland

The Central Highland contains the largest area of bazan soil in Viet Nam – more than 1. 7 million ha. Perennial industrial trees such as coffee, cashew, pepper and rubber grow well and their products are traded in the international market. People often practice the taungya system by mixing these trees with cash crops such as soybean, peanut, mulberry and *Ceiba pantandra*. In addition to this intercropping, farmers raise poultry to meet family needs. In some areas, this model is modified to interplant fruit trees of high economic value such as durian (Table 2).

The Central Highland is also known for combining the multipurpose tree Boi loi

do (*Litsea glutinosa*) with cassava which was previously grown in monocultures. However, this practice was found to be detrimental to the environment and unstable as a source of income. The branches, leaves, bark and roots of the *Litsea glutinosa* produce essential oils and its timber is of high quality. Leaves also provide fodder for the cattle.

Table 2 Agroforestry in the Central Highland

Modified Models
Coffee – (durian) (pepper) (cashew) (*Cassia siamea*) (fruit trees) (cash crops) (livestock)
Cashew – (squash) (green bean) (maize)
Pepper – (*Wrightia pubescens*) (Betel nut tree)
Rubber tree – (cacao) (coffee) (cash crops)
Litsea glutinosa – cash crops

Source: Nguyen Ngoc Binh and Pham Duc Tuan, 2005; Bao Huy. , Vo Hung. ,*et al.* , 2008.
Note: the components in brackets are optional.

2. 4 Agroforestry on sand dunes

North central Viet Nam, especially the provinces of Ha Tinh, Quang Binh, Quang Tri, Da Nang and Quang Nam, has large areas of moving sand which make it difficult for plants to grow. Before agriculture can be practiced, the sand must be stabilized. Since *Casuarina equisetifolia* can survive strong winds and shifting sands, the tree is most suited to this special region. Therefore, a typical agroforestry model consists of Casuarina belts (*Acacia orassicarpa*) – cash crops – grass. Most parts of the tree can be used for fuel and leaves provide fodder for the livestock or are employed in making paper powder. However, the protective function of the Casuarina is perhaps the most important. Moreover, new varieties of Acacia (*Acacia terulosa, Acacia tumida, Acacia difficilis*) that can tolerate drought conditions have been discovered and they are now being combined with cash crops as well.

3. Lessons Learned

Agroforestry plays an important role in achieving sustainable development. Planting multipurpose trees in combination with cash crops in the first few years can provide a stable income until the trees are harvested. Multistorey models take full advantage of all natural conditions (light, soil, water) and increase the number of products per land unit and length of time.

Some aspects of agroforestry require special knowledge, for example, to regulate light, apply specific techniques and preserve product quality after harvest. However, indigenous people in mountainous areas often lack capacity and information to obtain maximum benefits from their agricultural practices. Thus, it is important to research issues related to agroforestry systems and share the findings with farmers.

Finance is a significant barrier for poor people who wish to invest in agroforestry. The first few years normally require more money to set up the systems, with little or no return in the short term. Thus, policies should be developed to make it easier for farmers to obtain credit for capital expenditures as they start new businesses.

Information on market demand, requirements and trends is important for the success of agroforestry systems. Moreover, it must reach local people in a timely fashion. In this regard, agriculture and forestry extension staff play a key role in ensuring that local people have the knowledge, that they need to operate effectively. In addition to responding to market demand, products should have brand names so they attract international interest. The establishment of groups or cooperatives to promote fair trade of agroforestry products is another way to gain market share.

Risks associated with climate change (e. g. higher incidences of extreme weather, more frequent and intense natural hazards, increased prevalence of pests and diseases) are threatening the sustainability of agroforestry systems and, in turn, food security and rural livelihoods. Therefore, models that can survive changes in climate must be found – those which use plant varieties that can adapt to and tolerate different conditions.

Some experts maintain that a knowledge-based approach to agroforestry is the most suitable way to achieve sustainable land use and that selection of the components (trees, crops, animals) must respect natural conditions, be consistent with market trends and take into account local experiences and scientific findings. Otherwise, these systems are likely to fail. For example, cold spells kill acacia trees, cardamom trees do not develop fruit or farmers will destroy trees if their products have no market.

4. Looking Ahead

Government is facilitating the development of the agricultural sector by issuing supportive policies on credit, loans and investments. In addition, applied research is conducted annually to solve immediate problems and to provide a

scientific basis for agroforestry systems. International organizations are also helping Viet Nam to achieve sustainable rural development.

In 2011, the Australian Centre for International Agricultural Research, in collaboration with the World Agroforestry Centre and Viet Nam's Ministry of Agriculture and Rural Development, launched a 5-year project in Son La, Dien Bien and Yen Bai Provinces named "Agroforestry for livelihoods of smallholder farmers in north western Viet Nam". Aims are to develop agroforestry systems most suited to three agro-ecological zones i. e. the zones: below 600 m, 600 – 800 m and above 800m, improve the availability of high-quality germplasm to expand agroforestry, enhance market access and engage in processing to add value to products, improve adoption methods and policy dialogue to further implement agroforestry systems.

This project will help to establish and strengthen agroforestry systems in Viet Nam's northwest – one of the areas most vulnerable to the anticipated effects of climate change.

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Agroforestry in Myanmar

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Abstract

During its transition to a democracy, Myanmar has been seeking to reduce poverty and develop rural areas by adopting integrated approaches, securing technical assistance and mobilizing funds. It is endowed with vast forests and other natural resources on which it depends for social and economic development. The new National Forest Policy focuses on biodiversity conservation and emphasizes participatory forestry, consistent with legislation which allows villages to establish community plantations on public forestland, including on reserves. The Forest Department has also decentralized its management to relieve socio-economic pressure and reduce rural poverty. Programs have been launched, especially in environmentally critical areas such as the Ayeyardady Mangrove Delta, Southern Shan State, and the Dry Zone. Research has also been conducted, for example, on community forestry, agroforestry, non-timber forest products and small-scale forest enterprises as components of rural development.

1. Introduction

Myanmar's ecological features range from snow-capped mountains to tropical rainforests and coastal and marine ecosystems. This wide variety of environmental conditions support many diverse flora and fauna: 285 families of flora, including 10,000 species of trees, shrubs, herbs, bamboo and climbers – all of which can help to reduce poverty and achieve rural development.

Most agroforestry systems are based on traditional knowledge but require appropriate technologies to be effective and to yield benefits. Government is collaborating with UN (United Nations) agencies, civil societies, the private sector and non-government organizations at the international, national and local levels to reduce poverty and promote rural development.

As a land use practice, agroforestry can protect watershed areas and their functions, for example, through soil conservation and enrichment. It can also increase productivity and the number of products. In addition, it can rehabilitate degraded areas through afforestation and reforestation. Certain land in Myanmar, whether public or private, are kept under forest cover to secure their

optimal contribution to national development (Table 1).

Table 1 Land categories in Myanmar

Category	Area (km^2)	Percentage of total area (%)
Closed forest	293,262	43.35
Degraded forest	50,968	7.53
Forest affected by shifting cultivation	154,389	22.82
Water bodies	13,327	1.97
Non-forest	164,624	24.33
Total	676,570	100.00

Source: Forest Resources of Myanmar (1991).

Forests cover 344,23 km^2 (50.88% of total area, 20.66 % of which is reserved forests and public forests). As table 2 shows, forest types are highly varied.

Table 2 Categories of forests in Myanmar

Type	Area (ha)	Percentage of total area (%)
Tidal, beach and dune, and swamp	1,376,900	4
Tropical evergreen	5,507,800	16
1. Tropical wet evergreen		
2. Tropical semi-evergreen		
Mixed deciduous	13,425,300	39
Dry	3,442,400	10
Deciduous dipterocarp (Indaing)	1,721,200	5
Hill and temperate evergreen	8,950,100	26
1. Hill evergreen		
2. Dry hill		
3. Alpine		
Total	34,423,700	100

Source: Forestry in Myanmar, Forest Department (1999).

Table 3 summarizes the area of land under different uses.

Table 3 Land utilization in Myanmar (2009 –2010)

Type	Area (ha)
Net sown area	11.98
Fallow land	0.24
Cultivable waste land	5.61
Reserved Forests	16.90
Other forest	16.25
Other	16.68
Total	67.66

Source: Myanmar Agriculture in brief (2011).

2. Agroforestry in Myanmar

Agroforestry has been practiced in the Asia-Pacific region for decades. However, other than traditional systems in rural areas, farmers in Myanmar have not applied it widely because they lack knowledge about how to match the appropriate trees and crops with climate and topography. Information about market demand and pricing is also scarce. With rising population, the expansion of factories and urbanization, agroforestry is gaining in popularity. The development of markets is also making it easier for farmers to sell their products. The following agroforestry systems have been found in Myanmar.

2.1 Crop cultivation in Forests

(1) Crop + crab apple system.

(2) Crop + bamboo system: patches of bamboo form a border around croplands.

(3) Crop + trees: Tamarind,*Schima wallichi* ,*Butea monosperma* and many more broad leaf species are preserved on borders for shade and fuel wood.

(4) Crop + fruit trees + tree species: crab apple, dog fruit, avocado and forest tree species are retained on the border and between the fields. Bamboo patches are also found.

(5) Crop + scrub vegetation + forest tree species: in drier conditions, bushes/ shrubs help to demarcate the boundaries of fragmented land holdings. Middle-sized *Schima* or *Toona* trees are also retained and scattered across the area.

(6) Crop + banana + forest species: banana is cultivated on the bunds and borders.

(7) Crop + local fruit: avocado and dog fruit are cultivated along the borders.

(8) Crop + pear: pear is cultivated along the border of fields.

(9) Tea + forest trees + crops: this farming system is the main one found in Pindaya Mountain (Shan State) . Jew, an important cash crop of the area, together with ginger and turmeric, are cultivated on terraces between the rows of tea.

(10) Tea + cheroot + forest trees: tea is mixed with cheroot leaf in the forest.

(11) Coffee + jack fruit + forest trees: coffee plantations are established under jack fruit and other shade giving forest species. This practice is common in low-lying valleys with high rainfall. Avocado and dog fruit trees are also retained for shade.

(12) Banana + pineapple + forest trees: banana and pineapple are planted on terraces in drier sites, with avocado trees and other local trees growing along the border. In addition, vegetables (mainly cucurbits) are cultivated in furrows.

2.2 Paddy cultivation in mangrove forests

Rice paddies are established between mangrove plantations which the Forest Department rehabilitated. This system is prevalent in the Ayeyarwaddy Delta region but it is also practiced in the Rakhine and Tanintharyi regions. The trees are spaced 6 feet (1 feet = 0. 3048m) apart and paddies are cultivated in-between for 1 to 3 years.

2.3 Paddy cultivation in fresh water near dikes

Paddy cultivation near the embankment is done in the upper delta region which has access to fresh water all year. Vegetables (roselle, gourd, cucumber, long pea, snake pea, bitter gourd, mustard and others), bananas and areca nuts are planted in different seasons, and *Eucalyptus* and bamboo can be found in certain areas. Water asparagus is also grown and aquaculture is practiced on a small scale, including in salty areas during the rainy season.

2.4 Aquaculture and forestry

This system is found in salty areas flooded by tides. The soil should be clay and clay loam so that fish and prawns can be easily farmed. Trees are planted around ponds or drains.

2.5 Village nurseries

The success of reforestation and agroforestry in rural areas depends on having an adequate supply of seedlings. The Forest Department operates nurseries and distributes seedlings to institutions, schools and individuals. International and national environmental NGOs have also established tree nurseries and they provide training, financial support and materials to build others. The nursery funded by UNDP (United Nations Development Program) produces more than 200, 000 saplings per year, including mangrove trees, non-mangrove trees, fruit trees as well as horticulture and herbal plants.

2.6 Agroforestry in village communal places

Depending on the space available in communal places such as schools, foot paths and monasteries, villagers, students and teachers plant trees in these areas, including fruit trees. Organizations provide the funds to buy the seedlings from community or private nurseries or they are provided free of charge. To celebrate the International Day for Disaster Reduction on 13 October every year, government, international NGOs and villages organize tree planting in communal places on this day.

2.7 Trees on farms

Trees are grown in agricultural fields and often along farm boundaries to act as shelter belts and windbreaks. In the delta region, Eucalypts are commonly planted in these areas and on the bunds of paddy fields. When army worms destroy paddies, one farm shows no signs of the infestation because myna (*Acridotheres tristis*) and little egret (*Egretta garzetta*) make their nest in the Eucalypts and eat the pest.

2.8 Home gardens

A home garden is a farm unit in which a number of crops, including tree crops, are combined with livestock, poultry and fish production, mainly to meet basic family needs. Coconut, areca nut, guava, mango, citrus, tamarind, jack – fruit, papaya, banana, moringa, sesbania, custard apple and many multipurpose trees are grown in such areas, where agroforestry is also practiced. The Lutheran World Federation has trained most poor households in vegetable production and given them the seeds to grow crops for their own consumption and to earn revenue from the sale of any surplus.

3. Experience and Lessons

3.1 Community-based organizations and capacity building

Villages require capacity to engage in participatory processes, take advantage of emerging development opportunities and improve access to support services and inputs. In this regard, community groups have been set up to undertake activities and to act as receiving points for project services-development

committees, committees to reduce risks from disasters, as well as farmer, women (livelihood issues), and youth groups, for example. They promote solidarity, support each other, collaborate to solve problems, share knowledge and realize savings.

3.2 Environmental awareness

International NGOs raised awareness of environmental issues among rural people where projects are taking place, including on matters related to climate change, the ozone layer, natural disasters and resource degradation. As a result, management in these areas has improved.

3.3 Traditional medicine

Knowledge of traditional medicine and use of herbal plants is not widespread among rural people. Some herbal plants are grown with trees and new opportunities to establish small businesses are emerging. The Lutheran World Federation and the Myanmar's Traditional Medicine Department have provided training in traditional medicine and in the making of soap and shampoo from natural products. Both these areas can generate income and motivate villagers to manage resources in a sustainable manner.

3.4 Energy-saving stoves

Training has been given in project sites to make energy-saving stoves to sell and 97% of households are now using them. They consume 45% – 50% less wood and cooking time is shorter compared with the traditional method. Thus, fewer trees are cut, not as much money is needed to buy fuel wood and family members have more time for other things.

3.5 Revolving fund

Inadequate access to financial services is one of the most critical constraints to rural development and this problem affects many sectors. For example, small farmers have limited access to operating funds for the purchase of seeds, fertilizer and other inputs as well as to capital investment for livestock, irrigation equipment and post-harvest facilities. Those who manage to receive loans from the Myanmar Agricultural Development Bank generally obtain only a fraction of the cost of production. In the absence of formal financing, many farmers must resort to moneylenders and pawn shops, where interest rates are extremely

high. Therefore, many international NGOs, UNDP, Pact Myanmar, International Development Enterprise and the Lutheran World Federation are offering micro credit schemes and revolving funds to increase access to rural financial services.

3.6 Aquaculture

Fish are important for food security and income generation and this component is an integral part of some agroforestry systems. The Lutheran World Federation and other organizations, in collaboration with technical experts from the Fisheries Department, have showed people how to raise fish, prawns, crab and eel more effectively.

4. Conclusions

In terms of rural development, agroforestry offers both economic and environmental benefits. It also encompasses other sectors, including fisheries, livestock, agronomy and forestry. Participatory approaches are needed to achieve integrated sustainable resource management and community-based organizations/interest groups must be closely involved in development activities. Resource mobilization and training to acquire knowledge and learn new techniques are also prerequisites for successful implementation.

Inadequate access to financial services seriously constrain rural development. A community development fund, revolving fund or self reliant group would increase access to investment loans at low interest rates.

Every effort is being made to resolve issues related to population pressure, rural poverty and forest degradation. The challenge is not merely to find better ways to grow trees, conserve natural resources and harvest them more efficiently, but also to sustainably manage them to increase benefits without damaging the environment. Rural development and poverty reduction can be achieved by shifting from a top – down approach to a bottom – up one at national and regional levels.

Networking, capacity building, and information/knowledge sharing among government departments, UN agencies, international and local NGOs, and the private sector are essential to reduce poverty and achieve rural development.

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Agroforestry Practices in the Pacific

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1. Introduction

Agroforestry is a traditional Pacific Island practice which integrates trees with crops and/or animals. It is increasingly recognized as a way to combine sustainable agricultural production and economic development with environmental conservation and land improvement. Dr. Randy Thaman noteds that most species and techniques had not yet been subject to scientific experiments but generations of farmers had been testing them over time. This indigenous knowledge is invaluable because it provides a locally-based framework for future development of agroforestry systems.

Although Pacific Islanders plant and protect trees as a part of their traditional agroforestry and land use systems, they also accept new trees that improve their life and their island environments. Since it is more difficult to replace forests, agroforests, trees and rare cultivars of trees (e. g. breadfruit, coconut, pandanus and banana), experience has shown that it is better to protect what exists. Dr. Thaman also emphasized that knowledge about these systems and species must be kept alive.

Pacific Island states are especially vulnerable to the negative impacts of climate change and, in this regard, agroforestry systems are beneficial in two respects: they not only sequester carbon to mitigate its effects, but they also enhance the adaptive capacity of other agricultural systems in the region. Agroforestry practices have been developed and managed to meet basic needs for food and other products as well as to supply fertilizer, mulch, fodder and shade. The trees in the system also protect against erosion, wind and salt spray. For these reasons, the Secretariat of the Pacific Community (SPC) is implementing a program entitled ˝Forests and Trees˝, of which agroforestry is a key component, along with sustainable forest management. Early this year, it organized a regional training session to raise awareness of the concept and encourage Pacific Island states to adopt this approach.

2. Issues/Challenges

In the near future, SPC intends to set up demonstration plots to test agroforestry practices in one of the Melanesian islands, followed by Polynesia

and Micronesia. Training on plant propagation is also planned. For these and other activities, SPC looks forward to collaborating with APFNet, the African-Caribbean-Pacific Forest Research Network and the Technical Centre for Agriculture and Rural Cooperation and additional partners to secure much needed funding to carry out agroforestry projects.

The major issues faced by Pacific Islands are food shortages, nutritional insecurity and climate change. In this regard, an interesting study was conducted in Fiji to determine what interventions have survived over time and what trees people still plant for what purpose. For example, the use of trees for shade, live fences and ornamentals have a history, including the use of gliricidia in hedges on the island of Viti Levu (Calliandra hedges have had mixed success and, thus, are not widely adopted) . Thaman reported that the use of gliricidia as live fences did not take off until the 1980s but shade trees had long been used in the cultivation of coffee, cocoa, vanilla and pepper. Although trees continue to be used for conservation barriers, reforestation, green manure and soil enrichment, few inter-cropping and alley cropping techniques of the 1930s and 1940s are still part of today's farming systems.

Lack of linkages and cooperation among institutions involved in agroforestry appear to be a recurrent theme. Even within the same ministry, different divisions working in the same area often have little contact. Similarly, communications among people who work in agroforestry outside government is weak and some key institutions are sidelined.

The University of the South Pacific (USP) is also active, especially in traditional agroforestry, but its links to government are weak. In May 1988, a working group was formed to coordinate and guide all agroforestry initiatives in Fiji. Its establishment led to greater involvement and collaboration among different units in the Ministry of Agriculture Forestry and Fisheries (MAFF) but membership is limited to MAFF Extension, Research and Livestock Division, the Forestry Department' s Silviculture Research Division and the Fiji – German Forestry Project (see below) .

3. Approaches

3.1 About Tonga

Tonga's agroforestry system consists of a mixture of trees, shrubs and ground crops. It is usually practiced as shifting cultivation on an average of 8 acres (1 acres =4046. 86m^2) or less. When the land is prepared for a new garden, some

of the fast-growing pioneer tree species, most shrubs and grasses are cut, dried, then piled and burned. Other valuable trees in the fallow – breadfruit, mangoes, avocado, citrus trees, Malay apple (*Syzygium malaccense*), Polynesian plum (*Spondias dulcis*), ylang-ylang (*Cananga odorata*), and coconut palms – are protected or slightly pruned to allow sunlight to enter the garden. Other culturally important trees – koka (*Bischofia javanica*), Pacific litchi (*Pometia pinnata*), maululu (*Glochidion ramiflorum*) and toi (*Alphitonia zizyphoides*) – are pruned, often by cutting off most of the branches. This practice allows sunlight to reach the first crop, usually yams (*Dioscorea alata*). In addition, fallen leaves provide the soil with organic material and fresh new branches grow as the garden matures.

The larger cut branches are used to build trellises over each mound of yams which, when climbing off the hot volcanic soils, have higher yields, are freer from disease and are weeded more easily. Because Tonga has frequent and severe cyclones (known elsewhere as hurricanes or typhoons), the lower trellises are much better than those mounted on poles which are used in other parts of the region. When the yams are harvested in 7 –9 months, the branches make perfect firewood for the underground ovens.

In the garden, yams are usually intercropped with rows of giant taro (*Alocasia macrorrhiza*), plantains (*Musa cultivars*) and taro (*Colocasia esculenta*). Sweet yams (*Dioscorea esculenta*), pandanus for weaving, sugarcane and bush hibiscus spinach (*Abelmoschus manihot*) are often planted along the border or fence line. Living fences are made of candelnut tree (*Aleurites moluccana*), beach hibiscus or fau (*Hibiscus tiliaceus*), dadap or ngatae (*Erythrina variegata*). In some cases, a few rows of timber trees such as Casuarina equisetifolia or introduced species such as Australian kauri (*Agathis robusta*) or West Indian mahogany (*Swietenia macrophylla*) are planted along the perimeter or along the roadside border of the allotment. Sometimes, these timber trees form a small woodlot on part of the land. The garden also grows green onions (*Allium fistulosum* and *A. ascalonicum*), Chinese cabbage (*Brassica chinensis*) and corn (*Zea mays*), for example. Bird-sown chili peppers (*Capsicum frutescens*) are protected in these areas.

After the yams, giant taro and taro are harvested. Taro or tannia (*Xanthosoma taro*) is then planted in the softened soil and this second crop, along with bananas, remain. When these are harvested, sweet potatoes or cassava are planted next, sometimes in combination. If only sweet potatoes are planted at this point, cassava follows and completes the 3-to 4-year cycle. Sometimes, this rotation is extended a further 3 –5 years by either planting kava (*Piper methysticum*), an important social beverage plant, or paper mulberry (*Brousonnetia papyrifera*) which is used to make tapa cloth for Tongan ceremonies, to sell to tourists and to export. As the garden returns to fallow for 4 – 10 years, the plantains and

other trees continue to bear fruit. Other multipurpose trees continue to provide food, medicine and other products.

3.2 About Kiribati

Several varieties of coconut palm are planted as a major cash and multipurpose crop, sometimes in rows and sometimes in irregular patterns. Other multipurpose trees such as *Pandanus* , *Guettarda speciosa* , *Tournefortia argentea* and the shrub *Sida fallax* (te kaura in Kiribati or ilima in Hawaii) are protected or planted to enrich the soil and fertilize the swamp taro (*Cyrtosperma chamissonis*) pits that have been excavated down to the water table. *Pandanus* is also an important staple food on the atolls and a source of timber for houses, thatch for roofing, fibre for mats and baskets, medicine, and many other products. Because of its many uses, the people of Kiribati are referred to as the" Pandanus People" . Breadfruit, papaya, native fig (*Ficus tinctoria*) , banana and true taro (*Colocasia esculenta*) are also planted in or around the taro pit. The coastal forest on both the ocean and lagoon sides of the garden and the mangroves on the lagoon side are protected to shelter the plantation inland from salt spray, high waves, high tides and coastal erosion. The protection of these forests and trees also ensure that wood, medicine and other products remain available for future generations, including fish, shellfish, crabs, birds, other animals and small plants which depend on these ecosystems for their survival.

3.3 Post-independence Fiji (1970 – 1995)

The 1970s and early 1980s saw the Department of Forest reducing its work on the use of trees. The Soil Conservation Unit became part of the new Drainage and Irrigation Unit by 1970 and some of its conservation responsibilities were passed to the new Land Use Section in the Economic and Planning Division. The 1970s also focused on the development of commodities such as rice and sugar for export and less on trees in farming systems. Large reclamation of wetlands and irrigation schemes were implemented and research continued on the use of trees for shade and to support other crops – *Gliricida* for vanilla (*Vanilla fragrans*) at the Wainagata Research Station in 1973, for example. In addition, the Research Division conducted a study in the early 1980s on the use of *Terminalia ivorensis* as a permanent shade tree for cocoa versus other crops which only provide temporary shade.

A research programme on traditional agroforestry systems was initiated in the 1970s at the Laucala Bay Campus of the University of the South Pacific, with

Thaman (1988) describing those which were prevalent in Fiji at the time. The current focus is on learning about the trees used in traditional systems and on how to protect and make greater use of them. USP has promoted and supported such systems in rural and urban communities and has encouraged the incorporation of trees into national and regional conservation initiatives. Although links with MAFF are limited, USP is supervising the work of a post-graduate student in the ministry's agroforestry unit.

In 1972, the Forestry Department established a eucaplypt plantation at Lololo to test the feasibility of producing fuel wood. A second site was piloted in 1981, using ten species of eucalypt, along with *Casuarina equisitifolia* , *Leucaena leucocephala* , *Acacia auriculiformis* and *Pinus caribea* . A third was established in 1982 at Tavakubu in Lautoka using *Eucalyptus tereticornis* , *E. torelliana* and *E. grandis* , along with *Acacia mangium* and *Melaleuca quinquinervia* .

Other pilots were conducted from July 1982 to May 1983, with assistance from Australia. In 1989, three more took place at: ①Naboro, using *Sesbania grandiflora* and *Casuarina equisetifolia* ; ②Nausori Highland, using *Sesbania grandiflora* , *Casuarina equisetifolia* , *Calliandra calothyrsus* , *Paraserianthes falcataria* and *Acacia auriculiformis* ; and ③Nawaicoba, using *Sesbania grandiflora* , *Casuarina equisetfolia* , *Calliandra calothyrsus* , *Paraserianthes falcataria* , *Acacia mangium* and *Cassia siamea* .

In the early 1980s, the Fiji Pine Commission investigated the possibility of grazing cattle under plantations of *Pinus caribaea* to help reduce the fuel load and to test the use of cattle for site preparation and land clearing. However, efforts seem to have not succeeded because it was reported in 1988 that agrisilviculture in Fiji was non-existent.

Renewed interest in the use of trees in farming systems saw a move away from mono-cropping of the early years of the green revolution. Agroforestry was gaining in popularity and, in 1979, the International Center for Agroforestry Research (ICAFR) was established. It was seen as a potential solution to the problems of resource poor farmers and, by the 1980s, international organizations/donors shared this view—around the time Germany's development agency, GTZ (German Techical cooperation), collaborated with MAFF on a forestry project.

As this review shows, the Department of Agriculture and Forestry (now MAFF) tried a number of ways to use trees to conserve soil and improve soil fertility-planting several crops in the same field, combining fruit and leguminous trees with crops, grazing livestock under coconut and pine plantations, placing hedgerows along contours, practicing shifting cultivation and rotating crops. Though these systems combine agriculture and forestry, MAFF did not term

them agroforestry until practices became part of the Fiji – German project noted above. Activities included identification of potential sites and analysis of the economic aspects of agroforestry in Fiji.

In September 1988, the working group asked John Beer of the Centro Agronómico Tropical de Investigacióny Enseñanza in Costa Rica (CATIE) to design suitable agroforestry systems for Fiji and, in 1989, demonstration plots were established in Lomaivuna, the ginger growing district of Naitasiri, Central Division. In April 1991, the project was placed under the extension division of MAFF's Forestry Department and an agroforestry unit was established. Among other activities, alley cropping using calliandra (*Calliandra calothyrsus*) as contour hedges was developed but results were mixed and this system was not widely adopted. The unit is now targeting a wider range of farmers and agroforestry crops which include vanilla and fodder. It is also testing other tree species (*Flemingia macrophylla* ,*Gliricidia sepium*) and *Calliandra provenances*, in collaboration with the University of Oxford.

GTZ also funded a project which ran from 1987 to 1994, in partnership with the Pacific Regional Agricultural Program. The objective was to conduct research on agroforestry based food production systems in the Pacific Islands. Although activities have been completed, GTZ's regional program is still supporting the agroforestry unit in MAFF.

Other work on sustainable farming systems is being done in Fiji as well, for example, studies on the management of sloping lands and the Soil and Crop Evaluation Project which the PACIFICLAND Network of the International Board for Soil Research Management is funding. Whilst neither of these projects promote agroforestry *per se*, links have been established with the agroforestry unit to develop techniques which promote sustainable agriculture, including the inclusion of trees in farming systems.

4. Lessons Learned

In Fiji, trees are combined with crops for shade and other benefits, including soil conservation and enrichment. During the drought in 2009, taro production on one farm where agroforestry was practiced was not affected but it declined in both quality and quantity where other systems were used. The corm on the one farm averaged 1kg while the national average was half of that weight. For other island economies, it is still too early to draw conclusions but preliminary indications suggest that agroforestry is an ideal choice, given the scarcity of good arable land.

So far, tests have been successful but choosing the appropriate tree species to match local conditions and needs is critical because of the long time it takes for trees to reach maturity.

5. Results and Impacts

So much of what is considered modern agroforestry was actually tested in the 1930s and 1940s but the institutional knowledge has long been lost. Though a better understanding of traditional systems provides a good basis for moving forward, experience from previous trials by institutions is also useful for the development of agroforestry. The review of events in Fiji has clearly shown this is the case and it could well be true in other parts of the region.

Lack of linkages and cooperation within and among government institutions involved in agroforestry remain problematic. Similarly, communications among people who work in agroforestry outside government are weak and some key players are sidelined. In the 1940s and 1950s, education focused on conservation programs largely because of the efforts of the Department of the Environment and non-government organizations. This emphasis is probably changing, although the Department of Forestry continues to raise awareness of the importance of the environment.

The University of the South Pacific (USP) is also active, especially in traditional agroforestry, but its links to government are weak. Membership in the working group established in 1988 should be increased to include other departments and the private sector. Although this expansion would require time, effort and government support to make it work, they are essential to determine the appropriate role of institutions and traditional agroforestry and to develop sustainable systems for Fiji. The following lessons from the review were learned.

• Don't reinvent the wheel. Learn from the success and failure of previous interventions and identify the practices that farmers have adopted.

• Farmers apply the systems and they need to solve the problems that they face.

• Weak policies, insecure land tenure and economic disincentives can limit the adoption of otherwise sound agroforestry technologies.

• Links within and outside government to deal with agroforestry issues are often weak and activities uncoordinated.

• Institutional agroforestry often focuses on trees to support the production of cash crops rather than on the wider functions they perform in farming systems.

6. Looking Ahead

6.1 Major challenges

• Production of large volumes of crops for export reduces the potential to implement agroforestry systems.

• An increase in the incidence and severity of floods, drought and cyclones is having a negative impact on tree crops.

• Traditional farming practices are being replaced with commercial operations.

• Infrastructure development is placing greater demand on scarce flat land.

6.2 Opportunities

Many studies confirm that agroforestry systems, even if not designed to sequester carbon, can significantly increase carbon stocks in the terrestrial biosphere because they are widely applied as part of agricultural practices. Worldwide it is estimated that 630×10^6 ha are suitable for agroforestry.

The successful and well-managed integration of trees on farms and in agricultural landscapes provide for diversified and sustainable crop production, in addition to a range of environmental benefits. Systems such as hedgerow intercropping and boundary planting protect soils from erosion and restore some fertility in degraded areas. The World Agroforestry Centre, in collaboration with l'Institut de Recherche pour le Développement and the Kenyan National Agricultural Research Services, tested fast growing shrubs such as *Crotalaria grahamiana* and *Tephrosia* spp. to control soil erosion in western Kenya and found these species to be effective.

In addition to the biophysical resilience of agroforestry systems which allows the various components to withstand shocks due to climate variability, trees in agricultural croplands can provide farmers with alternative or additional sources of income. The value of tree products (timber, fodder, resins and fruits) are normally higher than maize or hard grains such as millet and sorghum and they can minimize economic hardship when crops fail.

Agroforestry systems also help to mitigate climate change through carbon sequestration, while providing enough flexibility and resilience to adapt to its negative effects, including climate variability. The Sahelian Eco-Farm (SEF) is a good example of how integrated natural resource management, with agroforestry as a base, improves the livelihoods of rural poor people in vulnerable

regions (Pasternak, unpublished). The SEF combines high value multipurpose trees/shrubs with soil and water conservation—a system which is mutually reinforcing. The value is in the form of food, firewood, forage, cash, plant nutrients, biomass for mulch (which increases the infiltration of rainfall and adds organic matter to the soil), and protection from wind erosion. The first test took place in 2002 at the ICRISAT(International Crops Research Institute for the Semi – Arid Tropics) Sahelian Center in Niger. Income from a 1-ha farm was an estimated US$600—12 times the value of a typical millet crop. Costs of establishing the SEF are not high: about US$60 per hectare for plant material; about US$10 for a one-time application of fertilizer; and the provision of labour for land preparation and tree planting by farmer households.

A review of how trees were used in past agricultural systems reveals that what is now considered modern agroforestry actually dates back to the 1930s and 1940s. By gaining a better understanding of traditional systems in Fiji, domestic practices will improve, as will those elsewhere in the region.

6.3 Potential to replicate successful measures in other parts of the economy/region

The forestry team at the Secretariat of the Pacific Community (SPC) has already established agroforestry demonstration plots in Tonga, Kiribati and Fiji and it plans to establish others if financial assistance can be obtained. Training and other types of support is also planned over next few years as a means to promote the wider application of agroforestry in the region. The SPC-funded Tree Seed Centre will play a vital role in this regard by supplying planting materials for the tree species to be included in the systems.

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Improving Livelihoods and Reducing Vulnerability of Poor Farmers in Jhirubas, Nepal through Leasehold Forestry and Animal Husbandry①

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① Based on a Technical Cooperation Programme of the Food and Agriculture Organization on leasehold forestry and livestock raising at Jhirubas, Palpa. Special thanks go to all contributors, especially Ms Melissa Boyd, Mr. Dipesh Pyakurel and Mr. Markus Zoja.

Abstract

This paper highlights the outcomes of a project on leasehold forestry which involved 214 of the poorest households in Jhirubas, Palpa. The government allocated an area of degraded forests for them to manage and, within 2 years, land productivity increased, along with incomes. The rehabilitation of fragile mountain slopes and new livestock practices had diversified sources of farmer revenue and made them self-sufficient. Within 3 years, household earnings from forestry and livestock were expected to increase 13-fold and 6-fold respectively. Promising results had been achieved within a 2-year period and could provide professionals and researchers with useful insights on which to develop policy. To conclude, this initiative could be replicated elsewhere in Nepal where land had been subjected to shifting cultivation and where social characteristics were similar.

1. Introduction

The Leasehold Forestry and Livestock Programme (LFLP), funded by the International Fund for Agricultural Development, began in 1994. Since 2004, it has been a key government initiative in 22 districts under the joint responsibility of the Department of Forests and the Department of Livestock Services. The Poverty Reduction Strategy Paper recognizes leasehold forestry and livestock development as the highest priority for poverty reduction—a priority that both the Ministry of Finance and the Ministry of Forest and Soil Conservation endorse.

The goal is to reduce the poverty of 44, 300 disadvantaged households by increasing forest and livestock production. It also aims to manage 31, 000 ha of forestland, conserve the environment, build institutional capacity and implement leasehold forestry in a gender sensitive way. With funding from Finland under the Technical Cooperation Programme of the Food and Agriculture Organization (FAO), a pilot phase is taking place in 5 districts (Palpa, Nawalparasi, Shyanja, Arghakhanchi and Gulmi) in western Nepal.

Koirala (2010) and others report that results from the programme are encouraging in terms of restoring degraded land and forests as well as

improving livelihoods, even among the poorest segments of the community. Thus far, more than 19, 990 ha of forested land have been leased to 38, 416 households within 4, 080 groups. A study published by FAO in 2009 revealed that, of 96 households surveyed in the 22 districts, 11% had sufficient food for 1 year. Prior to the programme, families suffered food deficits from 3 to 9 months. In addition, average income rose from NRs 25, 589 to 43, 768 (up 70% in 5 years). The income of female heads of households went up by 10% and those of male heads increased by 6%.

Community leasehold forestry is a well-established approach to forest management and environmental conservation but a complementary approach known as "common property management" is specifically designed to benefit the poorest groups (Ostrom, 1990). Leasing land with degraded forests to poor households for 40 years (renewable) provides them with secure tenure and the confidence to develop it. The income they generate from activities, along with other benefits, then allows them to move out of poverty. Both leasehold and community forestry are appropriate interventions and mutually supportive. They meet different needs and can be implemented within district forestry management plans (IFAD, 2005).

This paper highlights the outcomes of a project on leasehold forestry in Jhirubas, one of the most remote villages in the district of Palpa. Promising results have been achieved within a 2-year period and can provide professionals and researchers with useful insights on which to develop policy.

2. A Combined Approach to Improve Livelihoods

Leasehold forestry aims to improve the livelihoods of disadvantaged people by combining forestry, crop cultivation and livestock production. Groups of poor households are allocated degraded forests for their exclusive use for 40 years after signing contracts with the District Forest Office (DFO). Entitlement and management rights are granted once the group's constitution and operational plan are approved (Figure 1). This approach is also proving to be effective in reducing the vulnerability of poor rural people to the negative effects of climate change.

2.1 Programme beneficiaries and area leased

The 214 households participating in the programme live in 6 settlements (Khadar, Dundanda, Dharkesing, Jhirubas, Labed and Mauriya). Beneficiaries consist of 184 from the Magar ethnic group (Janjati), 8 Kami (Dalit or

untouchables) and 22 Thakuri (Table 1). Except in special cases, each household is leased a hectare of forested land where shifting cultivation was previously practiced.

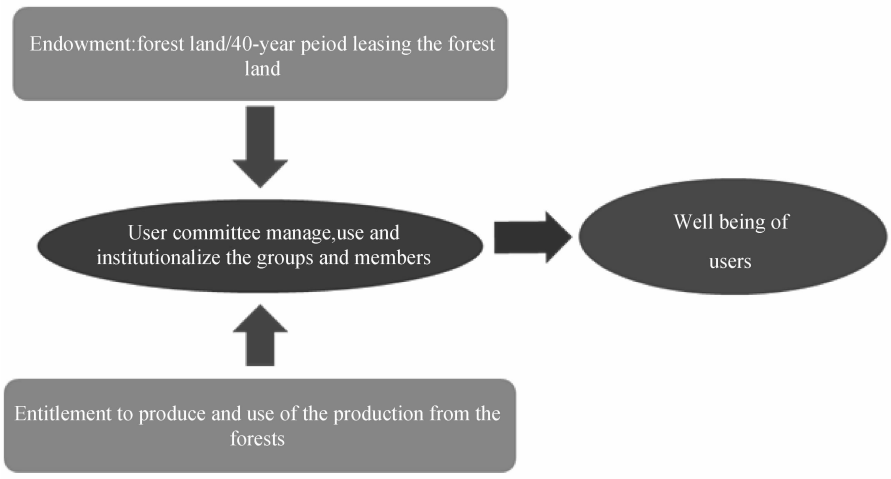

Figure 1 Conceptual framework of leasehold forestry

Table 1 Social status of forest user groups and area managed

Community	Soclal Status of Households	Number of Households	Area
Dundanda	Dalit (1), Janjati (10)	11	11
Kauledanda	Janjati (11)	11	11
Kaulepokhari	Janjati (11)	11	11
Satuwar	Janjati (11)	11	11
Khadar	Dalit (1), Janjati (11)	12	12
Gyamidanda	Janjati (12)	12	12
Mauladevi	Janjati (12)	12	12
Majhuwadanda	Janjati (3), Thakuri (9)	12	12
Govindakun	Janjati (12)	12	12
Milijuli	Janjati (5), Thakuri (6)	11	11
Khadardi	Janjati (13)	13	13
Wakbul	Janjati (13)	13	13
Birdanda	Janjati (12)	12	12
Bastudanda	Janjati (12)	12	12
Jugekhola	Janjati (13)	13	13
Sankhardanda	Dalit (3), Janjati (7)	10	15
Jamunadanda	Dalit (3), Janjati (9), Thakuri (1)	13	20
Nigoleni	Janjati (7), Thakuri (6)	13	20
Total	Dalit (8), Janjati (184), Thakuri (22)	214	233

Source: District Forest Office, Palpa (2011).

2.2 Programme intervention

As the government representative, the District Forest Officer grants villagers the entitlement to farm the forestland, the major objective of which is to improve livelihoods and alleviate poverty. Programme support includes the implementation of four components in 22 districts: leasehold forest group formation and forest development; livestock development; rural finance and social mobilization; and programme coordination and management. A support team of forestry and livestock technicians, based in Palpa, provide technical assistance in these areas.

2.3 Formation of leasehold forest user groups and forest development

The formation of user groups is a requirement of the programme and members number between 5 and 15 (12 on average). As noted earlier, DFO signs a 40-year contract with each group upon approval of its constitution and an operational plan, including work schedules and activities to improve livelihoods. Training was given to help the farmers to prepare this plan and to develop a constitution. They were also taught contour farming and how to plant seedlings on the bund, such as broom grass. Men and women participate in all activities—a prominent feature of the programme. In addition, 19 members received 5 days of training on the establishment of nurseries and on seedling production. During coaching, one nursery capable of growing 10,000 seedlings was established.

In general, seedlings are provided for boundary plantations, including species for fodder and for non-timber forests products (NTFPs). About 50,000 cuttings of Jatropha were planted along 13.5 km for both demarcation purposes and for bio-fuel. Similarly, 1,975,500 rhizomes of broom grass (*Thysanolaena maxima*) and 2,300 of Nigalo (*Dendrocalamus* spp). were planted in forest plots, along with 62,100 seedlings of Tejpat (*Cinnamomum tamala*); 1,075 of Timur (*Zanthoxylum armatum*); and 904 of Amala (*Phyllanthus emblica*). Fruit species were also planted: 355 orange, 220 lemon, 230 Junar and 1000 sets of pineapple. Altogether, plantations cover about 80% of the area.

To increase forage for the livestock, a variety of species were planted (7,000 on forestland and 13,000 on private land): about 20,000 sets of Napier (*Pennisetum purpureum* 'Mott'); 3,450 slips of Paspalum (*Paspalum attratum*); 3,450 slips of Mulato (*Hybrid brachiaria*); and 24,600 sets of Forage Peanut (*Arachis pintoi*). In addition, 40 kg of Stylo (*Stylosanthes guianensis*) and 5 kg

Photo 1 Women and men work together to prepare the forest land
(Photo by Palpa Hub Office, 2009)

of Cocks foot (*Dactylis glomerata*) were seeded on the same land. Some 100 kg of seeds were supplied for plantations, along with 7,000 polypot seedlings of Ipil Ipil (*Leucaena* spp.); 27,125 of Dudhilo (*Ficus nerifolia*); 400 of Tanki (*Bauhinia purpurea*); and 27,200 cuttings of (*Morus alba*).

2.4 Livestock development

The livestock development component includes animal farming and health support. Because this activity provides an additional source of income, it is a key strategy for group members to achieve self-sufficiency. Because they are adopting integrated farming systems, the programme is setting targets for both the production of seedlings for forestry species and the raising of livestock, especially goats and pigs, as options to generate income. Of the 214 households, 210 are involved in goat farming and 4 have pigs. Each farmer receives either 2 goats or pigs at a cost of less than NRs 5000. Each group is also given a buck.

With regard to animal health services, about 3000 goats were vaccinated and 4,200 goats were drenched. In addition, training was given to improve sheds and about 80 households have made changes to their traditional structures. To ensure that livestock farming is sustainable, group members will manage a resource center to breed and reproduce goats and this approach is being introduced in other districts as well. A local farmer underwent 35 days of training to become a village animal health worker and this training has increased community self-reliance.

2.5 Planning and coordination

An integrated approach to implementation calls for planning and coordination as well as regular feedback to improve interventions. Like the mainstreamed programme, the pilot established two bodies to guide project activities: the District Programme Coordination Committee (DPCC) and the District Development Committee (DDC). They are chaired by staff from line agencies and membership includes representatives from the beneficiaries. A District Programme Coordination Working Group (DPCWG), composed of the Livestock Officer and the District Forest Officer, provides strategic support to the DPCC. The DFO is chair and coordinates all activities from the local level to the central offices.

The DPCC and DPCWG met to select the site, implement activities and review progress. In addition, several meetings were convened to coordinate efforts at the field level and to draw on resources from other agencies. They also dealt with unforeseen problems which arose from time to time.

District agencies supports group members in a variety of ways. For example, In 2010, the DDC and the Village Development Committee (VDC) coordinated a project to install solar panels worth NRs 1,744,000 in 80 households to supply light and electricity for them to watch television and to recharge radios and mobiles. The Alternative Energy Promotion Centre and Local Governance for the Community Development Programme also supported the project. A 5-year community plan to improve livelihoods has been a major platform to seek support for village development. It is a new concept within the leasehold forestry programme that all groups and individual members state their vision and develop a concrete plan to upgrade their livelihood status. In terms of collective efforts, groups implement several projects, in addition to leasehold forestry. In 2011, support was received from the DDC, VDC and a member of Parliament (Table 2).

Table 2 Support received in 2011

Contributor	Activity	Contribution(NRs)	Outcomes
DDC, Palpa	Toilet construction	24,000	16 toilets
VDC, Jhirubas	Toilet construction	16,000	16 toilets
Mr. Dal Bahadur Raba, member of Parliament	Establishment of broom grass plantation	100,000	33,000 sets planted on leased land

Source: Palpa Hub Office.

2.6 Outcomes and potential impact

Leasehold forestry and integrated farming systems are reducing poverty and making farmers less vulnerable to the negative effects of climate change. With

sustained efforts to empower rural people and provide the technical and financial support they require, lives will continue to be improved, especially if natural resources remain available to them. Within a 2-year period, results have been promising. Earnings of the 214 participating households in 2009 averaged NRs 91,630 (US$ 1174 on 22 Feb. 2012) and they were able to save about NRs 4,872. Prior to the project, most families ran a deficit every year.

2.7 Restoration of areas previously under shifting cultivation

Before interventions, farmers grew crops such as maize and legumes, then left the fields in fallow for a few years. Land was unproductive, yielding less than a quintal of maize per household. Under the new system, not only is forage produced but twigs and unwanted plants are used for firewood. More than 7,000,000 seedlings of broom grass are growing well and are expected to provide regular income. Households will earn an estimated NRs 5000 in Year 2; 220,000 in Year 3; and 150,000 – 225,000 in Year 4 (Figure 2). In addition, these new plantings are conserving soil, maintaining greenery and sequestering carbon.

Photo 2 Unwanted shrubs cleared for plantation (Photo by N. Bhattarai, 2009)

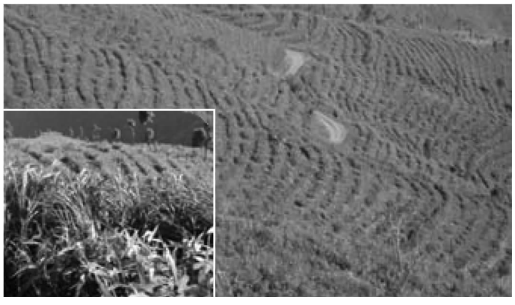

Photo 3 Broom grass/other forage plants after 1 year (Photo by P. Tara, 2011)

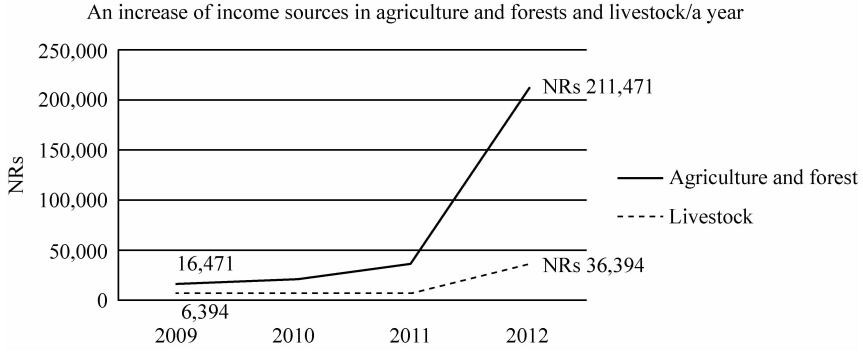

Figure 2 Expected income sources from forestry, agriculture and livestock
(Source: Palpa Hub Office, 2011)

2.8 Diversification of livelihoods

Traditionally, people farmed and raised livestock to meet their basic needs, mostly growing ginger and maize as well as rearing goats, buffalo, cows, pigs and other animals. With leasehold forestry, however, forest crops are more diverse, with broom grass providing quick returns. Other products such as fruit and firewood will also be sources of income in the near future.

Support from local experts for animal health and goat rearing, in addition to the establishment of a goat resource centre, are controlling in-breeding and encouraging commercial production. The farmers learned cut and carry methods to feed their goats in the shed, morning and evening. Surplus forage for cattle is available from the forest and their land. As a result, households are expecting to earn more than NRs 250, 000 from the sale of goats, ginger and broom grass (Palpa Hub Office, 2011).

2.9 Human resources development

Training sessions on forest management, nursery management and goat farming, in addition to the use of local resources, participatory decision-making and financial savings, have made farmers self-sufficient.

2.10 Social empowerment and resource pooling

Project interventions have created social cohesion by organizing and registering groups at the District Forest Office so they can lease forestland, along with associated entitlements. As an institution, groups have regular meeting to discuss issues and make decisions, including on the amount to deposit monthly into their savings account and on how funds will be spent—the purchase of ginger and vegetable seeds and farming inputs, for example. At the same time, the groups lobby district agencies and politicians for the support that they require to improve their physical and natural assets.

3. Conclusion

Entitlements under leasehold forestry agreements has empowered the people to move from shifting cultivation to productive management of the land. The combination of livestock, forestry and other components provides farmers with

regular and diverse sources of revenue to make them self-sufficient. Income of the 214 households is expected to increase 13-fold from forestry and 6-fold from livestock within 3 years. However, this approach requires ongoing professional support and future enterprise development is only possible if such services are provided, including access to markets. This initiative could be replicated elsewhere in Nepal where land has been subjected to shifting cultivation and where social characteristics are similar.

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Agroforestry Development
in the Asia-Pacific Region

Forest, Fish and Fruit: an Innovative Agroforestry Practice in Coastal Bangladesh to Reduce Vulnerability to Climate Change

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1. Introduction

Bangladesh is located between 20°34′N and 26°38′N and between 88°01′E and 92°41′E, with the Bay of Bengal to the south. Population numbers 151.41 million and total area is about 147,570 km^2, of which 423,394 ha is coastal forest.

Although not a significant contributor to climate change, Bangladesh is highly vulnerable to its impacts. According to its National Adaptation Plan of Action (NAPA), which was developed in 2005, and other scientific assessments, anticipated effects range from a greater intrusion of saline water and inundation of coastal lands. Key risks include drainage congestion, less fresh water, disturbance of morphologic processes and more intense flooding. Communities in the coastal region are especially vulnerable. They have high rates of poverty and villagers depend on natural resources such as forestry and fishery stocks for their livelihoods. The Intergovernmental Panel on Climate Change (IPCC) estimates that 35 million people in these areas will be adversely affected by a predicted 45 cm rise in sea level by 2050. Some 1,000 km^2 of cultivated coastal land and aquaculture farms are likely to become salt marsh due to increased salinity. Thus, food security and livelihood options will decrease significantly.

2. Issues and Challenges

Crowding along the coast is made worse by fragmentation and absentee landlords. Moreover, the area is becoming increasingly fragile due to river erosion and threats from climate change. Vast lands outside the flood-proof embankment are regularly inundated by saline water during high tide. Poor people are especially affected by these conditions and suffer additional hardships because of their limited access to financial institutions to start small businesses.

Since 2010, Bangladesh has been implementing a community approach to climate change through afforestation in 4 coastal sites. One of the innovative interventions is the forest, fish and fruit (FFF) model—an agroforestry system which generates products over the short, medium and long terms and, in doing so, offers have diversified livelihood options and increased security.

The main objectives of the FFF model are to provide protection from storm surges, cyclones and rise in sea level; produce timber, fruit, vegetable and fish; and diversify livelihoods. As part of the project, 8 poor families made ditches and dykes in 1 ha of naturally occurring open spaces of the mangrove forest (Figure 1) .

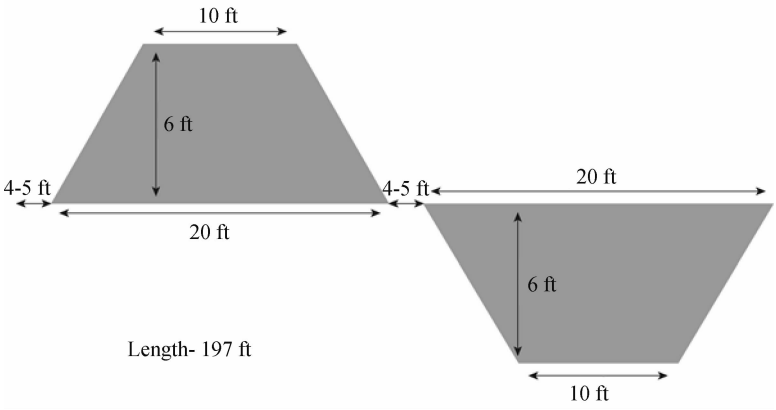

Figure 1 Dimensions of the FFF model

The FFF model consists of a combination of protective and productive vegetation, mounds and ditches, and a pond to support a fish nursery—all of which create multiple sources of income and mitigate the effects of climate extremes (Figure 2) .

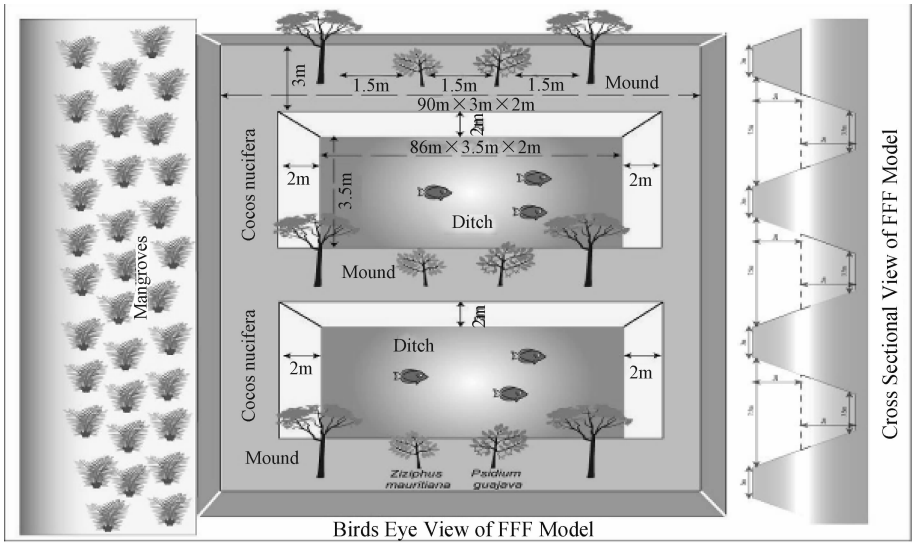

Figure 2 Birds eye view of the FFF model (Set A)

Components consist of a row of mangroves along the coast line which acts as a buffer against storm surges, strong winds and a rise in sea level. This barrier also protects nearby communities and homes and it supports the growth of a healthy water and shore ecology. Mounds and ditches are then built next to the mangroves. The mounds are made of compacted mud from the surrounding area and create a raised platform upon which timber species, fruit trees, vegetables and medicinal plants are grown.

• Fruit trees: quick growing and early yielding fruit trees such as bau kul (*Ziziphus mauritiania*) and apple guava (*Psidium guajava*) are planted on the mounds to generate income and produce food in the medium term.

• Forest trees: forest trees and palms (*Cocos nucifera*) provide timber, fuelwood from pruned branches and food. They also provide the land and communities with added protection from climate extremes.

• Vegetables: improved varieties of vegetables planted between the tree seedlings (for up to 5 years) provide households with immediate products for consumption. Scaffolding on the margins of the ditches extend the growing area by supporting creeper vegetables such as country bean, cucumber, bottle, bitter and sweet gourds (cucurbitaceous vegetables) .

• Fish: by excavating the ditches to 2m (Figure 2) , a single one can produce an estimated 140 – 150 kg of fish. They also double as a reservoir to collect rain to supplement regular water supplies for irrigating the plantations on the mounds.

3. Approach

A group approach (10– 15 people) was used to establish the agroforestry system described above. Each member was allocated 1 ditch and 1 dyke, with the last dyke jointly built and owned by the collectivity. Dimensions were 60m long, 3. 5 m wide and 2 m high. Each member, in turn, guarded the resources at night. As of April 2012, 60 ditches and dykes were constructed, 26 of which were finished before the rainy season (Set A, Figure 2) . In addition, households received other inputs and training.

Agencies, including the Forest Department, the Department of Agriculture Extension, the Department of Fisheries and the Department of Livestock, provided technical support to households as part of their efforts to build capacity and sustain operations. For the first time, agencies also supplied inputs—saplings, fish fry and ducks, for example.

The model was built in open spaces in the forest (Photo 1) and beneficiaries

become steward of the land. They cannot construct any accommodation, transfer or sell the agreement, or engage in illegal tree felling. They can grow and consume the vegetables, fruit and fish produced (Photo 2) and can keep 65% of the revenue from the sale of timber from mature trees. The Forest Department receives 25% and the remaining 10% is deposited in a fund earmarked for plantations.

To monitor, supervise and guide project activities, a co-management committee was formed. It was chaired by the Upazilla Nirbahi Officer (UNO) and consisted of 15 members, including from implementing agencies.

Photo 1 An open space inside the forest before establishing FFF model

Photo 2 Same space after establishing FFF model

4. Lessons Learned

After modifying the topography to prevent saline water from inundating the open spaces inside the coastal forest, the area can now support non-mangrove species and crops. Thus, they were highly prone to encroachment. However, since a huge number of poor people were benefiting from these changes, threats had been reduced and project participants were even helping the Forest Department staff to manage the coastal resources.

Beneficiaries also indicated that they were willing to share their newly acquired skills and knowledge with other farmers who were interested in growing vegetables, planting trees or engaging in aquaculture. In addition, villagers were hired as laborers to build the structures and to plant trees/crops. Thus, implementation of the model provided additional work for the community during lean periods. However, it is still not able to expand fast enough to meet demand.

In raising the contour of the land, the risk of flooding had been largely mitigated. The FFF structures also acted as the front line of defense against storm surges and cyclones.

Although it is too early to assess the impact of interventions, beneficiaries and other stakeholders had identified issues which seriously hindered productivity—for example, theft and conflict with wild animals (deer, fish cat and fox). In some instances, distance from houses to the project sites discouraged participation and made it difficult to maintain the resources. Land disputes were also problematic. In one case, the UNO placed an injunction on activities in Hatiya Upazilla, pending resolution of the layout for a new FFF. Some beneficiaries argued that the width of the ditches and dykes was not optimum and would like the design altered so that fish had more room to grow faster.

Lack of fresh water is another limiting factor. During the last dry season, most ditches were completely drained so that some farmers sold all their fish at market, even those which were below allowable size. Others stocked the fish in their homestead pond. However, almost all beneficiaries were unable to give their fruit trees enough water so that many of these fruit trees did not survive.

5. Results and Impacts

Beneficiaries earned income mainly from vegetables, fish and eggs. Set A beneficiaries averaged 381.5 taka/month for the season by selling country bean

grown on dykes (maximum 45 kg ldyke to a minimum of 2 kg/dyke) while Set B averaged 202. 75 taka/month (maximum 50 kg to a minimum of 5 kg) . Figure 3 shows that Set B earned more from fish sales than Set A. The difference is because Set B depleted stocks in the ditches, whilst Set A were still harvesting and expected more yield.

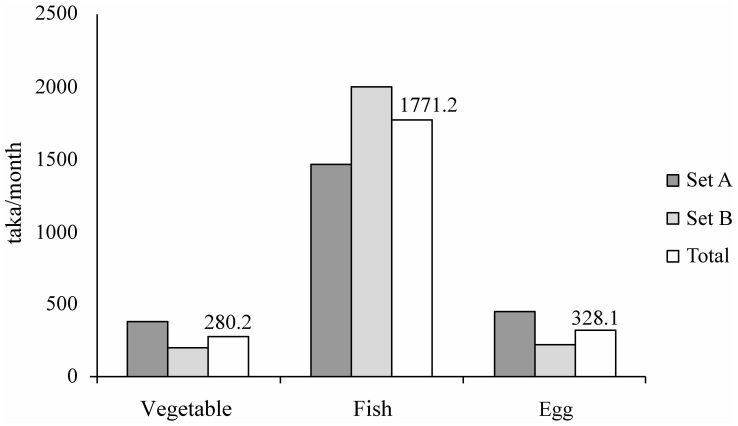

Figure 3 Multiple resource extraction from FFF model

Male beneficiaries derived more income than females (Figure 4) for 2 reasons: society discourages women from working in the field and they are not allowed to visit their sites at night—a factor that makes them extremely vulnerable to theft.

Despite less revenue, 25 of the 60 women participants were happy to be involved in this project. Not only did the additional income supplement their regular household earnings, the dykes provided them the land to grow vegetables which was not available around their homestead.

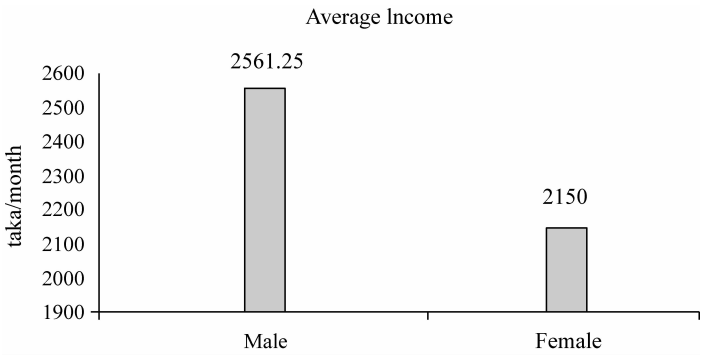

Figure 4 Income of male and female beneficiaries

6. Looking Ahead

6.1 High soil salinity

Though this model was designed to avoid or reduce soil salinity, levels were still high after 1 year. Beneficiaries hope that, after 2 rainy seasons, a significant reduction will occur to allow them to grow more vegetables and maximize their benefits.

6.2 Probability of overtopping of the mound

The model was built outside the flood-proof embankment (although it was protected by a belt of mangrove forest) and the dyke was lower than the embankment. Therefore, it is possible that saline water could overtop the mound during a storm surge and damage the fish farms and crops. However, local elders reported that no storm surge had produced waves equal to the height of the dykes during the last decade so beneficiaries remain hopeful such an event will not happen.

6.3 Conflict among group members

Sound management and protection of resources largely depend on good relations and a sense of solidarity among group members. For example, if one farmer fails to maintain fences around his/her ditch and dyke, resources of other dykes and ditches will become vulnerable to stealing and grazing.

6.4 Opportunities

6.4.1 *Group savings*

Beneficiaries can create a revolving fund by agreeing to set aside a small amount of money weekly or monthly. Doing so will allow them to obtain small loans in emergency situations and to purchase inputs on a large scale to minimize cost. Many NGOs working in the area can provide technical support to start such a saving scheme.

6.4.2 *Seedling business*

Given that some markets are near the project area, some beneficiaries can establish a small produce-based business. Since they have been taught to raise and manage seedlings, there is also significant potential for them to supply project participants and other local farmers.

6.4.3 *Knowledge sharing among groups/regions*

The group approach is conducive to members sharing knowledge and good practices among themselves. They can also exchange information with other groups in the area and other parts of the coast.

6.5 Potential to replicate successful measures in other parts of the economy/region

Because government allocation of more land for forestry is extremely limited, naturally open space occurring inside the forest could be used to establish more FFF models. This approach will not only involve and benefit local poor people but it will also reduce encroachment. The model can be replicated along other coasts and in low-lying areas of Bangladesh where land is not suitable for cultivation because of flooding. It could also be practiced in other parts of the world.

Photo 3 FFF model site in Burir Char Union of Hatiya Upazilla

Photo 4 Bilkis, a beneficiary is taking care of her fruit tree

Photo 5 Country bean on dyke (dry season)

Photo 6 A beneficiary is harvesting bean

Agroforestry for Forest Restoration and Poverty Alleviation in Gunung Walat Educational Forest

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1. Introduction

Gunung Walat Educational Forest (GWEF) is owned by the state but is managed for education and research purposes by the Faculty of Forestry at Bogor Agricultural University. It is located in Sukabumi District, West Java Province, about 60 km from the university and about 120 km from Jakarta. Monocultures of *Agathis loranthifolia* and *Pinus merkusii* which students planted as part of their practicum in the 1970s dominate the forest's area of 350 ha.

In 2002, a research team from the Faculty of Forestry collaborated with GWEF to design and establish 3 agroforestry systems in the forest, with support from South Korea under the ASEAN – Korea Environmental Cooperation Project (AKECOP). *Agathis* and *Paraserianthes* were the main tree components and these were integrated with crops such as maize, pineapple and peanuts. The first site was almost bare of trees, the second site contained between 25 and 100 trees (Figure 1), and more than 100 trees were found on the third site (Figure 2).

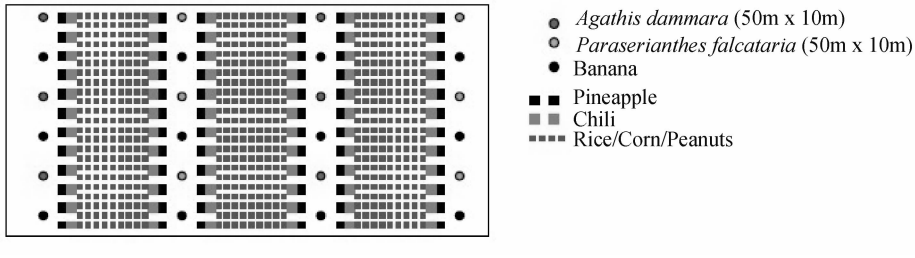

Figure 1 Design of the first and second agroforestry system

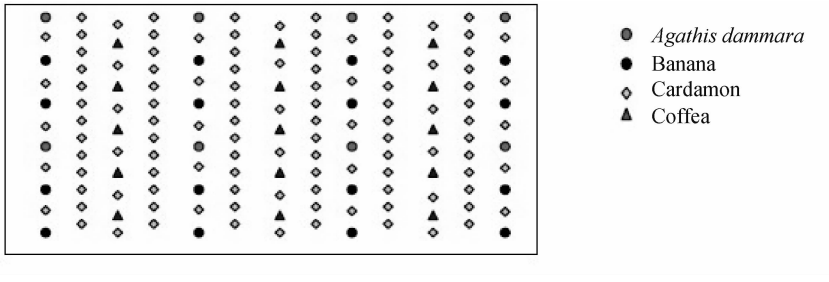

Figure 2 Design of the third agroforestry system

During the economic crisis (1997–2000), the GWEF suffered serious degradation due to illegal cutting and encroachment by people from the surrounding forest who were mostly landless and unemployed. Some 200 households slashed and burned about 75 ha to plant staple food crops such as cassava, upland rice and maize (Photo 1).

Photo 1 Slash and burn (left) **and illegal cutting** (right) **in the GWEF**

In most cases, it was impossible to expel the high number of people who entered the forest so an agroforestry project was implemented as one of the few options open to restore the ecology and improve the livelihood of local communities. It was extremely important to conserve the GWEF and to prevent further damage because of its location in a hilly and densely populated area (500–700 m above sea level) and because the forest was a source of water to meet household needs and irrigate crops. It also provided local people with food, fodder and firewood.

2. Approach

Farmers who encroached on the GWEF were asked to help to establish the agroforestry system. Since they had already planted food crops, agreement between them and management was reached through a series of meetings and focus groups. Contracts were entered into whereby the farmers were allowed to cultivate the forest area for food crops but only by practicing agroforestry. This participatory approach was chosen, based on the following considerations.

(1) People living in and near the forest need to be involved in developing the forestry sector in Indonesia because they are an integral part of the ecosystem and most of them deserve justice after being marginalized for so long. If ignored, they have the power to cause serious destruction but, if part of the decision-making process, they are likely to be supportive (Darusman, 2000).

(2) Forestry was shifting from a focus on forest protection to community involvement in forest management (van Gelder and O'Keefe, 1995).
(3) Forest management was increasingly based on partnerships and stakeholder participation (Campbell, 1997).

Agroforestry is not a new concept in Indonesia. The Dutch started it in the early 19th century when they wanted to establish teak plantations in Java. Perhutani (State Forest Enterprise) continues to use this system to this day. However, the project in GWEF introduced new aspects. For example, the local people choose the trees and crops to be planted, rather than the forest managers; they are allowed to manage their plots for 10 years (only 2 years in Perhutani) and this term can be renewed; and farmers received training and extension support to improve their agroforestry practices.

3. Lessons Learned

3.1 Forest restoration

After 4 years under the AKECOP project, illegal cutting stopped, no further encroachment has taken place and forest degradation has been reversed. Because agroforestry combined trees and agriculture crops, it provided food and cash, while restoring the forest ecosystem at the same time. In this regard, *Agathis* and other tree species which provide a range of economic and ecological benefits are ideally suited to agroforestry systems. Although farmers can harvest and keep 100% of the food crops, they are not allowed to cut *Agathis* but could tap it and keep 50% of the resin. They are also able to keep 50% of the wood from *Paraserianthes falcataria*.

3.2 Improved livelihoods

Agroforestry contributed cash income to farmers and gave them a more stable food supply. However, as Table 1 shows, agroforestry only increased household incomes in the GWEF by between 10% and 20%. The reasons are: ① the small size of plots, about 0.16 ha and ② the farmers only worked in their plots in their spare time so that management was not intensive.

Table 1 Contribution of agroforestry to household income

Year	Additional Cash Income [Rp/(year·farmer)]	Contribution to Household Income (%)
2002	480,000	10.5
2004	520,000	11.0
2007	854,250	20.0
2009	869,580	20.0

Source: AKECOP Annual Reports, 2002, 2004, 2008, 2009.

4. Results and Impacts

4.1 Increased biodiversity

Agroforestry in GWEF has restored the forest condition and prevented further degradation. As importantly, it has increased plant diversity, as shown in Table 2 which compares the plant species in agroforestry and non-agroforestry areas.

Table 2 Plant species in non-agroforestry and agroforestry sites in the GWEF

Non – Agroforestry	Agroforestry
Trees Damar (*Agathis lorantifolia*), Pine (*Pinus merkusii*), Puspa (*Schiima walichii*)	Trees Damar (*Agathis lorantifolia*), Pine (*Pinus merkusii*), Puspa (*Schiima walichii*), Sengon (*Paraserianthes falcataria*), Mahagoni (*Swietenia macrophylla*)
Agriculture crops None	Agriculture crops Cardamom (*Amomum cardamomum*), Taro (*Colocasia esculentum*), Cassava (*Manihot esculenta*), Coffee (*Coffea robusta*), Banana (*Musa* sp.)
Other plants Non economic valuable shrubs and tubers	Other plants Non economic valuable shrubs and tubers

Source: AKECOP Annual Report, 2005.

4.2 Greater security over access to and use of land

The AKECOP project has practically legalized crop cultivation in the GWEF, although people recognize that the land still belongs to the state. The 10-year duration of contracts, with possibility of extension, and the benefit-sharing arrangements noted above have given farmers a greater sense of security.

4.3 Interest and participation of local people

Success of the project depended on the interest and active participation of the local people. A Participatory Rural Appraisal was therefore conducted and regular meetings were held to discuss and choose the plant species. To further ensure their involvement, the cost of their time to attend meetings, taking training, going on trips and complete certain forest work were valued because most of them were needy people.

5. Looking Ahead

5.1 Challenges and opportunities

The major challenges of the GWEF project were to obtain local involvement, provide secure land tenure and improve livelihoods. A participatory approach seemed to be the best way to respond and to reconcile the high demand for agricultural land with the need to rehabilitate and conserve the forest.

5.2 Potential for replication

Conflict over land tenure is one of the biggest problems the Indonesian government faces. High population (237, 641, 326 in 2010) places extreme pressure on state-owned forests which are mostly managed by private companies through concessions. Illegal logging and encroachment occur almost everywhere and the GWEF project has the potential to be replicated in areas experiencing these problems. Such a project could also support one of the nation's top priorities—food security.

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Agroforestry for Rural Development in Lao PDR

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1. Introduction

The size of Lao PDR is 23.68 million ha, 70% of which slopes more than 11.31°. An estimated 69% of its 6.5 million people reside in rural areas, 27% of whom live below the poverty line (World Bank and UNDP, 2010). Its population density is relatively low (27 capita/km^2) and data from 2010 show that rural growth declined by 2%. Most rural people depend on agriculture and natural resources for subsistence. Current forest cover is approximately 40%.

Small-scale farming on unused (unclassified) fallow land and on degraded forestland has traditionally dominated rural landscapes. Now, some smallholders in the north are combining commercial tree species such as teak and rubber with many different field crops and non timber forest products (NTFPs). Often, these systems replace large-scale animal husbandry.

Most rubber plantations are 1 ha in size and, in the first few years before the trees are ready to be tapped, households grow crops in this area as well. Farmers register and obtain temporary land use permits for their rubber farms but foreign investors in large-scale operations are granted land concessions.

Recent government policy is to replace shifting cultivation with commercial production of crops and NTFPs. As a result, farmers are adopting more intensive practices and expanding the cultivation of maize, cassava, sugar cane and other crops that can be sold to domestic and regional traders.

2. Issues

2.1 Land management

Several factors are causing an increase in the number of conflicts, including government consolidation of remote rural villages and its promotion of commercial agriculture and rubber plantations. This expansion has resulted in a reduction of both forest cover and the area available for grazing. It also requires that fences be built to separate the livestock from crops. Farmers have no traditional bonds to their animals but consider them as marketable assets.

2.2 Lack of technical knowledge

Extension staff and farmers are not able to certify the variety or the source of the rubber they are using. In addition, they lack information and knowledge in terms of management, planting techniques and models of agroforestry. While many farmers are intercropping in the first few years before the canopy closes, it is uncertain how they will generate income in the ensuing period, until the trees are ready for tapping.

2.3 Socio-economic aspects

Most small-scale farmers who plant rubber have neither the money nor the labor to invest. Less well-off families are concerned about growing the rice they need for the year and worry that the income they earn from collecting NTFPs and planting mixed cash crops will not provide enough options to reduce their food insecurity. They mostly sell their raw outputs to middle men in domestic markets and, thus, do not benefit from any extra income they might earn through processing.

2.4 Contract farming

Contract farming is only practiced in some provinces. While it offers a viable option for farmers who do not have investment capital, terms of the contract and the contracting process itself are still vague and unclear. Because they are not consulted when the contract between district officials and the company is signed, most are dissatisfied with the terms. As a result, it is difficult for the company to find farmers to participate in the scheme. In addition, mechanisms must be developed to ensure that both parties adhere to the contract once they reach agreement. Finally, contract farming should not limit the options of farmers but provide a means to improve the livelihoods of those who lack access to credit and want to engage in commercial agricultural production.

3. Approach

Several programs focusing on forest-based rural livelihoods have been undertaken over the past 10 years and have helped modernize upland agriculture systems. The list below is a representative sample of such

initiatives. Experience gained and lessons learned should be considered and, if appropriate, applied in the implementation of similar projects in future. Farmers generally accepted the model which combined tree planting, cash crops and NTFPs.

• The Agro-biodiversity Initiative at the Ministry of Agriculture and Forestry (MAF) was supported by the Swiss Agency for Development and Cooperation and other partners. It seeked to achieve three objectives: sustainable agricultural systems that improve upland livelihoods and conserve biodiversity; improved marketing and sustainable management of NTFPs and agricultural products; and land use planning and allocation based on community participation and community land rights.

• The Livelihood Opportunities and Nutritional Gains Project was a 3-year pilot funded by the Office of the Poverty Reduction Fund and was supported by the World Bank and the Japan Social Development Fund. It operated through self-help groups in villages that had high levels of poverty.

• The Upland Research and Capacity Development Programme (2007 – 2012) at the National Agriculture and Forestry Research Institute was supported by the Swedish International Development Agency. The pilot testing and research conducted on livelihoods provided important lessons.

• The Forest Management and Community Support Project (2004 – 2009) was funded by the Japan International Cooperation Agency. It reduced the dependency of farmers on shifting cultivation by providing them with alternative livelihoods and, consequently, decreased pressure on forests.

• The Community Based Rural Development Project for Conservation of the Nam Beng/Nam Mau and Nam Phak Watersheds Project (1999 – 2006) was implemented by Deutsche Welthungerhilfe/German Agro Action, a private voluntary organization, in cooperation with the Oudomxay Provincial Agriculture and Forestry Office.

• The Project to Reduce Vulnerability of Ethnic Groups in Nam Beng, Nam Mau and Nam Phak River Basins introduced different upland crops and NTFPs into agroforestry systems to decrease the dependency on rice production of four ethnic groups (Khmu, Hmong, Tai Lu and Akha) in 19 villages.

4. Lessons Learned

The government policy to halt shifting cultivation motivated farmers to combine rice production with other field crops to diversify products, increase household

income and expand agricultural land for the cultivation of maize, cassava and sugar canes to sell to domestic and regional traders.

Many projects to enhance rural livelihoods are on-going or will start soon. They support the sustainable management of community forests and NTFPs, land use planning and agroforestry models.

Although, additional income from the sale of cash crops was not on a big scale, farmers learned how to mix cash crops with commercial trees and how to manage them. Moreover, farmers can use and manage their land by themselves.

Conflicts over land management and land reservation often occured within the village, between bordering villages and betweend land concessionaires. In some places, district officials issued land concessions permits which overlap ped with a farmer's land.

The market price of cash crops and NTFPs was not stable and middle men often negotiated low prices when buying products from farmers.

Government and the private sector did not support the establishment of community-based processing factories to add value to the products so that farmers could earn more income. In addition, contracts between farmers and buyers were non-existent.

After projects ended, farmer participation gradually decreased and local staff could not continue follow-up.

5. Results and Impacts

• Many smallholders/households were participating in commercial tree planting and incomes from this activity were steadily rising.

• Households were earning additional income from the cash crops they planted between the rows of commercial trees.

• Households/villagers gained experience, knowledge and understanding of tree planting, agroforestry models and marketing.

6. Looking Ahead

6.1 Challenges

• Smallholders/households will continue to expand commercial tree planting at

the expense of forestland. Therefore, conflict between villages and higher authorities must be resolved.

• The loss of grazing areas for cattle means that their numbers are decreasing daily.

• The market for rubber is uncertain and prices can vary significantly. This situation is made worse by the fact that no contracts or agreements exist between sellers and buyers.

6.2 Opportunities

Lessons learned from these and other interventions will help to develop forest-based alternative livelihood options for smallholder farmers through, for example:

• improved agriculture extension services to adopt sustainable crop production and grazing practices that are linked to markets and nutrition;

• better delivery of livestock services, market information (including prices), grading and post-harvest technologies; and

• institutional development such as participatory sustainable forest management, land tenure reform, promotion of farmer organizations, effective application of the rule of law, and clarification of public and private sector roles in providing access to assets.

With regard to agroforestry, farmer organizations could be established to:

• promote smallholder tree farms of teak and other tropical hardwood;

• undertake assisted natural regeneration in non-designated forest areas using fast-growing indigenous species, including bamboo and rattan;

• cultivate NTFPs on smallholder tree farms and non-designated forest areas to reduce food insecurity and to sell commercially;

• modify spacing on smallholder tree farms to create grazing areas for large livestock;

• cultivate high-value essential oils on smallholder tree farms and non-designated forest areas; and

• introduce nutraceutical crops and medicinal herbs for domestic and regional markets.

With donor support, many ongoing and new projects will focus on sustainable forest management planning, development and management of village forests and NTFPs, and agroforestry systems, including the cultivation of cash crops.

6.3 Key policy documents

• Report to the 9th Party Congress (March 2010) which includes the four steps to modernization;

• National Social and Economic Development Plan (2011–2015);

• Agricultural Development Strategy to 2020, prepared in 2010;

• Agriculture Master Plan (2011 –2015);

• Forestry Strategy to 2020, approved in 2005;

• National Nutrition Policy, prepared in 2008; and

• National Adaptation Programme of Action to Climate Change (2009).

7. Potential to Replicate Successful Measures in Other Parts of the Economy

Successful measures can be replicated elsewhere in Lao PDR and in the Asia-Pacific region, based on lessons learned from the past and ongoing projects on agroforestry for rural development. The key policy documents noted above will help villagers/smallholders to participate in sustainable forest management, agroforestry and the development of village forests, in collaboration with government authorities and staff at central, provincial, district and village levels.

Tree Domestication in the Peruvian Amazon

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1. Introduction

About 3.85 million people in the Amazon live in poverty or extreme poverty, a situation which has led to land degradation due to increasingly shorter fallow periods. Illegal coca cultivation is also taking place and forests are being converted to unproductive grasslands, driven partly by immigration from the coastal and Andean zones.

Original forest cover was reduced to about 90,000 km^2, of which 55,000 km^2 were either degraded or abandoned. Deliberate burning, low soil fertility, soil compaction and competition from native grasses and other herbaceous vegetation are all factors that inhibit the capacity of forests to recover. Degradation is most advanced in terms of magnitude and intensity in the high jungle (Selva Alta).

The study described in this paper focuses on the Amazon (Yurimaguas, Pucallpa, Iquitos) rather than on areas of extreme poverty and tree scarcity. In the Peruvian Amazon, two main types of agroforestry are found: traditional indigenous/smallholder systems and cacao mixed with coffee.

The fact that domesticated or partially domesticated tree species, such as *Bactris gasipaes* and *Theobroma bicolor*, grow in this region suggests that the indigenous people have been planting trees for generations. Colonist, and indigenous and riverine farmers continue to do so, whether in home gardens, managed fallows or other ways.

1.1 Ownership of property

The national government has decentralized its control over natural resources. It determines a person's ownership rights to a rural property (parcel farm or farm) and classifies the type of economic activity to formalize their status or improve their property rights, as appropriate. Only when farmers attach proof that they have possessed and exploited the land for 1 year can it be formally registered in their name at the Public Registry.

1.2 Issues

The following actions would help to address some of the most pressing problems in the Peruvian Amazon:

(1) Conserving valuable forest resources at farm, community and watershed levels to reduce deforestation in surrounding primary forests;

(2) Supplying prototypes of tree seeds and seedlings on a sustainable basis and encouraging smallholder farmers in different social, economic and cultural settings to use diverse and productive germplasm; and

(3) Making improved agroforestry tree germplasm available and providing information on potential use, benefits and conservation, while taking into account climate constraints and risks of invasive species.

1.3 Approach Taken

The Tree Domestication Program began in 1995, essentially to improve the livelihoods of smallholder farmers by facilitating their access to high quality germplasm for higher and more stable production of tree products, particularly in silvopastoral systems, agroforestry systems, multistorey systems and improved fallows. The program also sought to enhance the environment both directly (because domestication entails conserving genetic resources) and indirectly (because improved material may reduce deforestation). Tree improvement was at its core and a number of supporting activities supplemented this focus.

Research was mostly conducted in the Aguaytía Valley, with the intention to apply successful models more widely at the local level and throughout the Peruvian Amazon. Resource-poor farmers who engaged in deforestation formed the initial target group.

A participatory approach was used to choose the four species. The prioritization process included identifying the most important species according to farmers, evaluating their suitability for specific uses and consulting experts (Table 1).

Table 1 The prioritization process

Stage	Methods
Identification of priority agroforestry systems	Systems were chosen in collaboration with national institutions, universities and non-government organizations
Selection of study zones and target groups	Selection was based on research priorities
Evaluation of client needs	Farmers in Iquitos (64), Pucallpa (49) and Yurimaguas (20) each selected the 15 most-used species on their farm and ranked the 10 most important. The mean importance of each species was then calculated by study zones, along with the percentage of farmers who used each species
Evaluation of farmer priorities	The survey on products and services was used to identify the priority species (10 in Yurimaguas, 10 in Pucallpa, 12 in Iquitos) and the potential of each species to supply a given product was determined in each zone
Prioritization of species and trees for specific uses	Researchers and farmers assigned each species a weight, a score and a relative value according to its potential use and potential source for the product or service in question
Final prioritization of the species in each zone and for the Selva Baja in general	Based on the relative importance determined in the previous stages, the 15 species with the highest scores in at least 2 of the 3 zones were selected. The relative scores of each of these species were also calculated for the Selva Baja, using the scores of the previous stage and of each zone. Based on total scores and ease of use in agroforestry systems, 5 priority species were ultimately selected

1.4 Core tree improvement activities

1.4.1 *Participatory selection of mother-trees*

As a core part of the program, on-farm progeny tests were conducted on *Bactris gasipaes* , *Calycophyllum spruceanum* , and *Guazuma crinita* . Seeds were collected, in collaboration with farmers. In the case of peach palm, they selected mother-trees of the spineless Pampa Hermosa landrace, based on fruit characteristics (quantity, exocarp colour, oiliness, starchiness, texture and size). Open-pollinated seed was collected from 100 mother-trees in 4 locations along the Cuiparillo River, east of Yurimaguas and from 302 others in 12 sites along the Paranapura River, west of Yurimaguas. In the case of Bolaina, 209 mother-trees were selected in 14 locations of the Aguaytía Valley, using criteria which included stem and crown form. Later the same year and in the same location, 208 trees were selected and 75 others were chosen at random, using

the same criteria. For all species, selection intensities were kept low (1 in 20) to ensure high genetic variation in all traits.

1.4.2 *Progeny test/establishment of seed orchard*

Progeny from the above collections were raised and replicated in nurseries and then planted in seed orchards. The blocks were located randomly on smallholdings, with groups of 3 blocks nested within the zones. One experiment was conducted for bolaina, and 2 each for capirona and peach palm. Each test of *C. spruceanum* and *G. crinita* consisted of 9 blocks: 3 in each of the upper, central and lower Aguaytía watershed, i. e. closest to Pucallpa. A similar approach was used to test *B. gasipaes* in the Aguaytía Valley and in an area close to Yurimaguas. The capirona trial differed in that it sought to quantify the effect, if any, of the mild phenotypic selection of mother-trees, i. e. by comparing the performance of progeny from selected trees with trees chosen at random.

Farmers and program personnel selected sites based on soil characteristics and distance to sources of extraneous pollen (minimum 100 m). Each block consisted of 50 – 200 families, represented by a plot of 2 trees (experimental unit), spaced 2.5m^2 apart for peach palm and 3m^2 for the other species. For the capirona, each site consisted of 1 random and 1 selected plot consisting of 75 subplots of 2 individual progeny trees. This non-contiguous design was chosen partly because each block of about 0. 5 ha was considered small enough for households to manage. The design also allowed a range of conditions to be sampled, including farmer practices, than if blocks were concentrated on one site. In addition, it provided for different selection criteria and intensities to be used in the various blocks, so that the test results could be applied to seedling seed orchards, placing emphasis either on different traits or on genetic gain versus genetic conservation.

Landowners weeded the sites, typically every 2 – 3 months. As a means to ensure that blocks were consistently maintained, the program paid them US$ 12 – US$ 24 quarterly for this work. In many cases, growth and development in the experimental blocks was impressive. In other cases, site selection was inappropriate and the productivity of peach palm in the Aguaytía Valley blocks was disappointing.

1.4.3 *Provenance testing*

A similar design was used to test the provenance of *G. crinita* and *C. spruceanum* . Samples were taken from a wide area which experienced variable

conditions (4°S – 10°S, 71° – 77°W, 1800 – 4000 mm of precipitation/year, 100 – 300 m above sea level). Trees were selected randomly and a random block experimental design was used, consisting of plots of *G. crinite* (36 trees) and *C. spruceanum* (16 trees). Separate blocks were planted in the Aguaytía watershed which the farmers maintained under the same arrangements for the progeny tests/seed orchards described above. Final measurements of the provenance trials were carried out in the 3rd and 4th year, after which time maintenance was discontinued.

1.4.4 *PROSEMA (Aguaytía Watershed High-Quality Seed and Wood Producers Association) and agro-enterprise development*

From the onset, farmers were involved in the propagation and dissemination of planting material as an alternative way to deliver germplasm. It was also thought that seed production could be a potentially remunerative commercial activity for them.

2. Lessons Learned

The large number of species which farmers identified as the most important (15) or of the highest priority (10) indicated that there was little agreement. In Yurimaguas, 15% of the 58 species listed were considered important by more than 50% of the farmers, compared with less than 2% in Pucallpa and Iquitos. Species that supply wood were preferred, followed by energy and food. Of the 23 priority species, 5 were selected for agroforestry systems because they could adapt with ease. However, *Cedrelinga catenaeformis* was subsequently dropped due to its unsuitability for the soils in much of the target zone in the

Table 2 Species selected for agroforestry systems

Species	Uses and possible planting systems
Bactris gasipaes	Bears fruit from the 5th year and heart-of-palm from the 2nd year; can be planted with annual crops for 2 growing seasons, then with a leguminous cover crop for weed control
Cedrelinga catenaeformis	Possible component of multistrata systems in poor soils or for use in enriched fallows; is harvested for timber in the 40th year
Inga edulis	Can be planted in soils with high Al saturation as a short-term fallow; produces firewood/charcoal in the 2nd year and fruit in the 3rd year; excellent in alley cropping for Nitrogen fixation and its abundant green manure
Calycophyllum spruceanum	Grows in flooded areas; produces firewood/charcoal in the 4th year; posts in the 8th year
Guazuma crinita	Upland areas; production of firewood and charcoal in the 4th year, construction posts in the 8th year

Aguaytía Valley (Table 2). In spite of its high ranking, *Cedrela odorata* was not retained because of its susceptibility to pests and diseases in the early growing stages (i. e. presumably, *Hypsipyla grandella*, the mahogany shoot-borer).

Although the priority species were selected through a participatory process, some aspects of the approach, along with information from other studies, suggested that those chosen, particularly *Calycophyllum spruceanum* and *Guazuma crinita*, were not the most likely to be planted by farmers. However, it is not clear which alternatives might have been better choices, whether fruit or timber species. In large measure, the difficulty of selecting species reflects the current state of agroforestry in the Peruvian Amazon. As few tree species are planted on a commercial scale, prioritization of species for specific research or to illustrate specific approaches is subject to error or, at best, to decisions which could be flawed.

Independently of wider considerations on the appropriate modes of engagement for institutions, foresters or forest geneticists do not possess the breadth of expertise to implement a full domestication program, particularly one involving fruit trees. In the short to medium terms, it is unlikely that such expertise will be available. For this reason and others, collaboration on tree domestication between program staff and local partners needs to be strengthened, including to address specific problems through research and to identify new opportunities. Effective prioritization and selection of species/products require that institutions join efforts because it is not so much a matter of choosing winners and avoiding losers, but of mobilizing the human, institutional and financial resources to bring about the conditions that make success probable.

3. Results and Impacts

3.1 PROSEMA Seed

As noted earlier, the main objective of the program was to improve the livelihoods of smallholders by giving them access to high quality germplasm for agroforestry. Evaluation of this aspect is premature, given that the orchards in the Aguaytía Valley and Yurimaguas have only produced seeds in the last few years and no selection has yet been applied. Therefore, there is no evidence to conclude that PROSEMA seed is genetically superior, except to seeds from inbred or other unsatisfactory sources.

Like all tree improvement programs, financial benefits depend on three factors: the size of planted area, the value of the product and the increase in quantity or value of production due to genetic improvement. At present, it is unrealistic to expect major returns because current planting is modest and the PROSEMA seed is probably not of better quality. Although seeds from the program may be more genetically diverse than other seed sources, it is unclear what this difference means in financial terms. The question of whether the model will be replicated more broadly will also determine the extent of its impact.

3.2 Prioritization

In spite of previous findings which show that smallholders in the Peruvian Amazon prefer fruit trees, 4 of the 6 high priority species identified in the survey were for construction, fuelwood and sawn timber. It seems likely that this inconsistency arose from the fact that farmers were asked to identify their most important species. Undoubtedly, they placed a high value on those they use the most for house construction and fuel, for example. However, many species can be used for such purposes so opinions on which are the most important depend on which ones are available on the farm. For the same reason, farmers will choose the most abundant species-not a helpful indication because they would not plant such species (or those which are easy substitutes). Therefore, they are probably not good candidates for domestication.

The prioritization process raises the question of whether some species should be targeted for research more than others. It should perhaps have emphasized the need to identify species that farmers are interested in planting rather than those they consider important. The process also produced some unexpected results:

(1) the choice of two timber species that require high quality sites or high investment in soil amendments (*G. crinita* , *C. spruceanum*) when farmers often do not have the resources or would rather use them for food production;

(2) the choice of an exotic species (Brazil nut), rarely planted in the survey zones; and

(3) the absence of mahogany (*S. macrophylla*) on the list, despite expressions of farmer interest in the species.

The selection of peach palm appears to have been appropriate, at least in terms of farmer interests, but the impact of the program's work on this species was less than on bolaina and capirona.

4. Looking Ahead

The program's influence on the conservation of genetic resources is difficult to assess because there is no baseline data on which to conduct an assessment. However, it is likely that, as timber supplies become less accessible in natural forests, pressure on natural stands of bolaina and capirona will increase. Therefore, it should not be assumed that the genetic resources of these common species are safe in natural forests—a reality that suggests plantings play a valuable role in genetic conservation. Current tests on farms related to conservation over the medium to long term will probably require replication on land belonging to the Instituto Nacional de Innovacion Agraria (National Institute of Agrarian Innovation), the Instituto de Investigaciones de la Amazonia Peruviana (Research Institute of the Peruvian Amazon) and public sector.

A key policy concern is to ensure that improved infrastructures, including better market access, facilitate sustainable land use rather than more deforestation.

The question of inter-institutional collaboration is of profound importance to the domestication business and requires a wide range of actors to work together—producers, researchers, wholesalers, retailers, export promotion agencies, exporters, importers, import regulators and consumers, among others.

4.1 Improvement strategies

It could be argued that choosing the species for the program was not as important as demonstrating a viable approach that can be replicated elsewhere. In this regard, the program could have been more effective. Wider application requires that approaches not only be feasible for governments and non-government organizations, but that their impacts also be of sufficient magnitude to stimulate uptake. Such impacts depend on the use of improved germplasm to increase productivity, yet the quickest route to achieving this outcome, i.e. vegetative propagation and clonal testing, was not used for bolaina and capirona, and it is not feasible for peach palm. Although concerns about clones and the conservation of genetic diversity are valid, they do not imply that farmers should be denied access to better material, including clonal material.

Low-technology vegetative propagation techniques are available for tropical timber trees. With clonal selection, impressive gains in productivity and quality of both species (or indeed, of other timber species) could have been achieved

more cheaply than establishing and maintaining the extensive progeny tests conducted in Ucayali and Yurimaguas.

4.2 Tree improvement and tree domestication

Although the program engages in market research to some degree (e. g. for peach palm fruit) and silvicultural studies (e. g. undergraduate and postgraduate theses on the effects of sites and soils on the growth of priority species), it is largely a tree improvement program based on traditional approaches.

Tree improvement, as such, is an insufficient response to the challenges posed by agroforestry in the Peruvian Amazon and to the opportunities it presents in terms of specific species or products. By contrast, tree domestication—and wider connotations of agronomic and silvicultural research, product development, marketing and genetics—represent a more integrated approach to the discipline which can better engage, motivate and focus the efforts of research partners.

4.3 Potential to replicate successful measures in other parts of the region

The work with *G. crinita* and *C. spruceanum* has had a significant impact on the Peruvian forestry sector. The impressive growth in a number of highly accessible and visible experimental blocks has resulted in a better appreciation of the potential of the two species. Without a doubt, success of the trials has played a large part in placing options on the national and regional forestry agenda, including of organizations such as FONDEBOSQUE which captures and channels funds for development of the Peruvian forest industry and REFORESTA – Perú, a private company. However, the program's contribution to the increase in forest plantations is difficult to separate from that of other actors. Finally, members of PROSEMA have benefited from their involvement in the program through seed sales, payments for maintaining trial plots and training.

4.4 Prospects of achieving development goals

Many of the above points imply that the program is not as well designed and implemented as it could have been. However, expenses incurred in the past, as in all economic decisions, are irrelevant when determining if activities should be continued or not. The question now is what can be achieved at what cost, given the work that has been completed.

The program has endowed Perú with a highly valuable, structured genetic resource for 3 high potential species for use in agroforestry, forestry, and horticultural production systems. In addition, data analyses not only provide a sound basis on which to develop strategies for using these resources but more information can also be gleaned from current and future measurements. Both these aspects are sufficient to develop highly improved genetic material of *G. crinita* , *C. spruceanum* , and *B. gasipaes* and marginal benefits will likely exceed marginal costs because expenditures have already been incurred. Whether the availability of such material can improve livelihoods depends on whether wider domestication efforts complement those related to genetic improvement.

Agroforestry System Designing along the Landscape Continuum: the Cambodian Experience

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1. Introduction

Cambodia shares the Lower Mekong River with Lao PDR, Thailand and Viet Nam. Its dry forest ecoregion harbors a complex and intact landscape that provides habitat for the most diverse fauna in the world. As such, it is of global significance. Of these four economies, Cambodia's Mondulkiri Protected Forest is the largest of its kind at 429,450 ha.

This rich natural wealth, together with a world famous cultural heritage site—Angkor Wat—offer Cambodia the opportunity to develop economically, especially under transformed governance. In addition, its strategic location at the center of the Indochina Peninsula makes it a good trading partner in agricultural products, particularly with Thailand and Viet Nam. Given its vast plains and plentiful water supply from the Mekong River and Tonle Sap Lake, agriculture offers the best potential for development. It is the largest sector of the economy and contributed about 40% to the Gross Domestic Product (GDP) each year between 2001 and 2005. Cambodia is a member of ASEAN and joined the World Trade Organization (WTO) in 2005. Both affiliations open up many possibilities to further develop the sector.

The garment industry and tourism are also fueling growth, with 1.7 million people visiting in 2006 and 2.0 million in 2007. After decades of war, economic development remains a daunting challenge. More than 60% of the population depends on subsistence farming and many lack education and skills. The countryside is poverty-ridden and infrastructures are almost non-existent. However, government is addressing these issues with the assistance of bilateral and multilateral donors.

Today, the natural landscape, especially in uplands, is rapidly being transformed due to increasing population, deforestation and urban development. Logging and slash and burn agriculture continue to threaten the environment, notably in Ratanakiri, Mondulkiri, Stroeung Traing and the low-lying provinces. Unsustainable and destructive farming practices and the indiscriminate extraction of natural resources are degrading fragile upland areas. Coupled with rising immigration and low crop yields, farmers are compelled to clear more land both for agriculture and settlement. Under these circumstances, agroforestry stands as the most appropriate land use system to address Cambodia's fast growing economy amidst its changing natural landscape.

As a strategy to increase forest cover while containing the negative effects of shifting cultivation in the uplands, the Royal Government of Cambodia adopted the National Forest Program (2010 – 2029) which was developed through a participatory process. In support of it, the Institute for Forest and Wildlife Research and Development, the Forest Administration and the Ministry of Agriculture, Forestry and Fisheries implemented a pilot agroforestry project under Danish International Development Assistance (DANIDA) in Kampot, Kratie and Ratankiri provinces from 2010 to 2012. It documented best practices and lessons learned, with a view to producing a user-friendly manual for field practitioners and farmers to help them better protect forests, increase agricultural productivity, conserve biodiversity, and contribute to climate change mitigation and adaptation.

2. Objectives

This paper provides a general guide on how to design an agroforestry system that is best fitted to certain areas along the watershed landscape continuum. Specifically, it outlines how farmers make choices in terms of:

(1) selecting an appropriate agroforestry system for a given site;

(2) choosing the most suitable combination of crops according to soil, climate, location and function; and

(3) integrating agroforestry with food production, conservation of agro-biodiversity, establishment of nature parks and ecotourism.

3. Issues to Be Addressed

As agroforestry becomes a recognized alternative farming system amidst declining soil fertility in changing natural landscapes, it is a viable option to practice in Cambodia's highlands and lowlands. Choosing the right mix of crops depends on topography, soil type and intended function. However, because these factors do not necessarily reflect the farmer' s preference, some drawbacks and risks are involved:

• the combination of species or mix of crops sometimes does not match the topography and soil type;

• the choice of crops is not based on market demand, except in cases where it concerns food that households normally consume;

- processing to add value are not considered;
- other goods and services from agroforestry are not taken into account; and
- agroforestry systems are not linked to other areas such as tourism and green certification.

4. Approach

A team of experts comprised of 1 international consultant, 1 national consultant, 1 support staff member and the project leader conducted a 3-day field visit to agroforestry farms in Kratie and Siem Reap provinces from 29 September to 1 October 2012. A questionnaire guided interviews with 20 farmers to determine their views on agroforestry, their motivation to adopt this system, their concerns and problems they encountered with applying technology. In addition, 4 model farms were assessed in terms of biophysical conditions, crop combinations, structural and functional arrangements, species selection and end use.

From the observations and interviews, guidelines were drafted on how to select the appropriate agroforestry system that matches the soil, topography and location of the site along the landscape continuum. Based on this information, an agroforestry manual for extension officers and farmers will be developed.

5. Observations and Findings

The field visit and farmer interviews revealed the following.

5.1 In the Kratie Province

(1) Soil quality was poor and farms were under water during the rainy season;

(2) Long periods of drought occurred during the dry season;

(3) Fruit trees and a few hardwood species of lower timber value were planted;

(4) The pattern of intercropping was random and the purpose was not clear in terms of the structural/functional relationship among components;

(5) The focus was on tree and short-term crops but not on livestock or fish culture, despite excess water and year-round grass forage;

(6) After training, all farmers wanted to adopt agroforestry and raise their own seedlings;

(7) Farmers lacked knowledge to match crops with soil properties, to combine crops, and on different agroforestry systems;

(8) They had limited knowledge and experience in producing seedlings, growing fruit trees not familiar to them, and making organic fertilizers and pesticides for cleaner and greener production; and

(9) Most farmers were beyond subsistence in that they had other sources of income and secure land tenure or title.

5.2 In the Siem Reap Province

(1) All farmers in the community forestry project were trained to raise seedlings for agroforestry and forest restoration.

(2) They practiced integrated and sustainable agriculture and agroforestry in their back yards.

(3) Farms were close to Angkor Wat, a world-renown cultural heritage site.

(4) The commune had the potential to become a tourist destination by linking agroforestry to ecotourism.

(5) A similar site with natural regrowth forest a few kilometers away from Phnom Penh could also be developed into a tourist attraction under the theme ″Bringing Nature Closer to the City″.

The construction of home-stay units and the establishment of integrated sustainable farming systems that produce organic products in the two agroforestry sites could boost tourism in the area and, thus, increase farmer incomes and improve livelihoods.

6. Lessons Learned and Recommendations

Based on the findings and analysis of the field visit, the team of experts developed the following guidelines for selecting an agroforestry system that best matches the site along the landscape continuum.

(1) Identifying the most crucial landscape functions to improve land use cover

Agroforestry systems in Cambodia must be seen as an acceptable alternative to shifting cultivation. They must also restore degraded upland areas, improve productivity of lowland farms and protect/rehabilitate understocked forest (Figure 1) .

(2) Considering the topography and landforms to determine zoning

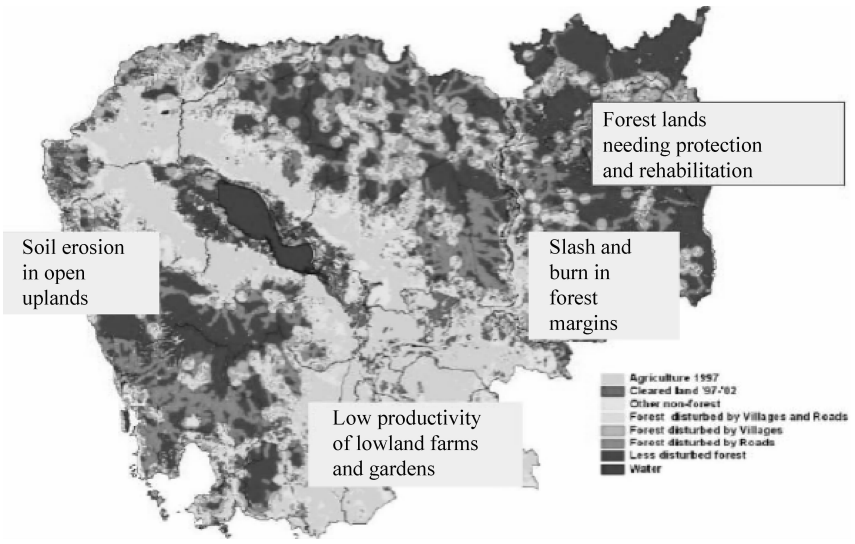

Figure 1 Four major spatial areas where agroforestry is needed most

Cambodia has forested mountains and well-watered plains. The central part forms a gigantic basin—the Tonle Sap (Great Lake) and the Mekong River. Between the Tonle Sap and the Gulf of Thailand lie the Cardamom Mountains and the Elephant Range which rise abruptly from the sea and eastern plains. The Dangrek Mountains in the north—320 km long and 300 –750 m high—mark the Thailand border. Kompong Som Bay (Chhâk Kâmpóng Saôm) is an important natural harbor along the short coastline to the southwest, where the port of Kompong Som is located.

The Mekong and the Tonle Sap dominate the life and economy of Cambodia. The Mekong overflows during the rainy season, deposits vast quantities of alluvial soil and causes the Tonle Sap to increase from about 2, 590 km^2 to 24, 605 km^2. The land is surrounded by mountain ranges in the west and northeast, bordering Thailand and Lao PDR respectively, with wide range plateaus and plains.

The topography consists of four major land forms or categories which can be used as the first level of screening to determine the most appropriate agroforestry system: plateau and mountain area (i. e. steep to moderate slopes in the uplands) ; plains (i. e. flat to gently slopes in the midland) ; Tonle Sap flood plains which are waterlogged most of the year; and Coastal area where the Mekong River drains to the sea.

As there are many combinations of plant species that match the type of climate, level of water tolerance and slope gradient in a given location, these

criteria would help planners of agroforestry projects, extension workers and farmers to choose the best mix of trees and agricultural crops. A wide range of options are available, depending on the farmer's primary use and needs of the household in terms of food and income. When deciding on the agroforestry model to help set up (i. e. for agro-biodiversity, soil and water conservation or carbon sequestration), donors usually prefer the type that comes closest to the theme they want to mainstream in the demonstration project. The four ecological zones are determined according to major landforms, topography, and level of water tolerance for tree and agricultural cropping (Figure 2).

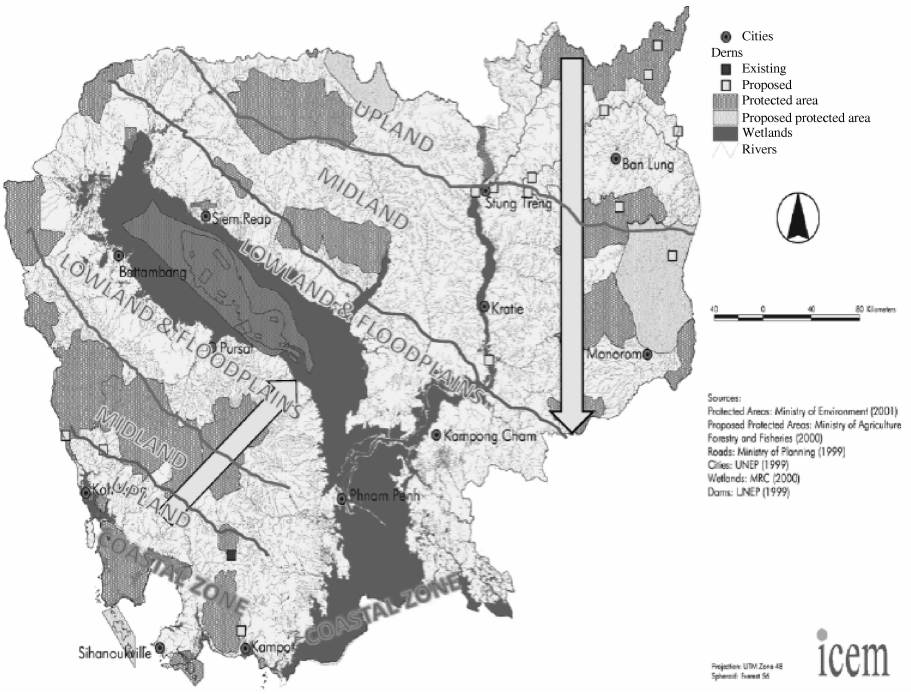

Figure 2 Cambodia's ecological zones

(3) Constructing a landscape continuum transect for climate and soil quality (Figure 3)

Selection of the appropriate plant species and crop combination is largely based on soil quality and texture (rocky, sand, silt or loam) and on properties such as the quantity of organic matter and nutrients, mineral content and degree of alkalinity. Some plants fix nitrogen and are suitable for phosphorous and nitrogen deficient soil while others thrive in acidic or waterlogged soils. Climate is another key factor. Some crops grow well under cold conditions while others perform best under dry and warm conditions. However, the rainfall pattern is the most important determinant of all and farmers usually adjust their cropping

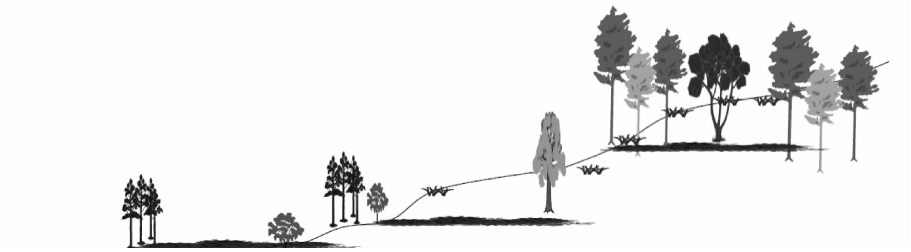

Figure 3 Profile of Cambodia's landscape continuum

calendar accordingly.

(4) Zoning the areas which are critical, vulnerable and have development potential

Using the most recent land use maps, examine the environmental stress and strategic vantage points for establishing agroforestry systems which match plant species or crop combinations with ecological functions or economic value (Table1) .

The following points should be taken into account when choosing plant species and crop combinations.

• Upland areas are prone to soil erosion, land slides and soil degradation.

Table 1 Ecological and economic mapping scenario of Cambodia

Characteristic	Lowland/Coast	Midland	Upland
Province	Siemreap, Kampot	Kratie, Pursat	Rattakiri, Mumdul kiri
Climate	Warm	Rather warm and cold	Cold
Rainfall (mm)	1,281 –2,211	1,858 –4,120	568 –2,449
Soil condition	Moderately poor, poor and degraded	Moderately poor, poor and degraded	Relatively richer
Forest stand	Brush land, shrubs, forest plantation	Spatial of forest cover, mixed tropical forest	Thin forest cover
Dominant land use	Paddy rice, plantation, crops (small)	Plantation crops or Chamcar	Less productive grassland
Farming	Intensive rice	Intensive rice and crops	Slash & burn and rice
Settlement	Highly organized	Densely populated and organized	Along the road
Water management issues/needs	Flood control/ irrigation	Sanitation and water quality	Water harvesting system
Threats/potential	Seasonal Flooding	River siltation and sedimentation	Grassland fire/erosion

(Continued)

Characteristic	Lowland/Coast	Midland	Upland
Environmental and social problems	Flooding, land degradation, sedimentation, river contamination, water stagnation, shortage of land, (≈1–2.5ha/farm), no systematic planting, or cropping	Moderate soil erosion, shallow soil mixed with gravel, lateritic soil, water stagnation, very damp or muddy, longer time to maintain crops, crop not suited to soil, no systematic planting or cropping, no sound land use planning and management	Severe soil erosion shifting cultivation transition from subsistence to industrial cropping, land reclamation, declining soil fertility, low productivity, crop not suited to soil, no systematic planting or cropping, no sound land use planning and management
Recommendations	Integrated farming system and organic farming	Integrated farming system and organic farming	Improved pasture, agroforestry, wood plant and conservation farming

• Flat areas, particularly around Tonle Sap Lake, are waterlogged most of the year.

• Moderately sloping areas have less landslides but suffer from riverbed siltation and sedimentation due to continuous soil movement from the uplands.

• Growth of tourism in Siem Reap can create a huge market for fresh, green and healthy farm produce and can open up instant opportunities for outdoor recreation for people who long to escape the city and get close to nature.

Given the above considerations, the choice of agroforestry type depends on what ecological function or economic value it would play to address both environmental and livelihood concerns.

(5) Focusing on three distinct dominant functions when selecting an agroforestry system

• Agroforestry for livelihoods: the aim is to increase food production and the source of income of subsistence farmers and other agroforestry practitioners, consistent with the government's program to alleviate rural poverty. This option explores how to link agroforestry and ecotourism in popular destination areas.

• Agroforestry for environmental services: the aim is to enhance ecosystem functions in watershed areas to achieve sustainable development for the

benefit of society. Services include soil and water conservation, increased soil nutrients, conservation of agro-biodiversity, carbon sequestration and improved water management.

• Agroforestry for food safety: the aim is to use agroforestry systems to meet the food safety standards set by WTO and various international trade agreements. As a member of WTO since 2005, Cambodia must compete in the global market by exporting a variety of quality products, including to niche markets. Organic and ecological farming is one way to gain an advantage, especially if practices are certified under green and fresh product schemes.

Agroforestry Practices in Papua New Guinea

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1. Introduction

Papua New Guinea (PNG) consists of the eastern half of the Island of New Guinea and several groups of islands offshore. It is divided into four regions: Central Highlands (mountainous); Momase (north of the mountains); Southern region; and the New Guinea Islands. Land area totals 462,840 km^2, of which 64% is forested. Papua New Guineans practice a traditional lifestyle and depend on their natural environment for survival. Most communities have established extensive areas of agroforestry within walking distance, which includes many planted and protected multipurpose tree species such as the native nitrogen fixing Casuarina (*Casuarina equistifolia*) that improves the soil and provides fuel.

This paper summarizes agroforestry practices over the past two decades by the former Department of Forests, now the PNG Forest Authority. It describes the issues that need to be resolved, the approaches taken, lessons learned, the results, impacts and planned future action.

2. Approaches

No national policy exists for agroforestry *per se*. Rather, a key statement in the National Reforestation Policy calls for it to be an integral part of the reforestation, afforestation and rehabilitation program. In terms of reforestation, the 1991 National Forest Policy promotes it as a means to maintain a permanent forest estate to supply forest industries now and in the future. It also states that economic criteria and feasibility studies will guide the development of plantations to assess the commercial potential to process material from these sources for a variety of end uses. A program to plant trees on non-forested and severely degraded land will be pursued as well. In addition, the National Forest Policy promotes the establishment of woodlots, agroforestry as a land use, and tree planting by youth groups in both rural and urban areas. It further indicates that forestry extension services will support such activities, especially in areas where wood and wood products for domestic consumption are in short supply.

Many non-government organizations are engaged in agroforestry, with most

focusing on small community-based activities. Several other agencies, apart from the PNG Forest Authority, are involved as well: the National Agriculture Research Institute (NARI), the Department of Agriculture and Livestock, the Forestry and Agriculture Colleges, the Coconut Research Institute in Madang and private companies such as Ramu Sugar.

The current objective for implementing agroforestry is to address issues such as REDD and REDD+; ecological and social economic conditions in communities; greater demand for food, fuelwood, timber and other products; environmental concerns; and food insecurity. These factors were all taken into account when the latest system was designed to ensure its sustainability.

3. Lessons Learned

Mr. Joseph Lelang, Secretary of the Department of Planning and Monitoring, refers to the Medium Term Development Plan (MTDP) 2011 – 2015 as a policy-driven document, supported by targets and cost estimates to achieve desired results. It is consistent with PNG's 2050 Vision which will drive development over the next 40 years. Goals for the agriculture and livestock sector as well as the forestry sector are set out in sections 4.1 and 4.3 of the MTDP. They call for the former to be of world class caliber, to be responsive to international and domestic markets for a diverse range of products, and to provide the best income and job opportunities. With regard to the latter, it should aim to be sustainable and profitable. Reaching these objectives will help to achieve the nation's vision which both charts PNG's future direction and reflects the aspirations of its people.

In the past, commercial agroforestry was not taken seriously, mainly because

- Land tenure issues and tribal/clan disputes were serious obstacles to development;
- Knowledge of what tree species and food crops to be planted was deficient;
- Market information, including product demand and pricing, was missing;
- Skilled personnel was not available; and
- Agroforestry was not taught as a separate subject until recently.

Therefore, in the early 1970s, agroforestry focused more on research than on actual application. Trials were carried out by the:

- Bulolo Forestry Research Station in Bulolo, Morobe Province (700 m above sea level and 1500 mm of annual rainfall);

• Lapegu Forestry Station in Goroka, Eastern Highlands Province (1500 m above sea level and 2000 mm of annual rainfall);

• Wahgi Swamp Forest Plantation near Mt. Hagen, Western Highlands Province (2600 m above sea level and 2000 mm of annual rainfall);

• Madang Forestry Station, Madang Province in the northern part of PNG; and

• Keravat Forestry Station in Rabaul, East New Britain Province.

Examples of the research they conducted are listed below.

• Coffee mixed with giant *Leucaena* : giant Leucaena (*Leucaena. Lecochaphalus*) was planted at a spacing of 4m × 4m and coffee (*Robusta arabica*) was planted between the rows. The technique proved successful and some farmers were using it to grow coffee on a small scale and selling it in local markets (in Bulolo).

• Coffee mixed with *Tmerminalia complanata* : *Terminalia complanata* was planted at a spacing of 9m × 9m and coffee was planted between the rows. However, because most trees died, the coffee did not grow well in the open and yield was low (in Bulolo).

• Coffee mixed with pine: coffee was mixed with Hoop pine (*Araucaria cunninghamii*) and *Pinus caribaea* but the survival and growth rate of the plant was poor (in Lapegu).

• Cocoa mixed with Talis and *Leucaena lecochaphalus* : Talis (*Terminalia kaenberkii*) was planted at a spacing of 9m × 9m and *Leuchaena lecochaphalus* was planted along the same lines. Cocoa was then planted at a spacing of 3m × 3m between the rows of trees. The cocoa grew well and produced many good beans. However, productivity was not assessed because settlers harvested them for their own use (in Bulolo).

• Cocoa mixed with *Eucalyptus deglupta* and *Acacia mangium* : these were small observation plots which were not successful (in Madang).

• Cocoa under coconut trees: this practice proved very successful and is now done on a large scale (in Keravat).

• Food crops planted between the rows of *Leucaena mexican: Leucaena mexican* was planted at a spacing of 3m × 3m and food crops such as pineapple, taro, banana, cassava, sugar cane and pumpkin were planted in-between. Some farmers are using this method to grow food crops in grassland areas for sale in local markets.*Leucaena mexican* produces a straight stem and long clear bole that residents use to make bush material houses (in Bulolo).

• Food crops planted between trees: in addition to mixing food crops with trees in traditional areas, this practice was applied near swamps, where *Cassuarina*

oligodon , *Eucalyptus grandis* and *E. robusta* were also used (in Wahgi) .

• Cattle grazing in the Hoop pine and Klinkii pine plantation: the plantation of *Araucaria cunninghamii* and *Araucaria hunsteinii* is state-owned but the cattle belongs to PNG Forest Products, a private company. By having the cattle feed on the grass in the plantation, maintenance costs were reduced. However, this project was not continued despite successful outcomes (in Bulolo) . Similar tests were conducted at the Lapegu Forestry Station but were not successful.

• Cattle grazing under Eucalyptus: the cattle of local entrepreneurs grazed in the *Eucalyptus grandis* and *Eucalyptus robusta* plantations to keep the grass short. However, this practice did not continue (in Waghi) .

• Shitake mushrooms grown on tree stumps: shitake mushrooms were grown on the stumps of *Castanopsis accuminitissima* but there was no local market for the product. Lack of project funding to continue operations was also a problem (in Bulolo) .

• Pasture trials: work was carried out to identify tree/plant species that would support cattle grazing, control soil erosion and increase soil nutrients (in Bulolo, Lapegu and Madang) .

• Farming of Ochroma lagopus: in addition to private companies planting balsa, villagers established woodlots using this species and were selling the products to businesses in East New Britain Province. The success of this activity had prompted an increase in balsa farming in this province and it is spreading to some parts of West New Britain Province.

Photo 1 A farmer planted *Eucalyptus pellita* in his home garden

Prior to the late 1980s and early 1990s, farmers did not consider planting timber tree species because they could obtain material to build their houses from the natural forest. Only when the former Department of Forests began planting trees did they realize they could do the same on their land for personal use and commercial sale. In the highlands, woodlots were established using *Casuarina oligodon* , *Eucalyptus grandis* , *Eucalyptus robusta* , *Pinus caribaea* , *Pinus strobus* , *Pinus patula* . In the lowlands, farmers used *Eucalyptus pellita* , *Tectona grandis* (teak), *Pometia pinnata* (Taun non edible fruit), *Ochroma lagopus* (balsa, mostly in East New Britain Province), *Pinus caribaea* , *Acacia mangium* and *Eucalyptus deglupta* (Kamarere), for example.

Photo 2 People planted fast growing species such as *Pometia pinnata* (Taun) for timber (These trees are 14 years old, with some reaching 45 cm DBH and 20 m high)

4. Results and Impacts

These trial plots were successful but lack of funding from the PNG Forest Authority prevented their maintenance. Therefore, further monitoring and data collection were not done. Most plots still exist but are now claimed by land owners who fell the mature trees for their private supply of timber, fuelwood and housing materials. Sites were abandoned or have disappeared and most communities no longer engage in forestry trials or in community forestry because mining and agriculture are more lucrative in the short term. Those

which remain involved have vast areas of grassland or savannah and financially benefit from the fuelwood and timber they produce to partly meet high market demand.

One way to renew community interest in agroforestry is for projects to adopt a participatory approach. Doing so will also help them become sustainable, achieve desired outcomes and accomplish the objectives stated in PNG's MTDP and 2050 Vision.

5. Strategies and Action Plans

5.1 Weaknesses

No strategies or action plans specific to agroforestry are currently in place in PNG, although some organizations plan to address key issues, including multipurpose tree species. In May 1989, three organizations formed the National Multipurpose Tree Species Committee: the PNG Forest Research Institute, the Department of Forestry at the University of Technology in Lae and the Bulolo Forestry College. Membership subsequently increased to 11 organizations, including the Department of Agriculture and Livestock, the Wau Ecological Institute, and provincial forestry divisions.

The objectives of the committee were to form a network to discuss current and future research, disseminate information to users and liaise with regional networks to promote and improve work on this group of species. It was hoped that the committee would be instrumental in planning and evaluating research, developing extension services nationwide, disseminating materials and avoiding duplication. However, it became dormant so that national strategies and action plans for agroforestry and multipurpose tree species were never developed.

5.2 Recommendations

• Reviving the National Multipurpose Tree Species Committee: information on agroforestry and multipurpose tree species is currently scattered. If the committee were revived, it could coordinate activities at the national level and report progress. International committees involved in similar work could be invited to attend meetings to jointly develop plans and projects.

• Establishing a regional committee on agroforestry and multipurpose tree species: a regional committee would be an effective means to share

information among member economies for domestic application, as appropriate. It could also serve as a venue to encourage agroforestry and multipurpose tree species within the region and for Pacific Island nations to develop one or two collaborative projects.

• Reviewing outcomes of past and current research: a review of trials should be undertaken to better determine what species to be planted where, potential markets for products, pricing and whether past research was conducted properly. This assessment would involve obtaining the views of communities and stakeholders on the importance and benefits of this research to them. The review would then help identify new projects, based on criteria such as market access and demand, potential benefits, contributions to forest plantation development and community interest.

• Encouraging agroforestry, the use of multipurpose tree species and community forestry: in addition to the review suggested above, other aspects of field trials should be examined—whether outcomes were successful, current status of the research, extent to which data were collected and procedures documented, and the techniques identified or developed. It would also be important to find out why results were effective, if they were replicated more broadly and, if not, why not. This information could then be used to improve the implementation of PNG's forest plantation development program.

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Rehabilitation of Forest Biodiversity, Poverty Alleviation and Climate Change Mitigation through Smallholder Tree Growing in Northeast Thailand

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1. Introduction

During the second half of the 20th century, forestry laws and regulations in support of sustainable land use were enacted in response to the rapid decrease in natural forest cover and associated loss of biodiversity from excessive timber exploitation. Moreover, the gap between fuelwood demand and supply was increasing—a situation which led to poor farmers using more and more crop residues and animal manure for fuel rather than as mulch and fertilizer to maintain soil productivity.

The integration of trees into farming systems was promoted in the late 1970s as a sustainable land use strategy, particularly in poor rural areas. Earlier, this system was promoted to address fuelwood shortages. With the introduction of integrated rural development programs in the 1980s, smallholder tree growing became popular again because of its potential to generate a wide range of tree products for both subsistence and commercial purposes, including timber, wood fuel, fruit, leafy vegetable, fodder, resin, oil and medicine. More recently, the role of tree farming in mitigating climate change through carbon sequestration is being highlighted.

This paper provides an overview of smallholder tree growing as a form of agroforestry and describes how this system helps meet household demand for wood, alleviate poverty and mitigate the effects of climate change in Northeast Thailand. Incentives to promote the establishment of private tree plantations are also summarized.

1.1 Overview of Northeast Thailand

The Northeast region occupies 1/3 of Thailand's land area (170,000km^2) and is home to 1/3 of its population (approximately 20 million) (Figure 1) . Although it is the poorest region, its potential for development is significant due to its vast populated area. During the last century, however, forest area declined from 90% in the 1930s to less than 14% today and unsustainable agricultural practices led to soil degradation and declining yields, both of which threatened long-term use of the land. Before Northeast Thailand was brought under Thai administration in 1830, the region was sparsely population and densely forested. As late as 1930, only 6.9% of the land was under agriculture but this area has since expanded considerably.

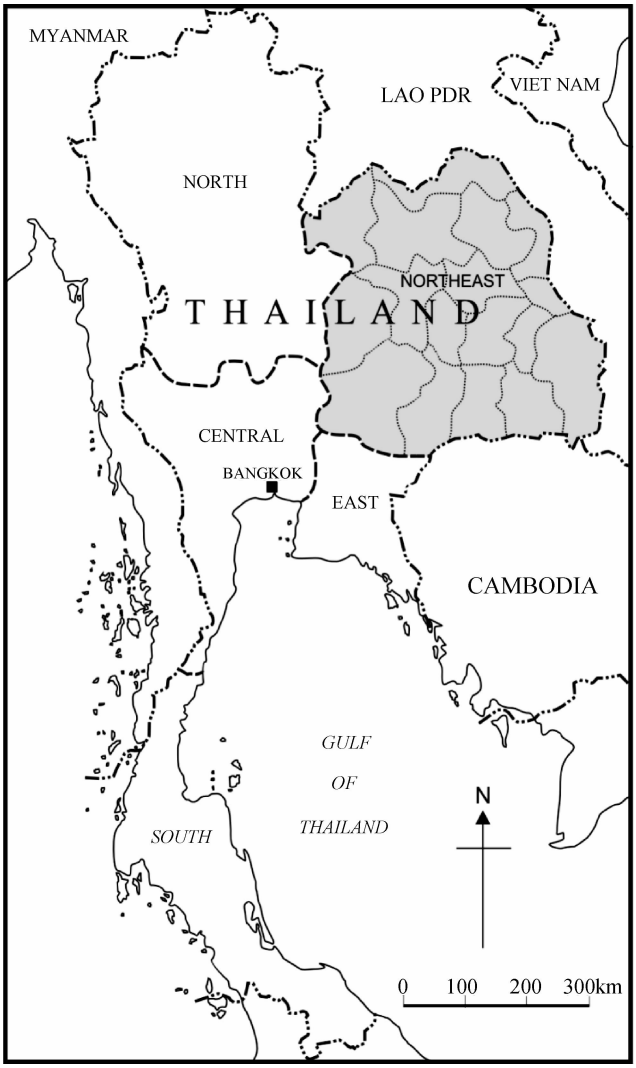

Figure 1 Map of Northeast Thailand

Growing rice to sell began on a small scale in the 1920s and 1930s when railway lines were established but it increased from the 1950s onwards. The mid-1950s also saw the extensive cultivation of upland cash crops. Table 1 summarizes prominent events in the course of land-use change in Northeast Thailand.

Table 1 Prominent events leading to land-use change

Year	Key events	Economy
1830	The Northeast was brought under Thai administration	
1902 – 1941	Evidence of earthen dams for irrigation of paddy rice was uncovered	Subsistence
1930	6. 9% of land area was cultivated with paddies and mostly irrigated	Subsistence
1920s – 1930s	Railway lines were established and allowed a small amount of commercial rice cultivation	Subsistence
1930s – 1940s	Cattle was exported to Central Thailand, signaling an element of commercialization of cattle raising	Subsistence
1930 – 1953	Shifting cultivation was common but, by 1953, only 3. 5% of farm households continued to practice it	Subsistence
1950s	Cultivation of cash crops on a commercial basis began and forests were rapidly lost	Commercial

The following factors influenced land-use change in Northeast Thailand.

• According to Thomas (1988), population in Northeast Thailand went from 3 million in 1920 to 18 million in 1985. As a result, farmers cultivated all usable land and those who lacked land migrated to frontier areas to establish new settlements.

• Markets expanded and commercial agriculture increased due to socio-political and economic changes at national and international levels. Since the mid-1950s, cash crops were grown in upland areas where paddy fields could not be established. As a result, mixed gardens were transformed into permanent upland fields, with cash crops of kenaf, maize, sugarcane, peanuts and cassava. Expansion of upland cropping pushed the forest frontier further back.

• Government efforts to integrate Northeast Thailand into the Kingdom started in the 19th century during the reign of King Chulalongkorn, in response to the threat of French imperialism. Enactment of National Socio-economic Plans followed under Field Marshall Sarit Thanarat in the 1950s and succeeding governments.

Main forest types are hill evergreen, dry evergreen and deciduous. Hydrological patterns within the landscape have more of an effect on vegetation than the amount of rainfall. Water tolerant vegetation survives in low land areas and in poorly drained soil. The Khorat platform is one of the driest regions in Thailand, where average annual rainfall is only 1050 mm in the lower part. In contrast, the far Northeast, along the Mekong River, receives more than 2030 mm. During the monsoon, winds can be cold in Khorat and daily temperature variations are

greater than those in the central valley and more maritime areas.

Various types of degraded soil are found in Northeast Thailand, the most serious problem being salt. These salt-affected soils cover 2.8 million ha and threaten 3.1 million more. The cause is attributed to the weathering of salt-bearing rocks and underground rock salts in the formations of Khok Kruat and Mahasarakham. Although it represents only 5.4% of Thailand's arable land, productive capacity is seriously compromised. Given that degraded soil has a direct impact on national agricultural production and rural poverty, government is implementing effective strategies and countermeasures such as reforestation and agroforestry to reduce soil salinity and cope with its adverse effects.

1.2 Smallholder tree growing

To meet increasing demand for wood, the Royal Forest Department (RFD) encouraged the Ministry of Agriculture and Cooperatives to seek government funding for the Private Tree Farm Incentive Plantation Programme. Although still operational, it was scheduled to run from 1994 to 2002 (except in 2001) and it targeted 1.28 million ha. Farmers and the private sector were encouraged to plant specific economic tree species at 1,250 seedlings/ha so as to utilize all marginal areas to improve the environment and reduce rural poverty. Government subsidized planting at US$469/ha and, after 5 years, the farmers were free to harvest or manage the standing stock as they saw fit. About 80,126 participated in the programme and planted 169,400 ha (13% of the target). Attractive subsidies for rubber partly accounted for the low intake but obstacles to investment in tree crops contributed as well.

1.3 Traditional agroforestry for subsistence needs and local trade

The forests surrounding villages in the Northeast are important to livelihoods because they provide construction material, fuel, food, medicine, dyes, resins and many other products. Mixed gardens are also a common feature in that they meet both the subsistence needs of households and generate income from the trade of any surplus in local markets. Traditional crops include leafy vegetables, chilies, peppers, eggplants, cucurbits, beans, bananas, papaya, various fruit trees, herbs and spices, tobacco, betel, mulberry, cotton, kapok, leucaena and eucalyptus. The mixed gardens are located in fertile upland areas with sufficient moisture: plots around homes, inside the village settlement, on the banks of ponds, in paddy fields after the rice harvest, on termite mounds and on field huts.

1.4 Modern agroforestry

JICA (2004) reported that, between 1992 and 2004, its Reforestation and Extension Project in the Northeast promoted planting by local people through a social forestry approach to restore the environment and improve living standards. The four project components were: ① forest management information, ② forest management techniques, ③ training and extension, and ④ monitoring. When the project concluded in 1998, four large-scale nurseries produced 89 million seedlings which were distributed to 2,444 villages and 143 training courses were given. In addition, 6,093 ha of demonstration plantations were established and several activities were undertaken to promote tree planting. The main species were selected based on farmer preferences, including *Eucalyptus*, *Neem*, *Pterocarpus macrocarpus*, *Acacia mangium* and teak. Smallholders planted trees on marginal lands, particularly on the boundaries of agricultural fields, and intercropped them with other cash crops for quick returns. Because the bushland mostly belongs to the community, the decision on planting is made collectively and community forest centers provide the seedlings. Marginal farmers who do not have many economic options are being encouraged to practice agroforestry. Most trained villagers work as informal extension agents and share their knowledge. While community forestry may focus on European Non-wood Frest Products (NWFPs), private forest owners want to produce timber because it gives them better economic returns. *Eucalyptus* and *Leucaena leucocephala* are grown on private lands to make charcoal and wood vinegar (alcatra). Farmers cultivate NWFPs such as mushrooms, bamboo shoots, jungle spice and medicine herbs because of the significant economic benefit that they bring.

1.5 *Eucalyptus* plantations

Various projects introduced *Eucalyptus* to Northeast Thailand in the late 1970s and early 1980s. For example, the Thai—Australia Thung Kula Ronghai Development Project (1976 – 1989) aimed to reforest the region with this species to reduce the spread of saline soil, alleviate flooding and make commercial use of the trees. However, when the tambon council agreed to establish *Eucalyptus* plantations on public community land, conflict arose between government and non-government organizations over the effect this might have on the environment, especially in the upland areas.

1.6 Teak for domestic consumption and carbon offsets

Teak planting in Thailand started in 1906 with the taungya system which was modified to suit economic and social conditions. From 1994 to 2000, the Royal Forest Department (RFD) assisted the private sector to establish about 100,000 ha of teak plantations. The production potential was an estimated 0.9 – 1.0 million m^3/year as long as thinning occurred in a timely manner. Because plantations are mostly in forest reserves, it is unclear whether they can be effectively managed for timber production due to the logging ban. Although the area under teak increased after government offered subsidies in 1993 to encourage private sector investment, complicated provisions in the Forest Plantation Act of 1992 caused lengthy delays in the approval of management plans, among other obstacles. However, the RFD foresees amending this legislation to address such issues.

The Forest Industry Organization has played an important role in establishing and utilizing teak plantations but a shortage in domestic supply remains a major concern of wood-based industries. Legal harvesting is only possible with a special license and the volume of confiscated logs (about 10,000 m^3/year) is only a fraction of what it was in the 1980s. More and more farmers and other landholders are planting teak in 20- to 30-year rotations. Recent research indicated that the teakwood produced was not significantly inferior in density and strength compared with natural teak. However, its lower heartwood makes it less durable and attractive.

Information on water use, on the potential of teak trees to sequester carbon and on suitable provenances/seed sources for quality timber production can facilitate the preparation of sustainable management plans. In addition, with the decentralization of nurseries and clonal orchards, standardized techniques for cost-effective vegetative propagation/clonal multiplication will help supply genetically superior planting material to teak growers.

The problems associated with teak plantations on private land are:

- planting on unsuitable sites where growth is poor;
- delays in thinning;
- lack of markets for the residues/products from thinning; and
- unclear silvicultural parameters such as rotation period, thinning densities, and pruning schedules.

It is now time to thin the large planted areas in the Northeast and timely execution is crucial to achieve the economic returns expected for the investment made.

In February 2011, Michigan State University paid US $8707.81 to a group of farmers in In-Paeng for offsetting 2,048.90 tons of CO_2—the first time in Thailand that carbon offsets were sold as a commodity. This agroforestry project started in 1994 and the developers (Mahasarakham University, National Research Council of Thailand and Michigan State University) were also the buyers. According to them, the voluntary carbon market opened up the possibility of making retroactive claims so that small-scale farmers could enjoy the benefits of agroforestry practices.

The network of farmers was established in 1987 during the farm debt crisis to help them become economically self-sufficient and the founders sought to revive indigenous agricultural practices. The project supported them to plant native forest trees which would provide food, timber and medicine. The decision to locate operations in In-Paeng was based on the fact that tree seedlings could be easily distributed to farmers in nearby communities. The network's structure is hierarchical, with a central board of leaders managing its funds. It was initially local in scope but activities now encompass farmers in at least 4 provinces in the Northeast.

1.7 Pterocarpus macrocarpus

Plantations of Pterocarpus macrocarpus are found in Northeast Thailand but only limited information is available on their characteristics. The species is suitable for the region as it can grow on sandy soil in lowlands, albeit more slowly than teak at first, but it becomes taller in about 15 years. Seedlings can be propagated from cuttings and the first gene bank of this species is reported to be operational. Basic knowledge on nursery techniques has also been developed. Once established with proper site preparation and fertilization, *P. macrocarpus* stands require tending to avoid loss of growth. Pruning is also recommended.

1.8 Rubber trees

Since 2004, rubber cultivation has expanded more rapidly in Northeast Thailand than in previous years, with government supporting the establishment of 320,000 ha. This assistance allowed smallholders to invest in what was previously the exclusive domain of large operators. Under climate variability and declining soil fertility, it appears that rubber plantations are the best option to generate a permanent and steady income for both holders and laborers. In 2010, government launched another national project, under the Office of the Rubber Replanting Aid Fund (ORRAF). The target is 128,000 ha, of which as much as 80,000 ha are for smallholders in the Northeast. As its name

suggests, ORRAF is responsible for supporting rubber farmers to replant old rubber holdings with more productive varieties. As a non-profit state enterprise, ORRAF draws on levies from rubber exports to administer and implement replanting schemes. In the early years, food crops such as cassava, mulberry, corn, pineapple and pea or neem (*Azadirachta indica*) were combined with rubber trees to earn quick revenue.

1.9 Economic performance of smallholder rubber-agroforestry

A study of the economic efficiency of smallholder rubber-agroforestry revealed that only two systems yielded higher farm net incomes than rubber monocultures: rubber mixed with food crops and rubber mixed with fruit trees (Table 2).

Table 2 Rubber trees combined with food crops and with fruit trees

Rubber – food crops	Net income [baht/(year·household)]	Rubber – fruit trees	Net income [baht(year·household)]
Rubber monocultures	83,428	Rubber monocultures	83,429
Rubber – pineapple	500,000	Rubber – custard apple	250,000
Rubber – corn	280,000	Rubber – mango	29,000
Rubber – rice	163,200	Rubber – jack fruit	6,000
Rubber – banana	116,107		
Rubber – cassava	111,668		
Rubber – papaya	75,000		

1.10 Agroforestry in saline areas

Cash crops, fruit trees, fast growing trees, native vegetables and fish ponds were introduced in an agroforestry project over areas which had high salinity. Given the positive responses from farmers, the Land Development Department extended coverage from 100 ha in 2003 to 230 ha in 2004. Trees which were tolerant to saline soil (*Azadirachta indica*, *E.camaldulensis* and *Acacia ampliceps*) were planted and, after 4 years, showed good signs of survival.

1.11 Incentives for smallholder tree growing

The early 1990s saw the development of numerous incentive schemes that were mainly administered via projects. In addition, the RFD continued to provide seedlings and to lease degraded reserved forestland to the private

sector. Because of the 8 ha restriction, private companies offered incentives to farmers to produce raw material for the wood-processing industries.

Since 1991, the RFD and the Bank of Agriculture and Agricultural Cooperatives have initiated four schemes to support private sector plantation development:

- Reforestation and Extension Project in Northeast Thailand (1991);
- Private Reforestation Extension Project (1994);
- Fast Growing Trees Reforestation Project (1994); and
- Overseas Economic Cooperation Fund for Forest Plantations (1998).

1.12 Current forest production and conservation policies

The National Forest Policy (1989) stipulated 40% forest cover, of which at least 25% was to be conservation forests and 15% production forests. This target was reaffirmed in the Seventh National Economic and Social Development Plan (1992 – 1997). The Agricultural Development Plan, a component in the 9th National Economic and Social Development Plan (2002 – 2006), stressed the conservation and rehabilitation of 30% of Thailand's total area. The Plan also promoted productive forest plantations, private plantations and community forestry over an area of 5.12 million ha.

Relevant sections of the New Constitution of the Kingdom of Thailand are as follows.

Section 46 Persons so assembling as to be a traditional community shall have the right to conserve or restore their custom, local knowledge, arts or good culture of the community and of the nation and to participate in the management, maintenance, preservation and exploitation of natural resources and the environment in a balanced fashion, as provided by law.

Section 56 A person and communities have the right to participate in the preservation and exploitation of natural resources and biological diversity and in the protection, promotion and preservation of the quality of the environment. Sanitary conditions and welfare or quality of life shall also be protected, as provided by law.

Section 79 The State shall promote and encourage public participation in the preservation, maintenance and balanced exploitation of natural resources and biological diversity and in the promotion, maintenance and protection of the quality of the environment in accordance with development principle as well as the control and elimination of pollution affecting public health, sanitary conditions, welfare and quality of life.

2. Research, Development and Extension

In 1964, the RFD established a research station in Chiang Mai to study the use of pine and other fast-growing tree species for pulp production. In 1967, it set up a nursery to examine the genetics of teak and pine in Lampang Province, and to produce and distribute seedlings to community groups and the public. In 1972, the Silvicultural Research Division was strengthened and mandated to conduct research on forest plantations, silvicultural systems and watershed improvement. 3 years later, a new policy was introduced to support the establishment of forest plantations and the development of communities living in forest areas. At the same time, the National Reserve Forest Land Division, the Wildlife Conservation Division and the Watershed Conservation Division were established. A Nursery Section under the Silvicultural Research Division was also created to produce seedlings for reforestation and afforestation. In 1982, the Central Forestry Research Laboratory and Training Centre were created to conduct research on forest plantations in northeast Thailand. In 1986, the RFD set up the Office of Private Reforestation and Extension to support the private sector in establishing commercial forest plantations. Its responsibilities included assistance in sourcing financial support through cooperatives, marketing, wood processing and long-term plantation management. In accordance with the government policy to reforest logged-over areas, the Forest Industry Organization expanded its mandate in 1974 to cover reforestation.

2.1 Tree improvement

Plantation programmes led to the establishment of national tree seed centers in 1997, with assistance from Danish Cooperation for Environment and Development. Prior to that, in 1965, the Danish International Development Agency supported efforts to improve teak (*Tectona grandis*) and this work was extended to tropical pines and eucalypts in 1969. Depending on future funding, 22 more species will be included in such programmes: *Acacia auriculiformis* , *Acacia mangium* ,*Afzelia xylocarpa* ,*Alstonia scholaris* ,*Azadirachta excelsa* , *Azadirachta indica, Bambusa* spp. ,*Casuarina equisetifolia* ,*Casuarina junghuhniana* , *Dipterocarpus alatus* ,*Hevea brasiliensis* ,*Hopea ferrea* ,*Hopea odorata* ,*Leucaena leucocephala* ,*Mangifera* spp. ,*Mimusops elengi* ,*Peltophorum dasyrachis* , *Pterocarpus macrocarpus* ,*Samanea saman* ,*Sandoricum koetjape* ,*Toona ciliate* , and *Xylia xylocarpa* .

2.2 The role of the private sector in providing incentives

For a number of reasons, it is difficult to fully understand the role that companies play in promoting forest plantations because most businesses are reluctant to provide data about their operations and policies. However, it is clear that several of them operate out-grower schemes as a means to obtain the raw materials that they need.

2.3 Constraints to smallholder tree growing

Smallholders in Northeast Thailand face the following constraints.

- Shortage of labor to expand the area under agroforestry;
- Lack of knowledge and skills in the selection of tree varieties, the production management, the solving environmental issues, and the biodiversity conservation;
- Reluctance to diversify and adopt innovative techniques due to low education;
- Irregular extension services, including in matters related to biodiversity;
- Lack of bargaining power to secure fair prices for their products;
- Uncertain government plans and policies;
- Focus on commercial (monoculture) tree plantations rather than diversification; and
- Inefficient marketing system for the products from mixed farming (low prices and local sale only) .

2.4 Opportunities for smallholder tree growing

Thailand's forests offer a number of significant opportunities.

- The potential of community forestry to alleviate poverty;
- Major expansion of commercial tree planting on marginal lands thanks to Thailand's competitive advantage;
- Payment for forest-based environmental services to forest managers and owners;
- Expanded production of high-demand non-timber forest products in the domestic and export markets; and
- Public awareness of the importance of planted forest for carbon sequestration.

3. Lesson Learned

Some movement is occurring in the direction of polyculture and self-reliance as the result of promoting integrated agricultural systems. Both government agencies and NGOs are encouraging the planting of more trees in rural areas. Indigenous farmers in the Northeast have formed several networks to promote integrated farming and reduce dependency on commercial agriculture. Government agencies, notably the RFD, are supporting community forestry and the integration of trees into cultivated fields by training farmers and providing them materials, such as seedlings.

Land-use change in the past century has transformed the Northeast from forest to agricultural fields, notably monocultures. Commercialization was the major factor that brought about this change which, unfortunately, was accompanied by serious land degradation. Reversing this trend is an urgent priority if development in the Northeast is to be sustainable. Replacement of monocultural agricultural systems, especially with systems which include trees, can help to achieve ecological, economic and social sustainability.

Mitigation of climate change from carbon offsets, including from agroforestry and forestry, provide a common good for a global problem. Permanence concerns aside, potential environmental and social benefits associated with agroforestry are often absent in plantations. Payments for agroforestry practices not only impact positively on climate change but also encourage diversification, increase biodiversity, improve soil health and foster entrepreneurialism—as the farmers in Inpang demonstrated in their marketing of secondary products such as wine, juice, herbal medicines, liquor, cosmetics and organic fertilizers. Economic constraints to adopting agroforestry may be overcome by paying farmers, in advance, for the carbon offsets that they get by planting woody perennials. Future work under the Inpang carbon bank project is to move from single-species smallholder agroforestry systems to more complex multi-species. The challenge is to develop accounting methods to ensure that the estimates of baseline carbon stocks are robust and that sequestration is timely and cost-effective.

4. Recommendations

Although the Re-afforestation Act of 1992 was designed to support private

reforestation, there is no clear strategy to amend provisions to reflect the economic conditions and the needs of large and small-scale investors, including removal of disincentives. To rectify the situation, the RFD should prepare such a plan, in consultation with key stakeholders to address the following weaknesses.

- Not all tree species are covered.
- The establishment of wood-processing industries is restricted in many provinces.
- The area of degraded reserved forest land that can be leased for growing trees is too small (8 ha).
- Ownership and use of chainsaws are prohibited.
- Timber of some species cannot be exported.

The following conditions are required to create a more attractive environment for forest plantation development.

- All tree species should be covered.
- Timber from plantations should be exempt from taxes, premiums and fees.
- All plantations should be registered with the RFD and procedures for obtaining harvesting permits need to be simplified.
- The Forest Act of 1941 should be amended to allow for the unrestricted use of non-timber forest products from forest plantations.
- Restrictions on the establishment of new sawmills need to be lifted.
- The National Reserve Forest Act 1964 should provide greater flexibility in leasing degraded reserved forest lands, in particular, the maximum size allowable.
- Plantation owners and registered personnel should be allowed to own and operate chainsaws.
- Regulations on the export of timber should be lifted and export taxes reviewed.
- Tax deductions for land used for forest plantations should be considered.

ITTO (2006) suggests the following elements for possible inclusion in a future strategy for planted forest management in Thailand.

- Secure usufruct/tenure rights over community forests.
- Greater reliance on industrial wood and less dependency on rubber wood in plantations.

• More efficient and transparent markets for forest products.

• The sustainable management and utilization of bamboo and rattan.

• Enhancement and remuneration, as appropriate, of environmental services from planted forests, including the mitigation of climate change and the conservation of biodiversity, soil and water.

• Establishment of a forest policy process grounded on NFP principles.

• Decision-making based on adequate information.

• Effective organization of forest communities and forest owners.

• Well-organized and educated civil society on forestry.

• Greater efforts by RFD to strengthen the coordination among agencies involved in planting rubber trees and the utilization of latex and rubber wood.

• Removal of the need for transit permits for logs from the thinning of teak outside forest reserves.

• Harvesting regulations for mature planted trees that are consistent with current enforcement policies.

• Development and promotion of wood measurement practices to protect the interests of sellers.

• Reduction of market risks to encourage private sector investment in forest plantations through the following government measures:

(1) adequate credit facilities;

(2) market transparency;

(3) promotion of diverse outputs;

(4) development of systems to measure and grade timber;

(5) support to organize producers; and

(6) Promotion of landowner – industry partnerships rather than the institution of a minimum price scheme.

① Establishment of a special forest fund for community and smallholder forestry.

②Assessment of the feasibility of using current banking institutions as the delivery channel for plantation development.

③In addition, smallholders would be more self-sufficient in tree growing if they formed local groups. Activities to achieve this goal include:

a. Arranging training courses on group dynamics and the benefits of collaboration;

b. Establishing an investment fund by charging group members a small percentage of the proceeds from the sale of their products;

c. Enhancing participation through group planning, decision-making and problem solving;

d. Setting up different committees to improve communications and information exchange among members, establish a system to monitor group operations, and administer a village capital investment fund;

e. Increasing knowledge of agricultural practices through training and field trips; and

f. Providing training on the management of small enterprises.

5. Conclusions

The considerable number of trees on farmland help restore productive capacity, especially on infertile degraded land, by rehabilitating agro-ecosystem functions. In addition, the domestication of indigenous tree species provides greater and more diversified products which can increase incomes and result in nutritional and health benefits. The commercialization of agroforestry tree plantations also promote the development of local enterprises, value-addition, entrepreneurship and job creation in rural communities.

Current economic barriers to implementing smallholder carbon offset projects are significant but technological advances in Internet computing are being made. The fair distribution of payments and the legal framework for risk assumption remain serious challenges. However, best practices are emerging as projects move forward and the promotion and development of agroforestry carbon offset projects such as the Inpang Carbon Bank are noteworthy.

Given that rural poverty in developing economies makes people perhaps the most vulnerable to the impacts of climate change, it is possible to tackle both problems through a single intervention – agroforestry. The sale of sequestered carbon brings farmers additional income and mitigates climate change as well. Agroforestry practices that transform landscapes from annual crops, which often require high fertilizer inputs, to carbon rich areas with trees and other woody perennials offer multiple benefits to local farmers. It also helps the global community stem the tide of greenhouse gas emissions and mitigate the negative effects of climate change.

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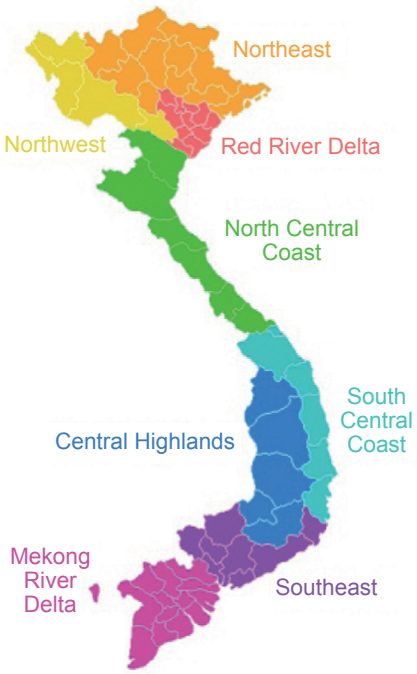


Agro-ecological zones in Viet Nam (Source: http://www.jpn-vn-redd.org) (text page 41)

Women and men work together to prepare the forest land (Photo by Palpa Hub Office, 2009) (text page 76)

Unwanted shrubs cleared for plantation (Photo by N. Bhattarai, 2009) (text page 78)

Broom grass/other forage plants after 1 year (Photo by P.Tara, 2011) (text page 78)

An open space inside the forest before establishing FFF model (text page 85)

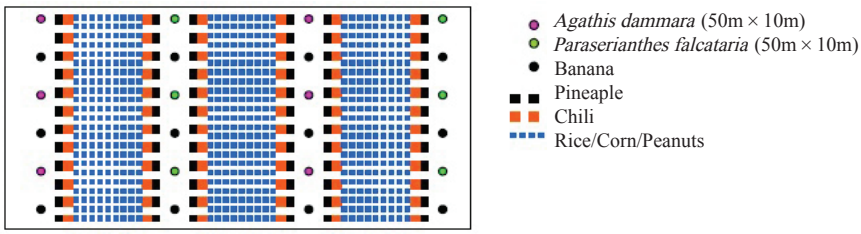
Same space after establishing FFF model (text page 85)

FFF model site in Burir Char Union of Hatiya Upazilla (text page 89)

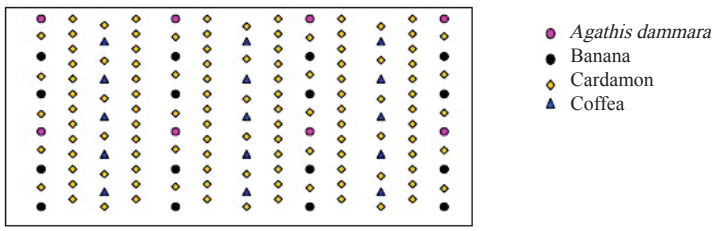
Bilkis, a beneficiary is taking care of her fruit tree (text page 90)

Country bean on dyke (dry season) (text page 90)

A beneficiary is harvesting bean (text page 90)

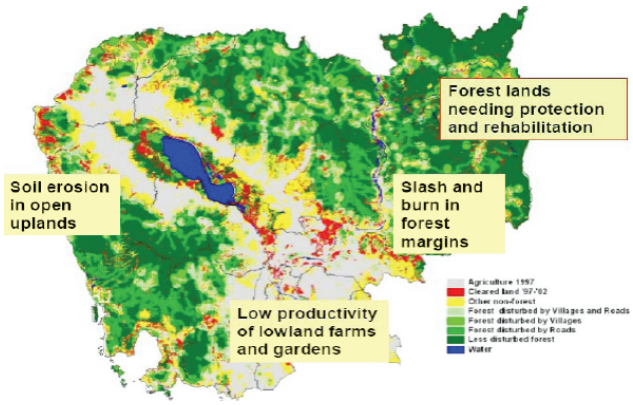


Design of the first and second agroforestry system (text page 92)

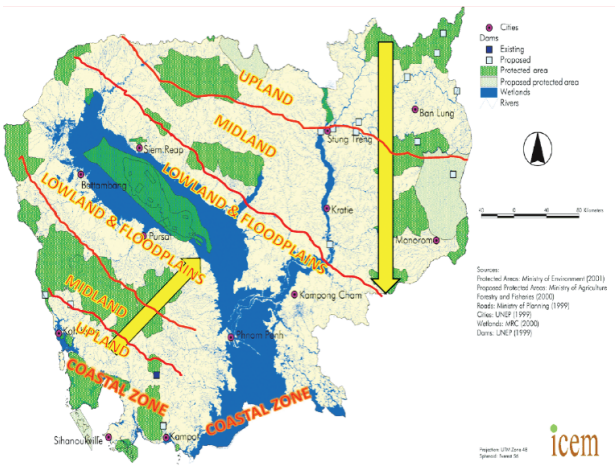


Design of the third agroforestry system (text page 92)

Slash and burn (left) **and illegal cutting** (right) **in the GWEF** (text page 93)



Four major spatial areas where agroforestry is needed most (text page 122)



Cambodia's ecological zones (text page 123)

A farmer planted *Eucalyptus pellita* in his home garden (text page 131)

People planted fast growing species such as *Pometia pinnata* (Taun) **for timber** (These trees are 14 years old, with some reaching 45cm DBH and 20m high) (text page 132)