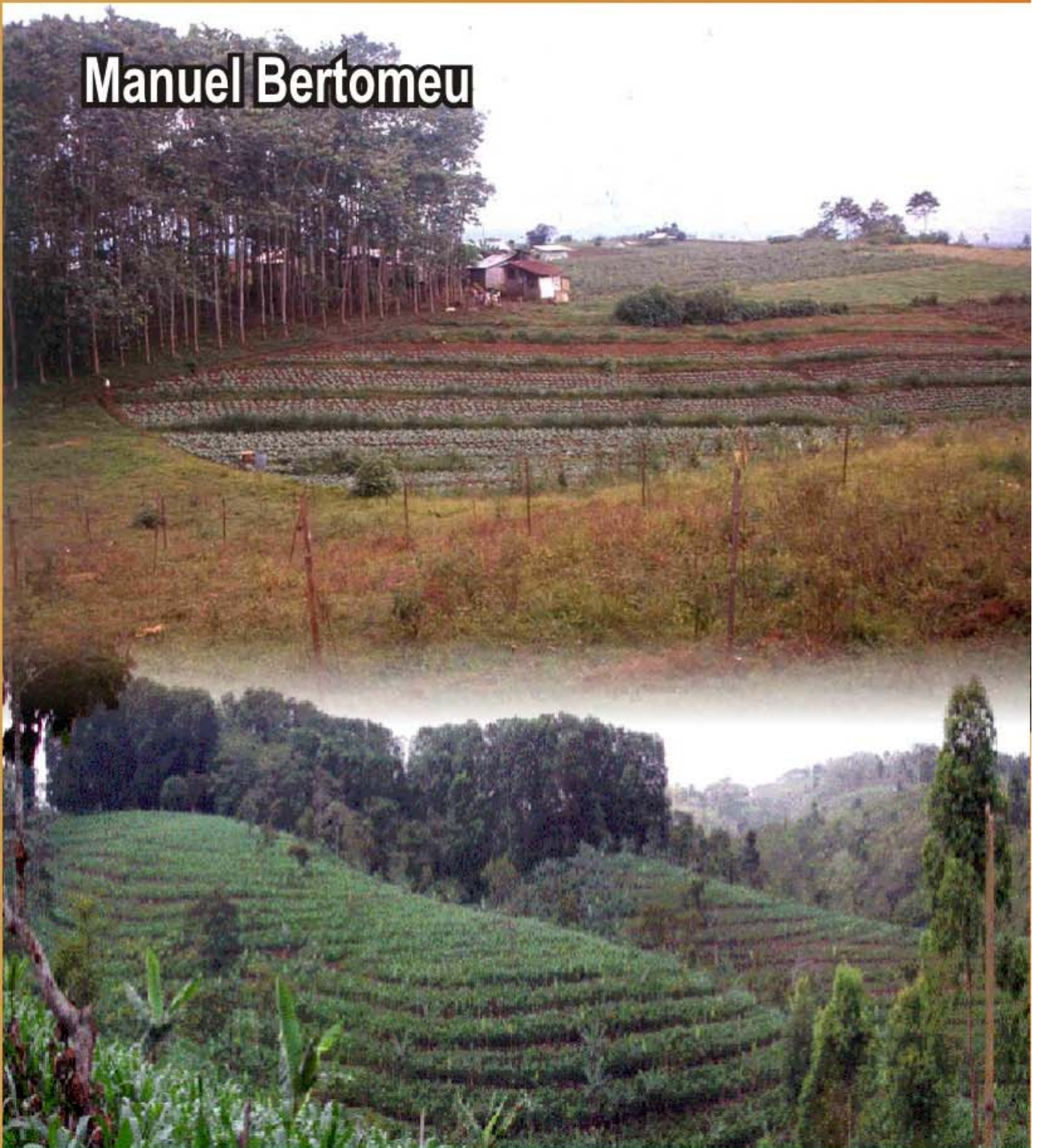# Smallholder Timber Production on Sloping Lands in the Philippines: A Systems Approach

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Smallholder Timber Production on Sloping Lands in the Philippines: A Systems Approach

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Acknowledgments

Preface

Deforestation and poverty are two sides of the same coin. Forest clearance for cultivation accelerates soil degradation, leading to poor yields, which in turn exacerbates poverty. The profound socio-economic and political changes experienced by many tropical countries over the past century have accelerated this process. It has had dramatic economic and environmental consequences. Under conditions of secure property rights, and adequate market access, small-scale farmers spontaneously initiate a rehabilitation phase by increasingly integrating a diverse range of tree species into their farm systems. This balances short-term profitability with medium-and long-term benefits derived from resource conserving practices. Development interventions can address poverty alleviation issues and reverse natural resource degradation by helping to accelerate up this agroforestation process.

This study focuses on timber-based agroforestry systems. It documents how smallholder farmers in the sloping uplands of northern Mindanao, Philippines, are taking advantage of timber production, accelerating the speed of land rehabilitation, and reviving the declining local and national timber industry. They have seized this economic opportunity by the widespread planting of fast-growing timber trees.

The study uses a range of participatory research methods to generate knowledge on the smallholder mode of timber production, its adoption and adaptation by farmers, and its impact on the household economy. It forms part of the Centre's research efforts to find alternatives to slash-and-burn systems in the tropics. The work was pursued in support of development activities funded by the Spanish Agency for International Cooperation (AECI) to scale-up conservation farming and agroforestry innovations to a large number of small-scale upland farmers in the Visayas and Mindanao.

Smallholder farmers throughout much of northern and central Mindanao have demonstrated that extensive industrial forest plantations not need to be the only path to timber production *in lieu of* logging natural forest. It supports the contention that scale economies do not necessarily apply to timber production.

The results demonstrate that timber production on small farms is an alternative that economically benefits a large sector in the society, particularly poor upland farmers. Thus, government policies and extension efforts should aim to promote and support smallholder farm agroforestry.

Although the study is focused on timber, the research was undertaken with a systems approach. It provided a complete understanding of the farm system, the links and interdependencies among its components, and how these components interact with the biophysical and socio-economic factors beyond farmers' control. The study first introduces the institutional context and the research approach, highlighting the need to understand farmers' tree planting practices from a systems perspective. It provides a holistic vision of the smallholder timber production and the components that influence the overall behaviour of the system.

The study then documents farmers' tree growing and management strategies, identifies the biophysical and socio-economic factors that influence timber tree planting, and elucidates farmers' perceived constraints to timber production. Building on farmers' increasingly popular practice of planting trees on contour lines at wide spacing, the study then investigates this practice. The results show that the practice of intercropping enhances tree survival and growth. It finds that intercropping trees in widely-spaced hedgerows provides higher economic benefits to the farmer than traditional woodlot systems. It also notes that returns to labour with tree-based systems are much higher than with monoculture crop systems. The evaluation of timber production systems concludes with a chapter that illustrates how in the smallholder context, adoption of tree planting is a gradual process, and the transition from monocropping to mixed intercropping systems can be done by cumulatively expanding tree hedgerow systems.

The last chapter examines timber marketing practices, demonstrating that smallholder farmers can produce large volumes of timber and efficiently supply local, national and even international markets. Clearly, tropical smallholders are efficient land managers and can be the foresters of the future.

D. P. Garrity

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List of Acronyms and Abbreviations

AECI	Spanish Agency for International Cooperation
ASB	Alternatives to Slash-and-Burn project
BCR	Cost-benefit ratio
Dbh	Diameter at breast height
DENR	Department of Environment and Natural Resources
FSA	Farming Systems Approach
FSR	Farming Systems Research
ICCs	Indigenous Cultural Communities
ICRAF	World Agroforestry Center
IRRI	International Rice Research Institute
LCR	Live-crown ratio
LGU	Local Government Unit
MAI	Mean annual increment
MPTS	Multipurpose Trees
NGO	Non-government organization
NVS	Natural Vegetative Strips
NPK	Mineral nitrogen, phosphorus and potassium (fertilizer)
NPV	Net present value
NRM	Natural Resource Management
PICOP	Paper Industries Corporation of the Philippines
SANREM	Sustainable Agriculture and Natural Resource Management
SSS	Small-scale sawmill
TLA	Timber license agreement

Summary

In the Philippines, timber tree planting on small upland farms has been promoted as a way to restore degraded lands and produce scarce tree products for household consumption. As natural forests continued to recede and timber demand and price increased, farm forestry emerged as a profitable farm enterprise. As a result tree planting spread all over the country and farm-grown timber trees became the source of raw materials, income, and employment for farmers and the local and national timber industry. Farmers' intensive tree establishment and management practices ensure tree survival and growth. However, the intimate association of fast-growing timber trees and crops on small farms severely reduces intercrop yields, thus decreasing net returns and increasing risks. Benefits from tree farming can be further reduced as farmers' management strategies to minimize tree-crop competition (e.g., severe pruning) adversely affect tree growth and timber quality. This study aims to document farmers' tree growing and management practices, to identify determinants of tree planting and constraints that limit farmers' potential to grow timber trees on farms, and to assess the profitability and adoptability of smallholder's timber production systems. Various participatory research methods were used in this investigation, such as on-farm trials, farm and market surveys, multiple farm visits and focused group discussions. The study was conducted in the context of a research program by the World Agroforestry Center (ICRAF) to rehabilitate and improve utilization of degraded uplands, and in support of development activities, funded by the Spanish Agency for International Cooperation (AECI), aiming to scale-up agroforestry innovations in several upland municipalities of Mindanao and the Visayas. An initial survey among farmers in Claveria showed that lack of access to germplasm, tree-crop competition, poor management practices, low timber price, and policy disincentives to tree harvesting and marketing impede further development of timber-based agroforestry systems. Field observation and discussions with experienced tree planters revealed that agroforestry systems with widely-spaced timber trees might be most appropriate for smallholder farm conditions. The possibility of intercropping for longer periods and enhanced tree growth due to a favourable light regime are the main benefits of this system. We conducted on-farm trials from September 1997 to January 2001 to assess the growth and economic performance of two popular fast-growing timber species, *Gmelina arborea* (gmelina) and *Eucalyptus deglupta* (bagras), in association with maize. Two tree-maize systems were tested, trees planted in blocks (woodlots) at close spacing (i.e., 2 x 2.5 m), and trees in hedgerows at wide spacing (i.e., 1 x 10 m).

The performance of these tree-crop systems was compared to maize monocropping. Even if planted 10 m apart, gmelina proved to be very competitive, reducing maize grain yields below the break-even after the third cropping season. Bagras, however, allowed for six maize crops above the break-even yield. It is, therefore, more appropriate than gmelina for intercropping systems. At the end of the experiment, trees planted in hedgerows showed larger diameter growth than trees planted in woodlots. This demonstrates that intensively-managed systems with low tree densities hold the potential to produce larger diameter logs. The financial analyses showed that at current stumpage prices, smallholder agroforestry systems that produce low timber yields are not a viable alternative to maize farming. However, if productivity levels of short-rotation (8 to 9 years) and medium-rotation trees (12 to 15 years) increase up to 110 m^3 ha^{-1} and 190 m^3 ha^{-1} respectively, agroforestry systems would be more profitable than maize monocropping at discount rates of 10 - 15% even if the current low timber price remain. On the other hand, higher returns to labour and capital invested from intercropping systems suggests that farmers with scarce labour and/or capital would maximize returns by establishing timber-based agroforestry systems on their excess land. Incremental planting or cumulative additions of widely-spaced tree hedgerows provides higher returns to land and reduce the risk of agroforestry adoption by spreading over the years labour and capital investment costs and the economic benefits accruing to farmers from trees. The market survey demonstrates that, in spite of the current low returns to land and existing policy disincentives to tree harvesting and marketing, farmers' tree production activities are crucial to support the local and national timber industry. Although not a substitute for large-diameter and quality logs, farm-grown timber is capturing other industry niches, such as veneering and panelling, thus increasing its share to the national timber industry and market. The Philippine government, the wood industry sector, and the society should recognize the role of smallholder upland farmers as land managers and efficient producers of many important agricultural commodities, including timber.

Resumen

En Filipinas, la plantación de árboles maderables se ha fomentado como una estrategia para restaurar terrenos degradados y generar productos forestales necesarios para el consumo familiar de los pequeños agricultores. A medida que la deforestación seguía avanzando y que el precio y la demanda de madera aumentaba, el cultivo de especies maderables en pequeñas explotaciones agrícolas pasó a ser una actividad rentable. Como consecuencia, la plantación de árboles maderables se ha extendido por todo el país y los árboles cultivados son ahora una fuente de materias primas, ingresos y empleo para los campesinos y la industria forestal local y nacional. Las prácticas culturales intensivas de los campesinos aseguran la supervivencia y el crecimiento de los árboles. Sin embargo, la integración en pequeñas fincas de árboles de crecimiento rápido reduce la producción de los cultivos asociados, disminuyendo así los ingresos y aumentando los riesgos. Esta reducción de beneficios puede ser mayor aún debido a que las prácticas culturales de los campesinos para minimizar la competencia entre árboles y cultivos (ej. podas altas y frecuentes) reducen el crecimiento y la calidad de la madera. Los objetivos de este trabajo son documentar las prácticas de plantación y cuidados culturales de los campesinos, identificar los factores que determinan la decisión de plantar árboles maderables y las limitaciones que reducen el potencial de los agricultores para establecer cultivos forestales en pequeñas fincas, y estudiar la rentabilidad de los sistemas de producción. El trabajo se llevó a cabo usando varios métodos de investigación participativa, tales como parcelas experimentales en fincas, encuestas y sondeos de mercado, grupos enfocados y periódicas visitas de campo. El estudio se realizó en el contexto de un programa de investigación del World Agroforestry Center (ICRAF) para la rehabilitación y la mejora del uso de las tierras degradadas de pendiente, y en apoyo a las actividades de desarrollo, financiadas por la Agencia Española de Cooperación Internacional (AECI), llevadas a cabo para diseminar innovaciones técnicas e institucionales a un mayor número posible de campesinos de varios municipios de montaña de Mindanao y las islas Visayas. Las encuestas iniciales entre los campesinos de Claveria muestran que la falta de disponibilidad de germoplasma, la competencia entre árboles y cultivos, las prácticas culturales inadecuadas, el bajo precio actual de la madera, y las normas que regulan la corta y la venta, impiden un mayor desarrollo y difusión de los sistemas agroforestales con árboles maderables. El trabajo de campo y las entrevistas a agricultores con plantaciones de maderables revelaron que en este contexto los sistemas

agroforestales con árboles a espaciamientos grandes son los más apropiados. La posibilidad de plantar cultivos intercalados durante más tiempo, y un mayor crecimiento en diámetro de los árboles debido al régimen favorable de luz son las ventajas principales de este sistema. Entre Septiembre de 1997 y Enero de 2001, llevamos a cabo experimentos de campo para evaluar el crecimiento y la rentabilidad de *Gmelina arborea* (gmelina) y *Eucalyptus deglupta* (bagras) en asociación con maíz. Se estudio el rendimiento de dos combinaciones agroforestales de árboles y maíz, árboles en bloque a espaciamientos pequeños (2 x 2.5 m), y árboles plantados en líneas a espaciamientos grandes (1 x 10 m). Estos sistemas se compararon con el monocultivo de maíz. La especie gmelina resultó ser muy competitiva, incluso cuando se planta a 10 m de distancia, produciendo sólo 2 cosechas rentables. Sin embargo, la asociación de maíz con bagras plantado a 10 m produjo seis cosechas rentables. Por tanto bagras es más apropiado que melina en sistemas agroforestales mixtos. Al final del experimento, los árboles plantados en líneas a 10 m tenían un diámetro mayor que los árboles en bloque. Esto demuestra que los sistemas agroforestales con densidades bajas y gestionados intensivamente pueden producir madera de mayores dimensiones que los sistemas clásicos de árboles en bloque. El análisis financiero mostró que a los precios actuales de madera en pie, los sistemas agroforestales que producen volúmenes bajos no son una alternativa viable al monocultivo de maíz. Sin embargo, si los niveles de producción de especies de turno corto (8 – 9 años) y medio (12 – 15 años) aumentan hasta unos 110 m^3 ha^{-1} y 190 m^3 ha^{-1} respectivamente, a una tasa de descuento del 10 al 15% y con los bajos precios actuales los sistemas agroforestales serían más rentables que el monocultivo de maíz. Por otra parte, la mayor rentabilidad a la mano de obra y al capital invertido en los sistemas agroforestales sugiere que aquellos campesinos con escasez de mano de obra y/o capital podrían maximizar sus ingresos estableciendo sistemas agroforestales con maderables en terrenos en barbecho. La plantación gradual de líneas de árboles proporciona ingresos mayores y reducen el riesgo de adoptar sistemas agroforestales al repartir a lo largo de los años los costes de inversión de mano de obra y capital y las ganancias que los campesinos obtienen de los árboles. El estudio de mercado demuestra que a pesar de los bajos ingresos y de las normas que desincentivan la corta y comercialización de la madera, la producción de madera por los campesinos está siendo crucial para el mantenimiento y desarrollo de la industria de la madera local y nacional. Aunque actualmente no es un substituto de la madera de calidad de gran diámetro, la madera producida en pequeñas fincas agrícolas esta empezando a capturar otros nichos del mercado, tales como la chapa y los paneles, incrementando así su contribución a la industria y al desarrollo de los mercados nacionales. El gobierno Filipino, el sector industrial y la sociedad en general deberían reconocer el

papel de los pequeños agricultores como gestores de los recursos naturales y como productores eficientes de varias materias primas importantes, incluida la madera.

Part I: Introduction, and Context of the Study

1 Introduction and context

1.1   Introduction

During the past century, rising consumption of timber and other forest products and the need for new agricultural land have dramatically accelerated the exploitation and destruction of the world's tropical forests. Once trees with commercial value are harvested, these forests are slashed and burnt by a rapidly growing rural population in search of agricultural land for their subsistence and commercial activities. Only in the past two decades, 17.8 million hectares of tropical forests have been lost (FAO, 2001). The World Bank estimated that 60% of tropical deforestation is the direct result of the agricultural activities of small-scale farmers (World Bank, 1991). Extensive deforestation has dramatic economic and environmental consequences. Forest loss increases poverty. It is in turn a cause of further deforestation. Rural families are deprived of fuelwood, timber and forests resources necessary for their subsistence and their livelihood. In areas without sufficient tree cover soil erosion is a major constraint to crop productivity. In the intensively-farmed uplands of Southeast Asia, soil erosion rates of 50 - 300 t ha^{-1} yr^{-1} are common (Garrity, 1993). As a result, soil degradation leads to a drastic decline of crop yields, the abandonment of cropped fields and eventually, the creation of unproductive degraded lands (Garrity, 1997). Farmers are then left with no other option but clearing a new patch of forest, thus perpetuating and advancing deforestation in ever more remote areas. Deforestation has also disrupted the economic development of timber-producing nations for which forests were a major source of employment and income. A number of countries, where once "inexhaustible" forests grew, are now net importers of timber (ITTO, 2001). World demand for timber and fiber-based products will continue to rise, expecting to reach 5 billion m^3 per year by 2010 (FAO, 1991). As the few more accessible remaining forests become strictly protected and timber extraction and forest conversion continue in remote and less accessible areas, there are growing concerns about the cost and adequacy of existing wood supplies for meeting future timber demand (Sedjo, 1983).

Tree planting has been actively promoted as an approach to alleviate the negative effects of widespread forest destruction. During the past 50 years, large forest plantations with fast-growing trees have been established on denuded land to produce wood and wood fiber, reduce the need of logging natural forest, rehabilitate degraded

lands, protect soils against erosion, and sequester carbon. However, given the difficulty to assess the many biophysical and socio-economic risks involved, plantation forestry has had limited success. In the late 1970s, social forestry emerged as a new paradigm that allows participation of rural communities in the planning and implementation of reforestation, and the protection and management of forest lands. Since then, the planting of trees on farms or agroforestry has been considered a sustainable land-use alternative that would slow down deforestation and reduce poverty. Unfortunately, many of those socially-oriented tree planting initiatives were conceived on only a partial analysis of rural people's needs and implemented as rigid extension packages, without recognizing the flexibility and diversity of farmers' responses to tree scarcity within their strategies to attain food security, generate income and avoid risk (Arnold and Dewees, 1997).

Agroforestry is based on the assumption that combining trees and crops in the same unit of land is more advantageous than tree or crop monoculture. There is a need, however, to test this premise empirically, considering the complexity of the biophysical and socio-economic factors and processes involved in agroforestry. Farming Systems Research (FSR) provides the analytical framework required to understand the complex interactions and links between agroforestry components. A systems analysis offers a view of smallholder tree growing options within the whole farming system, focusing on the interdependence and interactions between the system components controlled by the farm household and those biophysical and socio-economic factors beyond farmers' control. The aim of this study is to provide, from a systems perspective, a better understanding of smallholder timber tree-based agroforestry systems on sloping lands. The systems were studied within the framework shown in **Figure 1.1**. This framework provides a holistic vision of the smallholder mode of timber production and the components that influence the overall behavior of the system.

Over the past decade in Southeast Asia, The World Agroforestry Center (ICRAF) has been conducting research on mixed agroforestry systems (e.g., complex agroforests) as alternatives to the predominant models of continuous monocropping and monoculture tree plantations. In the degraded upland landscapes of the Philippines, the rapid spread of small-scale tree farming systems supported the premise that the integration of trees into smallholder farming systems is a more effective reforestation approach than large-scale reforestation efforts. Thus, ICRAF began to conduct studies on how the planting of trees on farms affects food crops and overall systems' productivity. Research has focused on developing a model of annual-perennial interactions and improving smallholder tree production systems by working on

methods of selection and propagation of quality germplasm and improved system management (Garrity, 1997).

Small-scale tree farming systems are popular among upland farmers and are receiving more attention from development organizations and forestry and agricultural extension offices. However, when fast-growing timber trees are planted on farm land, yields of intercrops may be severely reduced, producing low returns and increased production risks. Net benefits from timber-based agroforestry systems may be reduced even more as farmers intensive tree pruning to control the shading of intercrops negatively affects tree growth and yield. Moreover, if other constraints beyond farmers' reach are considered, such as the dissemination of poor quality germplasm, market saturation with poor quality timber of only a few species, and the existence of policy disincentives to tree harvesting and marketing, smallholder tree farming systems may never realize its potential as a livelihood strategy and an alternative reforestation approach. This study, therefore, has the following major research objectives:

1. To document farmers' timber tree growing and management practices and strategies to improve tree and crop production;

2. To identify the biophysical and socio-economic factors that influence the adoption of timber tree planting;

3. To assess and compare the profitability of timber-based production systems with the existing tree and crop monoculture alternatives;

4. To obtain a farmers' assessment and perceptions of timber production systems;

5. To identify constraints that limit smallholders' potential to grow timber trees on farms; and

6. To propose and assess a management strategy that would make tree farming systems more feasible and acceptable to farmers.

The overall objective of the study is to generate information that will better guide the promotion and dissemination of small-scale timber production systems and support the efforts of smallholder farmers to produce trees for the market. Several participatory research methods were used to achieve these objectives. Household and farm surveys were conducted among tree farmers to study tree growing and management practices and factors that influence tree planting. We studied the growth of trees and maize in association and in monoculture for seven cropping seasons in researcher-designed and -managed on-farm trials. Tree growers and farmers' involved in the management of the research trials assessed timber production systems in three focused-group discussions. Then, a strategy to make tree farming systems more

adoptable is proposed. Lastly, managers of mini-sawmills and owners of three large-scale wood processing plants were interviewed to identify marketing practices, and the opportunities and constraints of farm-grown trees as a source of timber for the wood industry. The study also benefited from multiple field visits and discussions with farmers, extension officers, development workers and scientists in the context of a three-year development project aiming at scaling-up successful agroforestry innovations.
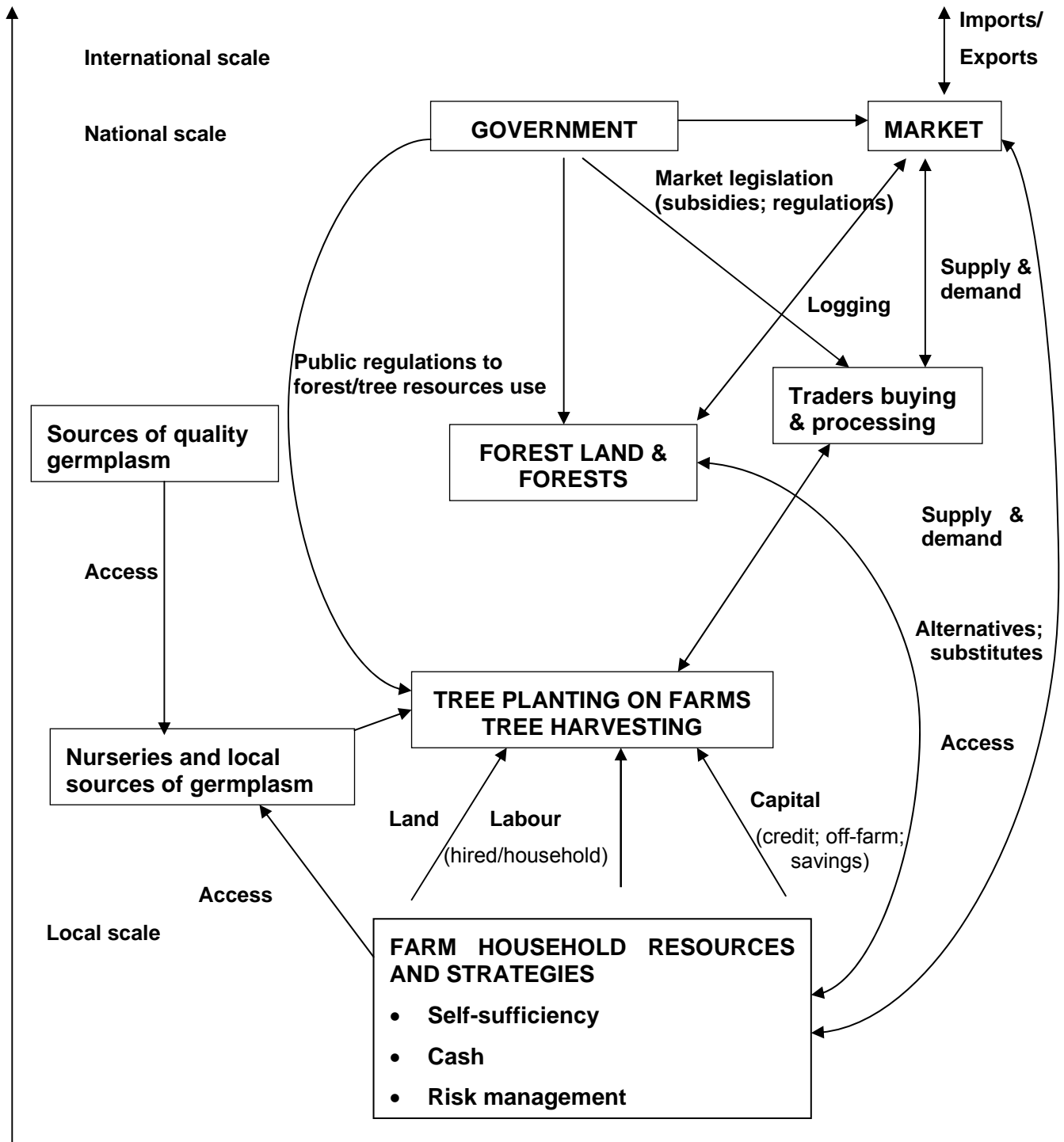
Figure 1.1: A systems analysis proposed to study smallholder timber production systems on sloping lands.

1.2   Context of the study

1.2.1   Traditional forest management and deforestation in the tropics: an overview

Historically, forests managed as common property provided forest dwellers and farmers with a variety of products critical to their subsistence. Food, energy, fodder, construction materials and other important forest products were obtained through sustainable shifting cultivation, hunting, gathering and pastoral activities (Arnold and Dewees, 1997). Shifting cultivation or slash-and-burn agriculture[1] is a land management system used for centuries in temperate and tropical countries (Myers, 1980). It consists of a cycle of clearing and burning the forest vegetation, a short period of cultivation and a longer fallow period to restore soil fertility and allow forest regeneration. Reduced crop yields, due to declining soil fertility, increasing weed infestation and pests and diseases after the short period of cultivation, force the cultivator to leave the cropped parcel and move to another patch of forest. A farmer may repeat the process in five to ten forest plots before returning to the first one 10 to 20 years after and start a new cycle (Brady, 1996).

Trees are important elements of traditional (also called sustainable) shifting cultivation. Although forest vegetation is cleared and burnt, the practice also involves the selection and deliberate conservation of useful trees, roots and seed stock necessary to ensure re-growth during the fallow period (Conklin, 1957; Lamprecht, 1989). In some areas, shifting cultivators even plant desired tree species. In Sumatra (Indonesia), farmers introduce rubber (*Hevea brasiliensis*) seeds or seedlings into their swiddens[2], transforming them into rubber-based agroforests (Foresta and Michon, 1997). In the Amazon region, indigenous groups enrich their forest fallows with the fruit trees *Bractis gasipaes*, *Inga* spp., *Poraqueiba* sp. and others. After few years, a selective thinning allows the regeneration and growth of valuable timber trees such as *Swietenia macrophylla* King and *Cedrela odorata* L. (Dubois, 1990; Uhl and Nepstad, 1990). More intensive production systems have also evolved from the practice of shifting cultivation. Taungya, a popular practice that combines trees with agricultural crops

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[1] Although often used as synonymous with shifting cultivation, "slash-and-burn" denotes the method of clearing forested land, whereas "shifting cultivation" is considered a farming system as described above.

[2] An old English term for a "burnt clearing". It is also used to designate the social group practicing slash-and-burn agriculture (Huxley and Houten, 1997).

during the early stages of tree growth, can be considered as an adaptation of traditional shifting cultivation. Studies show that this system was practiced by nomadic tribes in areas of south China, where crops were planted together with Chinese fir (*Cunninghamia lanceolata*) (Takeda, 1992). Thus, areas under traditional shifting cultivation were either left to recover via natural succession- from brushwood to secondary forest and to a climax forest formation- or were transformed into plantations with a forest-like structure, with high ecological stability and producing various useful tree products (timber, fruits, resins, etc.) (Lamprecht, 1989; Harwood, 1996; Foresta and Michon, 1997). Therefore, in its more complex form sustainable shifting cultivation could be regarded as an agri-silvicultural[3] system in which, as the system evolves, farmers' primary objective shift from tending agricultural crops to management of tree components in semi-natural forests.

Profound socio-economic and political changes experienced by many tropical countries over the past centuries have induced important modifications in the way traditional shifting cultivation was practiced. Shorter fallow periods, due to less land available for cultivation as a consequence of rapid population growth, causes a continuous soil nutrient depletion and erosion process that reduces crop yields, increases weed infestation, and eventually leads to the abandonment of the field and the clearance of more forests (Ruthenberg, 1980). In some regions, the vicious cycle of soil degradation, poor yields, and land clearance accelerated even more as migrants, attracted by land settlement programs and the expansion of commercially oriented activities (e.g., logging, ranching, large-scale plantations or mining), began to settle in sparsely populated forest areas. With knowledge on agricultural practices not suited to their new environment, and pursuing the idea of permanent food crop cultivation, these migrants cleared the land completely, without maintaining soil cover nor the tree stumps that would re-sprout during the fallow period (Bandy et al., 1993; Brady, 1996). This practice came to be known as "unsustainable shifting cultivation". In some countries, this situation was aggravated by inadequate forest and land use legislation that undermined traditional management systems. Laws established during the colonial era, which provided states with increased control over vast forest areas and deprived locals of common property resources and their traditional rights, were still in force until recently. In the Philippines for instance, the Regalian Doctrine, which claimed that the lands occupied and managed by the natives were presumed to be

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[3] In those areas where agroforests exist farmers themselves have achieved what Lamprecht (1989) considers one of the most urgent tasks of tropical silviculture, which is: "… to convert, in as natural a manner as possible, hitherto unmanaged forests into managed forests which are kept as close to nature as possible in order to fulfill economic and vitally important environmental functions such as conservation of biodiversity, soil conservation, etc."

owned by the Spanish sovereign, continued to provide a basis for land law as late as 1985 (Lynch, 1986; Poffenberger, 1990). In other countries, land use policies simply support unsustainable management practices, as when land clearing is considered a prerequisite to claim ownership (Anderson, 1990; Bandy et al., 1993).

Although the increase in population, expansion of extractive activities, and mismanagement of forest resources are the ultimate causes of widespread forest resource degradation, a large share of tropical deforestation is the direct result of unsustainable forms of shifting cultivation. Presently, between 300 to 500 million farmers are thought to be practicing slash-and-burn agriculture on about 410 million hectares (i.e., 30% of the global arable land) (Sanchez, 1996; Brady, 1996). During the 1980s and 1990s, tropical deforestation rates were estimated at 1.5 to 2% annually. However, recent studies have concluded that these figures were too high. Based on the latest FAO estimates (FAO, 2001), net tropical deforestation was just 0.47% (i.e., 9.2 million ha) of the total forest area in the 1980s and 0.46% (i.e., 8.6 million ha) in the 1990s (Lomborg, 2001).

But even if deforestation rates are not as high as it was feared 20 years ago, in many countries the rapid loss of tropical forests is having enormous social, economic and environmental impacts. Extensive tree removal deprives rural families of access to fuelwood, timber and minor forest products necessary for their subsistence and their economic activities (FAO, 1987). On sloping lands without sufficient tree cover, deterioration of the soil's physical, chemical and biological properties caused by erosion is a serious threat to agricultural productivity (Lal, 1990). Deforestation has disrupted forest-based local and national economies. Countries where forests were important sources of foreign exchange have become net importers of timber. Several producing nations of the International Tropical Timber Organization (ITTO), such as India, Malaysia, and the Philippines are now major importers of logs, indicating the extent of wood shortages in their domestic forest sector (ITTO, 2001). In Thailand, annual production of teak (*Tectona grandis*), an important timber commodity, fell approximately 87% between 1971 and 1985 (Jordan et al., 1992). There are vast areas of grasslands where tropical rainforest once existed. According to Garrity (1997), 4% of the total land area of tropical Asia (i.e., 35 million ha) has been converted into savannas covered by *Imperata cylindrica*. Downstream, sedimentation is destroying coral reefs from which many families depend upon for their livelihood. Sedimentation also reduces the life-period of reservoirs and irrigation channels and

has an effect on water quality and quantity[4] (Calder, 1999; Coxhead and Buenavista, 2001). Globally, we are just beginning to understand other negative effects of deforestation, such as the loss of genetic resources, changes in microclimate and rainfall patterns, and global warming. Lastly, forest destruction is not only the cause of economic or environmental problems but also of human injustice and inequity as well. Tropical deforestation has caused the loss of the homeland of forest dwellers and has resulted in the social exclusion of indigenous and rural people that are seen as forest destroyers, creating in this way political unrest and a lack of cohesion in rural communities (Poffenberger, 1990).

1.2.2   Combating deforestation and poverty in the tropics

Tree planting has been promoted as one of the solutions to the problem of deforestation and its negative socio-economic and environmental consequences. The reforestation approach relies on the assumption that global pressure on natural forests would be reduced as man-made plantations satisfy world demand for tree commodities and the associated forestry industries provide jobs in rural areas and promote economic growth. Simultaneously, tree plantations, it is assumed, would protect soils against erosion, increase biodiversity on degraded lands and help to mitigate climate change by acting as carbon sinks. Locally, planted trees are expected to increase farm productivity and thus, reduce farmers' need to clear more forests by helping to conserve the soil of cropped fields, diversifying farm income and providing farmers with tree products that would be, otherwise, obtained from natural forests (e.g., fuelwood).

1.2.2.1   Plantation forestry

Several centuries ago, forest plantations[5] were already developed in Europe and parts of Asia in response to reduced availability of natural stocks and rising prices of timber.

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[4] However, common assumptions about the relationship between deforestation/forest cover and downstream effects are being challenged. According to Susswein et al., (2001): "there is an urgent need to re-think conventional wisdom (regarding the effects of land use change on watershed functions)… as new evidence suggests that forests are not necessarily "good" for all watershed functions".

[5] The FAO (1998) defines forest plantations in the tropics as "forest stands established by planting and/or seeding in the process of afforestation or reforestation. They are even-aged stands either of one and/or two introduced or indigenous species planted at regular spacing. Pandey (1997) classified forest plantations into two categories: a) "industrial forest plantations", i.e., those for the supply of round wood for sawn timber, veneer and pulp; and b) "non-industrial plantations", which includes those for fuelwood, soil and water protection and amenity purposes. Regarding the mode of production, the word "plantation" refers, as in agriculture, to a large tree-

At the turn of the century and before World War II, some forest plantations using exotic pines and fast-growing eucalypts were established in Brazil, Chile, New Zealand, US, Africa and parts of Asia. But the pace of forest plantation establishment did not become significant until the 1960s. Diminishing supplies of tree products from natural forests and increasing world demand of wood and wood fiber provided financial and economic incentives that encouraged investments in industrial forest plantations (Sedjo, 1983). Given the extraordinarily favorable growth conditions in the tropics and encouraging initial results with exotic species, experts observed that a relatively small area of high-yielding plantations could meet the world's wood demand. According to Sedjo (1983), a mere 70 million hectares (i.e., 2,5% of the world's total forested area) of plantations capable of producing 15 to 20 m^3 ha^{-1} yr^{-1} could have met world's round wood demand in 1978. By the mid 1990s, tropical and subtropical forest plantations covered 55,4 million ha (i.e., 44,7% of the global forest plantation resources), with annual rates of plantation establishment at around 4 million ha (1,7 and 2,4 million ha in the tropics and subtropics respectively) (Pandey, 1997). Therefore, tropical forest plantations may have produced 22% of the total global industrial round wood production in 1995 (Brown, 2000).

But in spite of its achievements, in many tropical regions plantation forestry has had a disappointing history since the biological, economic, social and political risks involved are very difficult to assess and quantify. Consequently, its economic viability and social acceptability have been increasingly questioned. A number of commercial tropical trees can achieve remarkable growth rates if planted on favorable sites. But when these species are established in continuously hot and humid conditions and on nutrient-poor Oxisols and Ultisols[6], the poor adaptation to environmental conditions is manifested in reduced tree growth (Jordan, 1985; Jordan et al., 1992; Schulte, 1996).

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crop produced for commercial purposes and employing a relatively large number of hired wage labourers organized under a central management (Hayami et al., 1993). Other distinguishing features of industrial plantations are: mass nursery production and plantation; yearly targets; mass infrastructure development; centralized processing; capital intensive, mechanized management, and; owned by government and/or a corporation (Niskanen and Saastamoinen, 1996). In this study, plantation forestry, industrial plantations and forest plantations are used interchangeably. It should be noted that the extensive oil palm and rubber plantations found in some regions of Southeast Asia, even if presenting the above characteristics, are usually classified as agricultural tree-crops rather than industrial forest plantations.

[6] Oxisols are characterized by an oxic horizon within two meters of the soil surface and are poor in K, Ca and Mg. Low fertility and poor water retention are the most serious constraints of these soils. Oxisols occupy about 22% of the land area in the tropics. They are the most widespread soil group in South America and are important in Africa, but less well represented in Asia. Ultisols are characterized by an argillic horizon, with a base saturation below 35%, at least in its lower part. These soils can be very sensitive to compaction. Ultisols cover 11% of the tropics

Concerns have been also raised about the long-term sustainability of timber production in plantation forestry. In many forest plantations productivity decreases drastically after the first rotation due to nutrient losses caused by timber exports. Tabora (1991) reported high P and K exports when pulpwood plantations of *Paraserianthes falcataria* are harvested, and Schulte (1996) found that after a rotation period of 20 years, nutrient losses range from 1 to 3% of total N, 17 to 63% of total K, 4 to 38% of total Ca, and 2 to 35 % of total Mg reserves. These data demonstrate that although trees may accumulate considerable biomass and nutrients, tree harvesting for two or three rotations would result in a nutrient-depleted site (Fernandes et al., 1992). Therefore, if high growth rates are to be maintained, nutrient losses must be offset with additional fertilizer (Bruijnzeel, 1992; Schulte, 1996). Industrial plantations may be also ruined due to the outbreak of pest and diseases which are easily propagated on large-scale, even-aged monocultures of genetically uniform exotic species (Nair, 2001). Similarly, extensive plantations are also prone to damage by seasonal fires as their prevention and control is difficult in tropical areas with poor access and infrastructure (Garrity and Mercado, 1994; Goldammer et al., 1996; Wibowo et al., 1997). As Schulte (1996) stated: "when costs for fertilizers, disease prevention and control, fire damage and other risks are not taken into consideration the investment ends in an economic disaster".

Poor planning has also resulted in the failure of many other plantation initiatives. The financial returns from a 35,000-hectare plantation of *Acacia mangium* established in Malaysia between 1985 and 1987 were not sufficient to cover loan repayments since the species proved unsuitable for the purpose it was planted for. Similarly, no market was found for the roundwood harvested from several thousand hectares of *Gmelina arborea* planted in Sabah in the 1980s. Eventually, the wood had to be sold at a price that only covered the cost of harvesting and transportation (Killman, as cited in Brown (2000) p.74). Lastly, the use of large tracts of land for forest plantations has been also a source of social conflict. In many cases, plantations have been sabotaged due to farmer evictions and imposed restrictions on farmers' livelihood activities on land they had traditionally managed (Jordan et al., 1992; Beldt et al., 1994; Potter, 1997; Sedjo, 2000).

But even if risks are still difficult to identify and quantify, the establishment of large-scale industrial forests plantations in the tropics continue to be seen by many as a viable approach to meet growing demand for wood while rehabilitating degraded lands

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and are of particular importance in Southeast Asia, where they account for over 50% of the land area. Both soil groups suffer from an inadequate supply of P (by deficiency and fixation), low CEC, high exchangeable Al and deficiencies or toxicities of trace elements (Uexkull, 1986).

and reducing pressure on scarce natural forests. It has been estimated that by 2010, the round wood production potential from industrial forest plantations will almost double from the current 388 to around 600 million m^3. And beyond 2010, forest plantations may probably account for almost half of all industrial round wood production (Brown, 2000). A new emerging argument in support of plantation forestry is the role that large industrial plantations may play, as carbon sinks, in mitigating global warming. The Kyoto Protocol to the United Nations Framework Convention on Climate Change allows the inclusion of forest carbon stocks in the calculation of net changes in the carbon emissions of every country, and includes a number of provisions to establish market-based instruments that will encourage carbon emissions reduction and carbon sequestration projects (DiNicola et al., 1998). Therefore, it seems likely that following the ratification of the Kyoto protocol there will be, among others, increasing investments in carbon-offset projects to convert degraded lands into forest plantations (Brand, 1998).

1.2.2.2   Social forestry

During the past century, tropical forestry developed as a capital-intensive, industrial-oriented activity involving extensive tracts of land, large investments, major deployment of infrastructure and equipment, and centralized decision-making that excluded local people from taking part in forest management and use (Vergara and Fernandez, 1989). In the 1950s and 1960s, plantation forestry also gained prominence as both, a development strategy that would stimulate economic growth and a resource-conserving approach that would reduce the need to log natural forests (Sedjo, 1983). At the same time, the rapid expansion of a large and impoverished rural population into forest lands became a threat to forest conservation. Farmers' increasing demands for agriculture and forest products, particularly fuelwood, were considered to be the ultimate cause of deforestation. Thus farmers came to be regarded as forest destroyers (Potter, 1997). In Southeast Asia, fears that upland villagers would accelerate forest destruction led to forest legislation that further marginalized rural communities, undermining their tenurial claims and excluding them from forest protection, conservation and management (Poffenberger, 1990). However, these punitive approaches proved futile. By the mid 1970s, poverty, deforestation and in some countries insurgency continued to grow. Rather than excluding rural people from forest use, governments and policy-markers realized that development strategies should be designed to meet their needs in a sustainable way (Arnold, 1991). Thus,

social forestry[7] emerged in Asia as a new paradigm that would give individuals and communities more authority and autonomy in forest management and growing trees to meet their own needs as well as protect the land on which they themselves depend.

The social approach to forestry originated in Europe in the seventeenth century and was practiced for years, emphasizing social rather than commercial needs (Vergara and Fernandez, 1989). As a new concept in Asian countries, social forestry aimed at relieving pressure on forest resources while uplifting the living standards of rural people by involving them in a range of community forestry activities such as afforestation[8], agroforestry, tree farming and small-scale forest-based processing industries (Vergara and Fernandez, 1989; Udarbe, 1989; Colchester, 1992). With the advent of social forestry, the role of the government forestry agencies also began to change by rethinking new policies and management practices that respond to the needs of the large impoverished and marginal rural societies (Poffenberger, 1990).

Over the past three decades, the social forestry approach has gradually developed through three distinct phases (Wiersum, 1994). From its inception in the late 1970s until the mid 1980s (experimental phase), the emphasis was to address the problem of desertification resulting from the excessive removal of trees for energy. Therefore, activities focused on individual tree growing and the establishment of village woodlots so that rural people could meet their needs for fuelwood and other forest products in a sustainable manner. The second phase (consolidation phase), initiated on the 2nd half of the 1980s, put less emphasis on meeting the energy needs of the rural population

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[7] At the beginning, social forestry and community forestry were used as synonymous. The term "social forestry" was first used in the 1976 report of the National Commission of Agriculture in India to denote a program of activities to encourage people to produce fuelwood and other forest products. According to Arnold (1991), the term "community forestry" was originally coined by FAO and defined as "any situation which intimately involves local people in a forestry activity such as the establishment of woodlots and trees on farms for forest products, including processing at the household, or at the small industry level to generate income". Presently, many definitions of social forestry exist but it is now accepted as a concept broader than community forestry. Social forestry is a development strategy aiming to stimulate active involvement of local people in small-scale forest management activities as a means to improve their livelihood. Three general strategies may be distinguished: community or communal forestry; farm forestry and publicly-managed forestry for local community management. Community forestry refers to any form of social forestry activity undertaken by rural people (Wiersum, 1994). Four commonly recognized forms of community forestry are: farm forestry, village woodlots, roadside plantings and small-scale forest-based processing enterprises (Raintree, 1991). "Industrial forestry" is distinguished from "social forestry" in that the former "tends to serve narrow commercial interests while meeting the mass needs of the consumer society", whereas the latter is "designed specifically to deliver benefits to the local population, regardless of whether the local people actually participate directly in forestry production or not" (Raintree, 1991).

[8] Afforestation is the planting of trees and/or other vegetation on land that has long been without forest cover. Reforestation refers to the replacement of forests after felling.

and more on the integration of a variety of trees with different purposes into farming systems. Commercial farm forestry by individual farmers was promoted to increase wood stocks on farms and to produce raw materials for the industry. But by the end of the decade it was recognized that in spite of the successful attempts at increasing wood stocks on farms, forest degradation and deforestation continued unabated. Social forestry then began a new phase (diversification phase), in which attention shifted from the household and village lands to state forest lands (Dove, 1995), focusing on community-based conservation and management of existing forests, and the integration of forestry activities in local-level land use planning. During this phase, peoples' growing participation and autonomy in forestry induced two significant changes: i) a reversal of public land allocation and increasing community control over state forests lands; ii) the role of the government forestry agencies as a facilitator rather than a guardian of forest lands (Poffenberger, 1990).

During the 1970s, parallel to the development of social and community forestry approaches to tree resource management, the Farming Systems Approach (FSA) began to be used as a framework to the analysis of farm systems[9] (Hall et al., 2001). Agriculture was seen as a hierarchy of systems (i.e., each system is composed of sub-systems and is part of a higher level system), ranging from the cell at the lowest level, through the plant or animal, the crop or herd, the field or pasture, the farm, the village and the watershed. The farm is a system composed of the household, cropping, livestock and other sub-systems that transform the available land, labor and capital resources (inputs) into products that can be consumed or sold (outputs) (Fresco and Westphal, 1988). Similar to social forestry, the original approach to farming systems analysis has gradually evolved from a focus on the farm and the household, crops and/or livestock, and household food security, to increasing emphasis at a higher systems level, such as groups, the community or districts, multiple sources of household livelihoods, extension and support services, productivity and the environment (Collinson, 2000).

The development of FSA changed the way agricultural research is conducted. The traditional reductionist research methodology, focused on a single commodity or on one or few sub-systems at a time, proved to be inadequate to provide a complete understanding of the farm system and the complex interactions among its sub-

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[9] System is an arrangement of components or parts that interact according to some process and transform inputs into outputs (Odum, 1983). A farming system is "a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate" (Hall et al., 2001).

systems; for instance, the links between agroforestry components such as livestock-crop-tree and their interactions. The farming systems research (FSR) approach views the whole farm as a system and tries to systematically understand the interdependencies among its components, including the household, and how these components interact with the physical, biological and socio-economic factors not under the household's control (Chambers and Jiggins, 1986; Stroosnijder and Rheenen, 1991). Moreover, research is not only limited to describing the current characteristics of farm systems but also requires an understanding of the changes occurring in the farm systems that result from the interaction of the multiple socio-economic variables with ecological factors at all levels in the hierarchy of systems. This allows the development of technologies that enable farmers to make the transition from one farm system type to another (Fresco and Westphal, 1988).

The process of FSR should not be considered a strictly fixed sequential series of activities but as a number of definable iterative phases: a) the diagnosis, when target areas and farmers are selected, production systems described and problems and opportunities identified; b) development, during which on-farm research with potential improvements is designed and executed; and c) implementation, involving the testing, evaluation and extension of results (Chambers and Ghildyal, 1984).

Another important advantage of FSR over traditional research and development processes in agriculture is farmers' involvement in all stages of research. Chambers and Ghildyal (1984) suggested that farmers, especially resource-poor farmers, should be part of the process of technology choice, experimentation, development and dissemination, and their needs and problems should be the basis of establishing research priorities. Thus, farming systems research has become more participatory, with an increasing stress on indigenous knowledge, group planning, experimentation and monitoring. FSR is not only limited to the development of farming and rural livelihood systems but it is also expected to adapt and develop methodologies for the sustainable management of natural systems. Given the increasing number of case studies on the use of systems analysis in natural resource management (NRM), Ison et al., (1997) argue for further development of systems methodologies for research and development in sustainable NRM.

The simultaneous development of FSA and Social Forestry initiated the emergence of a paradigm shift in both agriculture and forestry, and more generally, in rural development thinking. This new paradigm is systems-focused, farmer or community-driven and socially-oriented (Hall et al., 2001; Rebugio, nd). Research and development in agriculture and forestry have evolved from: a) the reductionist view of problems amenable to simple technical solutions, to consider the importance of the

social dimension of problems as well, where households, gender, social networks, local institutions, information, policies and markets all play a role; b) the top-down imposition of analytical tools and solutions, to participatory diagnosis, planning, experimentation, monitoring and extension; c) from foresters and agronomists as the sole authority, technical experts and managers, to more responsibility, decision-making capacity and knowledge residing in the community.

1.2.3   The role and importance of trees in tropical farming systems

Tree planting on farms, or agroforestry, has been practiced by rural people since very early times (Meiggs, 1982; Brookfield and Padoch, 1994 as cited by Sanchez, 1995). During the 20th century in many tropical countries, as tree supplies from natural forests dwindled and systems of settled agriculture evolved, trees planted on farms have become increasingly important sources of supplementary food, timber, fodder and other essential products for rural families and for the market (Arnold and Dewees, 1997). The numerous reports on expanding tree planting on farms across Africa, Latin America and Asia provides persuasive evidence of the extent of this trend (Carter and Gilmour, 1989; Garrity and Mercado, 1994; Soerianegara and Mansuri, 1994; Garrity and Agustin, 1995; Filius, 1997; Arnold and Dewees, 1997; Pascicolan et al., 1997; Beer et al., 2000; Simons, et al., 2000). The importance of these tree stocks is such that the FAO has recently started a global inventory of trees on farms or "trees outside the forest" (Kleinn and Morales, 2002). Preliminary results show that in Punjab, India, farm trees account for 86% of the province's growing stock, and in Sri Lanka, over 70% of industrial wood comes from trees outside forests. Even in countries with vast forest resources, such as Indonesia, some 20% of the total wood consumed is derived from planted trees (FAO, 1998).

But despite its widespread use, it was only in the late 1970s that the role of trees and shrubs growing on farm land started to be recognized as an important component of many tropical farming systems. Thus, agroforestry began to be promoted in social forestry programs and projects to solve the perceived problems of wood fuel scarcity, desertification and deforestation and unsustainable land use practices. In the following years, the increasing popularity of social forestry and the holistic analytical framework offered by FSA facilitated the emergence of agroforestry as a focus for innovative research on integrated land management (Nair, 1984; Raintree, 1991). Early assumptions about the profitability and sustainability of agroforestry systems came under scientific scrutiny with the formulation and testing of hypothesis regarding the biophysical, socio-economic and ecological processes involved in the development of agroforestry land uses (Sanchez, 1995; Huxley, 1999).

Agroforestry was a term used to denote those "land-use systems and practices in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pasture) and/or livestock, in a spatial arrangement, a rotation, or both" (Lundgren, 1982). But advances in agroforestry research and development over the past twenty years have changed the early view of it as a static collection of different land use-systems in which trees and crops are grown in the same land unit. Now, it is recognized that agroforestry involves dynamic ecological processes, similar to those in natural ecosystems, providing multiple products and services that change with time, in space, and across scales. At the farm level, the increasing integration of trees into the land use system can be seen as a passage towards agroforestry systems of increasing ecological integrity. At the landscape level, agroforestry practices form a complex mosaic of patches composed of many niches in an agroecosystem (Leakey, 1996). Thus, Leakey (1996) recently defined agroforestry as: "a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and rangeland, diversifies and sustains smallholder production from increased social, economic and environmental benefits".

In 1992 in Rio de Janeiro, more than 178 Governments at the United Nations Conference on Environment and Development (UNCED), popularly known as the Earth Summit, adopted the Agenda 21, a worldwide program of action for sustainable development, the Rio Declaration on Environment and Development, and the statement of principles for the sustainable management of forests. Underlying Agenda 21 is the idea of a downward spiral between poverty and environmental degradation-poverty is seen as a cause of environmental degradation, which in turn maintains and increases poverty (Brown, 1994). Particularly significant roles for agroforestry land-use systems exist in Chapter 10 "Integrated approach to the planning and management of land resources"; Chapter 11 "Combating deforestation"; Chapter 12 "Combating desertification and drought"; Chapter 13 "Sustainable mountain development"; Chapter 14 "Sustainable Agriculture and rural development" and Chapter 15 "Conservation of biological diversity".

In line with the program areas and objectives identified in Agenda 21, The Alternatives to Slash-and-Burn (ASB) initiative was established in 1992 under the auspices of the United Nations Development Programme (UNDP). The program is coordinated by the World Agroforestry Center (ICRAF) in Kenya and involves over 50 national programs, international research centres, universities and NGO's around the world. As a worldwide initiative, research sites encompass locations corresponding to major ecological zones of the tropical regions of Latin America (Brazil, Peru, Mexico), Africa

(Cameroon, Zambia) and Asia (Indonesia, Thailand, Philippines). ASB aims to conserve forests and reduce poverty in the humid tropics by:

a)   The promotion of alternatives to unsustainable slash-and-burn agriculture.

b)   The reclamation of deforested and degraded lands.

Collaborative research activity by ASB partners has established benchmark sites in the Amazon of Brazil and Perú, the Congo Basin forest of Cameroon, the island of Sumatra in Indonesia, the northern mountains of Thailand, and the island of Mindanao in the Philippines. In each site of the network, participatory research and policy consultations at all levels guide the iterative processes necessary to identify and develop workable and relevant policy, institutional, and technological options (van Noordwijk et al., 2001).

Building upon ASB's objectives as general research themes and based on the strong relationship with the ASB consortium and other research institutions and networks (e.g., IRRI, MPTS, SANREM), in 1992 ICRAF established a regional research program for Southeast Asia. The program focused on 3 upland ecosystems: i) the forest margins; ii) the Imperata grasslands; and iii) the permanently cultivated hillslope farmlands. In each agro-ecosystem, research efforts were guided by the overarching hypothesis that agroforestry systems practiced by small-scale farmers are a superior alternative to either food crop systems or monoculture plantations (Garrity, 1997). From this initial focus on technological alternatives to slash-and-burn, ICRAF's research and development activities in Southeast Asia expanded over the years to include three new research themes in a nested structure: i) national policy constraints to agroforestry and upland resource management; ii) landscape-level impacts of land-use change and; iii) capacity building **(Figure 1.2)**.

In the uplands of the Philippines, research is mainly focused on three themes:

1.   Local modifications of contour hedgerow technology to sustain permanent annual crop production on the deep and acidic soils of the sloping lands of northern and central Mindanao and on the shallow calcareous soils of the central Visayan Islands.

2.   Evaluation and improvement of tree-crop systems developed by small-scale farmers on degraded grasslands and hilly lands.

3.   Development of locally-led natural resource management systems.

In the past two decades in the Philippines, favorable market conditions have induced small-scale farmers to grow trees for the market. Fast-growing timber trees such as

Gmelina arborea, *Acacia mangium* and *Paraserianthes falcataria* were planted with annual crops on farms and fallow lands. The present study is part of ICRAF research efforts to evaluate and improve from a systems' perspective these timber production practices prevalent in many upland areas of Mindanao and other parts of the country. The study was also conceived in support of development activities, funded by the Spanish Agency for International Cooperation (AECI), aiming at scaling-up conservation farming and agroforestry innovations to a large number of small-scale upland farmers in several municipalities of northern and central Mindanao, and the Visayan islands of Bohol and Leyte. Since 1998, the ICRAF - AECI project "Enhancing farming adoption of conservation farming and agroforestry practices through farmer-driven, knowledge-sharing institutions in the Philippines" has established a variety of applied agroforestry research trials in collaboration with Filipino farmers. Within the project context, the general objectives of the trials described in this study are the development and dissemination of timber-based agroforestry production systems for small-scale farmers in northern and central Mindanao and the islands of Bohol and Leyte.

Figure 1.2: The evolution of themes in ICRAF Southeast Asia research, development and education activities: from a focus on 'technology' to one on 'intergrated natural resource management'. Adapted from Garrity (1997) and van Noordwijk (2001).

1993–1996. Three ecosystem hypotheses:
Forest margins: agroforests provide a superior alternative for small-scale farmers to either food crop systems or monoculture plantations
Imperata grasslands: rehabilitation through small-scale agroforestry will be superior to plantation forestry in terms of production, equitability and participation
Hillslope farmlands: natural vegetative strips (NVS) is a superior, least cost foundation upon which to build agroforestry-based conservation farming

1997 - 2002. Adding three working themes:
1. Policy constraints to agroforestry and upland resource management
2. Landscape-level impacts of land-use change
3. Capacity building

ICRAF Southeast Asia regional themes

Capacity building and institutional strengthening
Policy development to enhance sustainable land use
Landscape-level impacts

Agroforest management options for **forest margins**

Improving agroforestry systems to rehabilitate **imperata grasslands**

Agroforestry systems for **hill slopes**

2003 Current work themes of ICRAF SE Asia research program

G = Governance processes
- Land use rights
- Rewards for environmental services

- Capacity building for integrated natural resource management

L = Multifunctional landscapes
- Watershed functions, Biodiversity
- Dynamics of land use change
- Community institutions & social capital

F = Farmers' Land Management
- Plot-level technologies
- Household decisions & extension
- Tradeoffs

T = Trees & Markets
- Tree options
- Planting material
- Markets

ICRAF SEA Themes

1.3   References

Anderson, A. B. (1990): Deforestación de la amazonia: dinámica, causas y alternativas. In: Anderson, A. B. (ed.): Alternativas a la deforestación. Volume 1. Quito, Ecuador: Ediciones ABYA-YALA, Fundación Natura y Museo Emilio Goeldi: 13-43.

Arnold, J. E. M. (1991): Community Forestry. Ten years in review. Community Forestry notes No. 7. Rome, Italy: FAO.

Arnold, J. E. M. and Dewees, P. A. (eds.) (1997): Farms, Trees & Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd.

Bandy, D. E., Garrity, D. P. and Sanchez, A. (1993): The worldwide problem of slash-and-burn agriculture. Agroforestry Today 5 (3): 2-6.

Beer, J., Ibrahim, M. and Schlönvoigt, A. (2000): Timber production in tropical agroforestry systems of Central America. Proceedings of ' The XXI IUFRO World Congress 2000: Forest and Society: The Role of Research. Sub-plenary sessions Vol. 1. 7-12 August, 2000, Kuala Lumpur, Malaysia: IUFRO: 777-786.

Beldt, R. V. D., Hatch, C., Sastry, C., Raintree, J., Ghosh, S., Saxena, N.C. and Garrity, D.P. (1994): Farm forestry comes of age. Farm Forestry News 6: 1-7.

Brady, N. C. (1996): Alternatives to slash-and-burn: a global imperative. Agriculture, Ecosystems and Environment 58: 3-11.

Brand, D. (1998): Opportunities generated by the Kyoto Protocol in the forest sector. Commonwealth Forestry Review 77 (3): 164-169.

Brookfield, H. and Padoch, C. (1994): Agrodiversity. Environment 36 (5): 7-11, 37-45.

Brown, C. (2000): The global outlook for future wood supply from forest plantations. Rome, Italy: FAO.

Brown, N. J. (ed.) (1994): Ethics & Agenda 21. Moral implications of a global consensus. New York, USA: United Nations Environment Programme.

Bruijnzeel, L. A. (1992): Sustainability of fast-growing plantation forests in the humid tropics with particular reference to nutrients. In: Jordan, C. F., Gajaseni, J. and Watanabe, H. (eds.): Taungya. Forest plantations with agriculture in Southeast Asia. Wallingford, UK: CAB International: 51-67.

Calder, I. R. (1999): The blue revolution. Land use and integrated water resources management. London, UK: Earthscan Publications.

Carter, A. S. and Gilmour, D. A. (1989): Increase in tree cover on private farm land in central Nepal. Mountain Research and Development 9 (4): 381-391.

Chambers, R. and Ghildyal, B. P. (1984): Agricultural research for resource-poor farmers: the farmer-first-and-last model. Proceedings of 'National Agricultural Research Project Workshop on National Agricultural Research Management'. Rajendranagar, Hyderabad, India. National Academy of Agricultural Research Management.

Chambers, R. and Jiggins, J. (1986): Agricultural research for resource-poor farmers: a parsimonious paradigm. Brighton, UK: Institute of Development Studies. University of Sussex.

Colchester, M. (1992): Sustaining the Forests: The community-based approach in South and South-east Asia. Discussion paper No.35. Geneva, Switzerland: United Nations Research Institute for Social Development.

Collinson, M., (ed.) (2000): A History of Farming Systems Research. Wallingford, UK: CABI International.

Conklin, H. C. (1957): Hanunoo agriculture: A report on an integral system of shifting cultivation in the Philippines. Rome, Italy: FAO.

Coxhead, I. and Buenavista, G. (2001): Seeking Sustainability: A Synthesis of Research in SANREM CRSP-Southeast Asia, 1993-98. In: Coxhead, I. and Buenavista, G. (eds.): Seeking Sustainability: Challenges of Agricultural Development and Environmental Management in a Philippine Watershed. Los Baños, Laguna, Philippines. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development:1-30.

DiNicola, A., Jones, D. J. and Gray, G. (1998). Carbon dioxide offset investment in the Asia-Pacific forestry sector: opportunities and constraints. RWEDP Field document No. 53. Bangkok, Thailand: FAO.

Dove, M. R. (1995): The theory of social forestry intervention: the state of the art in Asia. Agroforestry Systems 30 (3): 315-340.

Dubois, J. C. L. (1990): Los barbechos forestales como forma util del uso de la tierra en fronteras agrícolas de la amazonía. In: Anderson, A. (ed.): Alternativas a la Deforestación Vol. 3. Quito, Ecuador: Ediciones ABYA-YALA, Fundacion Natura y Museo Emilio Goeldi: 285-302.

FAO (1987): Assessment of Forest Resources in Six Countries. Special Study on Forest Management, Afforestation, and Utilization of Forest Resources in the Developing Regions (Asia-Pacific Region). Bangkok, Thailand: FAO.

FAO (1991): Wood and Wood Products 1961-1989-2010. Rome, Italy: FAO.

FAO (1998): Asia-Pacific Forestry-Towards 2010. Executive Summary of the Asia-Pacific Forestry Sector Outlook Study. RAP Publication 1998/22. Rome, Italy: FAO.

FAO (1998): FRA 2000 Terms and Definitions. Forest Resources Assessment Programme. Working paper No. 1. Rome, Italy, Food and Agriculture Organization of the United Nations.

FAO (2001): Global Forest Resources Assessment 2000: Main Report. FAO Forestry paper 140. Rome, Italy: FAO. ftp://ftp.fao.org/unfao/bodies/cofo/cofo15/X9835e.pdf.

Fernandes, E. C. M., Garrity, D. P., Szott, L. T. and Palm, C. A. (1992): Use and potential of domesticated trees for soil improvement. In: Leakey, R. R. B. and Newton, A. C. (eds.): Tropical trees: the potential for domestication and the rebuilding of forests resources. Edinburgh, UK: London: HMSO: 137-147.

Filius, A. M. (1997): Factors changing farmers' willingness to grow trees in Gunung Kidul (Java, Indonesia). Netherlands Journal of Agricultural Science 45: 329-345.

Foresta, H. D. and Michon, G. (1997): The agroforest alternative to Imperata grasslands: when smallholder agriculture and forestry reach sustainability. Agroforestry Systems (36): 105-120.

Fresco, L. O. and Westphal, E. (1988): A hierarchical classification of farm systems. Experimental Agriculture 24: 399-419.

Garrity, D. P. (1993): Agroforestry and the sustained productivity of Asia's humid uplands. In: Upland agriculture in Asia. Proceedings of a workshop, April 6-8, 1993, Bogor, Indonesia: 225-233.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven smallholder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

Garrity, D. P., Soekardi, M., van Noordwijk, M., de la Cruz, R., Pathak, P.S., Gunasena, H. P. M., Van So, N., Huijun, G. and Majid, N. M. (1997): The *Imperata* grassland of tropical Asia: area, distribution, and typology. Agroforestry Systems 36, Special issue 'Agroforestry innovations for Imperata grassland rehabilitation': 3-29.

Garrity, D. P. (1997): ICRAF's mission in Asia: a test of three-systems hypotheses. In: PCARRD: Developments in agroforestry research. PCARRD Book Series No. 160/1997. Los Baños, Laguna, Philippines: PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development): 8-21.

Garrity, D. P. and Agustin, P. C. (1995): Historical land use evolution in a tropical acid upland agroecosystem. Agriculture, Ecosystems and Environment 53: 83-95.

Goldammer, J. G., Seibert, B. and Schindele, W. (1996): Fire in dipterocarp forests. In: Schulte, A. and Schöne, D. (eds.): Dipterocarp Forest Ecosystems: Towards Sustainable Management. Singapore: World Scientific: 155-185.

Hall, M., Dixon, J., Gulliver, A. and Gibbon, D. (eds.) (2001): Farming systems and poverty. Improving farmers' livelihoods in a changing world. Rome, Italy and Washington D.C., USA: FAO and World Bank.

Harwood, R. R. (1996): Development pathways toward sustainable systems following slash-and-burn. Agriculture, Ecosystems and Environment 58: 75-86.

Hayami, Y., Quisumbing, M. A. R. and Adriano S. L. (1993): Toward and alternative land reform paradigm: A Philippine perspective. Manila, Philippines: Ateneo de Manila University Press.

Huxley, P. (1999): Tropical Agroforestry. Oxford, UK: Blackwell Science.

Huxley, P. and van Houten, H. (eds.) (1997): Glossary for agroforestry. Nairobi, Kenya: ICRAF.

Ison, R. L., Maiteny, P. T. and Carr, S. (1997): Systems methodologies for sustainable natural resources research and development. Agricultural Systems 55 (2): 257-272.

ITTO (2001): Annual review and assessment of the world timber situation 2001. Yokohama, Japan: ITTO.

Jordan, C. F. (1985): Nutrient cycling in tropical forest ecosystems. Chichester, New York: John Wiley and Sons.

Jordan, F. C., Gajaseni, J. and Watanabe, H. (eds.) (1992): Taungya: forest plantations with agriculture in Southeast Asia. Wallingford, UK: CAB International.

Kleinn, C. and Morales, D. (2002): Assessment of tree resources outside the forest. ETFRN News 36, Spring/Summer 2002.

Lal, R. (1990): Soil erosion in the tropics: Principles and management. London, UK: Mc Graw-Hill, Inc.

Lamprecht, H. (1989): Silviculture in the tropics. Tropical forest ecosystems and their tree species- possibilities and methods for their long-term utilization. Eschborn, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.

Leakey, R. (1996): Definition of agroforestry revisited. Agroforestry Today 8 (1): 5-7.

Lomborg, B. (2001): The Skeptical Environmentalist. Measuring the Real State of the World. Cambridge, UK: Cambridge University Press.

Lundgren, L. (1982): Introduction (Editorial). Agroforestry Systems 1: 3-6.

Lynch, O. J. (1986): Philippine law and upland tenure. In: Fujisaka, S., Sajise, P. and del Castillo, R. (eds.): Man, agriculture and the tropical forest: change and development in the Philippine uplands. Bangkok, Thailand: Winrock International: 269-292.

Meiggs, R. (1982): Trees and timber in the ancient mediterranean world. Oxford, UK: Clarendon Press.

Myers, N. (1980): Conversion of tropical moist forests. Washington D.C., USA: National Research Council.

Nair, K. S. S. (2001): Pest outbreaks in tropical forest plantations: is there a greater risk for exotic tree species? Bogor, Indonesia: Center for International Forestry Research (CIFOR).

Nair, P. K. R. (1984): Soil productivity aspects of agroforestry. Nairobi, Kenya: International Center for Research in Agroforestry (ICRAF).

Niskanen, A. and Saastamoinen, O. (1996): Tree plantations in the Philippines and Thailand: economic, social and environmental evaluation. Research for Action RFA series No. 30. Helsinki, Finland: World Institute for Development Economics Research of the United Nations University (UNU/WIDER).

Odum, H. T. (1983): Systems Ecology. New York, USA: John Wiley & Sons.

Pandey, D. (1997): Hardwood plantations in the tropics and subtropics: tropical forest plantation areas 1995. Report to the FAO project GCP/INT/628/UK. Rome, Italy: FAO.

Pascicolan, P. N., de Haes H. A. U. and Sajise, E. P. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forest Ecology and Management (99): 261-274.

Poffenberger, M. (1990): The evolution of forest management systems in Southeast Asia. In: Poffenberger, M. (ed.): Keepers of the forest. Land management alternatives in Southeast Asia. Quezon City, Philippines: Ateneo de Manila University Press: 7-26.

Poffenberger, M. (ed.) (1990): Keepers of the forest. Land management alternatives in Southeast Asia. Quezon City, Philippines: Ateneo de Manila University Press.

Potter, L. M. (1997): The dynamics of Imperata: historical overview and current farmer perspectives, with special reference to South Kalimantan, Indonesia. Agroforestry Systems 36: 31-51.

Raintree, J. B. (1991): Socioeconomic attributes of trees and tree planting practices. Rome, Italy: FAO.

Rebugio, L. L. (nd). Paradigm shift: the key to sustainable forestry and environmental resources management. In: Castro, C. P., Pulhin, F. B. and Reyes, L. C. (eds.): Community-based resource management: a paradigm shift in forestry. Los Baños, Philippines: Forestry Development Center, University of the Philippines, Los Baños, College of Forestry: 2-16.

Ruthenberg, H. (1980): Farming systems in the tropics. Oxford, UK: Clarendon Press.

Sanchez, P. A. (1995): Science in agroforestry. Agroforestry Systems 30: 5-55.

Sanchez, P. A. (1996): Introduction. Agriculture, Ecosystems and Environment 58: 1-2.

Schulte, A. (1996): Dipterocarp forest ecosystem theory based on matter balance and biodiversity. In: Schulte, A. and Schöne, D. (eds.): Dipterocarp forest ecosystems. Towards sustainable management. Singapore: World Scientific: 3-28.

Sedjo, R. A. (1983): The comparative economics of plantation forestry. A global assessment. Washington D.C., USA: Resources for the Future, Inc.

Sedjo, R. A. (2000): The social and economic impacts of plantation forests. Proceedings of the XXI IUFRO World Congress 2000, 7-12 August, 2000, Kuala Lumpur, Malaysia: Sub-plenary sessions Vol.1: IUFRO: 351-355.

Simons, A. J., Jaenicke, H., Tchoundjeu, Z., Dawson, I., Kindt, R., Oginosako, Z., Lengkeek, A. and de Grande A. (2000): The future of trees is on farm: tree domestication in Africa. Proceedings of the XXI IUFRO World Congress 2000, 7-12 August, 2000, Kuala Lumpur, Malaysia: Forest and Society: the role of research. Sub-plenary sessions Vol.1: IUFRO.

Soerianegara, I. and Mansuri (1994): Factors which determine the success of regreening in Gunung Kidul, Central Java. Journal of Tropical Forest Science 7 (1): 64-75.

Stroosnijder, L. and van Rheenen T. (1991): Making farming systems analysis a more objective and quantitative research tool. Proceedings of 'International Symposium on Systems Approaches for Agricultural Development'. Bangok, Thailand: Kluwer Academic Publishers.

Susswein, P. M., van Noordwijk, M. and Verbist, B. (2001): Forest watershed functions and tropical land use change. In: van Noordwijk, M., Williams, S. and Verbist, B (eds.): Towards integrated natural resource management in the forest margins of the humid tropics: Local action and global concerns. ASB Lecture Note 7. Bogor, Indonesia: ICRAF, Southeast Asian Regional Research Programme.

Tabora, P. C. J. (1991): Analysis and evaluation of agroforestry as an alternative environmental design in the Philippines. Agroforestry Systems 14: 39-63.

Takeda, S. (1992): Origins of Taungya. In: Jordan, C. F., Gajaseni, J. and Watanabe, H.(eds.): Taungya: forest plantations with agriculture in Southeast Asia. Sustainable Rural Development series No. 1. Wallingford, UK: CAB International: 9-17.

Udarbe, M. P. (1989): Social forestry in Sabah: a learning experience. In: Vergara, N. T. and Fernandez, R. A (eds.): Social forestry in Asia. Factors that influence program implementation. Los Baños, Laguna, Philippines. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA): 209-224.

Uhl, C. and Nepstad, D. (1990): Perturbaciones naturales y antropogenicas en la Amazonia. In: Anderson, A. B. (ed.): Alternativas a la deforestación. Volume 1. Quito, Ecuador: Ediciones ABYA-YALA, Fundación Natura y Museo Emilio Goeldi: 45-76.

van Noordwijk, M., Williams S. and Verbist, B. (2001): Towards integrated natural resource management in forest margins of the humid tropics: local action and global concerns. Bogor, Indonesia:ICRAF.

Vergara, N. T. and Fernandez, R. A. (1989): Introduction. In: Vergara, N. T. and Fernandez, R. A (eds.): Social forestry in Asia. Factors that influence program implementation. Los Baños, Laguna, Philippines. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA): 1-2.

von Uexkull, H. R. (1986): Efficient fertilizer use in acid upland soils of the humid tropics. FAO Fertilizer and plant nutrition bulletin No. 10. Rome, Italy: FAO.

Wibowo, A., Suharti, M., Sagala, A. P. S., Hibani, H. and van Noordwijk, M. (1997): Fire management on Imperata grasslands as part of agroforestry development in Indonesia. Agroforestry Systems 36: 203-217.

Wiersum, K. F. (1994): Social forestry in south and south-east Asia: history and new perspectives. Proceedings of 'The Philippine forests 2000, a northern Sierra Madre outlook: 2nd CVPED Work conference'. Isabela State University, Cabagan, Isabela, Philippines: Cagayan Valley Programme on Environment and Development.

World Bank (1991): The forest sector: a World Bank policy paper. Washington D.C., USA: World Bank.

Part II: Identification of the Research Problem

2 Identification of the research problem: literature review and research objectives

2.1   Deforestation and tree planting in the Philippines

"El capital leñoso ni es inmenso ni, por desgracia, inagotable, y las maderas preciosas van siendo raras en muchas, en muchísimas localidades donde abundaban pocos años ha, sin que se vea en ellas repoblados de la misma especie que las pueda sustituir"

Vidal y Soler, 1874. Memoria sobre el ramo de montes en las Islas Filipinas

The forests of Southeast Asia constitute, after the American, the second most extensive rain forest formations in the world. They extend from Sumatra in the east to New Guinea in the west, from the southernmost regions in China to the northeastern part of Australia and from the shorelines up to the upper montane zone (2,100 m) of all the mountains of the region. These forests define a distinct floristic region called Malesia. The flora of Malesia is extremely rich, comprising about 10% of the world's flora of which some 40% of the genera and many more species are endemic (Withmore, 1984). One of the distinguishing features of the lowland forest formations in this region is the dominance of trees belonging to the Dipterocarpaceae family. Dipterocarp trees are very tall, with large and straight boles commonly reaching 45 m, and forming extensive groups of emergent trees. Although some 386 Dipterocarpaceae species exist, typically, there are a large number of few commercial genera and species of dipterocarp trees per hectare. Thus, the existence of a high volume of commercial timber in any one place has made these forests of great economic importance for the South-east Asian countries (Withmore, 1984).

Because of their high proportion of valuable timber trees, Dipterocarp forests have been rapidly logged and in many regions of SE Asia primary forests have already disappeared or are seriously threatened (Schulte, 1996). When commercial forestry began in the early decades of the last century, forests were logged for firewood, poles and durable constructional timber (i.e., the heavy hardwoods), so that very few stems were removed at felling. But after World War II, the extent and intensity of forest exploitation increased dramatically. New demand of a larger number of light and medium hardwood species, increasing world consumption of tropical wood and the need for logging companies to get an adequate return to large investment in

infrastructure and machinery made desirable the extraction of all the species in a single felling cycle (Withmore, 1984). The expansion of logging activities opened vast areas of forest to a large and impoverished rural population who had no other subsistence option but to practice slash-and-burn agriculture. Deforestation, thus, occurred as a two-step process: primary forests were first transformed by loggers into secondary forests followed by the removal of the residual forests by the practice of agriculture (Kummer, 1992).

The Philippines is one of the most deforested countries of the tropical world. Substantial deforestation started to occur during the Spanish colonial period, as it can be deduced from the words of Jordana (1879): "La prohibición de cortar ciertas especies arbóreas, así como los árboles de escasas dimensiones y el acotamiento absoluto de los bosques cuya conservación interesa al buen régimen hidrológico es ya, hasta cierto punto, necesario en Filipinas"[10]. Shifting cultivation or kaingin[11], forbidden by the Royal Decree of June 8, 1874, and the expansion of commercial crops such as abaca, tobacco and sugar cane were probably the primary causes of forest removal at that time (Lopez-Gonzaga, 1987; McLennan, 1980; Lopez, 1996). According to Wernstedt and Spencer (1967), as cited by Kummer (1992), forest cover declined from a 90% of the total land area at the beginning of the colonization to approximately 70% by the turn of the XX century. But the most dramatic changes occurred after the World War II, when extensive exploitation of the dipterocarp forests began and agriculture, driven by an increasing and impoverished rural population, expanded into forested lands[12]. Between 1950 and 1980, forest cover declined from a 50% of the country's land area to less than 27% (Kummer, 1992). By the end of the 90s, the Philippine government estimated forest cover to be 5.4 million hectares or a mere 18% of the country's total land area, with only 800,000 ha of primary forests remaining (NSO, 1999). In other countries in the region, deforestation has also been extensive and forests resources continue to dwindle rapidly **(Table 2.1)**.

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[10] "A logging ban for small-sized trees and some species and the total protection of forests with important watershed functions is, to some extent, an urgent task in the Philippines".

[11] Kaingin is the Tagalog term used to denote shifting cultivation and Kaingineros are the practicioners of this agricultural system. During the colonial period, Spanish foresters strongly opposed the practice of shifting cultivation (Jordana, 1879).

[12] Although destruction of primary old-growth forest has been accomplished primarily by logging, followed by kaingin, deforestation in the Philippines is a complex process in which political and social issues (poverty, population growth, corruption, mismanagement and unemployment) are the ultimate deciding factors (Kummer, 1992).

Table 2.1: Forested land area, per capita forested area and *Imperata cylindrica*-dominated grasslands in selected tropical SE Asian countries.

Land cover	Philippines	Thailand	Malaysia	Indonesia	Vietnam	Laos	Cambodia
Forested land area[1] (% of total land area)	19.4	28.9	58.4	58.0	30.2	54.4	52.9
Per capita forested area[1] (ha per capita)	0.38	0.83	1.4	0.87	0.41	4.27	1.44
Imperata grassland[2] (% of total land area)	20	2 - 8	0.6	4.5	9	2.2 - 8.7	nd

Source: [1] Data corresponding to the year 2000 (FAO, 2000; World Bank, 2003)
[2] (Garrity, 1997)

The major civilizations of the Southeast Asian nations developed in the lowland floodplains of the major river systems based on the practice of wetland rice cultivation. Although of great economic importance, the lowlands comprise only a small percentage of the total land area in the region. By contrast, upland areas represent 60 to 90% of the total land area in Southeast Asia. Uplands are those lands with gentle to steep slopes (> 30% slope) that extend from the zone between the coastal plain and the high mountains (up to 1,000 m) (Garrity, 1993). The infertile and strongly acidic Oxisols and Ultisols are predominant in these areas. Under these soils, annual crop production cannot be sustained for more than a few years without a continuous input of fertilizers (Uexkull, 1986). Therefore in the past upland agriculture was limited to the practice of shifting cultivation, and permanent settlement possible only on those few areas with the most favourable volcanic soils.

Historically, the Philippine uplands have been inhabited by a number of different cultural minorities and ethnic groups. The uplands of Mindanao for instance are home to 18 indigenous tribal groups or Lumads[13] (Rodil, 1992). Besides hunting and gathering, these people have developed sustainable, subsistence-oriented farming systems like traditional swidden cultivation or terraced farming. But in the past decades wide socio-economic and political changes have induced a dramatic transformation of upland ecosystems. As the rural lowland areas and the national economy could not absorb a rapidly growing labour force, thousands of poor people, attracted by the availability of farmland, began to settle in the fragile uplands, putting pressure on Lumads' traditional farming practices and accelerating deforestation and soil degradation (Cruz et al., 1986; Garrity, 1993). Moreover, the consideration of most

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[13] Lumad is a term used to refer to the indigenous tribal communities of Mindanao, Sulu and Palawan.

upland areas as state forest lands exerted pressure on traditional land management systems based on communal private property and hastened the extinction of indigenous people's social systems (Poffenberger, 1990). In the 1960s, cultivated area in the uplands amounted to only 10% of the lowland cropped area but in the following two decades, it had increased by 40% (FAO, 1995). In 1980, 14.4 million people (i.e., 30% of the national population) lived in upland municipalities (Cruz and Zosa-Feranil, 1987) and arable land had declined to only about half a hectare per person (FAO, 1995). By the end of that decade population growth and density in the Philippines were the highest in Southeast Asia (Population Reference Bureau Inc., 1990). Recent estimates put the number of upland dwellers close to 18 million (i.e., almost a third of the national population) and projections for the year 2000 suggest that 24 to 26 million people will be living in upland areas (Garrity et al., 1993).

The land use pattern in a typical watershed of the Philippines is shown in **Figure 2.1.** As in most regions of Southeast Asia, the lowland dipterocarp forests have already vanished, mainly replaced by wet rice cultivation and other systems of permanent agriculture. The Department of Environment and Natural Resources (DENR) of the Philippines defines upland areas as "... those landscapes of slopes equal or greater than 18% including plateaus lying at higher elevations which are not normally suited to wet rice..." (Sajise and Ganapin, 1990). Based on this definition, the DENR claims control over 55% (16,5 million ha) of the country's land area (30 million ha) as public forest land (Cruz et al., 1986; Queblatin, 1992; Garrity et al., 1993). However, most of this land is devoted to agriculture as most of the recent deforestation in the Philippines has taken place in the uplands. Old-growth forest is seldom present below 800 m elevation and the forest margins are constantly moving upward due to slash-and-burn agriculture and forest fires. The grasslands of Southeast Asia in general are dominated by the specie *Imperata cylindrica* (L.) Raeuschel (hereafter referred to as imperata). This ecosystem has evolved from deforestation and intensive cultivation and is maintained in a fire climax. Today, imperata grasslands occupy around 35 million ha or 4% of the land area in tropical Asia. In the Philippines, it covers as much as 20% of the country land area **(Table 2.1)** (Garrity et al., 1997). These areas are usually perceived as under-productive and under-utilised land resources (Potter, 1997) and hence, targeted by reforestation programs. The more accessible and densely populated areas in the uplands are the hilly and gently sloping farmlands. These intensively-farmed lands present a mosaic of fallows, annual cropping and tree-based farming systems. In many places, these areas have been expanding into the degraded grasslands as farming practices are evolving into more permanent cropping systems (Garrity and Agustin, 1995).

Alienable and Disposable (14 M has)   Public Land (16 M has)

800-1000 m

600 m

Mangroves Lowland Crops   Hilly farmlands (rotational   Grasslands (grazing,   Natural forests
           (rice, fruit trees)   fallow/permanent cropping)   shifting cultivation)
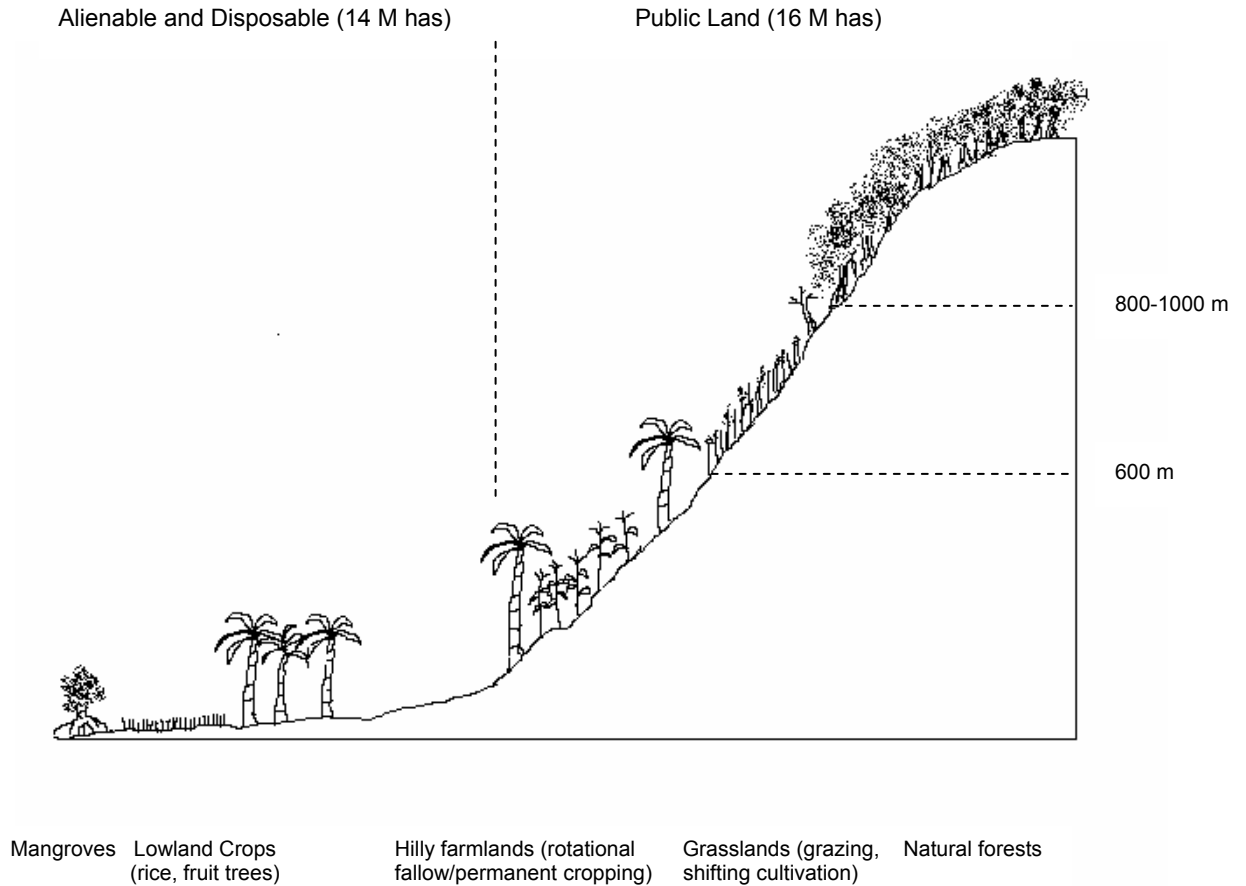
Figure 2.1: Actual land use and classification in a typical watershed in the Philippines. Adapted from (Garrity, 1997) and (Queblatin, 1992).

Forestry is one of the most important sectors in the developing economies of most Southeast Asian countries (Peluso et al., 1995). Dipterocarp forests are the main sources of timber and other raw materials for the domestic market, employment and foreign exchange. During the 1960s and early 1970s, the Philippines and Thailand were the leading exporting countries of tropical timber. In 1970 in the Philippines, the forestry sector was one of the major income earners, contributing 12,5 % to the gross domestic product (GDP) (ADB, 1994). Forestry activities began to decline in the 1980s due to overexploitation and decreasing timber resources. Log production followed a downward trend from 4.47 million m^3 in 1983 to 1.44 million m^3 in 1992, whereas log imports reached 530,000 m^3 in the latter year (Reyes, 1994). As a result of declining timber resources a log export ban was imposed in 1986 followed, three years later, by

a lumber export ban. In 1990, the forestry sector's share of the GDP was only 1,3 percent (ADB, 1994). The history of Thailand's forestry sector mirrors that of the Philippines. By 1968, Thailand was already a net importer of wood, and nowadays it is one of the largest tropical sawnwood importers (ITTO, 1996). Malaysia and Indonesia began large-scale harvesting of industrial roundwood from their natural forest later in the 1970s and 1980s. Presently, both countries are the top exporting leaders of tropical timber in Southeast Asia. Unfortunately, forecasts estimate that in few years the remaining natural forests of SE Asian countries may not be able to meet increasing annual timber demand due to excessive logging and deforestation rates (Schulte, 1996).

Other major socio-economic and environmental effects of deforestation have been studied at length. The replacement of natural forests with annual crops on sloping lands have had major on-site effects such as increased soil erosion rates and land degradation (World Bank, 1989; Sajise and Briones, 1996; Midmore et al., 2001); destruction of wildlife and loss of biodiversity (Agaloos, 1984; Myers, 1988; World Bank, 1989); and the loss of the homeland of many ethnic groups and of timber and non-timber forest products (fuelwood, rattan, gums, resins) economically important to them (Soler, 1874; Headland, 1987; Agaloos, 1984; De Beer and McDermott, 1989; Gibbs et al., 1990; Tadem, 1990). Off-site, silting has shortened the life spans of water impoundment structures and dams, affecting the capacity to generate hydroelectric power and the water supplies. As a result of sedimentation, irrigation channels and water quality have deteriorated and coral reefs are covered with silt (Briones, 1986; Finney and Western, 1986; Porter and Ganapin, 1988; Coxhead and Buenavista, 2001). The Master Plan for Forest Development (DENR, 1990) estimated that soil erosion and the deterioration of the hydrological functions of watersheds have on-site costs of at least Ph P. 4.9 billion per year and have set the country back by about Ph P 6.7 billion per year in terms of losses in productivity, utility of infrastructures and other off-site costs.

It is believed that before the arrival of the Spanish colonizers, 90% of the Philippine archipielago (27 million ha) was entirely covered by forest and inhabited by scattered tribal groups of hunter-gatherers and shifting cultivators. Although King Philip II of Spain and subsequent colonial administrations promulgated laws that recognized indigenous property rights[14], in practice, all land was presumed to belong to the Spanish Crown by virtue of the Regalian doctrine (Lynch, 1986). In the early years of

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[14] Philip II was a monarch notably concerned with forestry, forest conservation and reforestation (Bauer, 1991).

the colonial period, government-claimed ownership of forest lands had little effect on most rural dwellers. But in the nineteenth century, the Philippine forests became an important resource as a result of increasing timber demand and the expansion of international trade (Peluso et al., 1995). The creation in 1863 of the first Forestry Bureau, the "Inspección General de Montes", by the Spanish administration, marked the formal beginning of modern forestry in the Philippines. The agency studied the forests resources, laid down the regulations for cutting timber, forest planning and management and passed comprehensive laws imposing replanting (Agpaoa et al., 1976; Lopez, 1996). In the years before the end of the Spanish colonial period, centralized state control over forest resources increased. The Maura Act of 1894, requiring official registration of communal and individual land holdings, further undermined indigenous property rights as most of the villagers, unfamiliar with land documentation procedures, failed to do so (Lynch and Talbott, 1995). By the turn of the century, the government owned more than two-thirds of the Philippine territory (Lynch, 1986).

The American colonial period did not change much. The government maintained centralized control over forest resources and large-scale commercial exploitation began with the allocation of concessions within the public domain (Lynch, 1986). In the early 1900s, government-sponsored reforestation efforts also started with the establishment of the College of Forestry at Los Baños, Laguna, and the implementation of pilot reforestation projects with *Tectona grandis* (hereafter referred to as teak) and *Swietenia macrophylla* (hereafter referred to as mahogany) in other provinces of Luzon, on the eroded hills of Cebu and Mindanao (Jurvélius, 1997). Before the widespread destruction caused by World War II (WWII), 28,000 ha had been reforested in 35 projects targeting a total area of 535,000 ha (Agpaoa et al., 1976).

After WWII, a tremendous increase in demand for timber and other forest products accelerated forest exploitation dramatically. The Philippine government encouraged the logging of its vast forests resources by allocating to the wealthy, politically influential elite the rights to extract timber in large scale. On the other hand, rapid deforestation was viewed as the result of shifting cultivation, and farmers as forest destroyers. Consequently, new laws and policies forbidding the practice of slash-and-burn agriculture were enacted. Farmers and rural communities were thus marginalized by excluding them from management and conservation of the forest resources they depended upon (Poffenberger, 1990; Gibbs et al., 1990; Pragtong and Thomas, 1990; Potter, 1997).

In 1960, the creation of the Reforestation Administration under the Department of Agriculture and Natural Resources marked the beginning of a vigorous reforestation program (Agpaoa et al., 1976). Experiments with industrial tree plantations started in eastern and southeastern Mindanao in the early 1960s (Jurvélius, 1997), and tree planting rapidly increased at an annual rate of more than 10,000 ha per year. In 1973, the Bureau of Forest Development[15] maintained around 182,000 ha of plantations (Agpaoa et al., 1976). Private reforestation efforts of logged-over and denuded lands were also encouraged. Timber License Agreement (TLA) holders were required by law to reforest an area of denuded land equivalent to that selectively logged and to engage in industrial tree plantation (ADB, 1994). Unfortunately, it was later realized that neither private nor government-sponsored reforestation had contributed significantly to the rehabilitation of deforested lands because of the control of the TLAs by the political elite (Vitug, 1993), and corruption in the government sector who had, deliberately, manipulated government official data on forestry (Gibbs et al., 1990; Kummer, 1992).

In the 1970s, the inability of the Forest Management Bureau (FMB) to halt deforestation and enforce sustainable forest management, increasing public demands for improved living standards of rural people, and government's concern with insurgency in poorer regions spurred the emergence of social forestry (Quitzon, 1989; Gibbs et al., 1990). In 1972, the Industrial Tree Plantation Lease Agreement (ITPLA), funded by the World Bank, provided loans in support of farmers' tree growing and forest plantation activities (Jurvélius, 1997). That year the first major industrial tree plantation initiative began with the establishment of the Paper Industries Corporation of the Philippines (PICOP) pulp and paper mill in Surigao del Sur. PICOP developed 33,200 ha of plantations of *Paraserianthes falcataria* (hereafter referred to as falcata) and *Eucalyptus deglupta* (hereafter referred to as bagras) and a contract growing scheme with smallholder farmers (ADB, 1994). In 1974, the formulation of the Forestry Reform Code was the first attempt to abolish short-term permits to the industrial forestry sector, improve tenure security for settlers occupying public land, and grant 10- to 25-year licences for the establishment of forest plantations. Further revisions of the code in the following year (the Revised Forestry Code) included the concept of multiple-use, rehabilitation of degraded forest ecosystems, encouragement of wood processing and the gradual phase-out of log exports (Sajise, 1998). Between 1975 and 1980, the FMB initiated 3 more social forestry programs: the Forest Occupancy Management (FOM) program in 1975, which issued forest land occupancy permits for

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[15] In 1972, Presidential Decree No. 1 mandated the merge of the Bureau of Forestry, the Reforestation Administration and the Parks and Wildlife Office into the Bureau of Forest Development (Agpaoa et al., 1976).

farmers and regulated land-use practices in such as way that farmers could not expand their clearings nor adversely affect public forest; the Communal Tree Farming (CTF) program in 1978, intended to establish tree farms and to promote reforestation through cooperation between government agencies, local communities and the private sector; and the Family Approach to Reforestation (FAR) program in 1979, which, similar to the *Taungya* system developed in Burma, the FMB entered into short-term contracts with families to establish tree plantations inter-planted with agricultural crops on public land (Aquino et al., 1987).

However, in spite of these impetus, success of these early Social Forestry initiatives was rather limited for two reasons: (a) technical and regulatory issues addressing government objectives (e.g., minimizing shifting cultivation) still received more attention than social, economic and institutional aspects concerning farmers' needs (Gibbs et al., 1990); (b) the government forestry agency continued to view farmers as agents of forest destruction (Vitug, 1993).

The need to consolidate under an umbrella program the previous array of social forestry initiatives, led in 1982 to the creation within the FMB of a Social Forestry Division responsible for the implementation of the Integrated Social Forestry Program (ISFP). Unlike its predecessors, the ISFP addressed the issue of insecurity of land tenure by providing individual and communal stewardships contracts for 25 years renewable for another 25. The program also took a new approach to participation and began to develop and use a series of tools and techniques such as Rapid Rural Appraisal, Community Resource Management, Needs Assessment and Community Organizing, for participatory site selection, diagnostic studies, research, project planning and implementation (Gibbs et al., 1990; DENR, nd; Lynch and Talbott, 1995; Lindayati, 2000).

Community-based resource management gained further momentum when the new Constitution, enacted after the People's Power revolution of 1986[16], provided for the concepts of decentralization and devolution, Indigenous Cultural Communities' (ICCs) rights, the preferential use of natural resources by marginalized sectors, and the involvement of non-governmental organizations (NGOs) and people's organizations (POs) in all types of socially-related activities. This was translated in the following years into new laws and policies, and the implementation of a large number of donor-supported, community-based rehabilitation and resource conservation programs and projects. The National Forestation Program (NFP) launched in 1987, involved rural

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[16] In 1986, the People's Power Revolution, also called the "Edsa Revolution", restored democracy in the country after more than 30 years of dictatorship under Ferdinand Marcos.

families, communities, NGOs and corporations in reforestation activities by the development of 3-year contracts with the Department of Environment and Natural Resources[17] (DENR). Two years later the DENR launched the Community Forestry Program (CFP)[18], aiming at involving rural communities in the protection and sustainable utilization of virgin and residual forests. With the assistance of NGOs in the social preparation of communities and training (e.g., fund management; identification of livelihood alternatives), qualified groups could avail the land for 25 years through the following renewable agreements: a) Community Forestry Management Agreements for residual forest; b) Forest Land Management Agreements for areas which were planted under contract reforestation and assisted natural regeneration; c) Certificate of Stewardship (CSs) for individually occupied and cultivated upland farms (ADB, 1994).

In 1988 and for several years, the Philippine policy makers engaged in a major national debate on a total logging ban. The discussions culminated in the Senate in 1992 with the decision to ban all logging in old-growth forest, in all provinces with less than 40% of forest cover, and in those critical areas above 50% in mean slope and above 1,000 m in elevation (Vitug, 1993; PCARRD, 1994; Sajise, 1998; Vitug, 2000). In view of the logging prohibition, to ensure a sustainable supply of wood and other industrial forest products, private investors and corporations were encouraged to participate in sustainable forest management and reforestation through the Industrial Forest Management Agreement (IFMA) program of 1991. The program provided qualified investors with a twenty five-year renewable contract and other incentives, such as tax holidays and exemptions, for the management and protection of remaining residual forests and for converting deforested and degraded areas into plantations.

In the early 1990s, growing concern on how rural communities could obtain greater influence and control in the allocation, management and utilization of natural resources was manifested in new policies and programs within and outside the DENR bureaucracy. The Local Government Code of 1991 provided all local governments units (LGUs) with considerable powers to protect and conserve natural resources within their jurisdiction and devolved to the LGUs the responsibility for implementation of community-based forestry programs. In 1992, The National Integrated Protected Area System (NIPAS) Act provided for the establishment and management of a comprehensive system of natural parks, wildlife sanctuaries and nature reserves in

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[17] After the 1986 revolution the Ministry of Natural Resources was restructured into the new Department of Environment and Natural Resources (DENR).

[18] DENR Administrative Order DAO No. 123, Series of 1989: Community Forestry Program.

order to ensure sustainable use of the resources found within these areas and preserve their genetic diversity. In coordination with the DENR, rural communities, LGUs and NGOs would be involved in the identification and demarcation of land boundaries and undertake the preparation and implementation of site management plans (DENR, 1992; Sajise, 1998). A year later, a new type of tenurial instrument, the Ancestral Domain Claim (ADC), was developed in response to criticisms over the marginalization of ICCs and as research started to reveal the positive environmental aspects of "traditional" resource management systems and indigenous knowledge. Under this new policy instrument, the DENR issues certificates of ancestral domain claims (CADC) to ICCs declaring, identifying and recognizing their claim to a particular territory occupied and possessed in accordance to their customs and traditions since time immemorial (Sajise, 1998).

In response to the need for a more effective and efficient program planning and implementation, in 1995 the Philippine government integrated all previous programs into a national strategy for sustainable forest management known as the Community-Based Forest Management Program (CBFMP). Based on land tenure and the subject undertaking resource management planning, three modes of CBFM implementation can be distinguished: (1) Indigenous peoples awarded with a CADC; (2) Migrant communities and/or indigenous peoples who are granted a community-based forest management agreement (CBFMA); (3) Families who are granted individual access and use rights through Certificates of Stewardship (CS) endorsed by the POs holders of a CBFMA over the larger forest land area (DENR, 1998). Applicants are granted usufruct rights through 25-year renewable leases on specific areas after completion and approval of various requirements such as community resource management framework (CRMF), resource use plans (RUPs) and annual work plans (AWPs) (DENR, 1998). As in previous programs, NGOs can be contracted by the DENR to organize and implement any activity related to community organizing (e.g., official registration of groups and community profiles) and training for the sustainable management of forest resources (resource inventories, management plans and livelihood projects). Private investors are also envisioned to participate in the CBFM program as awarded POs and CS holders are allowed and encouraged to enter into contracts with private individuals or corporations for the development of forest plantations on portions or on their entire area. With this program, the DENR intends to place by the year 2008 58% of the country's total forest land area (i.e., around 9 million ha) under community management (DENR, 1998).

The development of social and community forestry during the past thirty years in the Philippines have led to important gains and progress in the way forests lands are managed. Specifically:

(1) Increasing involvement of upland communities in the use of local forest resources;

(2) Increasing democratisation of forest access, decentralization and devolution of power and responsibilities in forest management to LGUs, rural communities, NGOs and individuals through the various types of tenure instruments.

(3) Significant policy and institutional reforms undertaken within the DENR, as rural people became partners in forest management and protection.

(4) Raising awareness of issues related to environmental degradation and to some extent, articulating poor people's concerns and priorities.

This major shift in authority and responsibility has resulted in a new forestry paradigm[19] away from traditional forest resource use and control (DENR, 1998; Rebugio, nd).

However, in spite of its achievements, the progress of participatory forestry towards sustainable utilization of forest resources, and rehabilitation of degraded lands has been slow. A number of research studies and program reviews in the Philippines and elsewhere point to the following issues involved[20]:

(1) The use of an instrumental notion of participation. Many social forestry projects merely seek the agreement of local people on externally-designed targets, or paid participants to carry out project activities (e.g., tree planting) (Pascicolan et al., 1997; Contreras, 2000; Pulhin, 2000; Utting, 2000; Gollin and Kho, 2002). Thus, rather than using participation as a concept involving a "shift in power", community-based forestry has remained largely as a system of centralized control (Gauld, 2000).

(2) Consideration of uniform and homogenous communities, without recognizing the socio-economic, cultural, and other differences (e.g., gender) within communities that influence the access of individuals to local resources and their relations to the

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[19] A scientific paradigm is a set of assumptions about reality (Kuhn, 1962).

[20] I limit the discussion to the most immediate reasons behind the failure of government-driven programs and projects. However, a substantial part of the problem of poverty and environmental degradation lie beyond technical issues, institutional limitations or the tendency of the administration to keep central control and power, but in the country's economic circumstances, such as the external debt service or the adoption of certain macroeconomic polices with negative environmental consequences (Cruz and Repetto, 1992; Utting, 2000).

state and other groups (Raintree, 1991; Pulhin, 1997; Gollin and Kho, 2002). Consequently, there has been a lack of genuine interest in project objectives as farmers with different livelihood strategies have a different notion of the problem to be addressed. In other projects, community forestry benefited the more advantaged and powerful groups in the community rather than the poorest people (Rebugio 1995; Rhoades 1998).

(3) Limitations in program and project planning and design. The way program and project initiatives have been designed can be described as:

- Top-down, that is, when program and/or project design is driven by donors, consultants and government officials in response to their need for short-term and low risk projects with an emphasis on verifiable physical targets (e.g., number of hectares planted). This is inconsistent with the need of rural development forestry projects to be long-term, open-ended, flexible and responsive to the needs identified by local people (Guiang and Dolom, 1992; Lynch and Talbott, 1995; Byron, 1997; Dugan, 1997).

- Non-integrative, but concentrated on a single sector (e.g., forestry) and/or ministry (DENR) (Byron, 1997). Instead, given the multidimensional nature of forestry problems, programs and projects should be multi-objective, integrative and across multiple scales.

- Unrealistic in terms of targets and objectives. The design of mega-interventions with short-time frames for implementation has often been a failure. For instance the NFP, which awarded 20,000 reforestation contracts, covering 225,000 ha in just three years (Utting, 2000). There is also a need to be realistic about what a specific participatory forestry intervention (e.g., farm forestry) can and cannot do (Rhoades, 1998).

(4) Ineffective decentralization and devolution process, and lack of cooperation between government institutions. Progress towards a complete devolution to the LGUs of responsibilities on forest land management have been often undermined by: a) the lack of clear guidelines on the specific roles and tasks of the DENR and the LGU in program implementation; b) DENR's perception of the LGUs as interfering in their functions and/or incapable of handling technical functions; c) LGUs' lack of financial resources and/or capability to receive devolved forest management and protection functions; d) the "appropriation" and corruption of the decentralization process by local elites (Chiong-Javier, 1995; Contreras, 2000; Utting, 2000; SEIC 2001).

(5) Insufficient security of land tenure and use rights: The 25-year renewable CSC instruments of land tenure are not a sufficient incentive to invest in long-term forestry and environmental protection (Garrity et al., 1993). Moreover, resource use rights are transferred just partially. The DENR still maintain the power to decide "who" and "how" resources are used (i.e., right of exclusion and management) and the ability to transfer or revoke certificates (i.e., right of alienation) (Utting, 2000; Gollin and Kho, 2002). As Pulhin (1997) noted, the tenurial instruments "…tend to reinforce the government's territorial jurisdiction over these areas through a form of regulated freedom".

(6) Inter-program conflict. Although involvement in forest land management of a diverse range of agencies and actors is one of the positive features of participatory forestry, conflict often arise between stakeholders having opposing interests. For instance, in areas where IFMAs have been granted, existing communities of indigenous people and migrant farmers have other priorities conflicting with those of project proponents (Severino, 2000).

Because of these complex issues, success of participatory forestry and reforestation programs has been rather limited. A nationwide inventory of plantations showed that tree survival rates were on average as low as 26% (FMB, 1988). According to Pascicolan (1996), as cited by Pascicolan et al., (1997), only 10% of the total area of 225,000 ha targeted for reforestation between 1988 and 1992 were considered successful. And where trees survived, government-driven reforestation efforts have suffered from the use of inappropriate species and low quality planting materials; a lack of proper maintenance and silviculture; fires and encroachment (Garrity et al., 1993; ADB, 1994; Quimio, 1996; SEIC, 2001). Therefore, in spite of the considerable investment in people-oriented forestry during the past 30 years, the Philippines still experience high deforestation rates. Between 1990 and 2000, forest cover receded at an average rate of 1.4 % annually (FAO, 2000). During the past decade, the total forest area declined from 6.6 million to 5.8 million hectares, just 19 % of the country's total land area of 30 million hectares.

2.2   Farmers' spontaneous tree planting

Ironically, outside the government reforestation areas, successful spontaneous tree planting has been practiced for many years without any financial assistance. Indigenous people have long been managing several types of multi-storey agroforestry

systems, such as the *muyong*[21] in northern Luzon or the mixed gardens found in different parts of the country (Kivikkokangas-Sandgren, et al., 1995; Zita, et al., 1996; Gomez et al., 1998). In the past century, in the Philippines and in many tropical countries, planted trees have become important components of farming systems. As forest disappear and land frontiers close due to population growth, farmers increase the organization and flexible repertoire of tree management strategies in order to meet their demands for various tree products (e.g., food, fuelwood, construction materials) **(Figure 2.2)** (Raintree, 1991; Arnold and Dewees, 1997). In some regions of Southeast Asia smallholders have dramatically transformed large areas of treeless Imperata grasslands into productive agroforestry farms, increasing employment and incomes in these marginal upland rural areas. In Sumatra, about 4 million hectares have been converted by local people into various kinds of agroforests without any external support (Foresta and Michon, 1993). Indonesian farmers produce in these agroforests about 70% of the total amount of rubber, at least 80% of the damar resin, 80 to 90% of various fruits, and important quantities of main export tree crops such as cinnamon, clove, nutmeg, coffee and candle nut (Foresta and Michon, 1997). In Thailand and Malaysia, smallholders account for 95% and 72% of the total natural rubber production respectively (Bagnall-Oakeley et al., 1997). The imperata grasslands of the Philippines are also undergoing rapid transformation. A study on land use change during a 40-year period (1949 - 1988) in the upland municipality of Claveria, Mindanao, showed a rapid decrease of grasslands and an expansion of perennial crops[22] from 4% to 30% of the land surface (Garrity and Agustin, 1995). Similar transformations are also occurring in other parts of the country (Pascicolan et al., 1996).

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[21] A local term for a private forest managed by families with an area ranging from 0.5 to 3.0 ha and composed of second growth forest and associated commercial trees (Zita et al., 1996).

[22] Although in some areas this trend may be reversed. In Lantapan, Central Mindanao "…recent expansion of sugar and corn cultivation at low altitudes, and of vegetable and corn at higher altitudes, has occurred substantially at the expense of perennial crops, whether pasture/grassland, forest/bush fallow, or coffee" (Coxhead and Buenavista, 2001) p. 25.

Natural Forests	Degraded natural forest	Fallow lands	Intensively-managed farmland

Population

Natural regeneration	Coppicing	Stimulation of tree regeneration:	Tree farming of natural and introduced tree species

- Natural regeneration
- Off-take of tree products

- Coppicing
- Pollarding
- Pruning

Stimulation of tree regeneration:
- Protecting, cultivating and transplanting naturally germinating seedlings

Tree farming of natural and introduced tree species
- Tree nurseries; direct seeding
- Grafting; marcotting
- Ploughing, intercropping, fertilizing
- Weeding, pruning, thinning

Figure 2.2: The decline of off-farm tree resources and the development of smallholder tree farming systems. Based on (Arnold and Dewees, 1997) and (Noordwijk et al., 1997).

As a commodity, tropical timber has been traditionally harvested from natural forests or produced in industrial tree plantations. But nowadays in the Philippines, smallholder farmers are producing large quantities for household consumption and the market. In the early 1970s, the Paper Industries Corporation of the Philippines (PICOP, Inc.), a major industrial forest plantation initiative established at Bislig, Surigao del Sur, promoted for the first time in the country the planting of timber trees on farms (Garrity et al., 1993). Farmers within PICOP's forest concession area were encouraged to

plant falcata and bagras to supply a pulp and paper mill. The tree-growing scheme was so successful that farm forestry[23] quickly spread. In 1997, there were 15,000 ha of tree farms located nearby the mill site and another 29,000 ha further away but selling wood to PICOP (Jurvélius, 1997). But tree farming has not been restricted to the area of influence of PICOP. A decade later, timber tree planting gained further momentum when in response to high domestic timber prices and market demand farm forestry emerged in many parts of the country as a profitable farm enterprise (Garrity et al., 1993; Garrity and Mercado, 1994). Farmers planted short-rotation trees such as *Gmelina arborea* (hereafter referred to as gmelina) and *Acacia mangium* (hereafter referred to as mangium) among others, and in many cases, long-rotation premium timbers such as *Pterocarpus indica* (narra) and mahogany. A decade later, when planted trees started to reach harvestable age, small-scale timber processing and marketing flourished in many regions, supplying large-scale wood processors and industries with farm-grown timber (Garrity and Mercado, 1994).

Until recently, gmelina and to a lesser extent mangium, predominated in most of the small-scale timber tree plantations in Claveria, Misamis Oriental (Garrity and Mercado, 1994). Before gmelina became so common, falcata was widely planted as a shade tree in coffee plantations. Unfortunately, the gall rust disease wiped out this specie from many parts of Mindanao. A decade ago, the use of grass strips of natural vegetation (NVS) along the contour lines became a popular soil erosion control measure among farmers in the area. These vegetative barriers are typically established by leaving during land preparation narrow contour strips unploughed at a distance of 5 to 7 meters. Then, annual crops are planted in the alleys between the grass strips (Stark, 2000). Few years after the first farmers adopted NVS on their fields, a farmer-led movement known as Landcare began, with facilitation support from ICRAF, to disseminate this soil conservation technology to hundreds of farmers from Claveria and other upland municipalities of northern and central Mindanao. With the years, NVS proved to be an intermediate step towards agroforestry (Garrity et al., 1993). To make use of the space occupied by the grass strips, many farmers started to plant fruit and timber trees just above the strips, with alleys planted to intercrops (Garrity et al., 1998) **(Plate 2.2.1)**. Landcare farmers started then to disseminate

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[23] In this study "smallholder forestry", "farm forestry" and "small-scale forestry" are used interchangeably to denote "any tree farming practice that involves growing trees for timber, poles or fuelwood on farmland" (Huxley and Houten, 1997). The size of small-scale private plantations may vary widely between and within countries, encompassing micro-scale holdings of less than 1 ha to areas of 20 to 30 ha or more (Harrison et al., 2002). The term farm forestry may also apply to any type of tree, not just timber, and thus it can be simply defined as "farmers growing trees on their own land for economic return" (Beldt et al., 1994).

germplasm of a range of fruit and timber tree species and to train other farmers on their propagation and management. Nowadays, besides the ubiquitous gmelina, a number of other exotic and indigenous timber species are being grown on farms such as *Maesopsis eminii* (mosizi), the native bagras and several other Eucalyptus species, *Melia dubia* (mangolinaw), *Vitex parviflora* (molave) and others.

Plate 2.2.1: In northern and central Mindanao, the adoption of soil conservation practices is the first step towards more diverse tree-based farming systems.

2.3   The smallholder[24] mode of timber production

During the past 30 years, the establishment of private industrial forest plantations and reforestation with the involvement of the rural people have been the main goals of the forestry programs of the Philippine Government. Large-scale planting of timber trees is seen as an approach to rehabilitate degraded public forest lands, provide jobs and income to rural families and produce raw materials for the wood industry (DENR-ERDB, 1998). Yet, a majority of projects have failed to deliver the results foreseen. Instead, in response to favourable market conditions, smallholder farmers are producing substantial amounts of timber on private land outside the government purview. Since farmers have proved to be successful tree planters, smallholder forestry has been proposed as a viable alternative to costly government-driven reforestation programs (Pascicolan et al., 1997).

The failure of government-sponsored tree planting interventions is largely the result of the inadequate understanding of the goals and the socio-economic organization under which small-farm families operate. Thus tree farming, as other agroforestry technologies (e.g., contour hedgerow intercropping), has been promoted in standard extension packages (Garrity, 1996), without recognizing that many tree species with different attributes[25] and management strategies exist, and without considering the high degree of variability between and even within households for specific tree products and services. In a typical reforestation project, few timber species and a fixed set of management practices are promoted with the sole objective of maximizing timber yields[26]. Consequently, too many project interventions have encouraged tree growing where trees are not an appropriate component of the farm household

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[24] Smallholder is "a farmer who is relatively resource poor, who cultivates or keeps animals, or both, on a small piece of land, sometimes only a small plot. These farmers may or may not have access to other common land" (Huxley and Houten, 1997). The farm size of a smallholder may vary widely from one country to another and within countries. For instance, in Costa Rica small farms at the subsistence level may involve 6 to 30 ha (Current, 1995), while in some countries of Africa, like for example Rwanda, average smallholdings of 1 to 1.5 ha are common (Balsubramanian and Egli, 1989). In our study area the average farm size of a smallholder is 2.5 to 3 ha.

[25] Raintree (1991) distinguishes four types of socio-economic attributes of trees: a) Intrinsic, or biophysical attributes inherent to the tree; b) Ascribed, or socio-economic attributes given to trees by people such as for instance those with religious symbolism; c) Hybrid, or those objective biophysical attributes which are given a socially subjective interpretation; d) Intrinsic-modified-by-management, as those which are a manifestation of latent biophysical attributes that only reveal themselves under human management.

[26] See for instance the reference book of the First Visayas Tree Farmers' Congress (Ilo-Ilo City, November 6-7, 2000).

economy, or have attempted to induce growing of inappropriate[27] trees, or have encouraged tree management strategies not suited to farmers' goals, objectives and conditions (Raintree, 1991; Arnold and Dewees, 1997).

In smallholder agriculture, the farming system is embedded within the economy of the household and therefore, it is organized to meet both the production and consumption goals of the farm family (Sands, 1988). As opposed to the simple selection of tree species and the standard management practices involved in traditional reforestation (e.g., pruning, thinning), small-scale farmers will evaluate the suitability of a tree planting practice in terms of its compatibility with the goals of the farm household and the constraints and opportunities confronting the integrated household production system. These include the suitability of the small-farm's environmental conditions for tree growing and the access to the limiting resources land, labour and capital (Arnold, 1990; Sands, 1988). Therefore for a particular farmer, his socio-economic context and overall development strategy determine the function trees are intended to perform (e.g., timber trees as savings or land demarcation), which in turn influence the pattern (i.e., location within the landscape and spatial arrangement) of planted trees (e.g., tree rows on boundaries). And the pattern conditions the management system under which the trees are grown (e.g., pruning, thinning or coppicing). This set of interrelated decisions of a tree growing practice will eventually define the attributes of the appropriate tree specie to be selected for on-farm planting to perform the intended function (Raintree, 1991).

The function, patterns and management systems of smallholder timber plantations are markedly different from those found in natural forest, government-sponsored reforestation and plantation forestry (Harrison et al., 2002). Besides wood production, timber trees planted on farms serve a number of other purposes such as boundary demarcation, overstorey trees for shade-demanding crops, protection against erosion, insurance during periods of scarcity, shelter, etc. To better serve these functions, trees may be incorporated in various densities and arrangements in existing farm niches (e.g., cropland, fallow land, boundaries, homestead). Subsistence-oriented farmers cultivating small plots are likely to restrict tree planting to home gardens or farm boundaries away from cropped fields. In more advanced market-oriented agricultural

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[27] Any tree that is recommended for planting can be inappropriate for a particular group in at least five different ways (Raintree, 1991): a) Inappropriate function (not needed); b) Inappropriate market orientation (cash crop tree where trees are needed primarily for subsistence); c) Inappropriate land requirement (trees suited for monocrop blocks introduced where land is too scarce); d) Inappropriate labour or skill requirement (where labour is scarce); e) Inappropriate capital requirement (e.g., leguminous that need rhizobium).

areas, trees may be planted on crop lands either scattered, on rows mixed with agricultural crops, or on blocks (woodlots). In its less developed forms, smallholder timber tree plantations may just involve even-aged single tree species. But quite often, smallholder plantations evolve into highly complex, uneven-aged multi-storey polyculture of trees, such as in mixed gardens[28] and agroforests. Management practices also vary widely, from the low intensity management of naturally regenerated trees on non-arable or fallow land, to the intensively-managed trees planted in association with crops **(Plate 2.3.1 and 2.3.2)**.

The most significant advantage of this wide repertoire of tree production strategies is its flexibility to match farmers' individual needs and preferences within their specific conditions and changing circumstances. Thus, in situations where capital and labour are scarce, trees can be planted as a low-input, low-management crop, to make more productive use of land. Trees can also maximize returns to land when farm size and/or site productivity decline below economic levels. Lastly, trees can contribute to risk management through diversification of outputs, avoiding labour bottlenecks and spreading risks (Arnold, 1990; Arnold and Dewees, 1997). Therefore, as opposed to plantation forestry, smallholder tree planting is not just a production strategy for maximizing profit but a strategy to respond to farmers' changing resources and circumstances (Scherr 1997; Dewees, 1997).

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[28] It is "a land-use form on private land outside the village, dominated by planted perennial crops, mostly trees, under which annual (seasonal) crops are cultivated" (Huxley and Houten, 1997). Homegardens are mixed gardens surrounding individual houses with a definite fence and often with the inclusion of small livestock (Huxley and Houten, 1997).

Plate 2.3.1: The diverse, more disperse, and disorderly appearance of on-farm tree stocks. Smallholder tree plantations commonly constitute uneven-aged polyculture of trees planted for multiple purposes, such as timber, fuelwood, fruits, erosion control, or land demarcation, in various farm niches.

Plate 2.3.2: A woodlot and a coppiced plantation of *Gmelina arborea* intercropped with sweet potato (*Ipomoea batatas* (L.) Lam.) showing the various arrangements of trees on farms and farmers' flexible management practices.

It could be argued that, because of the scale economies (i.e., declining per unit cost in production as land size is increased) achievable by large, highly capitalized and mechanized operations, plantation forestry represent a more effective and efficient approach to reforestation and timber production than smallholder tree farming. However, there is strong evidence to believe that economies of scale do not necessarily apply to timber production. As Hayami et al., (1993) reasoned for other tree crops (coconut, coffee, cacao and rubber), timber may not need large units to minimize production costs since:

(1) There is no need of a precise schedule and control of the production process to meet market demand or to avoid overproduction during seasons of low demand since timber is not perishable and therefore, it can be easily storage as stumpage or as sawn timber. Timely harvesting of large quantities of timber could be done by developing appropriate forms of contract farming between producers and processing companies.

(2) The production and marketing of timber require neither large-scale machinery nor central management.

(3) It is not difficult for small-scale farmers to achieve the efficiency in land preparation and plantation establishment and management that would be achieved by plantation forestry. Specialized tasks such as weeding or pruning may be more efficiently performed and monitored by farmers, thus ensuring that trees reach a harvestable age.

The discussion in section 2.2 of this chapter on the important role of smallholders in the production of various tree crops and the large quantities of farm-grown timber produced nowadays by farmers in the Philippines provides enough evidence about the efficiency of the smallholder mode of tree production.

2.4   Balancing trade-offs: reducing crop yield suppression effects of trees and producing timber

One of the unique advantages of smallholder farmers in tree production is the practice of intercropping. In the tropics, and particularly on Imperata grasslands where early and timely weed control is imperative to successful tree growing (Zobel et al., 1987; Lowery et al., 1993; Kosonen et al., 1997), the frequent and intensive tending operations for crops, such as land cultivation, weeding and fertilization, ensure tree survival and promote higher growth by preventing weed infestation and improving site conditions (Garrity et al., 1997) **(Plate 2.4.1)**. Kapp and Beer (1995) observed lower

mortality rates of mangium in agrisilvicultural plots (16%) as compared to pure plots (41%), probably related to faster tree growth and greater distances between the roots, which reduced the spread of the infection of *Rosellinia* fungus. They also found that *Cordia alliodora* (hereafter referred to as cordia) associated with crops were 3.4 m taller than in monoculture because of the sensitivity of this specie to fertilization and reduced weed competition in the agrisilvicultural plots. Conversely, growth of associated crops may also benefit by the presence of trees as these reduce weed invasion and growth (Gajaseni and Jordan, 1992). Miah (1993) reported that weed infestation and weed dry matter yield in an upland rice-tree association were 30 to 38% lower than in the sole rice plots.

Planting trees and crops in association not only ensures high tree survival and growth but it is also economically more advantageous. According to Garrity and Mercado (1994), the practice of intercropping: a) reduces tree establishment and weeding costs as these are charged to the land preparation operations for crops and; b) reduces protection costs as cropped alleys function as effective fire-breaks. In Latin America, it has been estimated that the costs of soil preparation, weeding, and pest and fire control were 51 to 68 % lower in an intercropping system than in pure reforestation (Rodriguez 1998) as cited in (Beer et al., 2000). For all these reasons *Taungya*, the century-old system of reforestation in which intercropping is practiced during the first few years after tree planting, is one of the best strategies to tree establishment and survival, to reduce reforestation costs and to produce timber for farmers and the industry (Lamb, 1968; Jordan et al., 1992; Verissimo et al., 1995; Tyndall, 1996; Mayhew and Newton, 1998; Beer et al., 2000).

Plate 2.4.1: Trees planted on-farms benefit from land cultivation, fertilization and other management practices applied to intercrops.

But the planting of timber trees in close association with light-demanding annual crops often lead to a drastic suppression of crop yields as soon as the trees outgrow the crops. This detrimental effect is the result of competitive processes[29] between trees and crops for both above- and-below- ground resources, as the genetic potential of trees to grow fast makes them more "aggressive" (Huxley, 1999). With few exceptions, most common timber trees promoted for farm forestry have been reported to decrease crop yields of associated crops. In Guatemala, four years after planting trees at 3 x 2 m the yields of maize (*Zea mays*) and frijol (*Phaseolus vulgaris*) intercropped were reduced 35% by *Casuarina equisetifolia,* 83% by *Eucalyptus globulus* and 91% by *Alnus acuminata* as compared to the first year crop (Leiva and Borel, 1994). In Uganda, Okorio et al., (1994) found that all except one[30] of seventeen upperstorey timber trees planted in single row plots negatively affected the yields of maize and

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[29] In reality crop yield suppression is the net result of both, competitive and facilitatory processes occurring between trees and crops above and below ground level (Ong and Huxley, 1996; Huxley, 1999). If associated crops had different environmental requirements (i.e., tolerance to shading), facilitation may be the net outcome of the association, like for instance in the *Paraserianthes falcataria* - coffee systems.

[30] Interestingly, *Alnus acuminata,* the most competitive specie in Leiva and Borel (1994)'s study, had a positive effect on crop yields.

beans on both sides of the plots, with maximum average reductions through five seasons of 60% by *Maesopsis eminii*.

In view of the negative effects of timber trees on annual crops, serious concerns have been raised over the sustainability and appropriateness of tree farming for resource-poor farmers. In India, Shiva and Bandyopadhyay (1987) strongly criticized a farm forestry program promoting Eucalyptus species for its negative impact on food crop production and rural employment. Several studies quantified the substantial decline of annual crops due to the planting of timber trees on farms. Ahmed (1989) concluded that two years after planting Eucalyptus on farm bunds, wheat yields were increasingly reduced up to 49% of the total output in the 9th and 10th year. And Malik and Sharma (1990) found *Eucalyptus tereticornis* not suitable for row plantations in agroforestry in deep water table conditions of semi-arid regions, after observing a 41% average reduction of wheat and mustard yield in a 10-meter strip on both sides of a tree row[31]. Based on data collected on site inspection and interviews with farmers, Saxena (1991) estimated that crop losses due to bund planting of Eucalyptus in north-west India ranged from 2 to 8 times the total direct investment in raising trees. Consequently, even though farmers were better off after planting Eucalyptus, when crop losses were taken into account the profits were not high enough to cover the risk of production and of fluctuating output prices (Saxena, 1991).

When water and nutrients are freely available, as in areas of the wet tropics with well-distributed rainfall and where fertilizers are commonly used, light availability may be the most important limitation to the performance of the understorey annual crops (Ong et al., 1996). In intercropping systems, the amount of radiant energy intercepted by the understorey crop largely depends on the tree crown form and size and the tree-crop spatial arrangement. Okorio et al., (1994) noted that crop yields of understorey beans and maize were negatively correlated with crown size. Fast growing trees with broad and dense canopies (*Maesopsis eminii*, cordia) or tall canopies (*Markhamia lutea*, *Melia azedarach*) reduced solar radiation more than those that are slow growing (*Alnus* sp.) or with narrow and less compact canopies (*Casuarina* sp.).

Tree side-branch pruning is an effective management practice to reduce light interception by the tree canopy and thus, prolong the number of years that annual cropping can be practiced (Watanabe, 1992). However, to reduce light interception sufficiently enough to obtain acceptable yields, farmers may be "obliged" to practice severe branch pruning every season before the planting of crops. This intensive pruning will severely slow growth and reduce the final yield of the upperstorey timber

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[31] Observations made on a single row of Eucalyptus during one cropping season only.

trees. In the cropped alleys of unpruned *Gliricidia sepium*, *Acacia auriculiformis*, and mangium planted at 2 x 3 m, only 36 to 45% of full sunlight was available to the understorey crops. Whereas if trees were severely pruned[32] the mean reduction of light incidence was minimal (3 to 10%) (Miah et al., 1995). In the pruned plots, growth and yield of upland rice and mungbean were comparable to that of the sole crop plots, and superior to that of the unpruned plots by 61% for upland rice and 78% for mungbean. However, at the age of 2 years, the total biomass of pruned trees was 34% lower than the biomass of unpruned trees (Miah, 1993). In a hedgerow agroforestry system with gmelina planted at 1 x 6 m, Gonzal (1997) observed that pruning trees severely increased incident light radiation by more than 50%. Consequently, the grain yield of intercropped rice was three times higher than rice planted between unpruned trees. However, at the age of 20 months pruned gmelina trees had notably a smaller stem diameter (7.38 cm) as compared with unpruned trees (9.83 cm) (Gonzal, 1997).

Even if beneficial for intercrops, the practice of intensive tree pruning may reduce the profitability of tree farming below levels acceptable for farmers with a priority to grow trees for the market (Midmore et al., 2001). The detrimental effect of severe pruning on tree growth will eventually lead to a lower volume of harvested timber and a lower value per unit volume prevalent for small-sized timber. Although farmers recognize the effect of severe pruning on tree growth, they may not be aware of the potentially higher timber yield and value per unit volume of large diameter timber if proper pruning were practiced. In Claveria, a field survey on the production and marketing of gmelina revealed that most farmers think of tree growing as more profitable than maize or rice. However, 70% responded that the income received from selling gmelina trees did not meet their expected economic returns due to the lower prices offered by buyers and the inaccuracy of the scaling method in estimating the timber yield when sold by volume (Magcale-Macandog et al., 1999).

Existing policy restrictions to harvesting and transportation of planted trees in the Philippines may depress timber prices and encourage the existence of middlemen. However, given the good accessibility, the proximity to markets, and the existence of numerous timber dealers and sawmills in the vicinity of Claveria, it is not reasonable to believe on the control of timber prices by exploitative middlemen. Instead, farmers, unaware of market requirements, may have failed to identify market saturation with small-sized, low quality timber as the main reason for the current low price of farm-grown timber. It may be, therefore, intensive tree pruning and other management

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[32] A total of 3 severe pruning were done by cutting all side shoots from the base to the tip of the tree, leaving 4 to 5 small branches at the tip (Miah, 1993).

practices poorly implemented (e.g., the lack of thinning in woodlots), rather than unfair middlemen, the ultimate cause by which farmers are not able to realise the potentially higher value per unit volume of large diameter timber and greater returns from tree farming.

Farmers' experience with timber marketing in Claveria resembles that of farm forestry in India more than a decade ago. Comparative studies showed that in areas with legal restrictions on the transport and sale of wood, lack of market information, and market saturation due to the massive production of small-sized trees, farmers were disappointed with the prices obtained for farm-grown Eucalyptus timber (Saxena, 1991). In contrast, in those areas with high demand and good market access, where no permits for felling and transport of trees were required, and where farmers did not experience drastic yield reductions of annual crops (due to irrigation), farmers were enthusiastic about Eucalypts because they obtained better prices and were able to sell timber directly without relying on intermediaries (Conroy, 1993).

Reducing the tree-crop interface (i.e., the "intimacy" between plant components) by manipulating tree planting pattern could improve the performance of agroforestry systems involving strongly competitive trees (Huxley, 1999). In the tree-crop mixtures of this study, increasing the rectangularity (i.e., increasing the ratio of inter-row to intra-row spacing) of the planting pattern of upperstorey trees would enhance yield of intercrops, as the amount of tree-crop interface is substantially reduced. Thus in a system with 1,000 trees ha^{-1} planted at 2 x 5 m, there would be 5,800 linear meters (lm) ha^{-1} of tree-crop interface but only 2,000 lm ha^{-1} if trees were arranged at 1 x 10 m. Therefore, wider alleys (i.e., larger inter-row spacing) may promote higher crop yields and prolong the period of intercropping by helping to mitigate above-ground competition for light. At the same time, closer intra-row spacing provides the side shading needed to promote good stem form of timber trees (Gajaseni and Jordan, 1992; Huxley, 1999).

But increasing rectangularity of the tree planting pattern should entail a reduction of the optimum planting density if tree yield is to be maximized **(Figure 2.3)** (Huxley, 1999). In agroforestry systems with strongly competitive perennials, planting trees at densities lower than what is commonly recommended may further improve the performance of intercropping (Daniel and Ong, 1990), and provide higher returns because of the lower plantation establishment and management costs. Akyeampong et al., (1995) observed that inter-planting timber trees at 312.5 trees ha^{-1} (4 x 8 m) in a banana-bean system produce higher economic returns because trees did not compete excessively with crops earlier than three years after tree planting and output was diversified. In China, net economic returns of intercropping systems with *Paulownia*

elongata can be increased to a large extent if trees are planted at densities of 100 trees ha^{-1} (5 x 20 m) or less. If household demands for intercrops is not a priority, tree densities of 200 trees ha^{-1} (5 x 10 m) or 333 trees ha^{-1} (5 x 6 m) would produce higher accumulated returns even if crop yields were reduced 60 to 100% as a result of higher tree density (Yin and He, 1997).
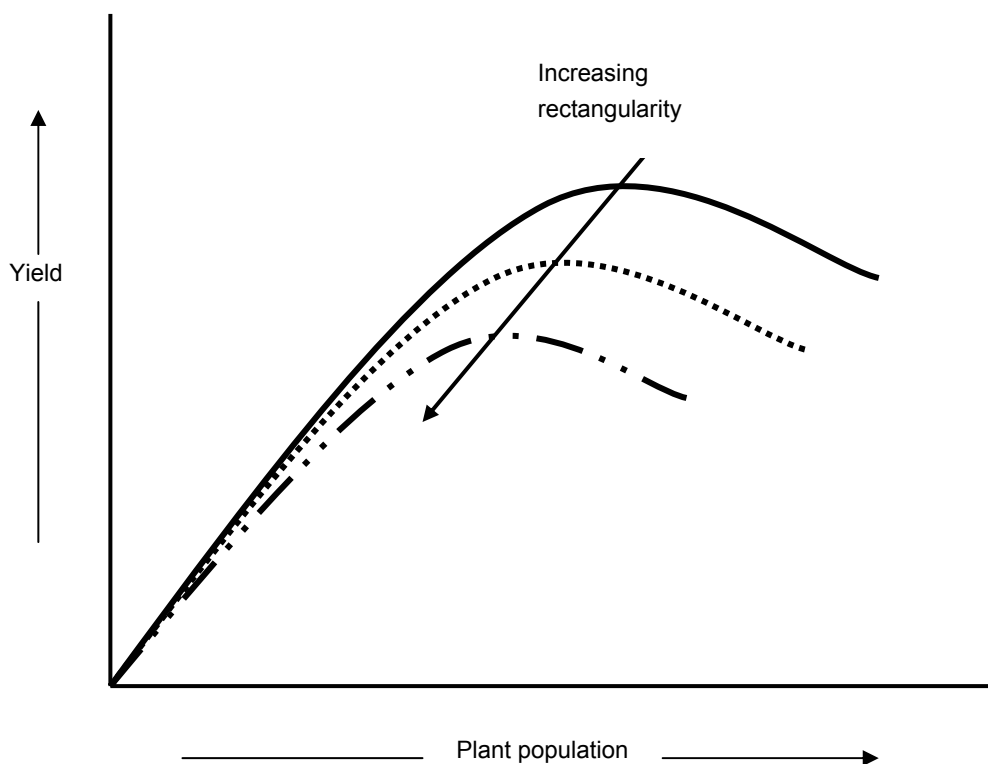
Figure 2.3: An increase in rectangularity (the ratio of inter-row to intra-row spacing) diminishes yield and lowers optimum planting density (Huxley, 1999).

Faster tree growth and shorter tree rotation as a result is another benefit of planting trees at low densities on widely-spaced rows. Habiyambere and Musabimana (1990) observed that the diameter at breast height (dbh) of *Grevillea robusta* (grevillea) planted at 3 x 3 m were significantly greater than the dbh of trees planted at 1.5 x 1.5 m. In response to reduced inter-tree competition and improved site conditions, the dbh of trees in association with crops at the age of 5 years were 24% (4.1 cm) for mangium and 61% (9.3 cm) for cordia greater than the dbh of trees in pure plots (3 x 3 m) (Kapp and Beer, 1995). Kapp et al., (1996/1997) also reported that because of the excellent growth rates, mangium, cordia, bagras and teak can produce timber in rotations of 10 to 20 years when planted on boundary lines of farms in the lowland humid tropics of Central America. According to Beer et al., (2000) the growth rate of the high value timber cordia can be exceptionally high (between 25.6 to 36.6 cm after 8 years) if grown in optimal conditions of drainage, weed control and fertilization, and wide spacing.

In the Philippines, high tree density and close spacing (e.g., 2 x 2 m; 3 x 2 m) have been typically promoted whether the objective was plantation forestry or smallholder agroforestry (Agpaoa et al., 1976; Valdez, 1991; Gacoscosim, 1995; DENR-ERDB, 1998). The only exception is the "line planting system" (LPS) or 1 x 10 m spacing promoted by PICOP in its tree farming scheme. According to Santiago (1997), with this arrangement trees grow faster and farmers are able to plant annual crops in between the trees at a commercial scale as there is less competition between trees and crops.

However, intercropping systems are not always productively superior to tree monoculture or monocropping. In linear agroforestry systems, more branching and poor stem form due to less lateral competition may affect timber production negatively. Peden et al., (1996) found that trees planted on lines are unlikely to produce high quality commercial poles in a short time. When quality timber is required, it is difficult to assess the extent to which improved management can substitute for a better light regime in line planting systems. Labour-constrained households may not be able to meet higher labour demand for tree pruning required to produce trees of acceptable quality. On the other hand, some trees, particularly fast-growing timber trees, are so competitive that even if planted in widely-spaced rows the association with annual crops would jeopardize household food security. Moreover, even though farmers can instinctively anticipate crop yield losses as trees grow, they would likely be unable to accurately predict the period of viable intercropping and the net profit over the tree rotation. Confronted with the dilemma of whether to integrate trees and crops and if so what level of mixture is appropriate, farmers may opt for segregation whenever mixed systems do not prove superior in terms of feasibility, financial profitability and food security.

Despite the detrimental effect of timber trees on crops when planted in association, agroforestry systems with widely-spaced trees at low densities have the potential of diversifying farm production, produce higher economic returns, and provide other benefits derived from tree planting. In Claveria, in spite of lower returns realized in the recent years, many farmers who have experienced timber tree growing are still interested on timber tree production. Seventy six percent (76%) of the experienced tree growers interviewed during a farm survey recommended that future plantings of timber trees should be done at densities such as 834 trees ha^{-1} and some even suggested densities as low as 400 trees ha^{-1} (Magcale-Macandog et al., 1999). There is a need, therefore, to study tree and crop productivity in timber tree production systems with widely-spaced trees, to evaluate the economic performance of these agroforestry systems, and to assess farmers' perceived constraints to timber production and their strategies to overcome these.

2.5   Research objectives

Field evidence demonstrates that smallholder farmers can be effective and efficient timber producers, not only for their own consumption but for the wood industry as well. But recommended practices and farmers' management strategies to overcome production constraints proved to be detrimental for the joint production of food crops and timber. Previous studies in the Philippines and elsewhere pointed to the biophysical and economic benefits of agroforestry systems with widely-spaced timber trees. Consequently, on September 1997 I initiated on-farm trials to measure the biological performance and economic returns of two tree-maize systems. Specific objectives of the experiment were: (1) to assess the response of maize intercropped between timber trees in two planting arrangements; (2) to evaluate the wood production potential of two popular tree species when planted at wide and close spacing and intercropped with maize, and; (3) to determine the net economic returns of the different tree-crop combinations as compared to tree or crop monoculture.

Yet, simple criteria of timber and crop yield maximization are not enough to determine the viability of timber tree production in smallholder farming systems. In this context, the suitability of timber tree planting must be evaluated also in terms of its conformity to the goals and socio-economic organization of the small-farm system. Therefore, research objectives also included:

(1) To identify and assess farmers' tree planting practices, management strategies (e.g., severe pruning) and preferences, such as arrangement, tree species and farm niches devoted to tree planting.

(2) To identify farm- and household-level biophysical and socio-economic factors which determine the planting of timber trees on-farms.

(3) To elicit farmers' assessment of timber tree farming systems.

(4) To study marketing practices, potential and constraints of farm-grown timber.

Overall, this study aims at evaluating the feasibility of integrating fast-growing timber trees into smallholdings. Part III presents the results of both an exploratory and a more in-depth field survey aiming at identifying farmers' practices and constraints to timber production and the factors that influence adoption of timber tree planting. Then, the biophysical performance of trees and crops in on-farm trials presented in Chapter 4.1 is followed by a financial analysis and farmers' evaluation of timber-based agroforestry systems in Chapter 4.2, and the development of an optimisation model of a joint tree-crop production combination in a typical small farm in Chapter 4.3. Finally, Chapter 5

presents a study on the marketing of farm-grown timber, providing evidence of the potential of smallholder farm forestry to meet timber demand.

2.6   References

ADB (1994): Forestry sector study of the Philippines. Manila, The Philippines: Asian Development Bank.

Agaloos, B. C. (1984): Silvicultural and logging systems in the Philippines. Proceedings of the 'First ASEAN Forestry Congress'. Volume 2. Bureau of Forest Development. Quezon City, The Philippines: 210-233.

Agpaoa, A., Endangan D., Festin, S., Gumayagay, J., Hoenninger, T. H., Seeber, G., Unkel, K. and Weidelt, H. J. (1976): Manual of reforestation and erosion control for the Philippines. Eschborn, Germany: German Agency for Technical Cooperation (GTZ).

Ahmed, P. (1989): Eucalyptus in agroforestry: its effects on agricultural production an economics. Agroforestry Systems 8: 31-38.

Akyeampong, E., Hitimana L., Franzel, S. and Munyemana, P. C. (1995): The agronomic and economic performance of banana, bean and tree intercropping in the highlands of Burundi: an interim assessment. Agroforestry Systems 31: 199-210.

Aquino, R. M., del Castillo R. A. and Payuan, E. V. (1987): Mounting a national social forestry program: lessons learned from the Philippine experience. Honolulu, Hawaii: Environment and Policy Institute, East-West Centre.

Arnold, J. E. M. (1990): Tree components in farming systems. Unasylva 41 (160).

Arnold, J. E. M. and Dewees P. A. (eds.) (1997): Farms, trees & farmers: responses to agricultural intensification. London, UK: Earthscan Publications Ltd.

Bagnall-Oakeley, H., Conroy C., Faiz, A., Gunawan, A., Gouyon, A., Penot, E., Liangsutthissagon, S., Nguyen, H. D. and Anwar, C. (1997): Imperata management strategies used in smallholder rubber-based farming systems. Agroforestry Systems (36): 83-104.

Balasubramanian, V. and Egli, A. (1989): The role of agroforestry in the farming systems in Rwanda with special reference to the Bugesera-Gisaka-Migongo (BGM) region. In: Nair P. K. R (ed.): Agroforestry Systems in the tropics. Dordrecht, The Netherlands, Kluwer Academic Publishers: 333-352.

Bauer, E. M. (1991): Los Montes de España en la Historia. Madrid, España. Servicio de Publicaciones Agrarias y Fundación Conde del Valle de Salazar.

Beer, J., Ibrahim, M. and Schlönvoigt, A. (2000): Timber production in tropical agroforestry systems of Central America. Proceedings of ' The XXI IUFRO World Congress 2000: Forest and Society: The Role of Research. Sub-plenary sessions Vol. 1'. 7-12 August, 2000, Kuala Lumpur, Malaysia: IUFRO:777-786.

Beldt, R. V. D., Hatch, C., Sastry, C., Raintree, J., Ghosh, S., Saxena, N.C. and Garrity, D. P. (1994): Farm forestry comes of age. Farm Forestry News 6: 1-7.

Briones, N. D. (1986): Estimating erosion costs: a Philippine case study in the lower Agno river watershed. In: Easter, W. K., Dixon, J. A. and Hufschmidt, M. M (eds.): Watershed Resources Management. Boulder, Colorado, USA: Westview Press: 205-218.

Byron, N. (1997): International development assistance in forestry and land management: the process and the players. Commonwealth Forestry Review 76 (1): 61-67.

Chiong-Javier, M. E. (1995): Hanging Out on a Limb: The ISFP Devolution Experience. Paper presented at the Third National Conference on Research in the Uplands. September 4-9, 1995. Cagayan de Oro City, Philippines.

Conroy, C. (1993): Eucalyptus sales by small farmers in eastern Gujarat. Agroforestry Systems (23): 1-10.

Contreras, A. P. (2000): Rethinking Participation and Empowerment in the Uplands. In: Utting, P. (ed.): Forest Policy and Politics in the Philippines: the Dynamics of Participatory Conservation. Quezon City, Philippines: Ateneo de Manila University Press: 144-170.

Coxhead, I. and Buenavista, G. (2001): Seeking Sustainability: A Synthesis of Research in SANREM CRSP-Southeast Asia, 1993-98. In: Coxhead, I. and Buenavista G. (eds.): Seeking Sustainability: Challenges of Agricultural Development and Environmental Management in a Philippine Watershed. Los Baños, Laguna, Philippines: Philippine Council for Agriculture, Forestry and Natural Resources Research and Development: 1-30.

Current, D. (1995): Economic and Institutional Analysis of Projects Promoting On-farm Tree Planting in Costa Rica. In: Costs, Benefits, and Farmer Adoption of Agroforestry. Project Experience in Central America and the Caribbean. Current, D., Lutz E. and Scherr, S. (eds.) World Bank Environment Paper Number 14. Washington, D. C., The World Bank: 45-70.

Cruz, M. C. and Zosa-Feranil, I. (1987): Policy Implications of Population Pressure in the Philippine Uplands. Background Report to World Bank Farm Study. Manila, The Philippines.

Cruz, M. C., Zosa-Feranil, I. and Goce, C. L. (1986): Population Pressure and Migration: Implications for Upland Development in the Philippines. Working Paper 86-06. Center for Policy and Development Studies. Los Baños, Philippines.

Cruz, W. and Repetto, R. (1992): The environmental effects of stabilization and structural adjustment programs: The Philippines case. World Resources Institute. Washington D.C., USA.

Daniel, J. N. and Ong, C. K. (1990): Perennial pigeonpea: a multipurpose species for agroforestry systems. Agroforestry Systems 10: 113-129.

De Beer, J. H. and McDermott, M. J. (1989): The Economic Value of Non-Timber Forest Products in Southeast Asia. Committee for IUCN. Amsterdam, The Netherlands.

de Foresta, H. and Michon, G. (1993): Creation and management of rural agroforests in Indonesia: potential applications in Africa. In: Hladik, C., Pagezy, H., Linares, O. F., Hladik, A., Semple, A. and Hadley, M. (eds.): Tropical Forests, People and Food: Biocultural Interactions and Applications to Development. Paris, France: Unesco & the Parthenon Publishing Group: 709-724.

de Foresta, H. and Michon, G. (1997): The agroforest alternative to Imperata grasslands: when smallholder agriculture and forestry reach sustainability. Agroforestry Systems 36: 105-120.

DENR (undated): Integrated Social Forestry Program. Social Forestry Division. Forest Management Bureau. Department of Environment and Natural Resources. Quezon City, The Philippines.

DENR (1990): Master plan for forestry development in the Philippines. Department of Environment and Natural Resources. Quezon City, The Philippines.

DENR (1992): NIPAS Act R.A. No. 7586 and Implementing Rules and Regulations DAO 25, S 1992. Department of Environment and Natural Resources. Quezon City, The Philippines.

DENR (1998): Moving CBFM into the 21st Century. DENR Strategic Action Plan. A Compilation of Policies on Community-Based Forest Management (CBFM). Department of Environment and Natural Resources. Quezon City, Philippines.

DENR-ERDB (1998): Development and Management of Forest Plantations: A Guidebook. Ecosystems Research and Development Bureau. College, Laguna, Philippines.

Dewees, P. A. (1997): Farmer responses to tree scarcity: the case of woodfuel. In: Arnold, J. E. M. and Dewees, P. A. (eds.): Farms, Trees and Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd: 174-197.

Dugan, P. (1997): Community forestry in the Philippines: exploring new pathways to sustainable forest management. In: Johnson, A. and Durst, P. (eds.): Implementing Sustainable Forest Management in Asia and the Pacific: proceedings of a regional expert consultation. December 12-15, 1995. Bangkok, Thailand: FAO Regional Office for Asia and Pacific.

FAO (1995): Sustainability Issues in Agricultural and Rural Development Policies. Training materials for Agricultural planning volume 1: trainee's reader. Rome, Italy: FAO.

FAO (2000): Forestry Information System (FORIS). Country profiles. http://www.fao.org/forestry/country/index. Rome, Italy: FAO.

Finney, C. E. and Western S. (1986): An economic analysis of environmental protection and management: an example from the Philippines. Environmentalists (6): 45-61.

Forest Management Bureau (1988): Natural Forest Resources of the Philippines. Philippine-German Forest Resources Inventory Project. Manila, Philippines: FMB.

Gacoscosim, M. M. (1995): Philippine Forestry in Action. Quezon City, Philippines: Phoenix Publishing House Inc.

Gajaseni, J. and Jordan, C. F. (1992): Theoretical basis for Taungya and its improvement. In: C. Jordan, F., Gajaseni, J. and Watanabe, H. (eds.): Taungya: Forest Plantations with Agriculture in Southeast Asia. Wallingford, UK: CAB International: 68-81.

Garrity, D. P. (1993): Sustainable land-use systems for sloping uplands in Southeast Asia. Technologies for Sustainable Agriculture in the Tropics. Madison, USA, American Society of Agronomy, Crop Science Society of America and Soil Science Society of America. ASA Special Publication 56.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

Garrity, D. P. (1996): Tree-soil-crop interactions on slopes. In: Ong, C. K. and Huxley, P. (eds.): Tree-Crop Interactions: A Physiological Approach. Wallingford, UK: CAB International: 299-318.

Garrity, D. P., Soekardi, M., van Noordwijk, M., de la Cruz, R., Pathak, P.S., Gunasena, H. P. M., van So, N., Huijun, G. and Majid, N. M. (1997): The *Imperata* grasslands of tropical Asia: area, distribution, and typology. Agroforestry Systems 36, Special issue 'Agroforestry innovations for Imperata grassland rehabilitation': 3-29.

Garrity, D. P. (1997): ICRAF's mission in Asia: a test of three-systems hypotheses. In: Developments in agroforestry research. PCARRD Book Series No. 160/1997. Los Baños, Laguna, Philippines: PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development): 8-21.

Garrity, D. P. and Agustin, P. C. (1995): Historical land use evolution in a tropical acid upland agroecosystem. Agriculture, Ecosystems and Environment 53: 83-95.

Garrity, D. P., Kummer, D. M. and Guiang, E. S. (1993): The Philippines. In: National Research Council: Sustainable Agriculture and the Environment in the Humid Tropics. Washington D.C., National Academy Press: 549-624.

Garrity, D. P., Mercado, A. R. and Stark, M. (1998): Building the smallholder into successful natural resource management at the watershed scale. In: de Vries, P., Frits, W., Agus, F. and Kerr, J.(eds.): Soil erosion at multiple scales: principles and methods for assessing causes and impacts. CABI and IBSRAM: 73-82.

Gauld, R. (2000): Maintaining centralized control in community-based forestry: policy construction in the Philippines. Development and Change (31): 229-254.

Gibbs, C., Payuan, E., del Castillo, R. (1990): The growth of the Philippine social forestry program. In: Poffenberger, M. (ed.): Keepers of the Forest. Land Management Alternatives in Southeast Asia. Quezon City, Philippines: Ateneo de Manila University Press: 253-265.

Gollin, K. L. and Kho, J. L. (2002): After the romance: rethinking community, participation, and sustainability in Philippine CBNRM. Manila, Philippines: The Ford Foundation.

Gomez, A. A., Kelly, D. E. S. and Baril, M. T. A. (eds.) (1998): Catalogue of Conservation Practices for Agriculture on Sloping Land. Los Baños, Laguna, Philippines: SEAMEO SEARCA.

Gonzal, D. G. (1997): Annual crop-*Gmelina arborea* interactions in contour hedgerow agroforestry systems for smallholder farm forestry. In: Developments in Agroforestry Research. PCARRD Book Series No. 160/1997. Los Baños, Laguna, Philippines: PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development): 106-126.

Guiang, E. S. and Dolom, B. L. (1992): An Update on the DENR Community Forestry Program. Paper presented at the Third Consultative Workshop of Upland NGO Assistance Committee, May 28-June 1, 1992. Ceby City, Philippines.

Habiyambere, T. and Musabimana, F. (1990): Effect of spacing on the growth and production of *Grevillea robusta* in the semi-arid Region of Bugesera in Rwanda. In: Hardwood, C. E. (ed.): Grevillea robusta in Agroforestry and Forestry. Nairobi, Kenya: ICRAF: 99-102.

Harrison, S., Herbohn, J. and Niskanen, A. (2002): Non-industrial, smallholder, small-scale and family forestry: What's in a name?. Small-scale Forest Economics, Management and Policy 1(1): 1-11.

Hayami, Y., Quisumbing, M. A. R. and Adriano, L. S. (1993): Toward and Alternative Land Reform Paradigm. A Philippine Perspective. Manila, Philippines: Ateneo de Manila University Press.

Headland, T. N. (1987): Ecosystemic Change in a Philippine Tropical Rainforest and Its Effect on a Negrito Foraging Society. Paper presented at the Conference on World Environmental History, April 30-May 2, 1987, Duke University.

Huxley, P. (1999): Tropical Agroforestry. Oxford, UK: Blackwell Science Ltd.

Huxley, P. and van Houten, H., (eds.) (1997): Glossary for agroforestry. Nairobi, Kenya, (ICRAF).

ITTO (1996): Annual Review and Assessment of the World Tropical Timber Situation. Yokohama, Japan: International Tropical Timber Organization.

Jordan, F. C., Gajaseni, J. and Watanabe, H. (eds.). (1992): Taungya: forest plantations with agriculture in Southeast Asia. Wallingford, UK: CAB International.

Jordana, R. (1879): Memorias sobre la producción de los montes públicos de Filipinas en los años económicos de 1874-1875 y 1875-1876. Madrid, España: Imprenta de Ramón Moreno y Ricardo Rojas: 65 pp.

Jurvélius, M. (1997): Labor-intensive harvesting of tree plantations in the southern Philippines. Edited by Tan, L.C. and Durst , P. B. Forest Harvesting Case Study No. 9. Bangkok, Thailand: FAO.

Kapp, G. B. and Beer, J. (1995): A comparison of agrisilvicultural systems with plantation forestry in the Atlantic lowlands of Costa Rica. Part I. Tree survival and growth. Agroforestry Systems 32 (3): 207-223.

Kapp, G. B., Beer, J. and Lujan, R. (1996/1997): Species and site selection for timber production on farm boundaries in the humid Atlantic lowlands of Costa Rica and Panama. Agroforestry Systems 35 (2): 139-154.

Kivikkokangas-Sandgren, R., Kinnunen, M., Hares, M. and Kiili, L. (1995): Agroforestry and tree planting in the new rainforest economy in Mindanao, The Philippines. FTP Publication 29. Helsinky, Finland: Finnida and FTP International.

Kosonen, M., Otsamo A. and Kuusipalo, J. (1997): Financial, economic and environmental profitability of reforestation of Imperata grasslands in Indonesia. Forestry Ecology and Management 99: 247-259.

Kuhn, T. S. (1962): The structure of scientific revolutions. 3rd edition, September 1996: The University of Chicago Press.

Kummer, M. D. (1992): Deforestation in the Postwar Philippines. Manila, Philippines: Ateneo de Manila University Press.

Lamb, A. F. A. (1968): Fast Growing Trees of the Lowland Tropics: *Gmelina arborea*. Oxford, UK. Commonwealth Forestry Institute. Department of Forestry. University of Oxford.

Leiva, J. M. and Borel, R. (1994): Evaluación de tres especies forestales en plantación pura y sistema taungya: crecimiento de los árboles y producción de los cultivos. In: Evans, D. O. and Szott, L. T. (eds.): Nitrogen Fixing Trees for Acid Soils, Nitrogen Fixing Tree Research Reports Special Issue 1995. Turrialba, Costa Rica: NFTA: 85-93.

Lindayati, R. (2000): Community Forestry Policies in Selected Southeast Asian Countries. Ottawa, Canada: International Development Research Centre.

Lopez, J. M. G. (1996): Forestales españoles en ultramar. La labor de los Ingenieros de Montes en las Islas Filipinas (1863-1898). Agricultura y Sociedad 78 (Enero-Marzo 1996): 237-270.

Lopez-Gonzaga, V. (1987): Capital Expansion, Frontier Development, and the Rise of Monocrop Economy in Negros (1850-1898). Occassional Paper No. 1 Bacolod, Philippines: La Salle University.

Lowery, R. F., Lambeth, C. C., Endo, M. and Kane, M. (1993): Vegetation management in tropical forest plantations. Canadian Journal of Forestry Research 23: 2006-2014.

Lynch, O. J. (1986): Philippine Law and Upland Tenure. In: Fujisaka, S., Sajise, P. and del Castillo R. (eds.): Man, Agriculture and the Tropical Forest: Change and Development in the Philippine Uplands. Bangkok, Thailand: Winrock International Institute for Agricultural Development: 269-292.

Lynch, O. J. and Talbott, K. (1995): Balancing acts: community-based forest management and national law in Asia and the Pacific. Washington DC, USA: World Resources Institute.

Magcale-Macandog, D. B., Menz, K., Rocamora, P. M. and Predo, C. D. (1999): Smallholder timber production and marketing: the case of Gmelina arborea in Claveria, Northern Mindanao, Philippines. International Tree Crops Journal 10: 61-78.

Malik, R. S. and Sharma, S. K. (1990): Moisture extraction and crop yield as a function of distance from a row of Eucalyptus tereticornis. Agroforestry Systems 12 (2): 187-195.

Mayhew, J. E. and Newton A. C. (1998): The Silviculture of Mahogany (*Swietenia macrophylla*). Wallingford, UK. CABI Publishing. CAB International.

McLennan, M. S. (1980): The Central Luzon Plain: Land and Society on the Inland Frontier. Quezon City, Philippines. Alemars.

Miah, M. D. G. (1993): Performance of Selected Multipurpose Tree Species and Field Crops Grown in Association As Affected by Tree Branch Pruning. PhD dissertation, Central Luzon State University, Muñoz, Nueva Ecija, Philippines.

Miah, M. D. G., Garrity, D. P. and Aragon, M. L. (1995): Light availability to the understorey annual crops in an agroforestry system. In: Sinoquet, H. and Cruz, P. (eds.): Ecophysiology of Tropical Intercropping. Paris, France: Institut National de la Recherche Agronomique (INRA): 99-107.

Midmore, D. J., Nissen, T. M. and Poudel, D. D. (2001): Making a Living Out of Agriculture: Some Reflections on Vegetable Production Systems in the Manupali Watershed. In: Coxhead, I. and Buenavista, G. (eds.): Seeking sustainabililty: challenges of agricultural development and environmental management in a Philippine watershed. Los Baños, Laguna, Philippines: PCARRD: 94-111.

Myers, N. (1988): Environmental Degradation and Some Economic Consequences in the Philippines. Environmental Conservation (15): 205-214.

National Statistics Office (1999): 1999 Philippine Yearbook. Manila, Philippines. NSO.

Okorio, J., Byenkya, S., Wajja, N. and Peden, D (1994): Comparative performance of seventeen upperstorey tree species associated with crops in the highlands of Uganda. Agroforestry Systems 26: 185-203.

Ong, C. K., Black, C. R., Marshall, F. M. and Corlett, J. E. (1996): Principles of Resource Capture and Utilization of Light and Water. In: Ong, C. K. and Huxley, P. (eds.): Tree-Crop Interactions: a Physiological Approach. Wallingford, UK: CAB International: 73-158.

Pascicolan, P. N., Calub, A. and Sajise, P. E. (1996): The Dynamics of Grassland Transformation in Salindingan, Ilagan, Isabela, Philippines. Imperata Project Paper 1996/10. Australian Centre for International Agricultural Research (ACIAR).

Pascicolan, P. N. (1996): Tree Growing on Different Grounds: an Analysis of Local Participation in Contract Reforestation in the Philippines. PhD dissertation. Leiden Universtity, Centre for Environmental Science. The Netherlands.

Pascicolan, P. N., de Haes, H. A. U. and Sajise, P E. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forest Ecology and Management (99): 261-274.

PCARRD (1994): Status of Industrial Timber in the Philippines. Los Baños, Laguna, Philippines. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development.

Peden, D. G., Okorio J. and Wajja-Musukwe, N. (1996): Commercial pole production in linear agroforestry systems. Agroforestry Systems 33: 177-186.

Peluso, N. L., Vandergeest, P. and Potter, L. (1995): Social Aspects of Forestry in Southeast Asia: A Review of Postwar Trends in the Scholarly Literature. Journal of Southeast Asian Studies 26 (1): 196-218.

Poffenberger, M. (1990): The Evolution of Forest Management Systems in Southeast Asia. Keepers of the Forest. In: Poffenberger, M (ed.): Land Management Alternatives in Southeast Asia. Quezon City, Philippines: Ateneo de Manila University Press: 7-26.

Population Reference Bureau Inc. (1990): World Population Data Sheet. Washington D.C., USA: Population Reference Bureau.

Porter, G. D. and Ganapin, D. (1988): Resources, Population, and the Philippines' Future. Washington D.C., USA. World Resources Institute.

Potter, L. M. (1997): The dynamics of Imperata: historical overview and current farmer perspectives, with special reference to South Kalimantan, Indonesia. Agroforestry Systems 36: 31-51.

Pragtong, K. and Thomas, D. E. (1990): Evolving Management Systems in Thailand. In: Poffenberger, M (ed.): Land Management Alternatives in Southeast Asia. Quezon City, Philippines: Ateneo de Manila University Press: 167-186.

Pulhin, J. M. (1997): Community Forestry in the Philippines: Trends, Issues and Challenges. Paper presented at the International Seminar on Community Forestry at a Crossroads: Reflections and Future Directions in Development of Community Forestry, 17-19 July, 1997. Bangkok, Thailand: RECOFTC.

Pulhin, J. M. (2000): Community Forestry in the Philippines: Paradoxes and Perspectives in Development Practice. Eight Biennal Conference of the International Association for the Study of Common Property (IASCP), Bloomington, Indiana, USA.

Queblatin, E. (1992): Agroforestry advances in the Philippines: a tour of the horizon. Paper presented at the International Agroforestry Symposium, 28-30 April, Nanjing, China. USAID, Manila, the Philippines.

Quimio, J. M. (1996): Grassland Vegetation in Western Leyte, Philippines. PhD dissertation. Schriftenreihe des Institutes fuer Landespflege der Universitaet Freiburg. University of Freiburg, Freiburg, Germany.

Quitzon, S. C. (1989): Social forestry: an age-old indigenous approach to rural development. In: Vergara, N. T. and Fernandez, R. A (eds.): Social forestry in Asia. Factors that influence program implementation. Los Baños, Laguna, Philippines. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA): 35-37.

Raintree, J. B. (1991): Socioeconomic attributes of trees and tree planting practices. Community Forestry Note No. 9. Rome, Italy: FAO.

Rebugio, L. L. (1995): How Participatory and Equitable is the Community Forestry Program?. Some Preliminary Evidences. Paper presented at the Third National Conference on Research in the Uplands, 4-9 September. Cagayan de Oro City, Philippines.

Rebugio, L. L. (nd): Paradigm shift: the key to sustainable forestry and environmental resources management. In: Castro, C. P., Pulhin, F. B. and Reyes, L. C. (eds.): Community-based resource management: a paradigm shift in forestry. University of the Philippines, Los Baños, Philippines: Forestry Development Center, College of Forestry: 2-16.

Reyes, L. D. (1994): Present Supply of the Wood-Based Raw Materials/Resources in the Philippines. In: Status of Industrial Timber in the Philippines. Los Baños, Philippines: PCARRD: 4-13.

Rhoades, R. E. (1998): Participatory Watershed Research and Management: Where the Shadow Falls. Gatekeeper Series No. 81. International Institute for Environment and Development.

Rodil, B. R. (1992): Ancestral Domain: A Central Issue in the Lumad Struggle for Self-Determination in Mindanao. In: Turner, M., May, R. and Turner, L. R.(eds.): Mindanao. Land of Unfulfilled Promise. Metro Manila, Philippines: New Day: 233-249.

Rodriguez, A. (1998): Estudio de caso: La Tite, manejo integrado de una finca. In: Actas del I. Congreso Latinoamericano IUFRO: El Manejo Sustentable de los Recursos Forestales. Desafio del Siglo XXI, Valdivia, Chile, CD-CONAF/IUFRO.

Sajise, P. E. (1998): Forest policies in the Philippines: a winding trail towards participatory sustainable development. In: A step toward forest conservation strategy (1): Current status on forests in the Asia-Pacific region (Interim Report 1998). Tokyo, Japan: The Institute for Global Environmental Strategies (IGES).http://www.iges.org.jp/eu/fc/phase1/ir98-3-16.pdf

Sajise, P. E. and Briones, N. D. (1996): Environmentally sustainable rural and agricultural development strategies in the Philippines: lessons from six case studies. Los Baños, Philippines. SEARCA.

Sajise, P. E. and Ganapin D. J. (1990): Overview of upland farming issues. In: Capistrano, L. N., Durno, J. and Moeliono, I. (eds.): Resource Book on Sustainable Agriculture for the Uplands. Silang, Cavite, Philippines: IIRR.

Sands, D. M. (1988): The technology applications gap: overcoming constraints to small-farm development. FAO Research and Technology Paper 1. Rome, Italy: FAO.

Santiago, R. G. (1997): Livelihood Enhancement Thru Agroforestry (LEAF) Program. In: Developments in Agroforestry Research. Los Baños, Laguna, Philippines: ICRAF, FAO-APAN, PCARRD and DOST: Book Series No. 160/97: 45-56.

Saxena, N. C. (1991): Crop losses and their economic implications due to growing of Eucalyptus on field bunds- a pilot study. In: Sullivan, G. M., Huke, S. M. and Fox, J. M. (eds.): Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu, Hawaii, USA. July 1991: 208-219.

Scherr, S. J. (1997): Meeting household needs: farmer tree-growing strategies in western Kenya. In: Arnold, J. E. M. and Dewees, P. A. (eds.): Farms, Trees & Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd.: 141-173.

Schulte, A. (1996): Dipterocarp Forest Ecosystem Theory Based on Matter Balance and Biodiversity. In: Schulte, A. and Schöne, D. (eds.): Dipterocarp Forest Ecosystem: Towards Sustainable Management: Singapore: World Scientific: 3-28.

SEIC (2001): Review of Forestry Policies vis-a-vis the watershed and ecosystem management framework and the CBFM strategy and program. Final Report, Volume I, Main report & Appendices. Sustainable Ecosystems International Corp. and Desarrollo Internationale Consult, Inc.

Severino, H. G. (2000): The Role of Local Stakeholders in Forest Protection. In: Utting, P. (ed.): Forest Policy and Politics in the Philippines: the Dynamics of Participatory Conservation. Quezon City, Philippines: Ateneo de Manila University Press: 84-116.

Shiva, V. and Bandyopadhyay, J. (1987): Ecological audit of Eucalyptus cultivation. Dehra Dun, India: Research Foundation for Science & Ecology Dehra Dun.

Soler, D. V. (1874): Memoria sobre el ramo de montes en las Islas Filipinas. Madrid, Spain: Aribau y Cía.

Stark, M. (2000): Soil Management Strategies to Sustain Continous Crop Production between Vegetative Contour Strips on Humid Tropical Hillsides. Technology Development and Dissemination Based on Farmers' Adaptive Field Experimentation in the Philippines. International Centre for Research in Agroforestry. Southeast Asia Regional Research Programme.

Tadem, E. (1990): Conflict over Land-based Natural Resources in the ASEAN Countries. In: Ghee, L. T. and Valencia, M. J. (eds.): Conflict over Natural Resources in South-East Asia and the Pacific. Quezon City, Philippines: Ateneo de Manila University Press: 13-50.

Tyndall, B. (1996): The socioeconomics of Grevillea robusta within the coffee land-use system of Kenya. Report No. 109. Agroforestry Research Networks for Africa (AFRENA).

Utting, P. (2000): An Overview of the Potential and Pitfalls of Participatory Conservation. In: Utting, P. (ed.): Forest Policy and Politics in the Philippines: the Dynamics of Participatory Conservation. Quezon City, Philippines: Ateneo de Manila Universtiy Press: 171-215.

Valdez, R. B. (1991): New techniques on site preparation and outplanting. In: Improved reforestation technologies in the Philippines. Book Series No. 121. Los Baños, Laguna, Philippines: PCARRD: 79-83.

van Noordwijk, M. , Hairiah, K., Partoharjono, S., Labios, R. V. and Garrity, D. P. (1997): Food-crop-based production systems as sustainable alternatives for Imperata grasslands? Agroforestry Systems 36: 55-82.

Verissimo, A., Barreto, P., Tarifa, R. and Uhl, C. (1995): Extraction of a high-value natural resource in Amazonia: the case of mahogany. Forest Ecology and Management 72: 39-60.

Vitug, M. D. (1993): The Politics of Logging. Power from the Forest. Manila, Philippines, Philippine Center for Investigative Journalism.

Vitug, M. D. (2000): Forest policy and national politics. In: Utting, P. (ed.): Forest Policy and Politics in the Philippines: the Dynamics of Participatory Conservation. Quezon City, Philippines: Ateneo de Manila Universtiy Press: 11-39.

von Uexkull, H. R. (1986): Efficient fertilizer use in acid upland soils of the humid tropics. FAO Fertilizer and Plant Nutrition Bulletin. Rome, Italy: FAO.

Watanabe, H. (1992): Tree-Crop Interactions in Taungya Plantations. In: Jordan, C. F., Gajaseni, J. and Watanabe, H. (eds.): Taungya: Forest Plantations with Agriculture in Southeast Asia. Wallingford, UK, CAB International: 32-43.

Wernstedt, F. L. and Spencer, J. E. (1967): The Philippine Island World. Berkeley, USA. University of California Press.

Withmore, T. C. (1984): Tropical Rain Forests of the Far East. Oxford, UK. Clarendon Press.

World Bank (1989): Philippines: Environment and Natural Resource Management Study. Washington, D. C., USA: World Bank.

World Bank (2003): World Development Indicators Database. Washington, D. C., USA: World Bank Group.

Yin, R. and He, Q. (1997): The spatial and temporal effects of paulownia intercropping. The case of northern China. Agroforestry Systems 37 (1): 91-109.

Zita, M., Toribio, B. and Orno, J. L. (1996): The indigenous agroforestry production system of the Ifugao. In: Sajise, P. E., Briones, N. D., Dakila-Bergonia, A., Butardo, M. Z., Duma, J. and Orno, J (eds.): Environmentally sustainable rural and agricultural development strategies in the Philippines. Lessons from Six Case Studies. College, Los Baños, Laguna, Philippines: SEAMEO-SEARCA: 43-61.

Zobel, B. J., Wyk, G. V. and Stahl, P. (1987): Growing exotic forests. New York, USA. John Wiley & Sons.

Part III: Documentation of Smallholder Tree Farming Systems

3 Growing timber trees on upland farms: a study of farmers' practices and factors influencing adoption

3.1   Timber production on small farms in Claveria, Philippines: farmers' tree growing strategies and management practices

Abstract

In the Philippines, tree farming has been widely promoted to provide farmers with important tree products (e.g., fuelwood), produce timber for household use and the market, enhance the fertility of soils and protect them against erosion. However as trees planted on cropland grow taller reduced crop yields due to tree-crop competition for above- and below-ground resources probably offset the economic and environmental benefits of tree intercropping. The yield reduction of crops planted next to trees can be even more drastic on sloping lands where draft animal plough for land cultivation is used because of the development of a fertility gradient due to the rapid soil displacement to the lower alley. In spite of this, tree competition with understorey crops has not prevented an increasing number of farmers in Claveria, and elsewhere in the Philippines, from becoming tree planters. Tree farmers have developed management practices to mitigate the detrimental competition effects of vigorous fast-growing timber trees on intercrops. For instance, severe tree branch pruning may allow sufficient sunlight to reach the understorey crops while improving, at the same time, stem form and wood quality. And root pruning by deep ploughing close to trees prevents tree roots from spreading into the cropped alley, thus reducing competition for below ground resources. In 1997, I conducted a survey among tree planters and non-planters to study local tree farming practices and assess farmers' perceived benefits and constraints of growing timber trees in farmland. The study aimed specifically to identify management strategies to overcome important constraints to timber production on small farms. Results of the study showed that most tree farmers possess substantial knowledge about timber trees and how to cultivate them. They commonly practice intercropping between newly planted trees as a strategy that saves labour, enhance tree growth and provide higher returns to the farmer. Tree farmers recognized that tree root and branch pruning are detrimental to tree growth. Also, they are uncertain whether increased crop yields as a result can compensate reduced tree

growth. One option to extending the intercropping period without severely reducing the growth of trees can be increasing alley width, i.e., the distance between tree rows, to provide intercrops with a more favourable light regime. Planting trees at wider distance will also provide higher economic returns to the farmer because of the faster tree growth, lower tree establishment and management costs and increased area devoted to crops. Therefore tree farmers will benefit from further research aiming to assess the viability of intercropping between widely-spaced tree hedgerows and the net returns over the entire tree rotation period. Findings reported in this study also highlight the need of agroforestry extension programs to address other important constraints to tree farming, such as: i) the lack, at the local level, of quality germplasm of a wider list of tree species suited to farmers socio-economic and environmental conditions; ii) management practices detrimental to tree growth (e.g., severe pruning; lack of thinning), and; iii) existing policy regulations that prevent the establishment and use of tree resources on farms.

3.1.1 Introduction

Since the early 1970s, the Philippine government has spent substantial amount of resources to encourage farmers to plant trees on the extensive degraded uplands. On the state forest lands of upper watersheds reforestation has mainly aimed at improving protection functions and preserve remaining natural forests by creating buffer zones around them. On private land, tree farming has been promoted to produce timber, fuel wood, fodder and other scarce tree products for household use and the market, control soil erosion and improve fertility of degraded farms (DENR, 1990). However, in spite of more than three decades of support, success of reforestation programs has been low. Planted trees did not survive or plantations were soon abandoned as externally-designed, heavily-subsidized initiatives promoting large-scale reforestation were not able to draw a genuine interest in tree planting (ADB, 1994; Pascicolan, 1996 as cited by Pascicolan et al., 1997).

By contrast, since long ago rural people in the Philippines have been planting trees without any outside support. Traditionally, complex agroforestry systems involving timber, fruit, medicinal and other trees have been established and managed by indigenous people in different parts of the country (Zita et al., 1996; Gomez et al., 1998). There is also evidence of spontaneous, farmer-driven increase of tree cover on degraded grasslands, such as the planting of fruit and timber trees by upland farmers of northern Mindanao (Garrity and Agustin, 1995), and northern Luzon (Pascicolan et al., 1996), improved rotational fallows with *Leucaena* sp. (Ipil - ipil) on the hilly limestone soils of Cebu, and various intercropping systems involving a range of fruit,

timber, fodder trees, and crops (Gomez et al., 1998). Since mid 1980s, tree farming has become increasingly popular among upland farmers because of the high price of timber as a result of diminishing supplies from natural forests and strong market demand (Garrity and Mercado, 1994). In Claveria, farmers began to plant fast-growing timbers such as *Gmelina arborea* (hereafter referred to as gmelina), *Acacia mangium* (hereafter referred to as mangium) and *Swietenia macrophylla* (hereafter referred to as mahogany) in a considerable scale. Trees were commonly planted in association with annual food crops either on blocks at 2 x 2 m, or on contour lines 6 to 8 meters apart (Garrity and Mercado, 1994). Recently, adopters of natural vegetative strips (NVS), an increasingly popular soil conservation practice consisting of narrow contour grass strips established 5 to 8 meters apart, have also shown strong interest in planting fruit and timber trees to optimise the use of the hedgerow space (Garrity et al., 1998; Stark, 2000).

Intercropping fast-growing timber trees with annual crops on sloping farms may have several advantages (Garrity and Mercado, 1994): i) lower plantation establishment and management costs as land preparation and weeding is charged to the intercrop; ii) reduced risk of fire as the cropped alleys become effective firebreaks; iii) faster diameter growth as trees benefit from the intensive weed control and fertilizer applied to the intercrops. However, as trees grow taller, reduced crop yields due to tree-crop competition for above- and below-ground resources probably offset these and other advantages of intercropping (e.g., modifications of microclimate and soil properties or improved nutrient cycling). Crop yield reduction next to tree rows can be even more drastic on sloping lands where draft animal plough for land cultivation is used because of the development of a fertility gradient due to the rapid soil displacement to the lower alley (Garrity, 1994). In Claveria, many of the early tree farmers discontinued growing gmelina after harvesting because of the severe yield decline of intercrops.

Farmers' tree management practices may be effective in mitigating the detrimental competition effects of vigorous fast-growing timber trees on intercrops. Tree branch pruning, for example, may allow sufficient sunlight to reach the understorey crops while improving stem form and wood quality. Research conducted in the Philippines to investigate the effect of tree pruning on intercrops showed that the yields of upland rice and mungbean intercropped between pruned multipurpose trees were significantly superior to that obtained in the unpruned treatment and comparable with those of monocropping (Miah, 1993; Gonzal, 1994). But to reduce substantially the shading of intercrops, trees had to be severely pruned and consequently, the total biomass and stem diameter of pruned trees were significantly smaller than that of unpruned trees.

In Claveria, Misamis Oriental, frequent and severe pruning has become a common practice to reduce shading of crops and prolong the period of intercropping. But recently, tree farmers suggested the reduction of tree density and the increase of inter-row tree spacing as strategies to enhance crop and tree growth (Magcale-Macandog et al., 1997). Widely-spaced tree hedgerows, combined with moderate tree pruning may allow prolonged periods of intercropping while producing trees of acceptable form and quality.

The failure of government-sponsored reforestation to promote tree planting and farmers' disappointment with the cultivation of *G. arborea* may lead us to think that in the context of smallholder farmers, whose main priority is to grow food crops, tree-crop competition is a major impediment to tree farming. However, it has not prevented an increasing number of farmers in Claveria, and elsewhere in the Philippines, from becoming tree farmers. In fact, farmers' tree management strategies have been, to some extent, successful and smallholder farmers are nowadays producing timber for the wood industry. Instead of promoting tree planting indiscriminately, farm forestry extension programs should develop tree farming systems by building on farmers' practical knowledge about tree growing and based on a deeper understanding of their opportunities and perceived constraints to developing productive tree-based farming systems compatible with other livelihood activities.

This section presents information on how and why smallholder farmers produce timber trees, their priorities, and perceived impediments to tree growing. In Chapter 3.1 a broad exploratory survey documents farmers' tree planting and management strategies, tree use practices, and current constraints to timber production. Chapter 3.2 presents a study on household and farm factors that may influence adoption of timber tree planting in Claveria. Overall, the study aimed at gaining deeper understanding of farmers' practices and knowledge on tree growing strategies that would guide future on-farm experimentation designed to further improve timber production systems on small farms.

3.1.2   Materials and Methods

3.1.2.1   Description of the study site

Bio-physical description

The study was conducted in Claveria, an upland municipality located 42 km north-east of Cagayan de Oro City, the capital of the province of Misamis Oriental in northern Mindanao, Philippines (8° 38' N, 124° 55' E) **(Figure 3.1.1)**. Claveria is the largest

municipality in the province, covering 112,175 hectares (DTI and PKII Engineers, 1996). Local topography is complex: only 7.4% of the land is classified as flat plateaus and alluvial plains with gentle slopes (0 - 3%), and 62% of the land are volcanic hills with rolling to very steep slopes (> 18%) (DTI and PKII Engineers, 1996). Soil erosion is a major problem in Claveria due to high rainfall and because 59% of the cropping occurs on lands of more than 15% slope (Fujisaka et al., 1994). Soils are generally deep (more than 1 meter) and acidic (pH 3.9 - 5.2) Oxisols, with low available P, low exchangeable K, and high Al content. Soil texture ranges from clays to silty clay loams (Magbanua and Garrity, 1988). Annual rainfall and the length of the rainy season increases with elevation. Average rainfall at lower elevations is about 2,000 mm yr^{-1}, with a wet season from June to December and 5 - 6 wet months (> 200 mm rainfall month^{-1}) per year (Garrity and Agustin, 1995).
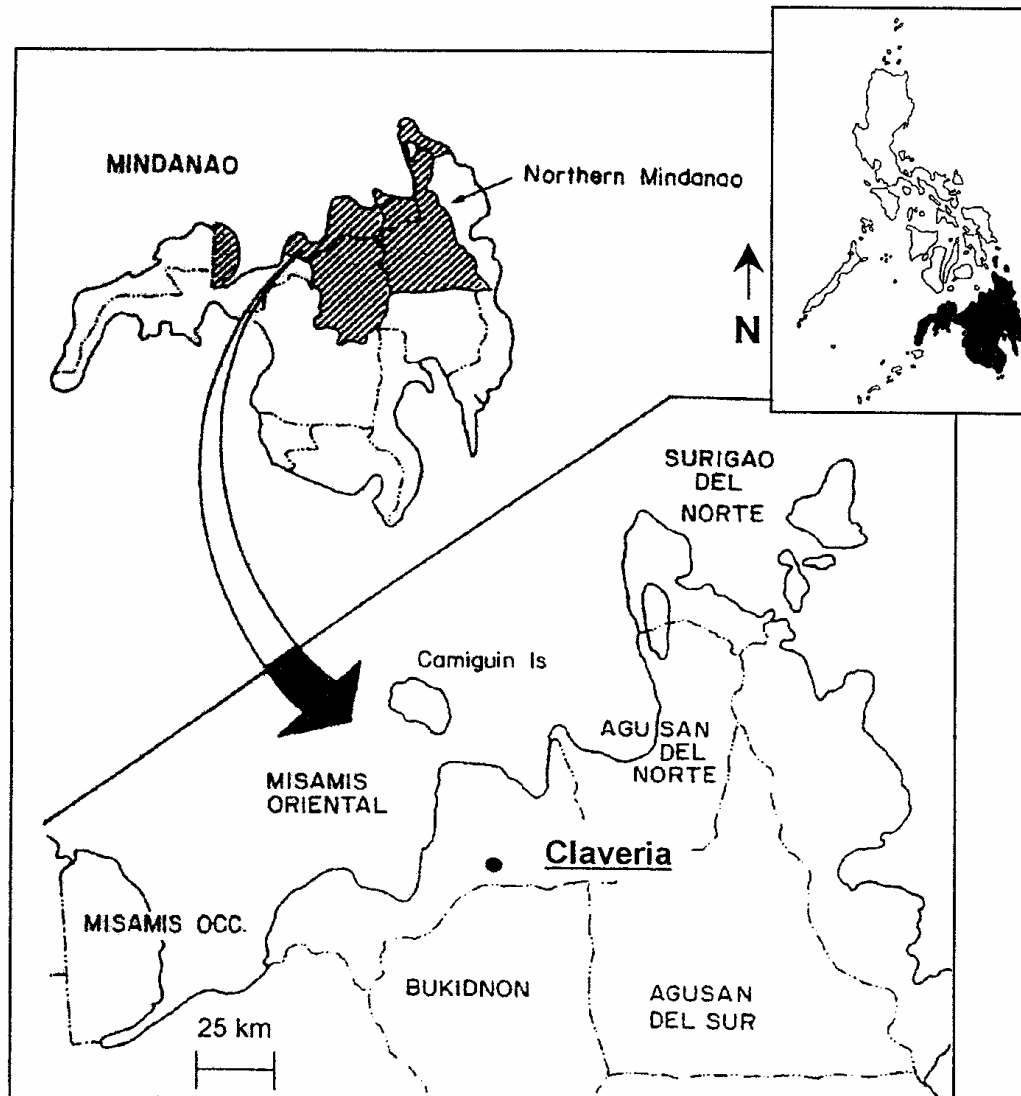
Figure 3.1.1: Location of the study site in northern Mindanao, Philippines.

More than half of the area (69,000 ha) is estimated to be classified as state forest land, although a large portion of this is under some form of cultivation (DTI and PKII Engineers, 1996). Primary forests are only found in the very steep slopes above 1,000 m in elevation (Magbanua and Garrity, 1988), and they continue to recede due to the practice of small-scale logging and slash-and-burn agriculture. There are two crop production zones in the municipality: a) Lower Claveria (300 to 600 m a.s.l.), where the main crops are cassava (*Mahinot esculenta* Crantz), traditional and improved varieties

of upland rice (*Oryza sativa* L.), and maize (*Zea mays* L.); and b) Upper Claveria (600 to 900 m a.s.l), where tomato and other high-input vegetable cash crops are produced (Magbanua and Garrity, 1988). Presently, maize is the dominant crop. It is cultivated twice annually without crop rotation in Lower Claveria and once a year, after a tomato cropping, in Upper Claveria. Land cultivation is done using water buffalo or cow as draft animal.

<u>Socio-economic conditions</u>

During the early part of the past century, Claveria was inhabited by the native Higao-non people who practiced swidden agriculture on a limited portion of the land. Since logging started in the early 1920s, population growth, estimated at a rate 8 - 9% a year during that period, was mostly due to immigration (Kenmore and Flinn, 1987). Small-scale farmers, mainly from the Visayas, followed the logging operations into the area in a process that characterized most of the upland ecosystems in the Philippines (Garrity and Agustin, 1995). Rapid population growth continued after the World War II and once Claveria became a municipality in 1950. Today, the municipality is composed of 24 villages or Barangays, and population growth is still high, with average annual rates of 4.6% for the period 1990 - 95. In 1995 the municipal population was estimated at 39,020 inhabitants (Provincial Capitol, 1997).

Logging was a short-lived industry that ended in the late 1960s (Kenmore and Flinn, 1987). During the 1960s and 1970s grasslands areas resulting from deforestation were used for large-scale cattle ranching (Fujisaka et al., 1994). But since the late 1960s, change in land use systems accelerated dramatically. The area of annual cropland doubled at the expense of grassland and perennial crops, especially coffee and other fruit trees, which became an important component of the agro-ecosystem (Garrity and Agustin, 1995)[33]. Although planting of coffee has stopped and many coffee gardens have been removed, especially since the tomato industry started in 1974, direct observation suggests that transition towards perennial-based systems continue as fruit and timber tree crops have become an attractive option for smallholder farmers.

The average farm size in Claveria is 3.0 ha and farmers commonly cultivate two or more parcels of land (Magbanua and Garrity, 1988). Average household size is 5.6 persons (DTI and PKII Engineers, 1996). Owner cultivatorship is the dominant tenurial arrangement although tenancy and lease-holding are also common, particularly

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[33] This study did not cover the entire land area of Claveria but just 8 x 10 km^2. It is assumed that land use changed in a similar way in the rest of the municipal land area.

among small farms (0.2 - 1.2 ha). About 70% of farmers' household income is derived from crop sales. Other sources of income include the sale of livestock, hired farm labour and off-farm work (Magbanua and Garrity, 1988).

3.1.2.2   Data collection

Two surveys were conducted for data collection:

Exploratory household survey

Interviews among experienced and non-experienced timber tree planters were conducted during July and August 1997, before the establishment of the on-farm trial plots described in Chapter 4.1. The objectives of the survey were: i) to learn about farmers' tree planting and management strategies and their use of tree resources; ii) to determine farmers' perceived constraints to tree planting and assess their importance to overall systems' productivity; and iii) to identify management strategies to overcome important constraints to timber production on small farms.

Interviewers used a semi-structured questionnaire including closed -and open-ended questions **(Appendices Chapter 3)** with the objective of gathering descriptive and quantitative[34] information on the tree production systems (tree species, arrangement, abundance, planting density) and management practices (i.e., weeding, pruning and thinning). The survey undertaken included farmers (household heads, males or females) from 12 villages (Barangays) of Claveria. Villages were clustered into 4 groups on the basis of proximity among villages, accessibility, and general biophysical characteristics considered to influence timber tree planting, such as the predominant farming system and the proximity to natural forest **(Table 3.1.1)**. As there was not information from the population of tree planters on the parameters necessary to estimate a statistically representative sample, sample size was estimated by just following the basic principle of spreading the sample through the whole population (Coe, 1996), and considering the time and resource constraints. Thus for each cluster of villages, between thirty to forty farmers were randomly selected from a list which combined the official census list of each village in the cluster. This sample was judged as sufficient for developing understanding of issues and hypotheses. In total, 139 farmers were included in the survey, 38 from Cluster I, 39 from Cluster II, 32 from Cluster III, and 30 from Cluster IV. Among the farmers interviewed, there were 27

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[34] In this survey farmers were simply asked to enumerate species, approximate number, and the farm niche (boundary, cropland, fallow land) where trees had been planted (Appendices Chapter 3). This information was validated in the field and complemented with more accurate data collected during an inventory of trees on farms conducted in 2001 (Chapter 3.2). Research results reported in this chapter have been estimated by using data from both surveys.

tenants (2 from Cluster I, 9 from Cluster II, 8 from Cluster III and 8 from Cluster IV) and 112 owners cultivating 158 farm parcels. Although some of the farms managed by tenants had planted trees, the study just focused on tree farming by owner cultivators as all tenants indicated that the landlord decides whether trees should be planted or not. Some of the topics of the survey were discussed only with those farmers with experience on the subject. For instance, only tree planters described tree management practices. Data analysis included simple descriptive statistics (table of frequencies and percentages and numerical summaries) and statistical tests (t-test and chi-square test) done with Excel computer software (Microsoft Corporation, 1997).

Table 3.1.1: General characteristics of the village clusters where the survey was conducted.

Villages	Elevation (m a.s.l.)	Accessibility	Predominant farming system	Presence of natural forest
Cluster I: Hinaplanan Cabacunggan Kalawitan Gumaod	400 - 500	Fair (all-weather road but not paved)	Maize-Cassava	None
Cluster II: Patrocenio Anei Claveria (Poblacion)	500 - 600	Good (paved road)	Maize-Maize	None
Cluster III: Lanesi Luna Tamboboan	700 - 800	Fair (all-weather road but not paved)	Maize-Vegetables	Proximity to natural forest
Cluster IV: Rizal Madaguing	600 - 700	Difficult (dirt-road)	Maize-Vegetables; Imperata grasslands	Scarce (remnants)

Household nursery survey

Although the number of respondents with an individual household nursery (or small-scale nursery) and the species raised at the time of the interview were recorded in the exploratory household survey, a second survey was conducted on July 1998 for a more in-depth study on farmers' tree propagation practices. For this study, twenty (20) owners of household nurseries were identified by chain sampling, (i.e., by simply asking respondents if they knew any other farmer with a household nursery) (Nichols,

1991), and interviewed during a visit to the nurseries. This survey aimed specifically at: i) identifying farmers' preferred tree species; ii) learning about seed sources, collection and propagation practices, and; iii) assessing and compare farmers' perceived advantages and disadvantages of individual household nurseries versus collective approaches to tree propagation (group nurseries[35]).

3.1.3   Results and discussion

3.1.3.1   Characterization of smallholder tree farming systems: establishment and management practices

Most reforestation projects in the Philippines have been designed on the assumption that farmers would plant trees to satisfy their needs for tree products and income. Instead farmers plant trees in response to the household's broader requirements and the resources and livelihood strategies available to satisfy them. To effectively support wider dissemination of tree farming systems, there is a need to understand the various factors explaining why and how smallholder farmers produce trees, and their perception of the role that trees planted on farms play in their livelihood. This section, therefore, describes some of the strategies by which farmers have responded to the need of tree products and the extent of their knowledge about trees and their management.

Germplasm procurement and diffusion and tree propagation

Trees planted on farms are the source of 82% of the seed used in the household nurseries surveyed. The remaining seed (18%) was provided by government agencies and private NGOs. These organizations are important to make available germplasm of species new to the place or germplasm for which collection and handling is difficult (e.g., the tiny seeds of *Eucalyptus deglupta*, hereafter referred to as bagras). Seed originating from trees growing on farms is commonly given by other farmers at no cost (38%), collected by the nursery owners themselves (36%) or in the case of fruit trees, purchased (26%) (seeds are extracted after eating purchased fruits). Seed collections take place mostly on farmers own farm or in neighbours' farms (83%), in friends' or relative's farms outside Claveria (11%) and roadside plantings (8%). The seed of timber trees which is not supplied by government or external agencies, is usually collected from trees on-farms, roadside plantings, or in the case of native hardwoods

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[35] Group or community nurseries refer to those typically supported by government or private organizations (NGOs, etc) and established and managed by a group of farmers.

species from natural regenerating trees. In Claveria, farmers do not commonly buy seed of timber trees. However, in the neighbouring municipality of Lantapan, Bukidnon, diffusion of timber tree germplasm by commercialisation and sale is important, and farmers have expressed their willingness to pay for improved quality or "certified" seed (Koffa and Roshetko, 1997).

Around 50% of the timber tree planters (n = 50) mentioned straightness of the bole, fast-growth, and the presence of small branches as the criteria for selecting mother trees. However, none of them had observed other recommended practices for seed collection, in particular those concerning the number of mother trees from which seed should be collected and the distance separating mother trees. According to Dawson and Were (1997) seed should be collected from a minimum of 30 trees, which are at least 50 m apart. But most farmers collected seed from a limited number of mother trees (3 - 10) within the same plantation. Koffa and Roshetko (1997) reported similar findings in a study on farmers' seed collection practices in Lantapan, Bukidnon. In the short to medium-term, collecting seed from a limited number of mother trees could result in reduced growth and poor stem form, as it has been suggested based on field observations for gmelina in Claveria (Simons[36], 1998 pers. comm.). In other countries, poor genetic management has hampered domestication of important timber trees due to inbreeding depression of yield and genetic deterioration of many exotic land races (Hardwood, 1997). Improving understanding of the need for improved genetic management and seed collection practices among small-scale farmers should be the focus of future research and extension efforts since it is key to develop productive tree farming systems.

Survey results suggest that farmer-initiated, small-scale nurseries are common in Claveria. At the moment of being interviewed, 24% of the respondents (n = 139) had a household nursery with seedlings of various fruit and timber trees **(Table 3.1.2)**, and 40% of the tree planters (n = 96) reported to have established, at least once, a small-scale nursery in the past. The size, production capacity and level of sophistication of these small-scale nurseries vary widely, from simple containers (recycled plastic bags) in which few seedlings of 1 or 2 tree species are grown, to well-fenced nurseries with several hundreds of seedlings of a number of tree species growing in polyethylene bags.

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[36] Anthony Simons, Co-leader theme Trees and Markets, World Agroforestry Center (ICRAF), Nairobi, Kenya.

Table 3.1.2: Raising fruit and timber trees in household nurseries is common among smallholder farmers in Claveria, Misamis Oriental.

Species	Household survey (n = 139)	Individual nursery survey (n = 20)		
	Nurseries reporting*	Nurseries reporting**	Seedlings	%
Timber trees				
Eucalyptus deglupta (bagras)	1	7	2,691	70
Gmelina arborea (gmelina)	6	1	700	18
Pterocarpus indica (narra)	0	1	418	11
Swietenia macrophylla (mahogany)	5	1	11	0.3
Others (Acacia mangium, Trema orientalis, Eucalyptus sp.)	-	1	34	0.9
TOTAL			3,854	**31**
Fruit trees				
Lansium domesticum (lanzones)	2	15	3,728	43.3
Garcinia mangostana (mangostan)		7	1,989	23.1
Nephelium lappaceum (rambutan)	4	8	1,158	13.5
Coffee sp (kape)	-	3	1,050	12.2
Durio zibethinus (durian)	1	9	257	3.0
Mangifera indica (mango)	13	3	190	2.2
Citrus sp		4	79	0.9
Artocarpus heterophyllus (jack fruit)	4	3	21	-
Sandoricum koetjape (santol)	3	2	18	-
Artocarpus odoratissima (marrang)	4	1	3	-
Others (Cocos nucifera, Psidium guajava, Anacardium occidentale, Artocarpus altilis)	1	1	118	1.8
TOTAL			8,608	**69**
GRAND TOTAL			12,462	

*A total of 24 nurseries were observed. Nurseries may have more than one species

** Some nurseries may have more than one species

Tree establishment practices

The popularity of household nurseries may suggest that seedlings are the most common type of germplasm used by smallholders. However, farmers employ and experiment with a wide repertoire of tree establishment strategies. Direct seeding and the use of wildlings are important methods of establishment of fruit trees **(Table 3.1.3)**. The use of wildlings is also important for timber species with seed difficult to germinate, such as *Melia dubia*, and species with seed that germinate easily (e.g., gmelina). The popular bagras is planted solely by using seedlings raised in controlled nursery conditions since its very small seeds and the susceptibility of newly germinated seedlings to damage by damping-off make it difficult to establish by other means. Moreover, propagation and establishment risks have to be minimized, as seed of bagras is very expensive.

Table 3.1.3: Type of germplasm used by tree growers for the establishment of common timber and fruit trees in Claveria, Misamis Oriental.

	% of farmers reporting the use of				
	Seedling	Wildling	Bare-root	Natural regeneration	Direct seeding
Timber trees					
Gmelina arborea (n = 94)	53	33	6	1	6
Swietenia macrophylla (n = 56)	57	19	4	2	3
Eucalyptus deglupta (n = 30)	100	0	0	0	0
Melia dubia (n = 12)	0	42	0	58	0
Fruit trees					
Artocarpus heterophyllus (n = 32)	25	19	9	0	47
Artocarpus odoratissima (n = 41)	12	46	5	0	37
Mangifera indica (n = 42)	31	12	2	0	55
Durio zibethinus (n = 11)	82	0	0	0	18
Lansium domesticum (n = 27)	48	33	7	0	11

According to the respondents, the use of direct seeding or wildlings has two major advantages over raising seedlings in nurseries: i) it reduces the cost and labour required for tree establishment. This is very important for farmers as establishment costs represent a large share of the total costs of timber production systems; ii) trees grow faster, as stress and damage caused to seedlings during transplanting is avoided. Future research should assess the benefits of these establishment methods in terms of labour saved and seedling quality and growth, as it may have implications

in the way agroforestry projects approach the issue of tree propagation and establishment on farms.

<u>Trends in on-farm tree growing: species preference, frequency and density</u>

The inventory of farm-grown trees showed that tree planters deliberately propagate and manage more than 42 tree species. About 70% of these are fruit tree species, 20% timber trees, and the remaining species are used mainly for fodder (*Leucaena leucocephala*), latex (*Hevea brasiliensis*) or soil fertility enhancement and erosion control (*Gliricidia sepium*). In terms of frequency, fruit trees represent over 60% of all the trees planted on farms and timber trees represent around 30% **(Table 3.1.4)**. The proportion of fruit trees (69%) to timber trees (31%) found in the small-scale household nurseries surveyed is in accordance with that of trees planted on farms (62% of fruit trees and 31% of timber trees). Farmers indicated that fruit trees are preferred to timber trees because of the seasonal income obtained from the sale of fruits and their contribution to the household food security and nutrition.

There is also a great diversity of naturally regenerating tree species growing on fallow lands. Farmers manage and value these trees as important sources of timber, fuelwood and other tree products but their abundance and thus, their contribution to the household economy is low as compared to planted fruit and timber trees. The potential to bring these species under cultivation is high, given the existing knowledge about their propagation and management and market demand. For example, the quality timber tree *Artocarpus blancoi* (Elmer) Merr. (antipolo) and the native fruit tree *Artocarpus odoratissima* (marrang), both commonly found on farm fallows, are sought by wood processors of Misamis Oriental for quality timber and veneer. Lawrence (1997) also reported the potential of other common fruit tree species valued for their wood, such as *Sandoricum koetjape* (santol) and *Artocarpus heterophyllus* (jack fruit), for quality timber production. As the list of timber species available and promoted for farm forestry is currently very limited, farmers and the wood industry will certainly benefit from domestication efforts aiming at bringing under cultivation these valuable species locally available.

Table 3.1.4: Trees planted on farms in Claveria, Misamis Oriental (year 2001) (farm parcels surveyed n = 158).

Tree category	Species		Abundance	
	No.	%	No.	%
1. Trees planted and managed on farms				
Fruit trees	29	69	28,810	62
Common timbers (mostly exotic)	8	19	14,263	31
Other trees (rubber, fodder trees)	5	12	304	1
Subtotal	42			
2. Natural regeneration				
Native trees (natural regeneration)*	26**		2,976	6
TOTAL			46,353	

*Farmers also manage these species though less intensively than trees in category 1. Some native hardwood species such as *Pterocarpus indica* (narra) and *Vitex parviflora* (molave), are also deliberately planted by farmers.

** Not all species were identified

Trees planted by smallholder farmers in Claveria can be grouped into five broad categories:

1. Exotic, fast-growing timbers, such as gmelina and mangium.

2. Exotic, long-rotation, premium timbers such as mahogany.

3. Native, pioneer, fast-growing timbers such as bagras, *Trema orientalis* (hinagdon), *Melia dubia* (mangolinaw), *Artocarpus blancoi* (antipolo).

4. Native, long-rotation, premium timbers such as *Pterocarpus indica* (hereafter referred to as narra) and *Vitex parviflora* (molave).

5. Fruit trees, naturalized (e.g., *Mangifera indica*, mango), and native, like for example *Artocarpus odoratissima* (marrang)

In Claveria, most timber trees planted on farms are fast-growing exotics (category 1). However, fast-growing, pioneer native species (*Trema orientalis, Melia dubia*), long-rotation exotic trees (mahogany), and native premium timbers (narra) were also frequently found in household nurseries and planted on farms. This contradicts the common belief among foresters and extensionists in the Philippines, and elsewhere (Dove, 1992), that smallholder farmers are only interested in fast-growing exotic trees. The popularity of medium to long-term rotation species, such as mahogany or the native narra, demonstrates that farmers are willing to wait longer than what it is

commonly assumed. It also shows that farmers' interests are not only limited to exotics but to native trees as well.

Gmelina and mahogany have become the most common timber trees on farms throughout the Philippines. In the study site, these species are the most abundant among the planted timbers, with both species accounting for 86% (62% for gmelina and 24% for mahogany) of all the trees surveyed. Of all the respondents, 71% had planted gmelina and 47% mahogany **(Table 3.1.5)**.

Table 3.1.5: Common timber trees on-farms: frequency and farmers' preference.

Common timber species planted on-farms	Trees surveyed		Respondents planting	
	No.	%	No.	%
Gmelina arborea	8,905	62	80	71
Swietenia macrophylla	3,415	24	53	47
Eucalyptus deglupta	1,223	9	32	29
Acacia mangium	443	3	17	15
Tectona grandis	160	1	10	9
Paraserianthes falcataria	113	1	22	20
Other timber trees (Eucalypts sp.)	5	0.04	1	-
Total	14,263			

Survey results confirmed that agroforestry is becoming an increasingly important land use system in Claveria as the great majority of the farmers have integrated trees in their farming systems. Of the 112 respondents surveyed only 6% had neither fruit nor timber trees; 7% did not have any fruit trees, and 22% had not planted timber trees on their farms **(Table 3.1.6)**. Landholding size appeared to have an influence on timber tree planting. Thirteen percent of the owners of large farms (> 3 ha) did not plant timber trees, whereas 26% of those farmers with farms of average size and 27% of the small farms did not have timber trees. Farmers on the large farms have planted more than twice as many timber trees than the owners of small farms. However, contrary to expectations, timber tree density (trees ha^{-1}) is three times higher in small farms than in large farms **(Table 3.1.6)**. High tree densities and consequently, limited crop production on the smaller farms may indicate that land-poor farmers have to engage in off-farm work or farm wage labour, thus devoting their farm plot to obtain seasonal income from fruit trees and to accumulate capital in the form of timber trees. Because of the influence of many other factors (e.g., availability of family labour), this exploratory survey is not conclusive about the relationship between farm size and tree

density. What this study indicates is that in Claveria farm size is not a deterrent to tree planting, and that trees planted on-farms are economically advantageous for both, large-scale and small-scale farmers.

Most farmers recognized their preference for the seasonal economic benefits obtained from fruit trees over the long-term income provided by timber trees. There are, consequently, for all farm size categories, more planters of fruit trees than planters of timber trees. The higher number and density of fruit trees on the large farms as compared to small farms is probably because wealthy farmers (assuming farm size as an indicator of wealth) have better access to expensive improved germplasm (e.g., grafted seedlings) of high value fruit trees such as mango (*Mangifera indica*), durian (*Durio zibethinus*), lanzones (*Lansium domesticum*) and others. It is also probable that wealthy farmers are in less need of wood fuel and building materials provided by timber trees than small-scale farmers, as they can afford the use of alternative energy sources (e.g., gas stove) and construction materials (e.g., cement). Therefore, large farms have three times as many fruit trees as compared with timber trees, whereas the proportion of fruit trees to timber trees do not differ that much in small and average size farms **(Table 3.1.6)**.

Table 3.1.6: Mean number of trees per household and tree density by size of landholding.

Number of trees and density of timber trees found on farms	Landholding size category		
	Small ($\leq$ 1 ha)	Average (1 - 3 ha)	Large (> 3 ha)
Surveyed farms/farmers	26	54	32
Timber tree planters	19	40	28
Fruit tree planters	25	49	30
Timber trees			
Trees per household	91*	158	221*
Standard deviation	283	273	195
Coefficient of variation (%)	312	172	88
Minimum	1	3	10
Maximum	1,250	1,271	686
Tree density (trees ha^{-1})	98	69*	34*
Standard deviation	282	113	30
Coefficient of variation (%)	287	165	89
Minimum	1	2	3
Maximum	1,250	508	98
Fruit trees			
Trees per household	69*	153*	653
Standard deviation	129	241	820
Coefficient of variation (%)	187	158	126
Maximum	600	1,211	3,258
Minimum	0	3	5
Tree density (trees ha^{-1})	75	74	94
Standard deviation	129	130	117
Coefficient of variation (%)	171	175	125
Maximum	600	692	543
Minimum	1	2	1

Notes: Average landholding size found in this survey is 3.17 ha.

*Within a table row, significantly different at 10% level, t-test.

Average number of fruit trees planted by owners of small and average farms and large farms are significantly different at 1% level, t-test.

Farmers have also showed a preference for planting more trees in their smaller plots **(Table 3.1.7)**. For all tree categories (timber, fruit and natural regeneration), tree density is higher on parcels smaller than 1 ha, and for timber trees, density on the smaller farm parcels is four (4) times higher than the density in the larger farm parcels. Fruit tree density is twice the density of timber trees on small and large parcels.

However, on farm plots of average size the density of fruit and timber trees is similar. On the aggregate, the density of fruit and timber trees on the small parcels is high (239 trees ha^{-1}). It is almost twice as large as the density on average size parcels (123 trees ha^{-1}) and almost four times greater than density in larger parcels (65 trees ha^{-1}).

Table 3.1.7: Average tree density on farm parcels in Claveria, Misamis Oriental.

Tree density found on farm parcels	Farm parcel size category		
	Small (≤ 1 ha)	Average (1 - 3 ha)	Large (> 3 ha)
Surveyed farm parcels	62	66	30
Parcels with timber trees	43	52	23
Parcels with fruit trees	59	62	28
Timber trees			
Tree density (trees ha^{-1})	84	60	22
Standard deviation	194	108	38
Coefficient of variation (%)	231	178	168
Minimum	2	1	1
Maximum	1250	538	143
Fruit trees			
Tree density (trees ha^{-1})	155	63	43
Standard deviation	208	111	54
Coefficient of variation (%)	135	176	126
Minimum	1	1	1
Maximum	810	726	208
Natural regeneration			
Tree density (trees ha^{-1})	15	9	13
Standard deviation	23	18	19
Coefficient of variation (%)	151	197	142
Maximum	93	122	62
Minimum	1	1	1

t-test indicates that there is a significant difference to 10% in the average density of timber trees between small and large farms and between average and large farms.

Density of fruit trees in small and average farm plots is significantly different at the 1% level, t-test.

Density of fruit trees in small and large farm plots is significantly different at the 1% level, t-test

<u>Spatial patterns of tree growing: distribution, configuration and niche</u>

Surveyed farmers were classified according to the density of trees found in their farms into three categories of planters: i) non-adopters[37], with 0 to 20 trees ha^{-1}; ii) low-intensity adopters, with 21-100 trees ha^{-1}; iii) high-intensity adopters, as those with more than 100 trees ha^{-1}. Based on this classification, results confirmed what field observation suggested, that there are a higher proportion of tree planters and higher tree densities on farms located in villages at lower elevations (Cluster I and II) than in those villages at higher elevations (Cluster III and IV) **(Table 3.1.8)**.

Table 3.1.8: Higher adoption rates in villages located at lower elevations, Claveria, Misamis Oriental (% of farmers under adoption category).

Village cluster	All trees (fruit, timber and natural regeneration)*			Timber trees**		
	Non-planters	Planters (trees ha^{-1})		Non-planters	Planters (trees ha^{-1})	
	$\leq$ 20 trees ha^{-1}	21 - 100	> 100	$\leq$ 20 trees ha^{-1}	21 - 100	> 100
Cluster I	11	53	36	53	42	5
Cluster II	12	32	56	35	36	29
Cluster III	26	42	32	95	5	0
Cluster IV	13	70	17	56	35	9
Total	14	48	38	55	32	13

*Note: Parcels under tenancy not included. Only parcels under management by owner and rented out included

*There exist a relationship between adoption (tree planters) and village cluster at 10% significance level, chi-square test

**There exist a relationship between adoption (tree planters) and village cluster at 1% significance level, chi-square test.

This difference in the number of adopters among clusters is markedly larger for timber trees. The percentage of non-adopters is significantly higher in villages of Clusters III and IV (villages located at higher elevations) than in villages of Clusters I and II (villages located at lower elevations). There may be two main reasons for this. First and foremost, in the Philippines most of the timber trees commonly promoted for farm forestry show good growth only at altitudes from the sea level up to 800 – 900 m. Gmelina, which approximately represents 60% of the planted timber trees in Claveria (Table 3.1.5), is not suitable on elevations around 800 m a.s.l. and above. In a species by elevation trial conducted in the neighboring municipality of Lantapan, Bukidnon, 2-

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[37] Of all the farmers within the non-adopters category, 35% (40 respondents) had only 0 – 5 trees ha^{-1} (i.e., considered as not interested in timber tree planting), and 20% (22 respondents) had planted 6 – 20 trees ha^{-1} (i.e., considered in this survey as non-adopters but in the process of testing timber tree planting).

year old gmelina planted at 750 m a.s.l., showed a dbh 6% smaller and a height 29% shorter than gmelina trees planted at 470 m (Ngugi et al., 1999) (Ngugi et al., nd). Poor growth of common timber trees at higher elevations has been also recognized by farmers in focused group discussions conducted to evaluate timber production systems (Chapter 4.2). Therefore, it is not surprising that 83% of the respondents of Cluster I and 90% of the respondents of Cluster II, but only 38% of the respondents of Cluster III, had planted gmelina. Secondly, vegetable farmers, predominant at higher altitudes, are probably reluctant to increase the risks of this high-input farming system by intercropping timber trees. Moreover, it is probable that farmers' decisions to plant trees on crop land are subordinated to approval by capital lenders and vegetable traders who control production and marketing of these high-value crops. In the near future, however, timber intercropping will probably become increasingly attractive to vegetable farmers in the event of opening markets to import vegetables and in view of long-term vegetable productivity decline and labor scarcity (Midmore et al., 2001).

Timber trees are integrated on small farms in several distinct planting arrangements. Tree lines along farm boundaries is the most common configuration in Claveria **(Table 3.1.9)**. Planted on this farm niche, trees serve the purpose of land demarcation and timber production while minimizing tree-crop competition. According to the respondents, timber trees are preferred over fruit trees for boundary planting because, based on customary rules, when fruit trees are planted on a farm boundary all fruits growing over the next farm lot can be taken by the neighbor.

Although farm boundaries are the most preferred location for timber trees, only 30% of all the timber trees surveyed were found on this farm niche. Almost as many as this number of trees have been established in mixed gardens **(Table 3.1.9)**. This planting configuration consists of a mixture of fruit, timber, and other useful species in a forest-like arrangement. In Claveria, mixed gardens typically involve small farm plots (< 1 ha) where farmers interplant various timber trees with shade-demanding fruit trees, such as lanzones or durian, palms and bamboos. When mixed gardens are mature, tree management is mostly limited to the protection of naturally growing tree seedlings and some enrichment planting with valuable species.

Woodlots and linear planting[38] are the preferred arrangements for tree monoculture on cropland. In Claveria, intercropping between tree lines is commonly practiced to

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[38] In this study, the term linear, line or hedgerow planting is used for rectangular arrangements in which the inter-row distance is notably larger (usually 3 or more times larger) than the intra-row distance. When the inter-row and intra-row distance are small and similar (e.g., 2 x 2 or 3 x 2 m), the term block or woodlot is used.

support the establishment of woodlots and tree hedgerows. Depending on the distance between trees, farmers usually plant 2 or 3 crops between tree rows, leaving the field fallow when cropping is no longer possible. In the case of a tree monoculture (typical with fast-growing species), annual crops are planted again after tree harvest and, if tree stumps have the capacity to re-sprout (e.g., gmelina), trees will be coppiced for a second tree rotation. But if the intercropping system involves a polyculture with several species of fruit and timber trees inter-planted, the system will eventually evolve towards a permanent mixed garden. Fruit tree orchards are also established with the support of intercropping. Fruit trees are preferred for intercropping because of their low stature and compact crown when cultivated for fruit production.

Scattered trees is the least common configuration of timber trees but it is relatively common for fruit trees. This arrangement usually evolves from naturally regenerating seedlings deliberately protected and managed and used for wood fuel and timber. Common timber species in this configuration are native fast-growing pioneer trees such as hinagdon and mangolinaw. Scattered configurations may also originate from woodlots or linear plantings with low survival rates. This is common for plantations of mahogany, as mortality can be high because of its shade-demanding temperament at young age and the susceptibility to shoot borer attacks when grown in open conditions **(Table 3.1.9)**.

Table 3.1.9: Common configurations of timber trees on-farms, Claveria, Misamis Oriental.

Configuration	% of farm parcels surveyed*	% of commonly planted timber trees**
Boundary planting (internal and external)	82	30
Mixed garden with timber and fruit trees***	35	29***
Woodlot (tree blocks)	23	28
Linear planting (trees lines on cropland or fallows)	16	9
Scattered or isolated trees (on cropland or fallows)	4	2

*N=77 farm parcels with timber tree density higher than 20 timber trees ha^{-1}. Some farm parcels may present more than one configuration.

**Species included: *Eucalyptus deglupta*, *Paraserianthes falcataria*, *Gmelina arborea*, *Swietenia macrophylla*, *Acacia mangium* and *Tectona grandis*

*** It includes timber trees on homesteads (2%).

Although planting trees on farm boundaries is common, more than 60% of the timber trees surveyed have been established on farm land **(Table 3.1.10)**. Invariably, respondents indicated that to make more productive use of their land, they practiced intercropping at tree establishment. Once intercropping is no longer possible, tree

plantations became fallows and pasture areas for livestock. Farmers also indicated that tree fallows are an important land management strategy to restore the fertility of degraded cropland. Growers of the nitrogen-fixing tree mangium noted its capacity to substantially improve soil fertility and consequently, this specie is mostly planted on farm land rather than on boundaries **(Table 3.1.10)**.

Table 3.1.10: Preferred farm niche by tree specie.

Tree specie	% of trees surveyed found on:				
	Farm boundaries		Farm land		Homestead
	External	Internal	Crop land	Pasture/fallow	
Gmelina arborea	29	3	6	60	2
Eucalyptus deglupta	18	11	15	55	2
Swietenia macrophylla	29	3	3	64	2
Acacia mangium	9	4	0	86	0
Tectona grandis	65	0	10	25	0
Paraserianthes falcataria	19	6	9	65	1

An analysis of the preferred farm niche and planting configuration by tree specie reveals that farmers also possess substantial knowledge about the growing habit and behaviour of particular timber trees. For example, because of its dense crown and competitiveness, more than 30% of the gmelina trees surveyed have been planted on farm boundaries away from crops **(Table 3.1.10)**. But when planted on cropland, blocks or woodlots is the preferred arrangement probably because of the poor stem form and profuse development of branches shown by this specie **(Table 3.1.11)**. By contrast, bagras, another fast-growing specie with straight bole, light canopy, small branches, and self pruning habit, is frequently planted on lines in association with annual crops **(Table 3.1.11)**.

Table 3.1.11: Preferred planting configuration for timber trees planted on farmland in Claveria, Misamis Oriental (% of the trees surveyed).

Tree specie	Tree configuration		
	Block	Scattered or isolated	Line planting
Gmelina arborea	62	29	9
Eucalyptus deglupta	15	37	48
Swietenia macrophylla	15	80	5

Tree management: weeding, pruning, and thinning

Timber tree management practices, weeding, pruning, and thinning, were documented and discussed with only those farmers who are experienced tree growers. There are not significant differences among them in the way weeding and pruning is practiced. The majority of the tree growers interviewed (98%, n = 96) reported that, except for ring weeding at planting, no other weeding activities are carried out exclusively for trees. Instead, tree weeding is done on "occasion to crops", that is, the ploughing, inter-row cultivation and hand weeding activities normally done for annual crops also serve the purpose of weed suppression around intercropped trees. This implies that in the agroforestry systems studied, intercropping is crucial for successful tree establishment. A description of these weeding activities commonly applied to annual crops illustrates the intensive weed control from which intercropped trees benefit during establishment. In a typical maize-maize farming system of Claveria, each cropping season weeding activities typically consist of land preparation by draught animal power (usually two ploughing, one harrowing and furrowing before sowing), inter-row cultivation, approximately 15 and 30 days after the emergence of maize (performed as a weed control measure and to hill up maize plants), and within-row hand weeding done on a need basis (Nelson et al., 1996). If the system involves maize cropping between natural vegetative strips (NVS) (an increasingly popular system of erosion control consisting of narrow grass strips established 6 to 8 meters apart along contour lines on which fruit and timber trees are commonly planted), weeding activities include, in addition, the slashing of the grass strips an average of 2 to 3 times each cropping season (Stark, 2000). Considering that farmers reported the practice of intercropping for at least two cropping seasons and that fast-growing hardwoods usually require weeding only through the first year (as trees quickly dominate the site due to their fast growth) (Lowery et al., 1993), these intensive land cultivation activities provides the early and timely weed control necessary for rapid and successful tree establishment. Besides, intercropping promotes early tree growth

because trees also benefit from the fertilizer applied to the intercrops. As all these tending operations are charged to the annual crops, the practice of intercropping not only is an effective establishment and management strategy that promotes faster tree growth but also, it is economically more efficient than traditional reforestation activities (Gajaseni, 1992; Garrity and Mercado, 1994).

Tree pruning is another management activity that smallholder farmers in the study area practice intensively. The majority of the gmelina planters interviewed (81%, n = 73) had pruned their trees at least twice. The remaining 19% had not pruned yet as the trees were still young (less than 1 year old), but planned to do so as trees grew taller. Since gmelina is a fast-growing tree with little apical dominance and branching profusely, pruning has to be done frequently to avoid forking and to produce trees with a stem form acceptable to sawmills **(Table 3.1.12)**. Farmers reported that the first pruning of gmelina is usually carried out one year after planting, when trees are 2 to 3 meters high (although often I have observed younger trees heavily pruned). Subsequent pruning operations are commonly done once or even twice a year (83% of the respondents) if necessary, to reduce the shading of intercrops. This pruning frequency is similar to that reported by Magcale-Macandog and Rocamora (1997) in a previous survey conducted in Claveria. Using a bolo or machete, farmers prune timber trees severely, typically leaving a live crown ratio (LCR)[39] of just 10 to 20% and large branch stubs where shoots soon develop as lateral buds are exposed to sunlight. Beyond the age of 3 or 4 years, once trees are tall and dominate the site, pruning is seldom practiced unless the farmer decides to plant shade-tolerant understorey crops. Although commonly used as fuel wood, pruned branches are considered a by-product derived from tree pruning.

Table 3.1.12: Reasons for pruning *Gmelina arborea* (n = 73 planters).

	% of farmers reporting
1. To produce straight trees	93
2. To reduce competition with crops	47
3. To obtain fuelwood	39

Note: Respondents may have reported more than one reason for pruning.

As practiced by smallholders in Claveria, tree pruning notably reduces the shading of understorey crops, but it also slows the growth of trees and reduces timber yields. On-

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[39] The percentage of length of stem clothed with living branches. If the ratio is allowed to decrease to 30% or less the general reduction in vigour will cause substantial loss of diameter growth (Smith, 1962).

farm trials conducted in the Philippines have demonstrated this. The yields of rice and mungbean planted in alleys between lines of severely pruned multipurpose trees (*Gliricidia sepium*; *Acacia auriculiformis* and mangium) were comparable with those of the sole crop plot. However, at the age of 2 years, the total biomass of the pruned trees was 34% lower than that of unpruned trees (Miah, 1993). In a hedgerow agroforestry system with gmelina planted at 1 x 6 m, the grain yield of rice in association with severely pruned trees increased by three-fold over the yield in the unpruned treatment, but pruned trees had a significantly smaller stem diameter (7.38 cm) than unpruned trees (9.83 cm) (Gonzal, 1994). Intercrop yield increases as a result of reduced shading may not compensate for the reduced tree growth and increasing labour costs, as trees grow taller, of heavy pruning. This is manifested in farmers' recent shift in preferred timber species as reported in this study. When asked about pruning, growers of mahogany (n = 53) and bagras (n = 32) reported that these species are not pruned as heavily nor as frequently as gmelina, saving considerable labour time. They cited the narrow crown and smaller branches of mahogany and the straight bole and self-pruning habit of bagras as the most significant advantages over gmelina.

Moreover, pruning does not increase the value of timber currently produced in Claveria. Most of the gmelina growers (78%) believe that the price of pruned timber will not be higher than the price of un-pruned trees. However, even if a premium is not paid for quality timber, farmers consider pruning as beneficial for two reasons: i) pruned trees are easier to sell, as traders select trees which are straight, and; ii) because of improved stem form, pruned trees have more board feet of saleable timber and thus provides higher returns to the farmer. These indicates that instead of trying to maximize profit by producing quality timber, farmers aim to producing trees which are "good enough" for the market while satisfying the need to reduce competition with intercrops.

In contrast to intensive weeding and pruning, thinning of closely spaced timber plantations is seldom practiced in smallholder farm forestry in the Philippines. Even if all farmers with trees in block arrangement (n = 18) expressed dissatisfaction with the growth of trees in blocks and recognized that trees grow larger diameters when given more space, none had thinned their woodlots (nor had planned to do it). The reasons were because of reported time constraint (60%), lack of experience (40%) and reluctance to cut immature trees (35%). As most farmers are not familiar with this forestry practice there is a need for farm forestry extension programs to demonstrate them the economic benefits derived from thinning.

Other uses of timber trees

Tree wood fuel is still the most important source of energy for most farm families in Claveria. Only 12% of the respondents interviewed (n = 139) use a gas stove daily. In spite of this, fast-growing trees are primarily planted to produce timber for household use and for the market (see **Table 3.1.16**) and therefore wood fuel from timber trees is regarded just as a by-product. The majority of the farmers from Cluster I and II reported that firewood has become more available now as a result of widespread tree planting **(Table 3.1.13)**. Branches of fruit and timber trees planted on-farms are main the sources of wood fuel, although naturally regenerating trees growing on fallow lands, creeks and river banks are also used if available. In Cluster III, however, where timber tree planting was less important, wood fuel is scarce. In these villages, other fuels of lower quality, such as maize cobs or sunflower (*Tithonia diversifolia*) stakes are commonly used. Widespread use of alternative wood fuels is manifested by the fact that just 4% of the respondents purchase fuel wood regularly.

Table 3.1.13: Changes in wood fuel availability in Claveria, Misamis Oriental.

	% of households reporting from			
	Cluster I (n = 38)	Cluster II (n = 39)	Cluster III (n = 32)	Cluster IV (n = 30)
More available	92	74	0	47
More scarce	8	26	97	40
No change	0	0	3	13

In spite of recent widespread tree planting, all interviewees responded that building poles and small-sized diameter logs are scarcer. Consequently, 43% of the farmers have had to purchase building poles and 15% had to re-use wood planks and posts from their old family house (usually built with hardwood from the premium timbers once growing in Claveria) **(Table 3.1.14)**. However, as the lack of thinning in smallholder plantations demonstrates, local demand and trade of building poles and posts is not large and a majority of farmers satisfy their needs of building poles and posts from trees growing on their farms or natural regeneration.

Table 3.1.14: Sources of building poles in Claveria, Misamis Oriental.

	% of farmers reporting	# respondents reporting
Own farm	40	55
Bought from neighbours	26	36
Bought in local market	17	24
Collected from old family house	15	21
Collected off-farm (creeks, natural growth on forests)	11	15
Given by neighbours or relatives	4	5
TOTAL		156

Some respondents may have reported more than one source of building poles.

Timber harvesting and marketing

Farmers usually sell their trees on stumpage (i.e., standing), either to middlemen or directly to the owners of the mini-sawmills located at the coastal towns. In the late 1980s and early 1990s, the stumpage price of gmelina timber ranged from Ph P 7 to 9 bdft^{-1} (board foot). However, in the mid 1990s timber price experienced a drastic decline and it has now stabilized at an average Ph P 4 bd. ft^{-1}. Although there is not a market information system in Claveria, tree planters have a good understanding of the reasons for the current low price of gmelina timber **(Table 3.1.15)**. Farmers reported that the market is likely to be saturated as plantation stocks rapidly increased when prices were high. In addition, lower demand and low timber quality are also contributing factors. Although some farmers indicated market control by exploitative middlemen as the reason for the current low timber price, there is no substantive evidence of a timber cartel since good market access and the existence of many buyers (just in the province of Misamis Oriental there are 135 mini-sawmills processing farm-grown timber) make trade of farm-grown timber fairly competitive.

Table 3.1.15: Reasons for the price decline of *Gmelina arborea* timber.

Reasons	Count (n = 96)	% of respondents
Oversupply	46	48
Do not know	19	20
Low demand*	14	15
Low quality**	14	14
Price controlled by middlemen	3	3
Total	96	100

*Low demand may be due to low quality and/or substitution by alternative products.

**Most farmers mentioned that *Gmelina arborea* timber bends easily after sawing.

In Claveria there is not active cooperative or local organization engaged in timber marketing. This is unfortunate as some farmers reported that the price of round timber at mill gate is over 50% higher than the current average stumpage price of Ph P 4 bd ft^{-1}. As Anyonge and Roshetko (2003) indicated, tree growers would certainly benefit from the development of cooperatives and farmer groups that enhance economies of scale of timber production on smallholdings by facilitating the marketing of farm-grown timber.

<u>Future plans with regards to timber tree planting</u>

In spite of the recent decline in the price of timber, interest in farm forestry is still high among smallholder farmers in Claveria. When asked about their future intentions regarding timber tree planting, 55% of the respondents (n = 112) are planning to plant timber trees. Of these, 59% were non-planters and thus farm forestry is new to them. The remaining 41% were already adopters who would like to expand their existing plantations.

There has been a change in farmers' preferred timber species. Of those interested in future planting, 52% chose mahogany, 32% bagras and only 16% would like to plant gmelina. From the respondents' point of view, mahogany and bagras have 3 advantages over gmelina: i) higher timber quality and market value; ii) less competition with understorey crops, thus allowing for longer periods of intercropping; iii) less labor demand for pruning because these specie do not branch profusely.

This shift in preferred tree specie for farm forestry indicates that the rate of on-farm planting of gmelina will slow down in the near future. However, as market demand is steady, gmelina will probably continue to be an important specie for farm forestry. Our

survey also indicates this, as fifty percent (50%) of gmelina planters (n = 73) reported that they will coppice their trees after harvest, 33% were undecided on what to do (since trees were still young) and only 17% planned to shift to other tree species, either fruit and/or timber. The fast growth of coppiced shoots and minimal labor demand for plantation establishment are the advantages of coppiced gmelina. stands cited by growers. Those farmers wanting to plant other tree species showed dissatisfaction with the competition effects of gmelina and low timber price.

3.1.3.2   Farmers' assessment of tree farming

<u>Farmers' perceived benefits from timber tree planting</u>

Why are smallholders in Claveria increasing the number and land area under timber trees? Responses indicate that timber trees are planted primarily for direct household use as building materials (timber and poles) **(Table 3.1.16)**. Without these tree resources on farms, materials for house construction would have to be purchased by paying with scarce cash. But timber trees are not only valued as a subsistence crop but as a market commodity as well. Capital accumulation (cash and savings) in the form of trees has been cited by a large number of farmers, indicating that timber markets are well established in the area. Trees are regarded as an insurance crop, providing farmers with cash for use in the case of emergencies or when extra amounts are needed (e.g., to pay school fees).

Although widespread planting of fast-growing timber trees has provided farmers with increasing supplies of wood fuel, firewood production is not among the most important objectives for planting trees. This also confirms the finding above that generally in Claveria fuelwood is not particularly scarce (see Table 3.1.13) as several other substitutes are commonly used. Therefore firewood produced by timber trees is considered as a by-product rather than the main product from timber trees.

The environmental benefits of timber trees are not less important than economic ones. Control of soil erosion, a problem affecting many farmers cultivating the sloping lands of Claveria (Stark, 2000), is the most cited environmental benefit derived from timber tree planting. Others include shade and shelter and environmental protection in general. Although in informal discussions tree planters recognized that soil conditions had improved after a fallow period with timber trees, few mentioned soil fertility improvement as one of the benefits derived from timber trees. Most of these respondents had planted mangium, a popular nitrogen-fixing timber tree, and indicated soil fertility enhancement as the most important advantage of this specie over other common timber trees.

Table 3.1.16: The benefits of timber tree resources on farms, Claveria, Misamis Oriental.

	Count (n = 87)	% of farmers reporting*
Construction materials	77	88
Erosion control	64	74
Cash	54	62
Savings	38	44
Fuelwood	33	38
Environmental protection	23	26
Better surroundings (fresh air, shade, beautification)	18	21
Improve soil fertility	10	12
Water conservation	10	12
Others (land demarcation, windbreak, fencing)	5	6
Total	323	

*Farmers could report more than one benefit derived from planting timber trees.

Planters and non-planters perceived constraints to timber tree cultivation

The lack of recognition of tree use rights is the most important deterrent to tree planting. All of the 27 tenants interviewed in this survey responded that the insecurity of land tenure associated to their status as tenants has prevented them from planting trees. In Claveria, tenants need the consent of the landlord to plant trees and even if sharing agreements between landlords and tenants to benefit from planted trees exists, most landlords are reluctant to allow tenants to plant trees unless it is decided by the landlord himself.

Other than the insecurity of tree use rights expressed by tenants, perceived risks and constraints to timber tree cultivation were explored in discussions with those farmer owners (tree planters, n = 20; and non-planters, n = 19) who indicated no interest in planting trees in the future. Not surprisingly, non-planters mentioned more factors preventing them from becoming tree farmers than tree planters **(Table 3.1.17)**. Tree competition with field crops is by far the most important impediment to tree farming. It was explicitly cited by a majority of experienced tree planters (60%), a large percentage of non-planters (21%), and implicitly mentioned by those farmers constrained by their small farm area (26% of non-planters and 15% of planters).

The long gestation period of tree crops is not by itself a major deterrent to timber tree planting. Only older farmers and few younger ones are discouraged to plant trees (whether for the first time or to expand their plantations) by long tree rotation periods. That long rotation period is not a constraint to tree cultivation except for older farmers is also supported by the abundance of mahogany on farms. Mahogany is usually harvested in rotations of 20 to 25 years and it is nowadays one of the most preferred timber species.

A more important impediment to tree cultivation is probably the lack of regular income from timber tree crops. During this survey, tree farmers have often cited regular cash income as one important advantage of fruit trees over timber trees. Income from the sale of fuelwood and poles from intermediate thinnings could make timber tree cultivation more attractive to farmers but unfortunately, as discussed in the previous section, demand for fuelwood and poles in Claveria is not high.

Eleven percent of the non-adopters observed that timber trees commonly planted in Claveria do not grow well in their farms. These are residents in villages located at higher altitudes. Their observation points to the need to promote species suited to the environmental conditions at higher altitudes as indicated already in this chapter.

Table 3.1.17: Constraints to timber tree planting as perceived by tree planters and non-planters.

	Constraint	Count	Non-planters (%)	Count	Tree planters (%)
1	Competition with field crops	4	21	12	60
2	Small farm area	5	26	3	15
3	Old age	3	16	3	15
4	Lack of regular income	3	16	2	10
5	Long rotation of tree crops	2	10	-	-
6	Poor tree growth	2	11	-	-
Total		19		20	

As it was realized during the survey that farmers' perceptions of risks and constraints to timber tree cultivation vary widely according to the tree specie planted, experienced tree growers were also asked about the factors that prevented them from planting a particular specie **(Table 3.1.18)**.

Competition with field crops is, by far, the most important constraint perceived by planters of gmelina. However, it is not a deterrent to the cultivation of mahogany and

bagras. Second to this, low market demand and price fluctuations discourage further planting of gmelina. That 27 % of the respondents do not feel any constraint to gmelina growing indicates that farmers have been able to overcome competition with field crops either by planting in other farm niches (e.g., farm boundaries) or by tree management (pruning).

Interestingly, none of the gmelina growers mentioned pruning labour as a major constraint of this specie. As reported above, in Claveria intercropping gmelina requires frequent and intensive pruning (typically once or even twice a year during the first 3 years) in order to reduce shading of intercrops and to avoid forking. That farmers recognized lower pruning requirement as a desirable characteristic of bagras and mahogany over gmelina is an indication of farmers' perception of pruning as a labour-demanding activity. Since trees can be planted in other farm niches (e.g., farm boundaries) or arrangements (e.g, blocks) which require neither frequent nor intensive branch pruning, high pruning labour requirement is probably considered just a disadvantage of intercropping rather than an impediment to tree planting.

Marketing constraints do not reflect a lack of demand of gmelina timber but its current low price and farmers' difficulty in selling their trees to sawmills because of oversupply of low quality trees. No major problems are expected for the marketing of mahogany and bagras because of the high demand and limited supply and the high price of these quality timbers.

Except for the susceptibility to attacks of shoot borers (*Hypsipyla* spp., Lepidoptera, Pyralidae), tree growers do not feel any other major constraint preventing them from planting mahogany. Similarly, attacks of the stem borer *Agrilus sexsignatus* Fisher (Coleoptera: Buprestidae) on bagras*,* together with farmers' difficulty in collecting and handling its very small seeds are the major impediments to cultivation of this specie.

Summarizing, farmers' perceived constraints explain the recent shift about preferred species for on-farm planting. Lesser competition with intercrops and expected higher demand and price are the main advantages of mahogany and bagras over gmelina.

Table 3.1.18: Tree growers' perceived constraints to cultivation of common timber species.

	% of farmers reporting		
	G. arborea	*S. macrophylla*	*E. deglupta*
Competition with crops	45	3	0
None	27	70	41
Lack of marketing opportunities	18	0	0
Instability of log prices	5	0	0
Pest and diseases	4	20	18
Unavailability of seeds/planting materials	2	0	29
Fire	0	0	12
Others (damage by stray animals, drought)	0	7	0
TOTAL No. of respondents	56	30	17

Farmers' observation of tree-crop competition

Tree planters and non-planters alike are well aware of competition between trees and crops when planted in association. All maize farmers interviewed have observed poorer crop performance, i.e., reduced plant height, smaller cobs and lower grain yield, next to tall timber trees. Although the number of maize rows affected by competition depends on tree height and the distance between tree lines, 38% of farmers with boundary plantings (n = 63) mentioned that when trees are tall (i.e., at least twice the height of mature maize) competition effects are noticeable as far as 5 to 7 meters, and between three to five rows of maize exhibited signs of much poorer crop performance. In previous surveys conducted in Claveria, planters of gmelina in block arrangement (2 x 3 m) reported that they were able to plant maize twice a year during 2 years in the 3-meter wide alleys (Mamicpic et al., 1998). Assuming that this typically fast-growing tree grows 2 meters in height per year, farmers would likely have to severely prune their trees during the second year if crops were interplanted.

Tree growers were also asked whether they could predict for how long intercropping would be viable if trees were planted at much wider spacing (9 - 10 m). Since timber tree growing is relatively new for many farmers in Claveria, the majority (65%) were hesitant and had difficulty to suggest a period of intercropping. Only twenty one percent of the respondents mentioned a total period of no more than 4 years (2 additional years to the intercropping period between trees planted in blocks), and the rest suggested 4 to 5 years. Although profitability was not discussed in this survey, in

view of farmers' difficulty to assess the intercropping period between widely-spaced trees, they would be unlikely to correctly predict net profit over the tree rotation period (Midmore et al., 2001). Tree farmers will therefore benefit from further research aiming to provide this information.

Farmers' strategies to reduce tree crop competition

Given the widespread adoption of agroforestry in Claveria and the substantial number of farmers who did not see any problem in planting timber trees on their farms, one can conclude that tree-crop competition is not an impediment to tree planting but a constraint which tree planters are able to overcome in one way or another. Consequently, tree farmers were also asked about the methods and strategies to reduce the competitive effects of timber trees on intercrops.

As many adopters of the increasingly popular NVS technology apply up to 2 more times more fertilizer on upper alley crop rows to overcome scouring effects and competition from strip species, and as many of these farmers are tree planters as well (Stark, 2000), we were expecting, at least among the NVS adopters interviewed, the use of a similar practice to reduce nutrient competition between trees and crops. However, no one mentioned a biased application of fertilizer on crop rows closer to the tree lines. Instead, most farmers practicing intercropping (72 %, n = 66) plough close to the tree rows during regular land preparation and interrow cultivation to control the spreading of the root system in the alley crops. Respondents also mentioned that this is also a good method to control weeds and thus, enhance tree growth. In addition, as indicated above, the majority of the respondents practice severe tree branch pruning to reduce shading of intercrops.

Although severing the lateral roots of trees and intensive branch pruning are, to some extent, effective methods to reduce tree-crop competition, farmers recognized in informal discussions that these practices are detrimental to tree growth. Almost half of those farmers practicing intercropping alleged that lateral root pruning reduces height and diameter growth, whereas 75% indicated that if frequently practiced, trees may become weak and prone to wind damage. This practice could be even more damaging for trees in the middle rows of intercropping systems as ploughing, and therefore root pruning, is done on both sides of the tree row. Also, almost two thirds of the respondents understood that reduced photosynthetic capacity as a result of frequent heavy branch pruning was detrimental to diameter growth. Moreover, it is not clear to

the farmers whether gains in crop yield will compensate the cost of pruning labour and the loss in timber yield.

Besides the practice of tree root and branch pruning, farmers mentioned three other broad strategies to overcome tree-crop competition. First, shifting to less competitive timber species, such as bagras, was seen by 55% of the gmelina growers as more advantageous than increasing the intensity of root and branch pruning. Secondly, planting timber trees in farm niches other than cropland (e.g., farm boundaries or very steep areas) was suggested by 27% of the gmelina planters. Lastly, 18% of farmers with tree blocks recommended reducing tree density and increasing the distance between tree rows to 6 to 8 m.

Planting less competitive timber species on hedgerows at wider spacing plus frequent, but moderate pruning may prove to be a management option superior to severe root and branch pruning. On the one hand, trees planted on widely-spaced hedgerows will grow faster and with larger diameters. Invariably, when asked to indicate the difference of growing trees on lines or in blocks, respondents to this survey recognized this. Moreover, all farmers surveyed with trees planted in woodlots manifested dissatisfaction with the growth of trees at too close spacing. A more favourable light regime by planting trees at wider distance will certainly benefit crop growth and prolong the period of intercropping. Although in this study the number of farmers opting for wider spacing is not large, as many as 76% of tree growers interviewed in a previous survey in Claveria recommended future planting of gmelina at 3 x 4 m (834 trees ha^{-1}), and some of the respondents indicated a much wider spacing of 5 x 5 m (400 trees ha^{-1}) (Magcale-Macandog et al., 1997). These recommendations show farmers' substantial knowledge about tree cultivation and provide a base for future research on the improved management of tree farming systems.

Other major constraints to tree farming

Lack of germplasm (seed, seedlings and other planting materials) from a wider list of tree species suited to the diverse environmental and socio-economic conditions of upland farmers is one the most important constraint to widespread adoption of tree farming. Currently, centralized group nurseries organized by development and research projects are the major source of germplasm of new tree species in Claveria. But for those trees that have been widely-planted, farmer-led seed collection and propagation activities are becoming increasingly important for the diffusion of tree germplasm and the adoption of tree farming systems. Farmers who have never

established an individual nursery reported that the lack of family labor to carry out labor-demanding nursery activities (e.g., pricking, weeding, root pruning) and the lack of capital for specific inputs, such as polyethylene bags, are the main constraints to individual nursery establishment. Planting trees by direct seeding or by using wildlings **(Table 3.1.3)** is a labor- and capital- saving strategy for these resource-constrained farmers. Since all owners of household nurseries interviewed had participated in the recent past in centralized community nursery activities, we also investigated their perceptions of the benefits and disadvantages of a collective approach to tree growing (group nurseries) as compared to raising trees in individual household nurseries.

For those with a household nursery, lack of labor was not an impediment to nursery establishment except for the high man-power required to store water, mentioned by 55% (n = 20) of respondents, as the majority of the farmers do not have water next to or within the household yard. Only 25% of respondents reported to have difficulties to carry out seedling maintenance activities, while the rest perceived that individuals could perform all labor-demanding nursery activities in a timely and efficient manner. Labor constraints for the production of seedlings are easily overcome by collective work on group nurseries. The main disadvantage reported by participants to group nurseries is the lack of a proper management and maintenance of seedlings due to the inadequate organisation and co-ordination of group activities.

Procurement of germplasm, high costs of seeds and other nursery materials (e.g., tools, polyethilene bags), and lack of information on sources of germplasm are perceived as constraints to the establishment of individual nurseries that could be easily overcome through group nurseries support. Interestingly though, seed source control is acknowledged as one of the benefits of individual nurseries. This shows farmers' awareness on the importance of the seed source to grow quality trees. The inappropriate seed procurement practices (as reported in section 3.1.3.1) probably reflect the lack of adequate information on proper collection practices.

Difficulties to protect seedlings from stray animals and seedling damage was experienced by 65% of the respondents with individual nurseries, indicating that the household courtyard may be an unsuitable location for a nursery. However, farmers' admitted that the danger of seedling damage by stray animals do not exist in community nurseries as group work results in a well-fenced and protected nursery.

Seven (7) respondents (35%) mentioned pest and diseases as an important constraint to tree propagation. These respondents referred exclusively to damping-off disease causing high mortality of small bagras seedlings. Aside from this, no other pest or

diseases seems to be a serious threat to the propagation of common tree species in the area.

Farmers value the opportunity provided by individual nurseries to sell seedlings and to grow and experiment with new tree species that may have high demand. The fact that 3 out of the 20 farmers with individual nurseries reported to have sold seedlings of fruit and timber trees to other farmers may indicate a growing demand for quality tree seedlings. As agroforestry practices become more popular, markets for quality germplasm will probably develop at the local level. The commercialisation and diffusion of quality germplasm among farmers will be crucial for large-scale adoption of agroforestry systems.

Learning and exchange of ideas are also important reasons for farmers to join a group nursery. These centralized nurseries act as learning centres where farmers interact and experience tree propagation and management. In many instances, nurseries have also become a meeting point where locals discuss other problems affecting the community. Lastly, the enjoyment of community work and social capital development must not be disregarded as one of the advantages of community nurseries.

Table 3.1.19: Farmers' perceived benefits and constraints of individual and group nurseries (n = 20).

Nursery type	Advantages	Disadvantages
Individual	• Better management and maintenance • Controlled source of seeds • Freedom to sell seedlings • No limitation in the number of seedlings	• Difficult procurement of germplasm (lack of information on sources and high costs) • Costs of tools and materials • More accessible to stray animals
Group	• Learning and exchange of ideas • Procurement of germplasm • Procurement of tools and materials (e.g., polyethilene bags) • Better nursery infrastructure (no access to stray animals) • More fun (enjoyable)	• Lack of proper co-ordination and/or participation in the management and maintenance

Although not explicitly mentioned by respondents to this survey, existing policy restrictions[40] about harvesting and transportation of planted trees and farmers' lack of knowledge and poor understanding about these regulations, may pose as a major constraint to tree cultivation. When asked about their knowledge on tree harvesting regulations, over 50% of the respondents did not know whether a permit is required or not. The rest (45%) are aware of the need to secure a permit for harvesting farm-grown trees. However, there was a lot of confusion about the government authority that must issue the permit, and the sort of permit required. Eighty percent (80%) of them mentioned that the permit must be issued by the village chief (Barangay Captain) and consists of a verbal authorization if harvested trees are for household use. If harvested trees are for sale the permit would cost Ph P 10 to 40 depending on the number of trees cut. The other 20% cited that the cutting permit has to be obtained from the office of the DENR or both. These introduced "barriers" to tree harvesting at the village level are probably a deterrent to widespread timber tree cultivation as farmers may opt for planting fruit trees or crops which do not require any harvesting fee. Moreover, further timber tree planting may be prevented by lower timber prices due to increasing transaction costs imposed on buyers and traders by the existing restrictions to tree harvesting and transportation.

3.1.4   Conclusions and recommendations

In Claveria, timber trees are becoming increasingly important components of agroforestry land use systems. Many smallholders spontaneously raise, plant and manage on farms a variety of exotic and native timbers for their own use and/or the market. Tree planters posses substantial knowledge about timber trees and how to cultivate them. They commonly practice intercropping between newly planted trees as a strategy that saves labour, enhance tree growth, and provides higher returns to the farmer.

Besides the lack of tree species suited to the different environmental conditions found in Claveria, tree planters and non-planters alike identified tree competition with field crops as the most important constraint to timber tree planting. Farmers have observed that crop yields can be severely reduced as far as five to seven meters from a row of fast-growing timber trees, and have reported short periods of intercropping when trees

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[40] When this survey was conducted, a harvest and transportation permit was still required for planted trees. But according to DENR Memorandum Circular 99-20, with regards to the harvesting of planted trees within titled and tax declared A & D lands, cutting and transport permit are no longer required. However, far from deregulation, farmers still have to go through a maze of registrations and permits to legally harvest and transport their trees.

are planted at close spacing. Nevertheless, tree-crop competition is not an impediment to tree farming as farmers have developed methods to control and reduce it. Severing tree roots spreading into the cropped alley by ploughing close to tree rows and frequent and severe tree branch pruning are commonly practiced to reduce below- and above- ground competition and prolong the period of intercropping. However, research studies and farmers themselves have recognized that tree root and branch pruning are detrimental to tree growth and it is uncertain whether increased crop yields as a result can compensate reduced growth.

The period of intercropping depends on the characteristics of the tree and crop specie used, tree inter-row distance and management of trees and alley crops. In addition to planting less competitive tree species, increasing alley width (i.e., the distance between tree rows), to provide intercrops with a more favourable light regime, can be one option to extending the intercropping period without severely reducing the growth of trees. Planting trees at wider distance will also provide higher economic returns to the farmer because of the faster tree growth, lower tree establishment and management costs and increased area devoted to crops. Tree farmers will therefore benefit from further research aiming to assess the viability of intercropping between widely-spaced tree hedgerows and the net returns over the entire tree rotation period.

The findings reported in this study also highlight the need of agroforestry extension programs to address three broader issues. First, the lack of quality germplasm of a wider list of tree species in general, and timber trees in particular, suited to farmers socio-economic and environmental conditions. If germplasm is made available, farmers have already proven to be active and successful tree growers. Secondly, there is a need to demonstrate to farmers the advantages of using quality germplasm and improved tree management practices, specially thinning. This can be addressed by a combination of on-farm trials with active involvement of farmers in design and management and more training. Thirdly, there is an urgent need of dialog with government agencies to lift existing policy regulations that prevent the establishment and use of tree resources on farms.

3.1.5   References

ADB (1994): Forestry sector study of the Philippines. Manila, The Philippines: Asian Development Bank.

Anyonge, C. H. and Roshetko, J. M. (2003): Farm-level timber production: orienting farmers towards the market. Unasylva 212 (54): 48-56.

Coe, R. (1996): Sample size determination in farmer surveys. (Unpublished). Nairobi, Kenya, ICRAF.

Dawson, I. and Were, J. (1997): Collecting germplasm from trees- some guidelines. Agroforestry Today 9: 6-9.

DENR (1990): Master Plan for Forestry Development. Quezon City, Philippines: DENR.

Dove, M. R. (1992): Foresters' beliefs about farmers: a priority for social science research in social forestry. Agroforestry Systems (17): 13-41.

DTI and PKII Engineers (1996): General land use plan. Municipality of Claveria. Cagayan de Oro, Philippines: Department of Trade and Industry (DTI)-Region 10.

Fujisaka, S., Jayson, E. and Dapusala, A. (1994): Trees, grasses, and weeds: species choices in farmer-developed countour hedgerows. Agroforestry Systems 25: 13-22.

Gajaseni, J. (1992): Socioeconomic Aspects of Taungya. In: C. Jordan, F., Gajaseni, J. and Watanabe, H. (eds.): Taungya: Forest Plantations with Agriculture in Southeast Asia. Wallingford, UK: CAB International: 18-31.

Garrity, D. P. (1994): Improved Agroforestry Technologies for Conservation Farming: Pathways Toward Sustainability. Paper presented at the 'International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Challenges, Opportunities and Prospects', 20-26 November 1994, Manila, Philippines.

Garrity, D. P. and Agustin, P. C. (1995): Historical land use evolution in a tropical acid upland agroecosystem. Agriculture, Ecosystems and Environment 53: 83-95.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

Garrity, D. P., Mercado, A. R. and Stark, M. (1998): Building the smallholder into successful natural resource management at the watershed scale. In: de Vries, P., Frits, W., Agus, F. and Kerr, J.(eds.): Soil erosion at multiple scales: principles and methods for assessing causes and impacts. CABI and IBSRAM: 73-82.

Gomez, A. A., Kelly, D. E. S. and Baril, M. T. A. (eds.) (1998): Catalogue of Conservation Practices for Agriculture on Sloping Land. Los Baños, Laguna, Philippines: SEAMEO SEARCA.

Gonzal, D. R. (1994): Gmelina arborea-Annual Crop Interactions in Contour Hedgerow Systems for Smallholder Farm Forestry. PhD dissertation, University of the Philippines, Los Baños, Laguna, Philippines.

Hardwood, C. (1997): Domestication of Australian tree species for agroforestry. In: Roshetko, J. M. and Evans, D. O. (eds.): Domestication of Agroforestry Trees in Southeast Asia. Proceedings of a Regional Workshop held in Yogyakarta, Indonesia, November 4-7, 1997. *Forest, Farm, and Community Tree Research Reports Special Issue*: Taiwan Forestry Research Institute and Council Agriculture, Taiwan, Republic of China; Winrock International, Morrilton, Arkansas, USA; and International Centre for Research in Agroforestry, Nairobi, Kenya: 64-72.

Kenmore, Z. F. and Flinn, J. C. (1987): An ethnohistory of an upland area: Claveria, Misamis Oriental. Manila, Philippines: International Rice Research Institute (IRRI).

Koffa, S. N. and Roshetko, J. M. (1997): Farmer-managed germplasm production-diffusion pathways in Lantapan, Philippines. In: Roshetko, J. M. and Evans, D. O. (eds.): Domestication of Agroforestry Trees in Southeast Asia. Proceedings of a Regional Workshop held in Yogyakarta, Indonesia, November 4-7, 1997. *Forest, Farm, and Community Tree Research Reports Special Issue*: Taiwan Forestry Research Institute and Council Agriculture, Taiwan,

Republic of China; Winrock International, Morrilton, Arkansas, USA; and International Centre for Research in Agroforestry, Nairobi, Kenya: 142-150.

Lawrence, A. (1997): Tree domestication in Leyte and Bohol, Philippines: the farmers' perspective. In: Roshetko, J. M. and Evans, D. O. (eds.): Domestication of Agroforestry Trees in Southeast Asia. Proceedings of a Regional Workshop held in Yogyakarta, Indonesia, November 4-7, 1997. *Forest, Farm, and Community Tree Research Reports Special Issue*: Taiwan Forestry Research Institute and Council Agriculture, Taiwan, Republic of China; Winrock International, Morrilton, Arkansas, USA; and International Centre for Research in Agroforestry, Nairobi, Kenya: 133-137.

Lowery, R. F., Lambeth, C., Endo, M. and Cane, M. (1993): Vegetation management in tropical forest plantations. Canadian Journal of Forestry Research 23: 2006-2014.

Magbanua, R. D. and Garrity, D. P. (1988): Acid upland agroecosystems: a microlevel analysis of the Claveria research site. In: Proceedings of the 1988 Acid Upland Research Design Workshop. Los Baños, Philippines: International Rice Research Institute (IRRI): 1-20.

Magcale-Macandog, D., Menz, K., Rocamora, P. M. and Predo, C. (1997): Smallholder Timber Production and Marketing: The Case of Gmelina arborea in Claveria, Northern Mindanao, Philippines. Imperata Project Paper 1997/9. University of the Philippines, Los Baños, Laguna, Philippines: The SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA).

Magcale-Macandog, D. B. and Rocamora, P. M. (1997): A Cost-Benefit Analysis of Gmelina Hedgerow Improved Fallow System in Claveria, Northern Mindanao, Philippines. Paper presented at the International Workshop on "Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia", 23-27 June, 1997. Bogor, Indonesia: ICRAF.

Mamicpic, M. A. E., Tinsley, R. L. and Magcale-Macandong, D. B. (1998): Natural Vegetation Strips (NVS) and Gmelina Cropping Systems. Imperata Project Paper 1998/1. University of the Philippines, Los Baños, Laguna, Philippines: The SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA).

Miah, M. D. G. (1993): Performance of Selected Multipurpose Tree Species and Field Crops Grown in Association As Affected by Tree Branch Pruning. PhD dissertation, Central Luzon State University, Muñoz, Nueva Ecija, Philippines.

Microsoft Corporation (2000): Microsoft Excel version 9.0.

Midmore, D. J., Nissen, T. M. and Poudel, D. D. (2001): Making a Living Out of Agriculture: Some Reflections on Vegetable Production Systems in the Manupali Watershed. In: Coxhead, I. and Buenavista, G. (eds.): Seeking sustainabililty: challenges of agricultural development and environmental management in a Philippine watershed. Los Baños, Laguna, Philippines: PCARRD: 94-111.

Nelson, R. A., Cramb, R. A. and Mamicpic, M. A. (1996): Costs and returns of hedgerow intercropping and open-field maize farming in the Philippine uplands. Working paper No. 11. University of the Philippines, Los Baños, Laguna, Philippines: SEAMEO Regional Center for Graduate Study and Research in Agriculture and Universtiy of Queensland.

Ngugi, M. R., Garrity, D. P. and Koffa, S. N. (1999): Niche Analysis and Matching of Climatically Suitable Sites of Six Agroforestry Tree Species Commonly Used in the Philippines. Lantapan, Philippines: International Center for Research in Agroforestry (ICRAF). 76 p.

Ngugi, M. R., Koffa, S. N. and Garrity, D. P. (undated): A Guide for Agroforestry Tree Species Selection for Landcare. Lantapan, Bukidnon, Philippines: International Center for Research in Agroforestry (ICRAF). 26 p.

Nichols, P. (1991): Social survey methods: a fieldguide for development workers. Oxford, UK: Oxfam.

Pascicolan, P. N., Calub, A. and Sajise, P. E. (1996): The Dynamics of Grassland Transformation in Salindingan, Ilagan, Isabela, Philippines. Imperata Project Paper 1996/10. University of the Philippines, Los Baños, Laguna, Philippines: The SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), Center for Agro-Socioeconomic Research (CASER) and Australian Centre for International Agricultural Research (ACIAR).

Pascicolan, P. N. (1996): Tree Growing on Different Grounds: an Analysis of Local Participation in Contract Reforestation in the Philippines. PhD dissertation. Leiden Universtity, Centre for Environmental Science. The Netherlands.

Pascicolan, P. N., de Haes, H. A. U. and Sajise, P E. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forest Ecology and Management (99): 261-274.

Provincial Capitol (1997): 1996 Provincial socio-economic profile of Misamis Oriental. Cagayan de Oro City, Philippines: Provincial Capitol.

Smith, D. M. (1962): The Practice of Silviculture. Seventh Edition. New York, USA: John Wiley & Sons Inc.

Stark, M. (2000): Soil Management Strategies to Sustain Continous Crop Production between Vegetative Contour Strips on Humid Tropical Hillsides. Technology development and dissemination based on farmers' adaptive field experimentation in the Philippines. International Centre for Research in Agroforestry (ICRAF). Southeast Asia Regional Research Programme.

Zita, M., Toribio, B. and Orno, J. L. (1996): The indigenous agroforestry production system of the Ifugao. In: Sajise, P. E., Briones, N. D., Dakila-Bergonia, A., Butardo, M. Z., Duma, J. and Orno, J (eds.): Environmentally sustainable rural and agricultural development strategies in the Philippines. Lessons from Six Case Studies. College, Los Baños, Laguna, Philippines: SEAMEO-SEARCA: 43-61.

3.2   Factors influencing smallholder farmers to plant timber trees in Claveria, Northern Mindanao, Philippines

Abstract

In the Philippines, incentive schemes to encourage farmers' participation in reforestation activities have not been able to draw a genuine interest on tree planting. Consequently, most plantations have been abandoned once payments and compensation were terminated. The failure of subsidy-driven reforestation and, by contrast, the success of spontaneous tree growing on farms suggests that farmers' involvement in tree planting is mediated by the individuals' unique land, labour and capital endowment and socio-cultural conditions and skills. This study was set to investigate the specific factors influencing upland farmers to plant timber trees in Claveria, Misamis Oriental, Philippines. The research was undertaken in support of project activities aiming at scaling-up conservation farming and agroforestry innovations through farmer-led organisations in northern and central Mindanao. The study consisted of an in-depth survey of timber tree planters (adopters) and non-planters (non-adopters) from 12 villages of Claveria, and an inventory of timber trees on farms. Then, using logistic regression techniques a household-level and a farm-level model were specified to determine household's socio-economic and farm's biophysical characteristics influencing farmers' decisions to plant timber trees. Although with some limitations, given the fact that a confounding effect was probably introduced in the model by the large number of farmers classified as "non-adopters" of timber trees who were actually planters of other type of trees (fruit trees), the study provides evidence of several factors stimulating timber tree planting. Logit models showed that the village where the respondent resides and farms is the factor more strongly associated to tree planting, with the likelihood of adoption decreasing with increasing altitude. The differential rates of adoption between farmers from villages at low altitudes and those in villages at higher altitudes is explained in terms of the varying climatic and agro-ecological conditions along the altitudinal gradient. The study also suggests that small farm size is not a deterrent to tree planting, as the number of planted timber trees per unit of land increases as farm size decreases. However, this does not imply that larger farmers do not plant timber trees. In fact, larger farmers have planted more trees, in absolute numbers, than owners of smaller farms. Therefore in Claveria, both large-scale and small-scale landowners are likely to plant trees, with higher tree densities taking place on smaller farms. The availability of off-farm income is not by itself a determinant of tree farming. Off-farm income appears to be an incentive to increasing tree planting when the allocation of farm family labour

to work off-farm limits investments on labour-demanding farm enterprises, such as annual cropping, and thus favours low labour-demanding activities such as tree planting. Draft animal owning seems to have some effect on tree planting behaviour as farmers with higher animal-to-land ratio were more likely to plant timber trees. This is probably because draft animals are an effective substitute for man labour during labour-demanding tree establishment activities critical to successful tree growing, such as site preparation and weed control. Therefore, using draft animal for land tillage is an effective way to put degraded grasslands under more intensive agroforestry land use systems. Other factors positively related to adoption are the location of the farm in relation to the nearest all-weather road, with increasing tree planting as the distance to the road decreases, and farmers' age, as younger farmers see tree farming as a long-term enterprise to accumulate capital and are more likely to be actively involved in village organisations in support of tree planting-related activities. The considerable tree planting and conservation undergoing in many upland areas of the Philippines, particularly in Claveria, and some of the counterintuitive results of this study indicate that it is necessary to question general assumptions about farmers' attitudes and practices with regard to trees. A thorough understanding of how farmers use their land, labour and capital resources to make decisions about whether to invest in agroforestry or another available alternative would help extension agents to better support and promote tree planting technologies appropriate to the diverse environmental and socio-economic conditions of upland farmers.

3.2.1 Introduction

For the past three decades, the Philippine uplands have been the target of numerous reforestation programs aiming to protect upper watersheds, rehabilitate degraded land and arrest rural poverty by creating forestry-based livelihood opportunities. Rural people's participation has been recognized as crucial to the success of this endeavour. Therefore, reforestation initiatives included incentive schemes to encourage farmers' participation in tree planting, management and conservation. Common incentives consisted of payments to local people as labourers for plantation establishment, compensation in the form of "food for work" schemes, the provision of loans, free seedlings and training. Unfortunately, these incentives were not able to draw in farmers a genuine interest on reforestation and most plantations were abandoned once payments were terminated (Pascicolan et al., 1997; Bagadion, 2000; Utting, 2000).

Subsidy-driven reforestation has implicitly assumed economic benefits as the sole and most important motivation inducing farmers to plant trees. Although profitability is

one purpose shared by a majority, it is not necessarily a determinant of tree planting (Current and Scherr, 1995). The failure of subsidy-driven reforestation and the success of spontaneous tree growing on farms suggest that the goal of profitable tree production is in itself mediated by other objectives. Whether farmers will undertake or not tree planting as a strategy to achieve their goals and objectives is greatly influenced by the individuals' unique land, labour and capital endowment, socio-cultural conditions and skills (Scherr, 1997).

An examination of previous studies conducted in different countries provides indication of what factors influence smallholders' decisions to plant trees and how these interact. Factors related to land resources are among the most important determinants of adoption of agricultural innovations in general and tree planting in particular. Among them, security of land tenure has been often cited as a requirement since land ownership gives farmers complete control and rights[41] over the land and tree resources. However, as Arnold (1997) concluded in his review of tree growing on-farms, "the occurrence of privately planted trees in a wide variety of tenurial contexts indicates that such generalizations are not always accurate" (p. 274). Tree planting may occur for example in situations where farmers are simply given use rights, as described by Dewees (1992).

Farm size is another important land-related factor influencing tree growing. In the context of subsistence farming, one may expect a large portion of smaller farms planted to staple crops, whereas farmers with larger landholdings may be able to devote some land for tree planting without the risk of interfering with food crops. Caveness and Kurtz (1993) found that owning several farm plots and thus larger farms contributes favourably to the adoption of agroforestry in Senegal. However, the inverse relationship between tree planting and farm size may be true when "tree density" (trees ha^{-1}), rather than "number of trees", becomes the indicator of adoption. For example in Java (Indonesia), Filius (1997) could not establish a clear relationship between farm size and tree planting as average tree densities on farms smaller and larger than 0.5 ha were similar.

The availability of family labour may motivate farmers to plant trees in different ways. In Kenya and Costa Rica labour-constrained farmers operating larger landholdings

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[41] According to Schlager and Ostrom (1992) as cited by Meinzen-Dick and Knox (1999) property rights in relation to natural resources can be classified as: i) Use Rights, including *access* (right to enter the resource domain) and *withdrawal* (right to take something out) and; ii) Control Rights which include *management* (right to modify or transform the resource), *exclusion* (right to determine who else can use the resource) and *alienation* (the ability to transfer all rights to others).

are more likely to plant low labour-demanding tree crops (Dewees, 1991; Scherr, 1992; Thacher et al., 1996/97), whereas in Senegal, larger farms and more labour availability contribute to perceived security and increased willingness to accept the risk of agroforestry adoption (Caveness and Kurtz, 1993). Generally, tree farming systems are considered as less labour-demanding than annual cropping and therefore, a shortage of family labour usually motivates farmers to plant tree crops.

Farmers may also expand the area occupied by tree crops if cash is available to them, either in the form of credit (Hyman, 1983), or from off-farm sources (e.g., remittances). Moreover, when family labour is engaged in off-farm employment, farmers are more likely to invest in tree planting as a low-labour land use strategy (Dewees, 1992; Godoy, 1992; Thacher et al., 1996/97). Farmers' wealth status have been found to increase the likelihood of adopting agroforestry in Orissa, Western India (Mahapatra and Mitchell, 2001), and to be a good predictor of farmer participation in social forestry in Java, Indonesia (Sunderlin, 1997). However, tree planting is not practiced only by wealthy farmers. In Zimbawe, Price and Campbell (1998) indicated that the wealth status of farmers made no difference to the density of trees planted and conserved in households.

Besides farmers' resources, several studies have also emphasized the influence on tree planting of individuals' personal characteristics such as gender (Adesina and Chianu, 2002); farmer's age (i.e., older farmers are more likely to plant trees because of low labour requirements) (Bannister and Nair, 2003; Dewees, 1992); educational level (Sunderlin, 1997); and, personal behaviour, like for example progressiveness (Mahapatra and Mitchell, 2001), or enterprising attitude and collective co-operation (Pascicolan et al., 1997).

Tree growing decisions are also affected by farm biophysical characteristics and other factors related to land productivity. Expansion of tree growing has been observed in response to declining soil productivity as a result of erosion and fertility depletion (Filius, 1997). On the other hand, increasing the productivity of staple crops have helped to reduce pressure on the land for subsistence food production and thus to increase the area occupied by tree crops (Caveness and Kurtz, 1993; Filius, 1997). The location of the farm in relation to the homestead and the road network are also factors that may influence tree planting on a particular farm parcel since proper access is a requirement for harvesting, loading and transporting heavy and bulky tree products. In Haiti, Bannister and Nair (2003) found that the tree density decreases as the distance from the residence to the field increases. And in Java, the success of the re-greening program was influenced by the road density and distance to the planting site (Soerianegara, 1994).

This study was set to investigate the specific factors influencing farmers to plant timber trees in Claveria, Misamis Oriental, Philippines. The research was undertaken to support the activities of a project funded by the Spanish Agency for International Cooperation (AECI) and implemented by the World Agroforestry Center (ICRAF) aiming at scaling-up conservation farming and agroforestry innovations through farmer-led organisations in northern and central Mindanao. The project supported the establishment of individual and group-based nurseries with germplasm of farmers' preferred fruit and timber tree species, and provided more than 3,000 farmers with training on soil conservation and agroforestry technologies. The characterisation of participants would allow project managers to discern between potential tree planters and non-planters and hence, improve targeting and efficiency of propagation and tree planting activities.

3.2.2   Materials and Methods

3.2.2.1   Description of the study site

History of settlement and land use

The study was conducted in Claveria, an upland municipality located 42 km north-east of Cagayan de Oro City, the capital of the province of Misamis Oriental in northern Mindanao, Philippines. The history of Claveria is similar to that of most upland municipalities of Mindanao. During the early part of the past century, Claveria was inhabited by the native Higao-non people who practiced swidden agriculture on a limited portion of the land. Since logging started in the early 1920s, population growth, estimated at a rate 8 to 9% a year during that period, was mostly due to inmigration (Kenmore and Flinn, 1987). Small-scale farmers, mainly from the Visayas, followed the logging operations into the area, in a process that characterized most of the upland ecosystems in the Philippines (Garrity and Agustin, 1995). Rapid population growth continued after the WWII and is still high today, with average annual rates of 4.6% for the period 1990-95. Today, the municipality of Claveria is composed of 24 villages (Barangays) with an estimated population of 41,109 inhabitants (Ford-SAFDZ, 2001).

Logging was a short-lived industry that ended in the late 1960s (Kenmore and Flinn, 1987). During the 1960s and 1970s extensive grassland areas resulting from deforestation were used for large-scale cattle ranching (Fujisaka et al., 1994). But change in land use systems accelerated dramatically since the late 1960s until late 1980s. The area of annual cropland doubled at the expense of grassland, and

perennial crops, especially coffee and other fruit trees, became an important component of the agro-ecosystem (Garrity and Agustin, 1995)[42]. During that period, *Paraserianthes falcataria* (falcata) was the most abundant farm-grown timber tree planted for shading coffee plantations. Unfortunately, falcata has almost dissapeared from Claveria's landscape after insurgents in the area burnt many plantations and the gall rust disease, caused by the fungus *Uromycladium tepperianum*, decimated remaining trees. Since large-scale tomato cultivation started in 1974, many coffee gardens have been removed to give way to tomato and vegetable growing. However, direct observation suggests that transition towards perennial-based systems continue as fruit and timber tree crops have become an attractive option for smallholder farmers.

Claveria is a large municipality covering 112,175 ha from which more than half (69,000 ha) is estimated to be classified as state forest land. However, a large portion of this is under some form of cultivation (DTI and PKII Engineers, 1996). Nowadays, primary forests are only found in the very steep slopes above 1,000 m in elevation (Magbanua and Garrity, 1988), and they continue to recede due to the practice of small-scale logging and slash-and-burn agriculture. Average farm size is 3.0 ha and farmers commonly cultivate two or more parcels of land (Magbanua and Garrity, 1988). Average household size is 5.6 persons (DTI and PKII Engineers, 1996). Owner cultivatorship is the dominant tenurial arrangement although tenancy and lease-holding are also common, particularly among small farms (0.2 to 1.2 ha). About 70% of farmers' household income is derived from crop sales. Other sources of income include the sale of livestock, hired farm labour and off-farm work (Magbanua and Garrity, 1988). Based on altitude, there are two crop production zones in the municipality: a) Lower Claveria (300 to 600 m a.s.l.) where the main crops are cassava (*Mahinot esculenta* Crantz) and traditional and improved varieties of upland rice (*Oryza sativa* L.) and maize (*Zea mays* L.); and b) Upper Claveria (600 to 900 m a.s.l), where tomato and other high-input vegetable cash crops are produced (Magbanua and Garrity, 1988). Presently, maize is the dominant crop. It is cultivated twice annually without crop rotation in Lower Claveria and once a year, after a tomato cropping, in Upper Claveria. Land cultivation is done using water buffalo or cow as draft animal.

A deep canyon formed by the Cabulig river divides Claveria into two zones: i) the southern arm of the watershed, composed of 18 villages, including the town of

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[42] This study did not cover the entire land area of Claveria but only 8 x 10 km^2. It is assumed that the data discussed can be extrapolated to the rest of the municipal land area.

Claveria, and; ii) the northern arm of the watershed (called Tabok district), which includes 6 villages. Both zones differ in important respects. The southern arm is closer to the city of Cagayan de Oro, enjoying better access to the city and among villages (higher road density), have higher population density, better government services and most of its land is classified as "alienable and disposable (A & D). By contrast, the northern arm is remote and more difficult to access (it can only be reached by a long, dirt-road), population density is low, government services are almost inexistent and a large portion is classified as "state forest land" (though most of it is deforested). As a result, land use in the southern arm of the watershed markedly differs from the northern part. Imperata grasslands still dominate in the north, as lower population pressure and high transportation costs have thus far limited the amount of land converted from shifting cultivation to vegetable farming or agroforestry. However, in the southern part the dominant land use pattern have been undergoing rapid transformation for the past 50 years, from forests and grasslands to annual cropping and agroforestry (Garrity and Agustin, 1995).

During the past two decades, there have been significant changes in the farming practices in the southern arm of the watershed of Claveria. First, small-scale tree planting has rapidly increased in response to favourable market conditions (Garrity and Mercado, 1994). As a result, timber trees such as *Gmelina arborea* (hereafter referred to as gmelina), *Acacia mangium* (mangium) or *Swietenia macrophylla* (mahogany) and a number of fruit tree species are now common components of the farming systems. Secondly, natural vegetative strips (NVS), a farmer adaptation of the widely promoted contour hedgerow with leguminous trees technology, became a popular soil conservation measure because of its low labour requirements and low competition with alley crops (Stark, 2000). This soil conservation measure may be an initial step in the evolution towards more complex agroforestry systems (Garrity et al., 1993), since farmers plant trees on the previously established NVS to optimise the use of space (Garrity et al., 1998; Stark, 2000).

In response to increasing farmer demand for training in soil conservation and agroforestry technologies, ICRAF in collaboration with local partner institutions (government, farmer organizations and NGOs) began in 1999 through 2002 the Landcare agroforestry extension project with funding support from the Spanish Agency for International Cooperation (AECI) and the Australian Center for International Agricultural Research (ACIAR). The project was implemented in two geographical regions, Mindanao, including 9 upland municipalities of the provinces of Misamis Oriental, Bukidnon,and North Cotabato, and the Visayan islands of Bohol and Leyte. In Claveria, the Landcare movement started in 1996 as a small group of

farmers concerned with soil and water conservation and agroforestry. After participating in a training on soil conservation and agroforestry practices, these farmers organized themselves in the Claveria Landcare Association (CLCA). As the movement grew over the years, the CLCA became a federation of village-based groups of farmers interested in promoting and developing agroforestry practices. Throughout this period, ICRAF facilitators have worked with over 3,000 farm families through small farmer-led organisations. In Claveria, the Landcare movement promoted the adoption of a farmer-developed, low-cost, low-labour soil and water conservation technology and the planting of fruit and timber trees. Farmer groups and individuals organized hundreds of small-scale nurseries for the propagation of popular fruit and timber trees. Towards the end of the project, activities concentrated on facilitating marketing of farm-grown timber by establishing links with various wood industries interested in substituting imported timber with local sources. In 2001, as part of the research efforts in support of project activities, project staff conducted a formal field study to determine the factors that influence farmers' decisions to plant timber trees. Based on the above review of literature on the determinants of tree planting, the study hypothesized that socio-economic factors related to the farm household and the bio-physical characteristics of the farm parcels influence farmers' decision to plant timber trees.

3.2.2.2   Selection of respondents and data collection

The study consisted of two parts: i) in-depth interviews of household deciders and; ii) an inventory of timber trees on farms. The household survey included timber tree growers (n = 50) (adopters) and non-growers (n = 62) (non-adopters) from 12 villages of Claveria who were interviewed in the exploratory survey undertaken in 1997 (Chapter 3.1). Assuming a population of 41,109 (Ford-SAFDZ, 2001) and an average family size of 5 or 6 members, the proportion of the farm families of Claveria included in the sample (sampling fraction) ranged approximately from 1.3 to 1.6 %. Based on the literature review on the factors influencing farmers' decision to plant trees and on the author's field experience in Claveria, 14 household- and 9 farm-level variables were selected for this study. Information was collected by means of a structured questionnaire (see Appendices Chapter 3), and direct field observation and sketching (tree inventory).

All respondents surveyed possessed land title. A variable indicating the land tenure status was deliberately not included in this study since all the 27 tenants interviewed in the exploratory survey (Chapter 3.1) responded that they need landlord's consent to plant trees.

The questionnaire related to the data on the socio-economic status of the household, including the household composition (age, sex and years of school attended for each resident and dependents, whether resident in the household or not); the village where the family reside, whether the household was a migrant to the locality or not, and the number of years living in the village; distance from residence to the closest all-weather road; affiliation to village organisations; sources of off-farm income and whether the decider work as farm wage labourer; access to formal and informal cash lending schemes; farm size owned; important farm assets (e.g., vehicles, farm machinery); number and type of livestock owned; and type of house construction (bamboo with thatched roof, wooden house with galvanized iron roof, cement house).

Data about each farm parcel owned by the respondents (n = 158 farm parcels) included: size; distance of farm parcels to the homestead and to the closest all-weather road; tenurial status (owner, tenant, rented out, partially rented out) and the number of years the farmer had been cultivating the parcel; average slope; the existence of soil and water conservation measures; present land use system (cropland, fallow or pasture land); species, number, arrangement (line, hedgerow, block planting, scattered, isolated trees) and farm niche (cropland, fallow or pasture land, boundary, homestead) of planted timber and fruit trees. When possible, farmers were requested to participate in the tree survey.

3.2.2.3   Exploratory data analysis and hypotheses

The information gathered was encoded in Excel computer software (Microsoft Corporation, 1997). Two data sets were constructed, one with the socio-economic variables of the 112 farmers interviewed (the Household-level set) and the second with the biophysical variables of the 158 farm parcels surveyed (Farm-level set). For each data set, a dichotomous response variable was constructed to indicate "adoption of timber tree planting" (ADOPTB) at both, the household and the parcel level. A farmer was considered "adopter" (Y = 1) if tree density (number of planted timber trees/total area owned in hectares) was higher than 20 trees ha^{-1}. Similarly, in each farm parcel "adoption" (Y = 1) was arbitrarily specified when tree density (number of timber trees in the parcel/area of the parcel in hectares) was higher than 20 trees ha^{-1}. Farmers and farm parcels with 20 or less timber trees per hectare were considered within the category of "non-adopters"[43] (Y = 0).

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[43] Within the category of non-adopters, there were only 25 farmers and 40 farm plots with no timber trees planted, and 37 farmers and 55 farms with few timber trees at densities between 1-20 timber trees ha^{-1}. In the strict sense, the latter could be considered as testers rather than non-adopters.

Some of the variables measuring similar factors were recoded and combined into new variables. Farmers' wealth status (WLTH) was specified using a rank score. Respondents were categorized as "very poor" (rank 1 - 4), "poor" (rank 5 - 8) and "wealthy" (rank 8 - 12) depending on the size of the farm owned (less than 1 ha = 1; 1 – 2.5 ha = 2; 2.5 – 4 ha = 3; more than 4 ha = 4), farm assets (basic tools = 0; kart and or plough = 1; motorbike = 2; jeep or car = 3), source of off-farm income (none = 0; 1 unskilled job = 1; 2 or more unskilled jobs = 2; skilled job = 3) and type of house construction (bamboo with thatched roof = 0; wooden with galvanized iron roof = 1; cement and hollow blocks = 2). Based on this categorization, there were 26 farmers under the "very poor" category (23%), 69 under the "poor" category (62%) and 17 under the "wealthy" category (15%). This variable reflecting wealth status showed no relationship to timber tree planting, indicating that rural differentiation does not necessarily apply to timber tree planting.

Three variables were used to characterize available farm labor: i) "Farm family labor" (FARMLAB), estimated as the labor-to-land ratio (available family labor[44]/hectares managed[45]). Labor-to-land ratios ranged from 0.03 to 10, with average of 1.6 for non-adopters and 1.8 for adopters. Farmers with labor-to-land ratio between 0 - 0.99 were categorized as farmers with "much labor shortage"; between 1 and 2.5 are farmers with "some labor shortage", and more than 2.5 as farmers with no labor shortage; ii) "Draught-animal labor" (ANLAB), estimated as the draught-animal labor-to-land ratio (draught-animals owned/farm area managed). Animal labor-to-land ratio ranged from 0 to 6, with a mean of 0.48 for non-adopters and 0.85 for adopters; and iii) involvement of decider in farm wage labor (WAGLAB). Further information on farm and household characteristics of tree planters and non-planters is given in **Table 3.2.1**.

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[44] Assuming that young and elder people are often active members of the household, "Farm family labor" = household members between 12 and 60 years of age + (household members schooling + household members older than 60 years)/2.

[45] The number of hectares managed = size of parcels owned + size of parcels rented + size of area under sharecropping ("prenda") – size of parcels rented out.

Table 3.2.1: Mean household and farm characteristics of sampled timber tree planters and non-planters.

Variable	Tree planters (adopters) (n = 50)	Non-planters (non-adopters) (n = 62)
Residents in villages at low elevations (Clusters I & II) (%)	78	50
Household size	5.3	5.2
Farmer migrants (%)	57	43
Age of decider (years)	49	47
Length of residence in village (years)	29.8	30.1
Education of decider (years)	7.3	6.7
Farmers with off-farm income (%)	46	54
Average farm family labourers	3.3	3.4
Labour-to-land ratio	1.81	1.60
Livestock owned (heads draft-animal)	1.7	1.2
Animal labour-to-land ratio	0.85	0.48
Total farm size	2.95	3.34
Farm parcels (number)	63	95
Farm parcels (n = 158) (%)	40	60
Farmers with more than 2 farm parcels (%)	8	3
Farmers with soil and water conservation (%)*	26	16
Farm parcels with soil and water conservation (%)	21	10

*Farmers with at least 1 parcel fully or partially under soil and water conservation.

Once all variables were defined and categorized, major patterns and relationships between the large number of explanatory variables and "adoption" were first examined by estimating the *sample odds* of adoption, $\omega = \pi / (1 - \pi)$, (i.e., if π is the sample proportion or probability of adoption, the sample odds of adoption ω is the ratio of the proportion of adoption to the proportion of non-adoption cases) and the *log odds ratio*, $\log \Phi = \log (\omega_1/\omega_2)$. The *odds ratio* describes binary response outcomes (adoption or non-adoption) for the explanatory categories, indicating that there are Φ farmer adopters in the explanatory category 1 for every one non-adopter in the category 2. After comparing and interpreting the resulting odd ratios, several household and farm variables, most of which passed a 0.1 significance level, were selected as having the greater influence on timber tree planting **(Table 3.2.2)**.

Table 3.2.2: Important explanatory variables and expected contribution to timber tree planting.

Variable name	Description	Response range and units	Odds ratio (Φ)	Expected contribution: the odds of planting timber trees are "Φ" times greater for/on:
Household variables				
BRGY*	Village of residence	(a): Villages of Cluster I and II (b): Villages of Cluster III and IV	1.99	Residents from Cluster I and II villages (low altitude)
YRSLIV*	Years living in village	(a): 20 yr or less (b): > 20 yr	2.1	Farmers with less than 20 years of settlement in the village
EDLEV*	Formal education (deciders)	(a): > 20 years (b): 0 - 20 years	2.33	Farmers with more years of formal education
LNDAREA	Farm area owned	(a): 1.5 ha or less (b): > 1.5 ha	2.01	Farmers with smaller farms
ANLAB*	Animal labour-to-land ratio	(a): No shortage of draft power (b): Shortage of draft power	2.23	Farmers with no shortage of draft animal power
Farm variables				
DISTALLWR*	Distance parcel to all-weather road	(a): 0 - 2000 m (b): > 2000 m	2.4	Parcels closer to an all-weather road
SWC*	Adoption of soil conservation	yes (y) no (n)	2.21	Parcels with soil conservation measures (NVS or leguminous hedgerows)
PARCSIZ*	Farm parcel size	(a): smaller than 2 ha (b): $\geq$ 2 ha	1.7	Farm parcels smaller than 2 hectares

*Significant $p \leq 0.1$ level

3.2.2.4   Confirmatory analysis and hypothesis testing

Model building and assessment of the importance of explanatory variables was done by logistic regression using the General Statistics Software (GenStat) computer program (Lawes Agricultural Trust, 2000). Two logit models were specified:

1. A household-level model to determine the socio-economic characteristics of the farm household driving farmers to plant timber trees.

2. A farm parcel-level model, to determine the biophysical characteristics of farm plot influencing tree planting on that particular plot.

Since both, the socio-economic status of the household and the nature of farm plots influence farmers' decision to plant trees, variables measured at the household level were also used at the farm level and vice-versa. Thus, given the important explanatory variables in **Table 3.2.2**, the most complex form of the model explaining adoption of timber tree planting is:

$\text{Log} [(P (\text{adoption} = 1) / (1 - P (\text{adoption} = 1))] = \beta_0 + \beta_1 \text{ BRGY} + \beta_2 \text{ YRSLIV} + \beta_3 \text{ EDLEV} + \beta_4 \text{ LNDAREA} + \beta_5 \text{ ANLAB} + \beta_6 \text{ DISTALLWR} + \beta_7 \text{ SWC} + \beta_8 \text{ PARCSIZ} + \epsilon_i$

The process of model building began by assessing a "reasonable" model based on the results of the exploratory analysis and knowledge on timber tree planters derived from project activities. Then, the process consisted of "forward selection", to assess the effects of new variables and their interactions, and "backward elimination", to drop unimportant terms and to see whether important effects were masked by "noise" introduced by other variables. The contribution to the model of each of the explanatory variables introduced was assessed by the drop-in-deviance chi-squared test. The drop in deviance is the sum of squared deviance residuals from the model without the variable under test (i.e., the reduced model) minus the sum of squared deviance residuals from the model with the variable (i.e., the full model). The analysis aimed at building a model without a large number of variables but with an acceptable prediction rate (low residual rate).

3.2.2.5   Limitations of the study

This study attempted to find out the particular set of household and farm conditions in which timber tree planting, as a "specific" agroforestry technology, is applicable. To do this, surveyed farmers were classified as adopters (planters) and non-adopters (non-planters) of timber trees after the field inventory. Among the 112 farmers surveyed, there were 62 (55%) non-adopters and 50 (45%) adopters of timber trees. However, 46 (74%) of the non-adopters and all (100%) of the adopters of timber trees had also

applied other "specific" tree planting technologies such as fruit trees and/or management of naturally regenerating trees. Since farmers can apply these and other "specific" tree planting technologies, within the same set of household and farm conditions, to meet their goals with similar success[46] (e.g., labour-constrained farmers may make a more productive use of fallowed land by planting timber trees, or fruit trees), there has probably been a confounding effect introduced in the model by the large number of farmers classified as "non-adopters" (of timber trees) that are actually tree planters. Ideally, to study the factors influencing the planting of just timber trees (as a specific technology), comparisons should have been made between tree planters (either with fruit and timber trees or only timber trees) with non-planters (neither timber nor fruit trees planted), and/or between planters of fruit trees with planters of both, fruit and timber trees.

Several tables with 3 categories and multi-way tables presented small sample sizes in some cells. Ideally, the sample size should have been increased to avoid this (Coe, 1996). However, increasing the sample was not possible due to time and resource constraints. Instead, those response variables in multilevel tables presenting small sample sizes were recoded and converted into dichotomous variables with just two categories. Consequently the precision of the information provided by some of the variables was significantly reduced and some of the potential interactions between variables could not be assessed (e.g., only one farm parcel with soil conservation measures was observed at a distance from all-weather road greater than 2000 m).

3.2.3   Results and discussion

3.2.3.1   Household model

The results of the logit household model showed that the village of residence (BRGY), the farm size (LNDAREA), and the availability of off-farm income (OFFINCOM) are the most significant determinants of timber tree planting in Claveria **(Table 3.2.3)**. The village where the farmer resides is by far the factor more strongly associated to timber tree planting. The drop in deviance (21 with 3 degrees of freedom) provided convincing evidence of this. Farmers living in villages at lower elevation (Clusters I and II) are more likely to plant timber trees than those residing at higher elevations (Clusters III and IV). As other variables included in the model do not explain the village

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[46] Of course, there may be cases in which for a particular set of household and farm conditions, only a "specific" form of tree planting option technology may be applicable (e.g., farmers aiming at a regular source of income from fruit trees or farm parcels requiring soil fertility improvement).

effect, more data would be needed to carefully assess differences between villages that may explain the influence in timber tree planting. Nevertheless, field observations and discussions with tree planters suggest that timber tree cultivation in villages located in the upper elevations is limited due to the unsuitability of promoted timber species to growing conditions prevalent in those areas. This has been recently confirmed by the results of studies conducted by ICRAF in a nearby watershed to test the performance of common timber species at different elevations [Ngugi, 1999 #21]. Another important factor explaining the low adoption of timber tree planting in the villages at higher elevation may be the reluctance of vegetable growers to practice intercropping because of the increasing perceived risk due to tree-crop competition. Although vegetable growing, particularly tomatoes, is highly profitable, the costs of inputs are also high and the market price of vegetables quite volatile (it is not uncommon to observe a full harvest of tomatoes dumped on the road side because market prices are well below the break-even threshold). In these circumstances then, farmers may be unwilling to accept the risk of lower crop yields due to tree-crop competition.

Table 3.2.3: Influence of household characteristics on timber tree planting in Claveria, Misamis Oriental.

Variable	Description and response range	Coefficient**	Standard error	Significance (p-value)
Constant		2.32	1.46	0.112
BRGY	Respondent from a village of Cluster I*			
	Respondent from a village of Cluster II	0.936	0.535	0.080
	Respondent from a village of Cluster III	-2.95	1.20	0.014
	Respondent from a village of Cluster IV	-0.031	0.572	0.957
LNDAREA	Farm size < 1 ha*			
	Farm size 1–2.5 ha	-3.22	1.51	0.034
	Farm size 2.5–4 ha	-2.52	1.63	0.123
	Farm size > 4 ha	-2.78	1.77	0.117
OFFINCOM	Farmers without off-farm income*			
	Farmers with off-farm income	-3.30	1.73	0.056
LNDAREA x OFFINCOM	1 < Farm size < 2.5 & off-farm income	4.28	1.85	0.021
	2.5 < farm size < 4 & off-farm income	3.93	1.99	0.048
	Farm size > 4 ha & off-farm income	2.96	2.11	0.160

Residual deviance = 123

Residual degrees of freedom = 101

*Reference level

**Effect as compared to the reference level

Farm size is also a characteristic associated with timber tree planting. As the negative sign of the coefficient of LNDAREA indicates, the odds of timber tree adoption decreases as farm size increases. However, this does not imply that larger farmers do not plant timber trees. In fact, considering the average number of planted trees instead of tree density (number of trees per unit of land), farmers with landholdings larger than 3 ha have more planted timber trees (mean number of planted timber trees = 221) than owners of farms $\leq$ 1ha (mean number of planted timber trees = 91) (Chapter 3.1, Table 3.1.6). Therefore, we should expect both, large-scale and small-scale landowners to plant trees, with more intensive tree planting taking place on smaller farms. Another conclusion is that tree densities of the level considered in this study

(70% of adopters have tree densities ranging from 20 - 100 timber trees ha^{-1}) do not deter farmers from planting trees on small-size farms. This range of tree density seems acceptable to farmers with the double objective of producing food and tree crops in the same farm parcel.

Contrary to expectations, off-farm income is not greater incentive to the adoption of trees. In fact, there was a negative association between timber tree planting and off-farm income. This suggests that the level of income from off-farm sources considered in this study (income derived from unskilled labour) is not enough to improve farmers' capacity to assume the risk of timber tree planting. There is, however, suggestive evidence of an interactive effect between farm size and off-farm income. The odds of timber tree planting are significantly higher among those farmers with average and large farms and off-farm income. This can be interpreted in relation to the availability of farm family labour (FARMLAB), even if the influence of this variable on timber tree planting was not captured by this study. The allocation of family labour off-farm to generate cash income limit the availability of labour for investments on the farm, especially in the larger landholdings. Since tree cultivation is not as labour-demanding as annual cropping (except for tree planting and pruning), timber tree farming is likely to be a viable option for labour-constrained households with large farms, and more attractive than other land use alternatives such as grass and bush fallows or share-cropping. On the other hand, if fast-growing timber trees are intercropped with annuals, the use of scarce family labour for pruning (commonly practiced for 2 to 3 years as reported in Ch 3.1) may have a too high opportunity cost since the yield increase of the intercrop (due to reduced tree-crop competition for light) and the small price increase, if any, of pruned timber may not compensate the income foregone. Farmers' practice of intensive pruning and preference for timber species with a self-pruning habit (e.g., *E. deglupta*), as well as other labour-saving strategies such as direct seeding reported in Chapter 3.1, do provide evidence of this.

The influence of other important household variables is unclear in this study. Indicators of farmers' educational level (EDLEV) and their affiliation to village organisations (ORGAN) were found to influence timber tree planting as hypothesized, although their effect was not significant enough to be explanatory factors of adoption. This was probably because of the confounding effect discussed in the section above "limitations of the study". Similar studies conducted in Claveria (Lapar and Pandey, 2000), and elsewhere in the Philippines (Cramb, 2000), reported that higher education levels and participation in community organisations are factors positively associated to the adoption of soil conservation technologies (some of which involved tree planting). This probably applies to tree farming as well. The high level of participation in Landcare

extension project activities in Claveria, such as information campaigns, nursery establishment and training, suggest that access to information and training facilitated by village-based organisations are key factors influencing increasing rates of tree planting.

The variable reflecting farmers access to credit did not show any influence on tree planting. Although in some specific situations the provision of credit may be a determinant of timber tree planting (Hyman, 1983), in Claveria, like in many other upland areas in the Philippines, smallholder farmers are unlikely to use short-term, high-cost credit supplied by local money lenders for a long-term investment such as tree planting.

3.2.3.2   Farm model

Farmers' decision to plant timber trees in a particular farm parcel was explained by several farm- and household-level factors **(Table 3.2.4)**. As in the household model, the location of the farm parcel is the most influential determinant of timber tree planting. As all the farm parcels surveyed were located in the village where the respondent resides, the discussion presented above on the reasons behind decreasing likelihood of tree planting with increasing altitude holds here as well.

The location of the farm parcel in relation to the nearest all-weather road (DISTALLWR) is another factor positively related to adoption, with increasing tree planting as the distance to the road decreases. It is well known that facilitating access to markets by improving rural infrastructure like roads accelerate change in agricultural practices. The question that remains is whether change would be desirable or not. For example, in Java, Indonesia, Filius (1997) found higher tree densities (though lower diversity) in hamlets with asphalted road and nearer to town markets. However, in a remote part of a watershed in the island of Negros, Philippines, road construction allowed owners of large sugar cane haciendas in the lowlands to claim all of the lands in the area and plant sugar cane in the most part of it (Walters et al., 1999). The impact of accessibility on inducing change in land use patterns can be easily observed in Claveria, where land use in the remote northern arm of the watershed with poor accessibility is markedly different from land use in the southern part with better infrastructure (see this Chapter's section "description of the study site"). A recent study has also demonstrated how adoption of contour hedgerow technology is significantly influenced, among other factors, by improved access to markets (Lapar and Pandey, 2000). Better infrastructure facilitates access to the site of extension agents, information, and the establishment of other infrastructure (e.g., nurseries) necessary for tree planting. Also, we can expect that a good infrastructure have a favourable

effect on the marketing of perishable tree products, such as fruits, and bulky timber, stimulating in turn tree planting.

Draft animal owning seems to have some effect on tree planting behaviour as planters and non-planters differed significantly in their livestock ownership. The model results shows that farmers with available draft animal power (i.e., with higher animal-to-land ratio) are more likely to plant timber trees than those farmers without it. Contrary to what many would expect, the presence of draft animals in smallholdings is compatible and supportive of tree growing. Using draft animals for land tillage is one of the most effective ways to reclaim Imperata-infested grasslands and to put these under more intensive land use systems such as permanent food cropping and agroforestry (Garrity et al., 1997). In the Philippines, the common use of draft animals for land tillage is probably a key factor contributing to the success of tree growing. The frequent and intensive land cultivation activities (harrowing, hilling-up or inter-row cultivation), possible with the use of draft animal, reduces weed competition, promotes better tree growth because of improved soil conditions, and keep the site free from grassland fires (Garrity and Mercado, 1994; Pascicolan et al., 1997). Integrating livestock with crop and/or timber production also offers several advantages to farmers (Calub et al., 1997): i) reduced labour and/or chemicals required for weed control, because of weed suppression by the grazing animal; ii) increased production and earlier cash returns (specially important for long-term timber plantations); iii) faster nutrient cycling and nitrogen inputs, and; iv) reduced risks of accidental fires. In Claveria, woodlots of gmelina are commonly established with the support of maize intercropping between tree rows. All land preparation activities for the maize crop are done with the use of draft animals, cows or buffaloes. Once intercropping is no longer possible because of canopy closure, these tree plantations became areas used for tethering cattle (Mamicpic 1997; Mamicpic et al., 1998).

The interaction between "BRGY" and "ANLAB" is unclear in this study. It probably reflects a prevalence of the "village" effect over the effect of "animal ownership", as a majority of farmers with draft-animal power from Cluster I and II are tree planters, whereas in Cluster III and IV there are more non-adopters than adopters among those with available draft power. Also, this study cannot provide a clear answer to the fact that the proportion of adopters to non-adopters among farmers with available draft power is substantially higher in Cluster I (87% versus 13%) than in Cluster II (60% versus 40%). And vice-versa, it is not clear why the proportion of non-adopters to adopters among farmers without draft power is higher in Cluster I (69% versus 31%) than in Cluster II (42% versus 58%).

Table 3.2.4: Influence of household and farm characteristics on timber tree planting in a particular farm plot, Claveria, Misamis Oriental.

Variable	Description and response range	Coefficient**	Standard error	Significance (p-value)
Constant		-0.451	0.364	0.215
BRGY	Plot located in a village of Cluster I*			
	Plot located in a village of Cluster II	1.405	0.501	0.005
	Plot located in a village of Cluster III	-1.93	1.08	0.074
	Plot located in a village of Cluster IV	0.633	0.530	0.232
ANLAB	Shortage of draft-animal labour*			
	Available draft-animal labour	3.01	1.15	0.009
BRGY 2 x ANLAB	Plot in a village of Cluster II & available draft-animal labour	-3.20	1.38	0.021
BRGY 3 x ANLAB	Plot in a village of Cluster III & available draft-animal labour	0.00	1.77	0.999
BRGY 4 x ANLAB	Plot in a village of Cluster IV & available draft-animal labour	-3.30	1.74	0.058
DISTALLWR	Distance from parcel to nearest all-weather road < 2000 m*			
	Distance from farm parcel to nearest all-weather road > 2000 m	-0.984	0.573	0.086
YRON	Less than 20 years cultivating parcel*			
	More than 20 years cultivating parcel	-0.873	0.385	0.023

Residual deviance = 173.2

Residual degrees of freedom = 148

*Reference level

**Size of effect as compared to the reference level

The number of years a respondent has been cultivating a farm parcel, "YRON", was a variable included in the model as an indicator of soil nutrient status. It was hypothesized that timber tree planting, as a fallow land use strategy, would occur on those farm parcels that have been cultivated for longer periods. But contrary to this hypothesis, results showed that the odds of timber tree planting are lower when farmers have been cultivating a parcel for more than 20 years **(Table 3.2.4)**. Rather

than indicating soil fertility status, which depends on many other factors such as cropping pattern and management, the effect of the variable YRON on tree planting can be better understood in relation to farmers' age (AGEDEC). A closer inspection of survey data revealed that the majority (75%) of the parcels that have been cultivated for less than 20 years are managed by younger farmers (20 to 50 years of age). And adding the variable "AGEDEC" to the farm logit model showed an inverse relationship between farmers' age and tree planting (though not significant, p-value = 0.26). Therefore, younger farmers are probably more active planters of timber trees than older ones. This conclusion is also supported by the results of the exploratory survey presented on Chapter 3.1 (Table 3.1.17). Older farmers perceived their age as an impediment to tree planting because they will not be able to obtain any benefit from such a long-term enterprise. They also remarked that the decision to plant trees rely now on their sons. Moreover, the fact that 68% of the farmers between 20 to 50 years of age reported affiliation to village organisations (against just 32% of older farmers) and the role of village-based institutions in the promotion of tree planting (discussed in the section above) is also an indication of the likely effect of farmers' age in tree planting.

The presence of soil and water conservation practices (SWC) in a farm parcel was also a factor positively associated to timber tree planting, although not significant in this study. The rapid modification of the popular natural vegetative strips (NVS) into highly productive agroforestry systems observed in Claveria (Stark, 2000) is clearly an indication of the higher likelihood of tree planting on parcels with soil conservation measures. Lastly, it should be noted that although farmers plant timber trees for soil conservation (Chapter 3.1, Table 3.1.16), no relationship was found between the slope of the farm parcel "SLOP" and timber tree planting. In fact, more tree plantations were observed on farm parcels with slopes below 18% than on parcels with slopes greater than 18%. This may simply be an indication of the need to protect the soil even on gentle and moderate slopes.

3.2.4   Conclusion

Although with the limitations indicated above, this study shows household and farm characteristics that influence farmers' decision to plant timber trees and constraints to wider timber tree planting in Claveria. First and foremost, the village where the respondent resides and farms was a good indicator for tree planting, with the likelihood of adoption decreasing with increasing altitude. Since the variables studied did not provide evidence of major differences between villages in the quality of basic land and other endowments such as topography, soils, and accessibility, the differential rates of

adoption between farmers from villages at low altitudes and those in villages at higher altitudes can be explained in terms of constraints to tree planting posed by the varying climatic and agro-ecological conditions along an altitudinal gradient. On the one hand, most of the timber trees promoted for on-farm planting perform well only at the lower altitudes of the watershed (300 – 700 m a.s.l.). Consequently, diffusion of timber tree planting in the uplands is constrained by the very limited choice of tree species. Secondly, vegetable growers predominant at higher altitudes may be less willing to assume the risks of planting trees on crop land, probably because of their perception of vegetable growing as an already high risk activity due to the rapid and wide fluctuations in the price of vegetables and their level of debt for costly inputs (seed, pesticide and fertilizers). However, there are indications that in the Philippines timber intercropping is becoming increasingly attractive for vegetable farmers as they face declining vegetable productivity and labour availability (Midmore et al., 2001). If smallholder upland farmers are to benefit from tree farming in the future, it will be imperative, therefore, to provide them with a larger list of tree species suitable to the wide range of agro-ecological conditions in the uplands. ICRAF has already undertaken steps in this direction by conducting an evaluation of timber tree species across a watershed gradient in central Mindanao (Ngugi et al., 1999).

Results also contradict widely held beliefs that better-off farmers, owning the larger landholdings, are the segment of the rural people most likely to adopt tree farming. On the contrary, the study suggests that small farm size is not a deterrent to tree planting. It also shows that availability of off-farm income is not by itself an incentive to invest on tree farming. In Claveria, the number of planted timber trees per unit of land increases as farm size decreases. This indicates that integrating timber trees at densities within the range found in this study (20 – 150 trees ha^{-1}) do not compromise crop production in mixed intercropping systems. Therefore, owners of larger landholdings with an interest in tree farming (as demonstrated by the mean number of trees) may opt for substantially intensify land use by increasing the level of timber tree planting without compromising crop production. In this case, the availability of off-farm income appears to be an incentive to increasing tree planting as the allocation of farm family labour to work off-farm limits investments on labour-demanding farm enterprises, such as annual cropping, and favours low labour-demanding activities such as tree planting.

The availability of draft animal labour stimulates and makes tree planting successful. There is a supportive relationship between draft animals and trees. When planting annual crops, using draft animal labour for land cultivation is an effective substitute for man-labour for the labour-demanding tree establishment activities (i.e., site preparation and weed control) critical to successful tree growing. In Claveria, site

preparation activities for double-cropping of maize typically consist of up to ten annual land cultivation schedules (i.e., plowing, harrowing, interrow cultivation) (Stark, 2000). Such intensive site management is key to the survival and growth of trees. As planted trees grow tall and intercropping becomes no longer possible, tree plantations are then converted into productive fallows where controlled grazing is practiced and livestock tethered.

Other factors influencing tree planting are not difficult to understand. Good access (farm-to-market roads) is a requirement for tree planting in general and commercial tree farming in particular. The contrast between the treeless northern arm of the Claveria watershed (with very poor access) and the tree-covered southern arm (with good access) exemplifies this. Also, it is not surprising that younger farmers are more active tree planters, as farmers think of tree farming as a long-term enterprise to accumulate capital for the future and/or save labour. Besides, younger farmers, as the more active members of the village, are more likely to be actively involved in groups and village organisations in support of tree planting-related activities.

If a majority of smallholder upland farmers are to benefit from tree farming, the most urgent task for farm forestry extension programs in the Philippines should be, instead of subsidizing reforestation indiscriminately, to facilitate access to germplasm of a wider range of tree species suited to the varying agroecological conditions in the uplands. As germplasm of suitable tree species is made available to farmers, farm forestry extension efforts to improve management and production must be placed within the context of the specific biophysical and socio-economic conditions of the locality and farmers' livelihood strategies (Arnold and Dewees, 1997). A thorough understanding of how farmers use their land, labour and capital resources to make decisions about whether to invest in agroforestry or another alternative would help extension agents to support and promote technologies appropriate to different farmers. But extension agents should also keep in mind that even if a specific form of a technology turns out to be inappropriate in a given location, the generic principles of the technology might still be applicable (Cramb, 2000). For example, as commonly promoted in the Philippines, woodlot planting (a specific technology with trees planted at close spacing and with a more or less fixed management schedule) may not be acceptable to farmers with small farms and whose priority is food production. However, as this study showed, farmers may take the generic principles of tree farming and adapt them to develop alternative specific technologies which are more applicable, like for instance increasing tree intra-row distance or severe pruning to reduce the shading of intercrops.

The considerable tree planting and conservation undergoing in many upland areas of the Philippines, particularly in Claveria, and some of the counterintuitive results of this study indicate that it is necessary to question general assumptions about farmers' attitudes and practices. Perhaps the most important, because of the policy implications it has, is the view of farmers as indiscriminate tree cutters. Penalizing farmers by requiring complicated procedures and permits for the use of farm-grown trees do not benefit widespread tree planting.

3.2.5   References

Adesina, A. A. and Chianu, J. (2002): Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. Agroforestry Systems (55): 99-112.

Arnold, J. E. M. (1997): Retrospect and prospect. In: Arnold, J. E. M. and Dewees, P. A.(eds.): Farms, Trees and Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd.: 271-287.

Arnold, J. E. M. and Dewees, P. A. (eds.) (1997): Farms, Trees & Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd.

Bagadion, B. C. (2000): Social and Political Determinants of Successful Community-Based Forestry. In: Utting, P. (ed.): Forest Policy and Politics in the Philippines: the Dynamics of Participatory Conservation. Quezon City, Philippines: Ateneo de Manila University Press: 117-143.

Bannister, M. E. and Nair, P. K. R. (2003): Agroforestry adoption in Haiti: the importance of household and farm characteristics. Agroforestry Systems 57: 149-157.

Calub, A. D., Anwarhan, H. and Roder, W. (1997): Livestock production systems for Imperata grasslands. Agroforestry Systems 36: 121-128.

Caveness, F. A. and Kurtz, B. (1993): Agroforestry adoption and risk perception by farmers in Senegal. Agroforestry Systems 21: 11-25.

Coe, R. (1996): Sample size determination in farmer surveys. (Unpublished) Nairobi, Kenya, ICRAF.

Cramb, R. A. (2000): Evaluation of Soil Conservation Technologies: A Summing Up. In: Cramb, R. A. (ed.): Soil Conservation Technologies for Smallholder Farming Systems in the Philippine uplands: a Socioeconomic Evaluation. ACIAR Monograph No. 78, 228 p. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR): 195-212.

Cramb, R. A. (ed.) (2000): Soil Conservation Technologies for Smallholder Farming Systems in the Philippine uplands: a Socioeconomic Evaluation. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR).

Current, D. and Scherr, S. J. (1995): Farmer costs and benefits from agroforestry and farm forestry projects in Central America and the Caribbean: implications for policy. Agroforestry Systems (30): 87-103.

Dewees, P. A. (1991): Woodlots, Labour Use and Farming Systems in Kenya. Paper presented at the 'International workshop on Socio-Economic Aspects of Tree Growing by Farmers', 11-14 March, 1991. Institute of Rural Management, Anand, India.

Dewees, P. A. (1992): Social and Economic Incentives for Smallholder Tree Growing: A Case Study from Murang'a District, Kenya. Rome, Italy: FAO.

DTI and PKII Engineers (1996): General land use plan. Municipality of Claveria. Cagayan de Oro, Philippines: Department of Trade and Industry (DTI)-Region 10.

Filius, A. M. (1997): Factors changing farmers' willingness to grow trees in Gunung Kidul (Java, Indonesia). Netherlands Journal of Agricultural Science (45): 329-345.

Ford-SAFDZ (2001): Claveria Agricultural Baseline Study. Claveria, Misamis Oriental, Philippines: Local Government Unit and Local SAFDZ Task Force.

Fujisaka, S., Jayson, E. and Dapusala, A. (1994): Trees, grasses, and weeds: species choices in farmer-developed countour hedgerows. Agroforestry Systems 25: 13-22.

Garrity, D. P. and Agustin, P. C. (1995): Historical land use evolution in a tropical acid upland agroecosystem. Agriculture, Ecosystems and Environment 53: 83-95.

Garrity, D. P., Kummer, D. M. and Guiang, E. S. (1993): The Philippines. In: National Research Council: Sustainable Agriculture and the Environment in the Humid Tropics. Washington D.C., National Academy Press: 549-624.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

Garrity, D. P., Mercado, A. R. and Stark, M. (1998): Building the smallholder into successful natural resource management at the watershed scale. In: de Vries, P., Frits, W., Agus, F. and Kerr, J.(eds.): Soil erosion at multiple scales: principles and methods for assessing causes and impacts. CABI and IBSRAM: 73-82.

Garrity, D. P., Soekardi, M., van Noordwijk, M., de la Cruz, R., Pathak, P.S., Gunasena, H. P. M., van So, N., Huijun, G. and Majid, N. M. (1997): The *Imperata* grassland of tropical Asia: area, distribution, and typology. Agroforestry Systems 36, Special issue 'Agroforestry innovations for Imperata grassland rehabilitation': 3-29.

Godoy, R. A. (1992): Determinants of smallholder commercial tree cultivation. World Development 20 (5): 713-725.

Hyman, E. L. (1983): Smallholder tree farming in the Philippines: a comparison of two credit programs. Unasylva 35 (139): 25-31.

Kenmore, Z. F. and Flinn, J. C. (1987): An ethnohistory of an upland area: Claveria, Misamis Oriental. Manila, Philippines: International Rice Research Institute (IRRI).

Lapar, M. L. A. and Pandey, S. (2000): A Socioeconomic Analysis of Adoption of Soil Conservation Practices by Upland Farmers in Cebu City and Claveria. In Cramb, R. A. (ed.): Soil Conservation Technologies for Smallholder Farming Systems in the Philippine Uplands: a socioeconomic evaluation. Canberra, Australia: Australian Center for International Agricultural Research (ACIAR): 179-194.

Lawes Agricultural Trust (2001): GenStat-4.2. Fifth edition. Oxford, UK. VSN International Ltd.

Magbanua, R. D. and Garrity, D. P. (1988): Acid upland agroecosystems: a microlevel analysis of the Claveria research site. In: Proceedings of the 1988 Acid Upland Research Design Workshop. Los Baños, Philippines: International Rice Research Institute (IRRI): 1-20.

Mahapatra, A. K. and Mitchell, C. P. (2001): Classifying tree planters and non-planters in a subsistence farming system using a discriminant analytical approach. Agroforestry Systems 52: 41-52.

Mamicpic, M. A. E. (1997): Livestock in Natural Vegetative Strips (NVS) and Gmelina Cropping Systems. MSc dissertation. School of Environment, Resources and Development, Asian Institute of Technology, Bangkok, Thailand.

Mamicpic, M. A. E., Tinsley, R. L. and Magcale-Macandong, D. (1998): Natural Vegetation Strips (NVS) and Gmelina Cropping Systems. Imperata Project Paper 1998/1. University of the Philippines, Los Baños, Laguna, Philippines: The SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA).

Meinzen-Dick, R. and Knox, A. (1999): Collective Action, Property Rigths and Devolution of Natural Resource Management: A Conceptual Framework. Paper presented at the 'Conference on Collective Action, Property Rigths and Devolution of Natural Resource Management: Exchange of Knowledge and Implications for Policy'. 21-25 June, 1999 Puerto Azul, The Philippines. Available at: www.capri.cgiar.org/pdf/devolution_meinzenknox.pdf.

Microsoft Corporation (2000): Microsoft Excel version 9.0.

Midmore, D. J., Nissen, T. M. and Poudel, D. D. (2001): Making a Living Out of Agriculture: Some Reflections on Vegetable Production Systems in the Manupali Watershed. In: Coxhead, I. and Buenavista, G. (eds.): Seeking sustainabililty: challenges of agricultural development and environmental management in a Philippine watershed. Los Baños, Laguna, Philippines: PCARRD: 94-111.

Ngugi, M. R., Garrity, D. P. and Koffa, S. N. (1999): Niche Analysis and Matching of Climatically Suitable Sites of Six Agroforestry Tree Species Commonly Used in the Philippines. Lantapan, Philippines: International Center for Research in Agroforestry (ICRAF). 76 p.

Pascicolan, P. N., de Haes, H. A. U. and Sajise, P E. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forestry Ecology and Management (99): 261-274.

Price, L. and Campbell, B. (1998): Household tree holdings: A case study in Mutoko communal area, Zimbawe. Agroforestry Systems (39): 205-210.

Scherr, S. (1992): Not out of the woods yet: challenges for economic research on agroforestry. American Journal of Agricultural Economics (74): 802-819.

Scherr, S. J. (1997): Meeting household needs: farmer tree-growing strategies in western Kenya. In: Arnold, J. E. M. and Dewees, P. A. (eds.): Farms, Trees & Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd.: 141-173.

Schlager, E. and Ostrom, E. (1992). Property-Rights Regimes and Natural Resources: A Conceptual Analysis. Land Economics 68 (3): 249-262.

Soerianegara, I. (1994): Factors which determine the success of regreening in Gunung Kidul, Central Java. Journal of Tropical Forest Science 7 (1): 64-75.

Stark, M. (2000): Soil Management Strategies to Sustain Continuous Crop Production between Vegetative Contour Strips on Humid Tropical Hillsides. Technology development and dissemination based on farmers' adaptive field experimentation in the Philippines. International Centre for Research in Agroforestry (ICRAF). Southeast Asia Regional Research Programme.

Sunderlin, W. D. (1997): An ex-post methodology for measuring poor people's participation in social forestry: an example from Java, Indonesia. Agroforestry Systems (37): 297-310.

Thacher, T., Lee, D. R. and Schelhas, W. (1996/97): Farmer participation in reforestation incentive programs in Costa Rica. Agroforestry Systems 35 (3): 269-289.

Utting, P. (2000): An Overview of the Potential and Pitfalls of Participatory Conservation. In: Utting, P. (ed.): Forest Policy and Politics in the Philippines: the Dynamics of Participatory Conservation. Quezon City, Philippines: Ateneo de Manila Universtiy Press: 171-215.

Walters, B. B., Cadelina, A., Cardano, A. and Visitación, E. (1999): Community history and rural development: why some farmers participate more readily than others. Agricultural Systems (59): 193-214.

Part IV: Evaluation of Timber Production Systems

4 The biophysical and economic performance of timber-based agroforestry systems

4.1   Tree growth and maize grain yield in smallholder timber-based agroforestry systems in Claveria, northern Mindanao, Philippines

Abstract

In the Philippine uplands, the integration of fast-growing timber trees in smallholder farming systems have been extensively promoted to diversify farm output and produce timber for household use and the market. On-farm experiments were conducted in an upland environment to study over a 4-year period the growth of two popular timber trees, *Gmelina arborea* (hereafter referred to as gmelina) and *Eucalyptus deglupta* (hereafter referred to as bagras), as well as their impact on the grain yield of intercropped maize. The experiment consisted of maize monocropping plots (control), and maize intercropped between trees planted in block arrangement at 2 x 2.5 m (2,000 trees ha^{-1}) and widely-spaced hedgerows at 1 x 10 m (1,000 trees ha^{-1}). After tree planting in the block system, three maize crops were sown in the plots before canopy closure but only the first two cropping produced viable grain yields. Therefore, farmers planting fast-growing trees in block arrangement will be able to grow only one maize crop with average yield and a second crop with reduced grain yield. In the widely-spaced hedgerow system, all maize rows showed decreasing grain yields after the first year but more notably in association with gmelina. In the second year, crop yield was reduced approximately by 50% within a 2.5-meter distance from the gmelina trees and within 1.5 m from bagras. Overall, by the seventh cropping season gmelina reduced maize grain yields by 60% and bagras by 40%. Both tree species performed well in all experimental sites indicating their suitability to the area. Mean annual increment (MAI) in height over the 4-year study period for trees in hedgerow and block was 4.0 m yr^{-1} for gmelina and 3.6 m yr^{-1} for bagras. For both species, the diameter at breast height (dbh) grew faster in hedgerow than in block arrangement, with the difference increasing with age. The MAI in dbh of gmelina over the 4-year study period was 4.7 cm yr^{-1} for trees in hedgerow and 4 cm yr^{-1} for trees in block. At the age of 4.5 years, mean dbh of gmelina in hedgerow plots was 16% greater than in block plots (19.9 vs. 17.1 cm). For bagras, MAI in dbh over the 4-year study period was 3.4 cm yr^{-}

[1] for hedgerow arrangement and 3.1 cm yr^{-1} for block. At 4.5 years age, mean dbh of bagras trees in hedgerow was 14% greater than in block (15.6 vs. 13.7 cm). Based on these results, we estimated that at the end of an eight-year rotation period timber volume of gmelina would range from 69 to 110 m^3 ha^{-1} if planted in hedgerow arrangement and 61 to 104 m^3 ha^{-1} if planted in block arrangement. For bagras, the volume of timber produced in a rotation period of 12 years would range from 146 to 185 m^3 ha^{-1}. The study concluded that if mixed agroforestry systems with fast-growing timbers are to produce acceptable levels of intercrop yields tree basal area should be maintained within the range of 2 to 4 m^2 ha^{-1}. This is equivalent to a density of 41 to 81 trees ha^{-1} when average dbh is 25 cm or 28 to 57 trees ha^{-1} when mean dbh is 30 cm. For higher densities, fast-growing trees should be planted in other farm niches, such as home gardens, farm boundaries, pastures or fallows, rather than on cropland.

4.1.1   Introduction

Since the emergence in the late 1980s of farm forestry as a profitable enterprise, upland farmers have been successfully growing timber trees on their smallholdings. Farmers' practice of intercropping is an effective and efficient strategy to grow timber trees for two reasons: (i) the intensive land preparation for crops ensures tree survival and promotes growth; and (ii) the costs of tree establishment and management can be charged to the intercrop (Garrity, 1994).

However, competition effects may reduce or override productivity gains and the positive economic aspects of growing crops in association with trees. When fast-growing timbers, such as those commonly planted in the Philippines, are combined with annual crops, the growth of the understorey crop will probably be inhibited by competition for water and nutrients and shading (Ong et al., 1996). If water and nutrients are freely available (as may occur, to some extent, in the study area where rainfall is high and well-distributed and the use of fertilizers common), the tree spreading crown and increasing biomass will probably make light the primary limitation to crop growth (Ong et al., 1996). Subsistence-oriented farmers will probably increase the frequency and intensity of branch pruning to control the dominance of trees (Watanabe, 1992). However, the gains in yield of annual crops derived from reduced shading may not compensate for increasing labor costs and the detrimental effect on

tree growth[47] as a result of frequent and intensive pruning. Therefore, farmers may have no other option but to either fallow their land or discontinue tree farming.

Minimizing the amount of tree-crop interface by increasing rectangularity (the ratio of inter-row to intra-row spacing) of the tree planting pattern and reducing tree density may help to mitigate competition for light (Huxley, 1999). Thus, systems with trees planted in widely-spaced hedgerows (at 10 or more meters) may allow for higher crop yields and prolong the period of intercropping. Trees will also grow faster and with larger diameters as they benefit from a more favourable light regime. Similar patterns of trees planted in lines far apart have been proposed in the Philippines, and elsewhere, as the most appropriate for smallholder timber-based agroforestry systems (Santiago, 1997; Beer, 1994).

In September 1997, I initiated on-farm trials to assess empirically the benefits of growing maize intercropped between widely-spaced hedgerows of fast-growing timber trees. Specific objectives of the experiment were to: (1) assess the effects of two popular timber species planted in block (2 x 2.5 m) and hedgerow (1 x 10 m) arrangement on the grain yield of intercropped maize; (2) quantify maize yield and its distribution across the sloping alleys between widely-spaced timber tree hedgerows; (3) evaluate the timber yield of these species when planted in these two arrangements and assess the benefits of wider spaced hedgerows on tree growth and yield; and (4) determine the profitability of timber-based agroforestry systems relative to maize monocropping.

Tree species examined in this study are *Gmelina arborea* R.Br. (family Verbenaceae) (gmelina) and *Eucalyptus deglupta* Blume (family Myrtaceae) (bagras). In the late 1980s, gmelina became popular among farmers because of its fast growth, acceptable timber quality and market demand. But as trees grew, its popularity declined as farmers observed severely reduced yields of crops growing next to gmelina. Farmers' attention has shifted recently towards bagras because, besides its fast growth and timber quality, its straight bole, light canopy, and self-pruning habit are desirable attributes for intercropping systems.

Maize farming is dominant among agricultural systems in the Philippine uplands. In Claveria, it is widely grown at low and medium elevations (300 - 700 meters) as a major food and cash crop (Kenmore and Flinn, 1987). Farmers are aware of the negative effect that fast-growing timber trees have on the yield of intercropped maize.

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[47] In Claveria, we estimated that the local practice of retaining a live-crown ratio (LCR) of just 20 to 30 % reduces the dbh of gmelina by 3 cm (20%) at the age of 3.5 years, as compared to the recommended practice of retaining a LCR of 60 to 70%.

However, it may be difficult for them to predict the level of maize yield reduction and the net profit through the tree rotation period in systems with trees planted in widely-spaced rows at low densities. Results from this study will provide indication of the viability and advantages of growing fast-growing timber trees at wide spacing in association with maize intercropped. These results will be used in the next chapter to assess the profitability of smallholder timber-based agroforestry systems.

4.1.2   Materials and methods

4.1.2.1   Description of the study site

The study was conducted in Claveria, an upland municipality located 42 km northeast of Cagayan de Oro City, in northern Mindanao. The municipality covers an area of 112,175 hectares, has a mountainous topography with 62% of the area having slopes of 18% or greater and elevation ranging from 390 - 2,000 m. a.s.l. (DTI and PKII Engineers, 1996). Soils are derived from volcanic parent material and classified as deep acidic (pH 3.9 - 5.2) Oxisols with texture ranging from clay to silty clay loams, with low available P, low CEC, high Al saturation and low exchangeable K (Magbanua and Garrity, 1988). **Table 4.1.1** and **4.1.2** presents the physical and chemical properties of the soil at the trial sites at the start of the experiment. Average rainfall is 2,500 mm with a wet season from June to December (> 200 mm rainfall per month) and a short dry season from March to April (< 100 mm rainfall per month) (Kenmore and Flinn, 1987). Daily rainfall at the trial site was recorded with rain gauges from October 1997 throughout January 2001. Monthly average values are presented in **Figure 4.1.1**. From November 1997 up to May 1998, there was only 359 mm of rainfall due to the severe drought caused by the El Niño phenomenon. Temperatures experiment little variation throughout the year, with an average maximum of 28.6 °C and average minimum of 21.3 °C.

At lower elevations (400 - 700 m), maize (*Zea mays* L.) is the dominant crop, cultivated twice a year or in rotation with cassava (*Mahinot esculenta* Crantz) or upland rice (*Oryza sativa* L.). Typically, a wet season crop planted on the onset of the rainy season (May) is followed by a dry season crop planted in September or October. Tomato and other vegetable cash crops are commonly grown on the higher elevations (700 - 900 m. a.s.l.). Average farm size is 2.5 to 3 ha with farmers commonly cultivating two or more parcels of land.

In the past 50 years, land use in Claveria has experienced a rapid transformation from natural forests to grasslands to a mosaic of intensive cash and food cropping and

perennial-based systems (Garrity and Agustin, 1995). Recently, the use of grass strips of natural vegetation (NVS) along contours as a measure to control soil erosion has become common among farmers in the area. This practice is also the base for the incorporation of fruit and timber trees (Stark, 2000)

Monthly rainfall at trial site (Tunggol, Claveria) (September 1997 - January 2001)

Total rainfall   1998: 2,140 mm;   1999: 3,152 mm;   2000: 2870 mm;   Elevation: 500 m
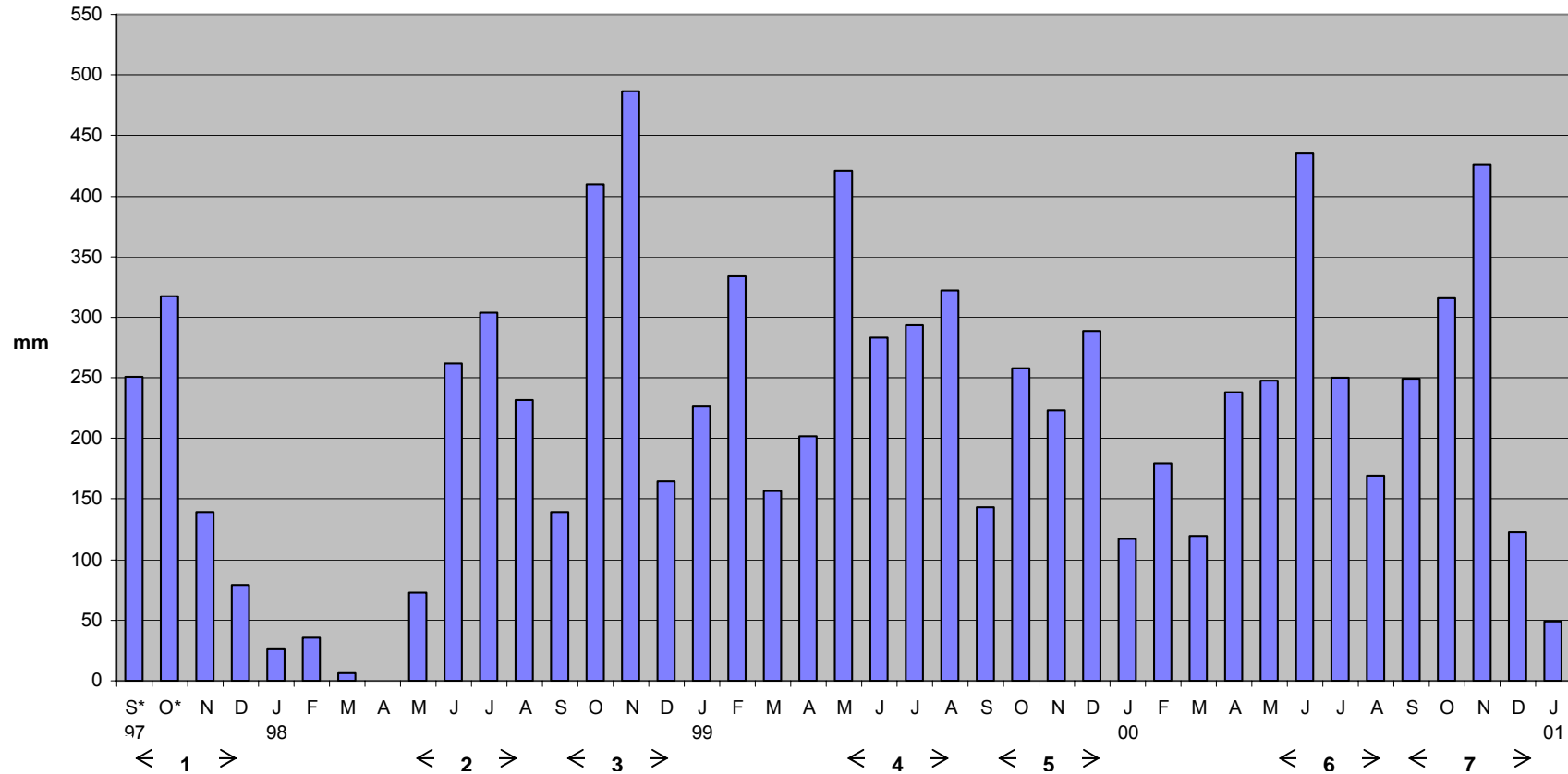
Figure 4.1.1: Monthly rainfall at the trial sites located at Tunggol, Claveria, from September 1997 to January 2001, and duration of trial crop seasons.

Table 4.1.1: Physical and chemical soil properties at the trial sites with *Gmelina arborea* before the start of the experiment.

Site	Depth (cm)	Slope Zone	Org. C (%)	Total N (Kjeldahl) (%)	Avail. P (Bray II) (mg/kg)	Exch. K (me/100g)	CEC (me/100g)	Exch. Al (me/100g)	Exch. Ca (me/100g)	Exch Mg (me/100g)	pH (1:1 H$_2$O)	Clay (%)	Silt (%)	Sand (%)
Tunggol	0-15	Up	1.850	0.200	1.40	0.155	13.40	0.231	4.41	2.170	4.8	62	26	12
	15-30		1.110	0.128	2.10	0.089	11.40	0.563	3.35	2.070	4.7	76	16	8
	30-60		0.751	0.086	1.90	0.056	11.70	1.030	2.70	1.750	4.7	83	12	5
	60-100		0.625	0.065	0.20	0.047	10.90	1.820	2.43	1.420	4.8	85	11	4
	0-15	Down	2.210	0.233	2.30	0.160	12.70	0.111	4.32	1.450	4.9	65	24	11
	15-30		1.350	0.164	0.81	0.133	11.50	0.231	2.98	1.240	4.9	72	18	10
	30-60		0.812	0.110	2.20	0.143	9.43	0.402	2.42	1.110	4.9	79	13	8
	60-100		0.498	0.063	2.10	0.107	8.98	0.855	2.11	0.770	5.0	81	12	7
Ane-i	0-15	Up	1.850	0.180	11	0.187	10.30	1.82	1.56	0.140	4.2	70	26	4
	15-30		1.320	0.126	2.7	0.114	8.09	1.60	1.47	0.140	4.2	73	23	4
	30-60		0.865	0.090	3.3	0.090	6.39	1.58	1.20	0.120	4.2	76	20	4
	60-100		0.605	0.060	2.8	0.066	7.40	1.69	0.85	0.130	4.4	76	20	4
	0-15	Down	1.900	0.183	13	0.211	9.94	1.75	1.37	0.110	4.0	70	26	4
	15-30		1.340	0.137	2.5	0.135	9.07	1.50	1.20	0.140	4.1	74	22	4
	30-60		0.898	0.094	1.1	0.078	7.35	1.57	0.98	0.100	4.1	78	19	3
	60-100		0.585	0.066	1.1	0.074	7.29	1.36	0.88	0.130	4.3	79	17	4

Table 4.1.2: Physical and chemical soil properties at the trial sites with *Eucalyptus deglupta* before the start of the experiment.

Site	Depth (cm)	Slope Zone	Org. C (%)	Total N (Kjeldahl) (%)	Avail. P (Bray II) (mg/kg)	Exch. K (me/100g)	CEC (me/100g)	Exch. Al (me/100g)	Exch. Ca (me/100g)	Exch. Mg (me/100g)	pH (1:1 H_2O)	Clay (%)	Silt (%)	Sand (%)
Tunggol (Rep1&2)	0-15	Up	1.840	0.203	1.90	0.311	18.00	0.101	6.64	3.440	4.7	53	35	12
	15-30		1.350	0.167	0.06	0.132	15.50	0.402	5.47	3.050	4.8	64	26	10
	30-60		0.858	0.113	0.95	0.202	15.00	0.734	4.62	3.280	4.7	74	18	8
	60-100		0.571	0.073	0.13	0.063	14.90	1.900	3.54	3.030	4.5	73	16	11
	0-15	Down	2.190	0.233	2.20	0.234	12.50	0.080	4.30	1.570	4.6	66	23	11
	15-30		1.310	0.152	0.15	0.162	11.10	0.251	3.29	1.430	4.6	76	16	8
	30-60		0.832	0.099	0.17	0.168	11.30	0.483	2.71	1.220	4.9	82	12	6
	60-100		0.645	0.075	2.40	0.122	9.21	1.240	2.39	0.780	5.0	83	11	6
Tunggol (Loping) (Rep 3)	0-15	Up	2.350	0.223	3.10	0.196	14.10	0.101	5.14	2.490	4.9	63	25	12
	15-30		1.350	0.151	2.10	0.110	11.30	0.603	3.27	2.060	4.7	75	16	9
	30-60		0.812	0.093	0.13	0.065	10.60	1.330	2.73	1.530	4.8	83	11	6
	60-100		0.645	0.074	0.13	0.073	11.30	1.160	3.06	1.520	4.8	85	10	5
	0-15	Down	2.140	0.221	1.50	0.156	11.80	0.302	3.47	1.500	4.6	67	21	12
	15-30		1.250	0.148	0.52	0.125	11.50	0.553	2.60	1.530	4.6	76	15	9
	30-60		0.758	0.094	0.43	0.085	9.78	1.470	1.91	1.150	4.6	81	12	7
	60-100		0.524	0.065	0.22	0.046	9.61	2.030	1.60	0.940	4.8	83	11	6
Tunggol (Tuling) (Rep 4)	0-15	Up	2.060	0.212	3.40	0.223	17.70	nil	7.53	4.290	5.3	57	31	12
	15-30		1.310	0.150	0.34	0.119	18.80	0.704	5.34	3.600	4.7	66	24	10
	30-60		0.758	0.095	0.07	0.089	16.40	1.880	4.37	3.230	4.6	74	18	8
	60-100		0.558	0.065	0.15	0.068	18.90	2.800	4.06	3.180	4.5	75	18	7
	0-15	Down	1.880	0.194	1.00	0.279	13.70	0.060	5.62	2.280	4.9	62	24	14
	15-30		1.710	0.182	0.73	0.215	15.00	0.171	5.29	2.250	4.8	68	19	13
	30-60		0.952	0.114	1.80	0.095	13.10	1.030	3.73	2.030	4.6	76	15	9
	60-100		0.511	0.068	0.04	0.112	13.10	2.480	2.61	1.580	4.7	80	14	6

4.1.2.2   Experimental design and approach

The performance of gmelina and bagras intercropped with maize were assessed and compared to that of maize monocropping. Gmelina is a fast-growing medium-sized deciduous tree original from Pakistan, Sri Lanka and Myanmar. It has been widely planted in Southeast Asia, tropical Africa and Latin America in plantations to produce wood for light construction, crafts, veneers, pulp, fuel and charcoal. It has been also planted in *taungya* systems with short-rotation crops and as a shade tree for coffee and cacao. Rotations are usually 6 years for pulpwood and 10 years for sawnwood (Hossain, 1999; Lamb, 1968). During the late 1980s and 1990s, gmelina was extensively planted across the Philippines.

Bagras is a fast-growing tree with a straight regular bole, often reaching a height of 20 to 30 m and a diameter of 200 cm. The specie is native to Mindanao, Sulawesi, Irian Jaya and Papua New Guinea and it has been planted from Samoa and Fiji to Malaysia, Ivory Coast and the humid tropics of Latin America. Bagras is sensitive to site conditions, showing slow growth when planted in poor sites. It is used for furniture, moulding, pulp, plywood, blockboard, construction wood and electric poles. Rotations vary from 5 to 12 years if planted for pulpwood and 16 to 18 years if planted for sawnwood (FPRDI, nd; Francis, 1988). In recent years, bagras has become popular for planting on-farms because of its fast growth, good form, light canopy, self-pruning habit and high market demand.

The study consisted of researcher-designed and –managed on-farm trials (Type 1) with experimental plots laid out in a randomized complete block design with 3 treatments and 4 replications. Based on the prevalent monocropping farming systems in the study area and farmers' practice of intercropping with trees planted either in woodlots at close spacing (e.g., 1 x 2 m or 2 x 2 m) or in lines 6 to 7 m apart (see survey results Chapter 3.1), we chose the following treatments:

- T_1 (NVS): maize mono cropping between narrow strips of natural vegetation (NVS) 10 meters apart.

- T_2 (Block): timber trees in block (also called woodlot) at 2 x 2,5 m (2000 stems ha^{-1}), with maize inter-planted in the 2,5-meter alleys until canopy closure.

- T_3 (Hedgerow): timber trees on hedgerows (also called line planting) 1 x 10 m apart (1000 stems ha^{-1}), with maize intercropping in the 10-meter wide alleys.

10 m

1 m

↔

10 m

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

Tree net plot

Maize net plot

| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |

| 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
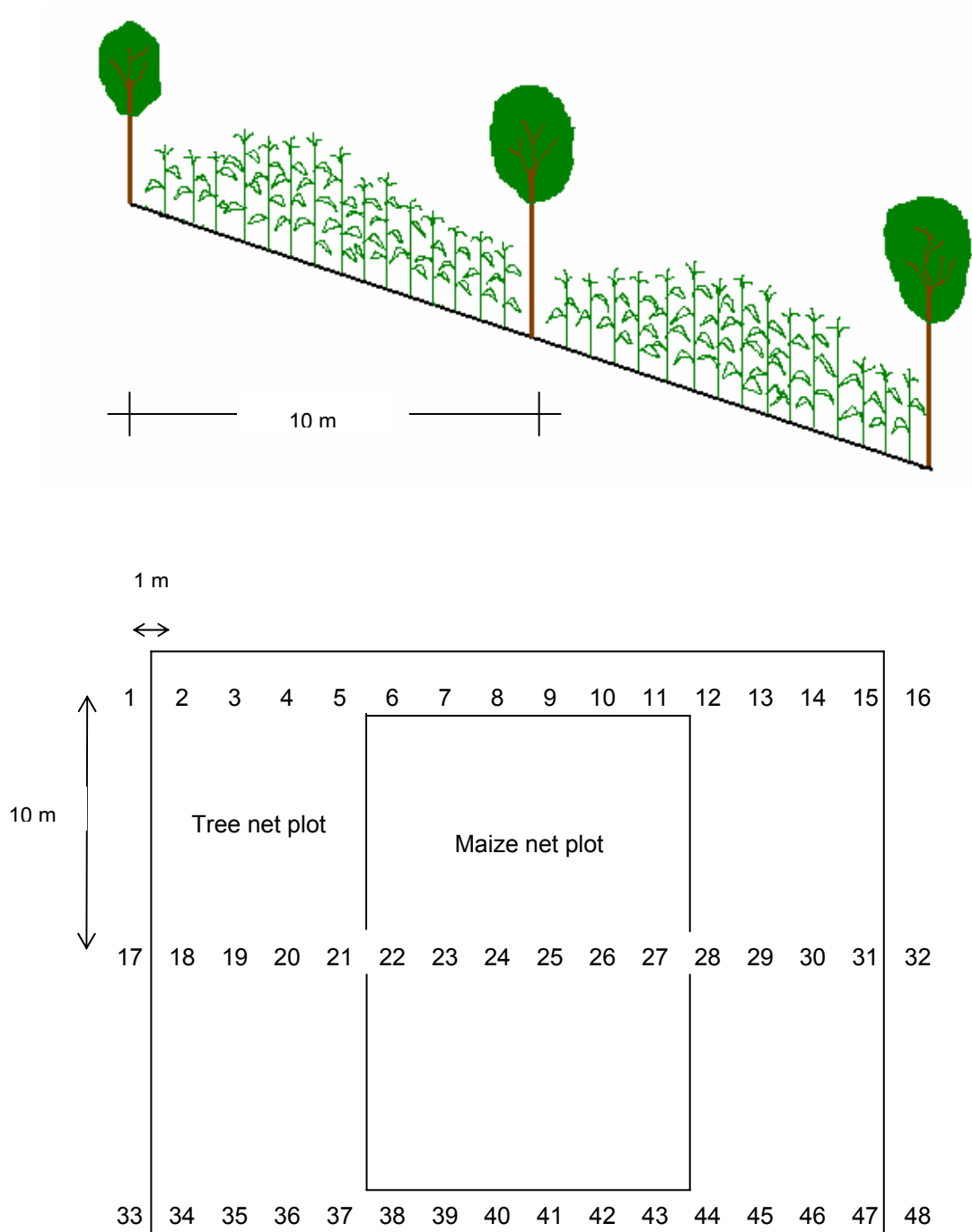
Figure 4.1.2: Layout of tree-maize experimental plot in hedgerow arrangement.

2.5 m

2 m

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72

2.5 m
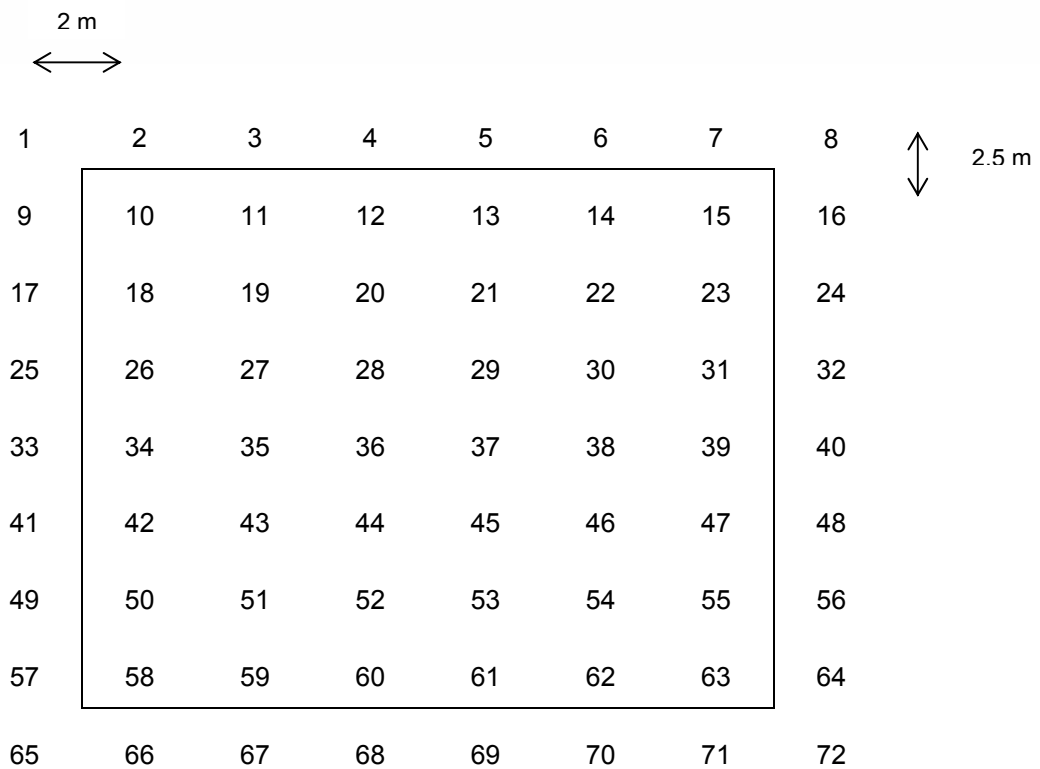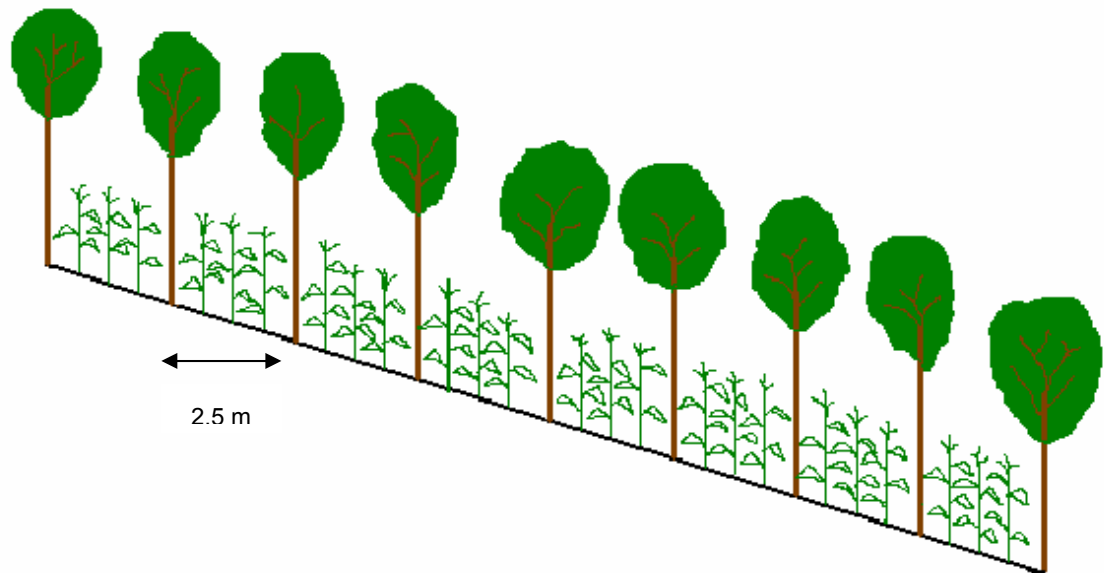
Figure 4.1.3: Layout of tree-maize experimental plot in block arrangement.

Block plots contain 9 lines of trees with 8 trees per line (i.e., 72 trees); and hedgerow plots contain 3 lines of trees with 16 trees per line (i.e., 48 trees). Fifteen (15) rows of maize were planted in each of the two alleys of the NVS and hedgerow plots. In the block plots, three (3) rows of maize were planted in each of the 8 alleys between tree lines **(Figures 4.1.2 and 4.1.3)**.

Plots were 300 m^2 (15 x 20 m), with a centered net plot of 6 m, a border of 4,5 m on both sides of the net plot, and a guard area of 8 to 9 m between plots to avoid the influence on observations of trees from adjacent plots. Slope of the experimental plots ranged from 20 – 30 %.

The objective of this experiment was to collect the information necessary to test the hypothesis under study, which is:

The practice of intercropping maize between trees planted in hedgerows at wide distance (i.e. 10 m) is more profitable, feasible and acceptable to smallholders than maize monocropping and woodlots since:

1. Crops can be planted in the alleys between rows of trees for longer period.

2. Farmers would benefit from the reduction of area lost to trees and lower tree establishment and management costs.

3. Trees will grow faster because of the more intensive management and favorable light regime.

4.1.2.3   Research plot set-up and management

We collected seeds of gmelina from local trees, de-pulped and soaked them in water for 24 hours, and then sowed the seeds in plastic bags filled with topsoil. Seeds of bagras were bought from PICOP's nursery in Bislig, Surigao del Sur and were immediately sown into seed boxes. Tree seedlings were raised for about three months in a nursery at Claveria until they were 25 to 30 cm tall. Then, on the last week of September and first week of October 1997, we planted the seedlings at the trial sites just above the strips of natural grass (NVS) established during land preparation of the first crop. Dead trees were replaced until the end of December 97. From January to May 1998, we watered the trees twice a month due to the severe drought caused by El Niño. In June and July 1998, after the dry spell, mortality was replaced to keep plot conditions homogenous. Trees replaced after the drought were not included in the calculations of tree parameters presented below.

Maize cropping started on October 1997 (2nd crop 1997) and continued, in the NVS and hedgerow treatments, for 7 cropping seasons until the last harvest on January

2001. Only 3 maize crops were possible in the block system before canopy closure. Contour hedgerows of natural grass (NVS) were established in the research plots by leaving a 50 cm-wide unplowed strip along the contour. Every year, a wet season of maize crop was planted in May and harvested in early September, followed by a dry season crop sown in early October and harvested in January. Draught animal power was used for land preparation, consisting of two plowing and one harrowing operation. All other maize farming operations (i.e., fertilizing and weeding) were performed manually following local practices. Every cropping season, a hybrid maize variety, Pioneer 3014, was sown into furrows at a spacing of 30 cm along each row and 60 cm between rows. Each maize crop was fertilized with the recommended dose of 80-30-30 kg NPK ha^{-1}. Phosphorus (Solophos 0-18-0) and potassium (Muriate of Potash 0-0-60) fertilizer and the insecticide-nematicide Furadan 3G were applied at sowing. Maize re-sowing was done 5 to 7 days after emergence (DAE). Nitrogen (Urea 46-0-0, 46% N) was applied as equal split doses by side dressing 15 and 30 DAE. After nitrogen application, interrow cultivation was performed to cover the fertilizer with soil and as a weed control measure. Manual hand weeding of the maize crop was also done as needed, usually one to two weeks after second interrow cultivation.

Lime (calcium carbonate, $CaCO_3$) was applied at the rate of 3 ton ha^{-1} to all plots before the third cropping season (September 1998), as maize growth in a portion of the net plot of the hedgerow and control plot located at barangay Ane-i was severely affected by soil acidity, showing aluminum-induced symptoms of Mg deficiency (see Appendices Table A 4.1.1). Before the sixth cropping season (May 2000), lime was applied at the rate of 2 ton ha^{-1} again only on the research plots located at Ane-i. The lime rates used were estimated in accordance with the recommendation of adding 1.5 to 2.0 t ha^{-1} of $CaCO_3$ for every 1 me 100 g^{-1} of exchangeable Al (based on a soil depth of 15 cm) (Uexkull, 1986; Ahn, 1993).

Fertilizer was applied only to the crop as described above. However, trees have probably benefited from the fertilizer applied to the maize. Ringweeding was conducted at planting. Subsequent weeding operations consisted of two grass slashing per cropping season for trees in hedgerows. Trees in blocks were weeded only through the third year.

Pruning was done so as to leave a live crown ratio (LCR) of 40 to 60%. One singling and form pruning was conducted to retain a single stem and improve form when the trees were 1 year old. Branch pruning operations were performed three times during the four-year period. A 50% intensity thinning was conducted at 34 months after planting.

4.1.2.4   Data collection and analysis

Prior to the establishment of trial plots, soil samples were taken with a soil auger from each farm in which plots were to be established. One composite sample from the upper and lower part of the slope in each trial site was derived from several sub-samples. After the first cropping season, soil samples were taken again from the affected and adjacent areas (control) in one of hedgerow and control plots located at Anei to determine the cause of poor maize growth in these plots (Appendix A 4.1.1). All soil samples were analyzed at the soil laboratory of the International Rice Research Institute (IRRI) at Los Baños, Laguna, Philippines (**Table 4.1.1 and 4.1.2**).

Maize grain yield data was taken row by row from a 6 meter-wide centered net plot. At harvest, fresh grain and total biomass were measured and two plant samples taken from each of the upper, middle and lower alley zones. Grain yield at 14% moisture content was obtained after oven-drying the sub-sample.

Diameter at breast height (dbh) and tree height were recorded twice a year until the age of 54 months. At the age of 40 and 48 months, diameter at 8 feet height was also recorded to calculate taper (i.e., the cm of change in diameter for each meter of length).

Grain yield variation across the alleys between tree lines was studied by standard regression analysis using the General Statistics Software (Genstat) program (Lawes Agricultural Trust, 2000). Quadratic curves were fitted to the average grain yield over the replications. As the pattern of yields across the two alleys in each plot of each replication was almost identical, a single curve was fitted to the two sides. Thus curve analysis was done for alleys rather than for pair of alleys.

Tree height reported corresponds to the Lorey's mean height, which is the average height weighted by basal area (Philip, 1994). Average tree diameter at breast height (dbh) was estimated as the diameter corresponding to the mean basal area (Philip, 1994). To study the differences in dbh growth of trees planted in hedgerows and blocks a paired T-test was conducted on the average dbh per plot, excluding border trees, at some selected time points. Tree height, average dbh, and basal area were calculated with the parameters of trees inside the net plot.

Data on average dbh and minimum merchantable diameter (small-end diameter) at harvest was derived from measurements taken on 175 harvested logs of gmelina and interviews among 16 mini-sawmill operators. It was not possible to measure average dbh of harvested logs of bagras as most planted trees in the area have not reached maturity yet and therefore it was not found in mini-sawmills.

Merchantable height at harvest was estimated using the taper reported in this study and assuming a small-end diameter of 14 cm. Then, the following tree volume equations were used to calculate timber volumes at harvest:

Log V = -38579 + 1.6844 log D + 0.8671 log H (R^2 = 0.993) for gmelina (D = dbh in m; H = merchantable height in m; V = volume in cubic meters) (Virtucio, 1984);

Log V = 0.030318 + 2.049154 log D + 0.739098 log H (R^2 = 0.995) for bagras (D = dbh in m; H = merchantable height in m; V = volume in cubic meters) (Tomboc, 1976).

4.1.3   Results and discussion

4.1.3.1   Maize grain yield

Maize grain yield in the wet season crop (1st crop) were consistently higher than those of the dry season crop (2nd crop) (**Tables 4.1.3 and 4.1.4**). It seems that the dry spell caused by El Niño did not negatively affect maize yield of the first dry cropping season (2nd crop 1997). On the contrary, the occurrence of the drought during the later part of the cropping season (December 1997) may have benefited grain development and maturity. In the second dry cropping (2nd crop 1998) and wet cropping (1st crop 1999), widely-spaced gmelina reduced maize grain yield by almost 50% over the previous dry and wet crop yield. Bagras was less competitive than gmelina, showing a less drastic reduction of maize grain yields.

Table 4.1.3: Effect of *Gmelina arborea* in two agroforestry systems on grain yield of hybrid maize.

Treatment	Grain yield (t ha^{-1})						
	2nd Crop 1997	1st Crop 1998	2nd Crop 1998	1st Crop 1999	2nd Crop 1999	1st Crop 2000	2nd Crop 2000
Control (NVS)	2.95 a	5.68 a	2.48 a	4.61 a	3.17 a	4.51 a	2.81 a
Hedgerow (1 x 10 m)	2.72 a	4.82 a	1.71 b	2.55 b	1.38 b	2.45 b	0.95 b
Block (2 x 2.5 m)	3.01 a	4.97 a	0.32 c	-	-	-	-
LSD (5%)	1.033	0.897	0.491	0.385	0.539	0.472	0.442
CV (%)	20.6	10.1	18.9	13.3	10.5	6.0	10.4

Yield per hectare, discounting area occupied by NVS.

Means in a column followed by the same letter are not significantly different from each other at the 5% level; LSD test.

Table 4.1.4: Effect of *Eucalyptus deglupta* in two agroforestry systems on grain yield of hybrid maize.

| | Grain yield (t ha^{-1}) | | | | | | |
Treatment	2nd Crop 1997	1st Crop 1998	2nd Crop 1998	1st Crop 1999	2nd Crop 1999	1st Crop 2000	2nd Crop 2000
Control (NVS)	3.41 a	6.87 a	3.20 a	5.31 a	4.05 a	4.75 a	3.01 a
Hedgerows (1 x 10 m)	3.37 a	6.30 ab	3.09 a	4.01 b	2.59 b	3.70 b	1.74 b
Block (2 x 2.5 m)	3.20 a	5.65 b	1.57 b	-	-	-	-
LSD (5%)	0.628	0.749	0.533	0.343	0.560	0.787	0.762
CV (%)	10.9	6.9	11.7	3.3	7.5	8.3	14.3

Yield per hectare, discounting area occupied by NVS.

Means in a column followed by the same letter are not significantly different from each other at the 5% level; LSD test.

Three maize crops were planted in the narrow alleys of the block planting system before canopy closure. However, the third crop was greatly reduced, particularly in the block with gmelina. It should be noted that high grain yields in the 1st crop of 1998 (wet season crop) were because of the reduced tree-crop competition due to poor tree growth during the first eight months after tree planting. During this period, trees attained an average height of only 1 to 1.5 m. With normal rainfall conditions, in six months trees would grow to an average height of 2 to 3 meters and thus, the maize yield of the second crop (1st crop of 1998) would have been reduced to an estimated 1.5 to 2 t ha^{-1}. Therefore, farmers planting trees in block arrangement could expect to grow only 1 maize crop producing an average grain yield and a second crop with greatly reduced grain yield.

4.1.3.2   Maize grain yield distribution across alleys in the hedgerow intercropping system

The results on intercrop performance from the trials with the two tree species planted at wide spacing conform to a similar pattern (**Figures 4.1.4 and 4.1.5**). The first year showed irregular crop yields probably due to occurrence of the El Niño during the later part of the first cropping (the dry season crop) and the variability of soil conditions within the trial sites at the start of the experiment. As trees grew and trial management created more uniform conditions within the plot, the pattern of maize grain yield across the alley became that of a bell-shaped curve. All maize rows showed decreasing grain yields after the first year but more notably in association with gmelina. In the second

year, crop yield was reduced approximately by 50% at the distance of 2.5 meters (3 rows of maize) from the gmelina trees, and at 1.5 meters from the line of bagras (2 rows of maize). On the average, maize associated with bagras produced 100 to 200 gr lm^{-1} of grain more than maize with gmelina. With time, the bell-shaped curve of maize grain yield became less pronounced, indicating the spread of competition effects across the alley.
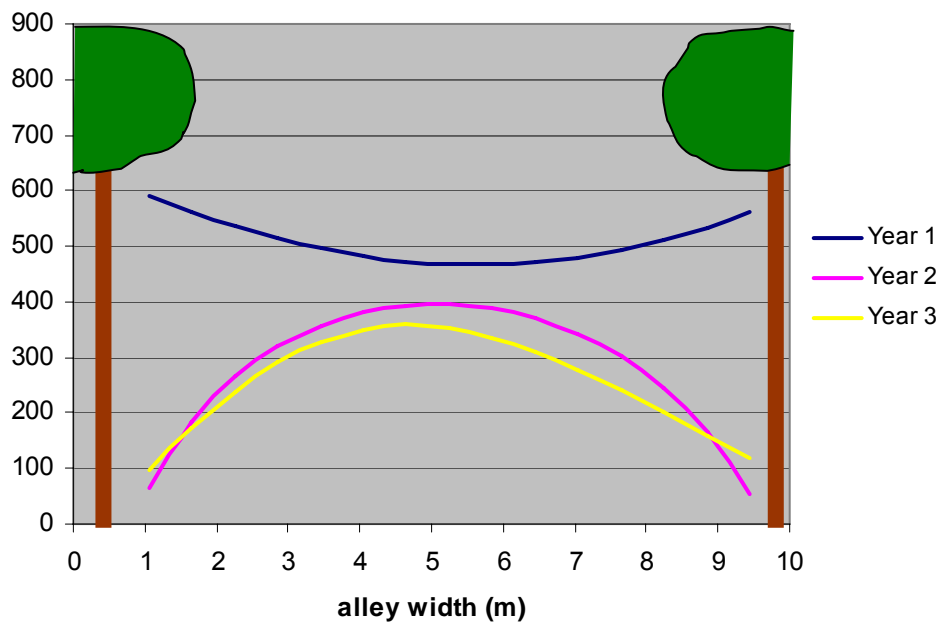
Figure. 4.1.4: Maize grain yield (gr lm^{-1}) across the alley between rows of *Gmelina arborea*.

Year 1: Y=-19634+(20283/(1-0.0153 X))-372 X $R^2_{adj.}$= 0.44
Year 2: Y=1151-(1493+27.1 X)/(1+0.420 X-0.0378 X^2)R^2_{adj} = 0.95
Year 3: Y=-792+(741+90.7 X)/(1-0.073 X+0.0162 X^2) R^2_{adj} = 0.93
R^2_{adj} = Adjusted coefficient of determination
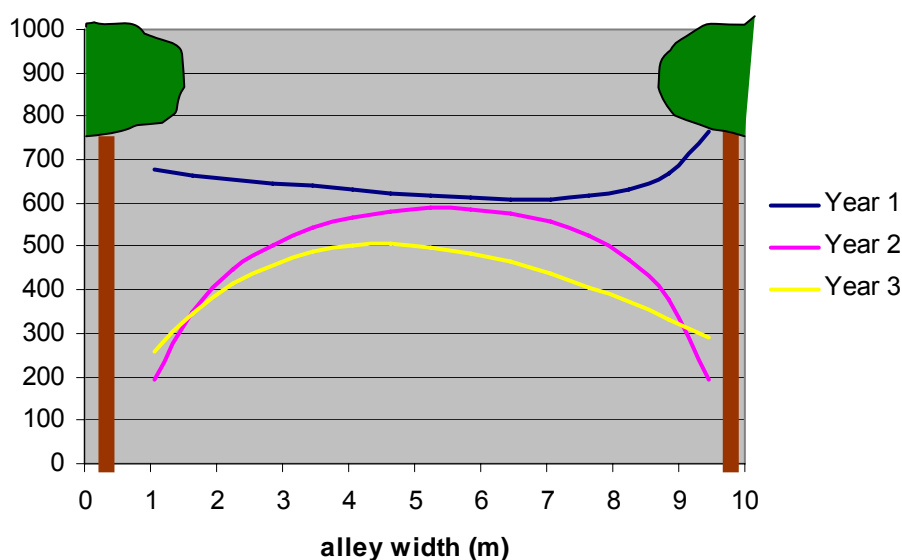
Figure 4.1.5: Maize grain yield (gr lm^{-1}) across the alley between lines of *Eucalyptus deglupta*.

Year 1: Y= 665.9+(27.6/(1-0.09573 X))-19.92 X $R^2_{adj.}$ = 0.51
Year 2: Y=948+(-1677+36.7 X)/(1+1.240X-0.1227 X^2) $R^2_{adj.}$ = 0.95
Year 3: Y=2614-(2602/(1+0.1685 X))-139.8 X $R^2_{adj.}$ = 0.91

Intensive tree pruning before planting of crops is a common practice among farmers to minimize tree-crop competition for light. However, severe pruning will be detrimental to tree growth. Studies conducted in the Philippines showed that the total biomass of severely pruned trees was 34% lower than that of unpruned trees (Miah, 1993). At age 20 months, severely pruned gmelina planted at 1 x 6 m had a notably smaller diameter (7.4 cm) than un-pruned trees (9.8 cm) (Gonzal, 1997). Leaving the area next to the tree line (3 to 4 intercrop rows) fallow once trees overtop the intercrop may not be an option as neither the trees would benefit from the enhanced growth nor the farmer from reduced tree establishment costs associated to the intensive fertilizing and weeding of crops. Farmers could instead plant shade-tolerant crops underneath and in the proximity to the tree row **(Plate 4.1.1)**, leaving the central part of the alley for light-demanding crops. In Claveria some farmers already practice intercropping with shade-tolerant crops. The benefits of this practice should be assessed empirically in the future.

Plate 4.1.1: Once fast-growing trees overtop light-demanding crops the area next to the tree line should be planted with shade-tolerant crops, such as the ube (*Dioscorea* sp.), sweet potato (*Ipomoea batatas* L.), and coffee (*Coffea* sp.) planted next to a row of *Eucalyptus deglupta* by this farmer (Claveria, 1998).

4.1.3.3   Tree growth

Mortality

During the three months after tree planting 10% of the seedlings of gmelina and of bagras were replanted. After the 5-month drought caused by El Niño (January-May 1998), another 7% of gmelina and 11% of bagras were replanted to achieve uniform growing conditions in all the trial plots. After the second replanting and throughout the experiment, mortality was as low as 1 % for gmelina and 2 % for bagras, indicating their suitability to the site.

Pest and diseases

Attacks of measuring worm, *Ozola minor* Moore (Lepidoptera: Geometridae) and the bee-hole borer, *Xyleutes* sp., (Lepidoptera: Cossidae) were observed on gmelina trees at the trial plots. The measuring worm feeds on young and old leaves making numerous holes. Stems affected by the young larva of the bee-hole borer are partially or completely girdled, eventually breaking off at the damaged portion (PCARRD,

1995). Both pests were found on only few trees, without causing much damage that would affect the overall growth of gmelina in the trial plots.

More important was the attack of the varicose borer, *Agrilus sexsignatus* Fisher (Coleoptera: Buprestidae) on bagras at the research plots. The larvae of this coleoptera tunnel under the bark and feed on the tree's inner portion and outer wood. The stem and branches affected become riddled with tunnels, causing them to break off and die prematurely (PCARRD, 1995). In our experiment, we observed 64 trees in the hedgerow plots (33% of the 192 trees planted) and 69 trees in the block arrangement (24% of the 288 trees) affected at one point in time throughout the whole duration of the experiment. However, most trees affected recovered well after the attack by producing new strong leading shoots.

The risk of pest problems in forest plantations increases with the extent of the planted area (Nair, 2001). In the Philippines, the varicose borer has caused serious infestations in the extensive bagras plantations of PICOP in Surigao del Sur (PCARRD, 1995). The insect attacks weakened, stressed or suppressed trees (Braza, 1992). Probably, the pest did not cause major damage to the research plots because bagras have not been extensively planted in Claveria yet. Promoting vigorous growth of trees in intensively managed, small-scale and diverse agroforestry systems may be an approach towards effective prevention of varicose borer infestation in bagras.

4.1.3.4   Tree height

There were no significant differences between heights of gmelina and bagras planted in hedgerows as compared with block arrangement (**Figures 4.1.6 and 4.1.7**).
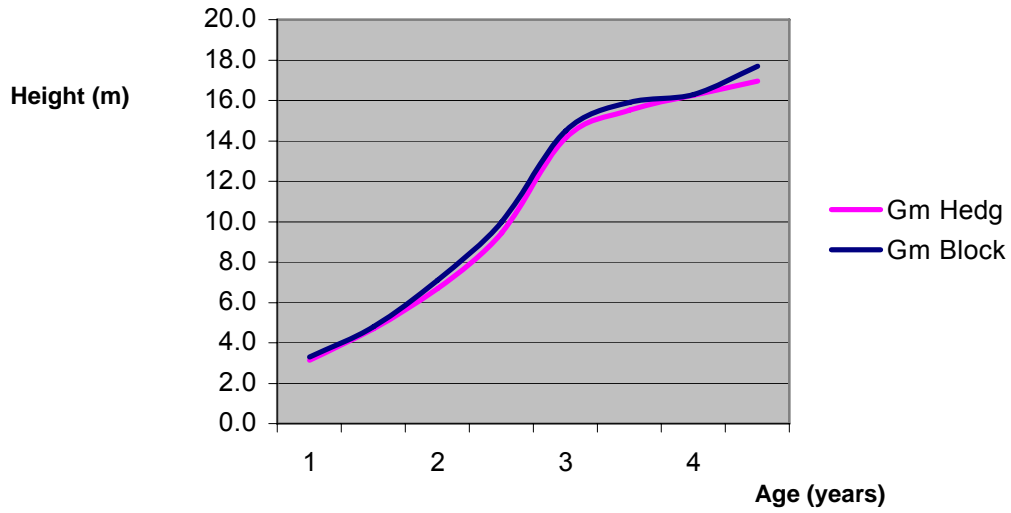
Figure 4.1.6: Mean height of *Gmelina arborea* planted in hedgerow and block arrangement in Claveria, Misamis Oriental, Philippines.
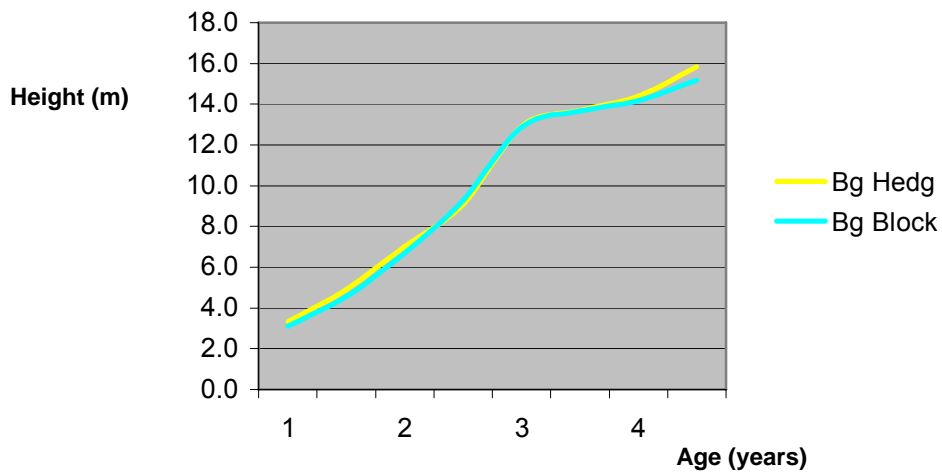
Figure 4.1.7: Mean height of *Eucalyptus deglupta* planted in hedgerow and block arrangement in Claveria, Misamis Oriental, Philippines.

Both species showed a similar growth pattern, with the greatest increase in height between year 2 and 3. The mean annual increment (MAI) in height over the 4 year study period for trees in hedgerow and block was 4.0 m yr^{-1} for gmelina and 3.6 m yr^{-1} for bagras. At age 4, gmelina was 2 meters taller than bagras. For both tree species, average height throughout the experiment has been found to be similar to that reported by Miah (1993) for gmelina (7 to 8 m in 20 months) and Francis (1988) for bagras (15 to 20 m at the age of 4 years).

Assuming a merchantable small-end diameter of 14 cm (reported by owners of mini-sawmills interviewed, Chapter 5) and a taper of 2 cm for gmelina in hedgerow and 1.5 cm for gmelina in block and 0.8 cm for bagras in both hedgerow and block arrangement (see section taper and pole quality in this chapter), merchantable height at the end of the tree rotation period was estimated to range between 8.6 to 11 m for gmelina in hedgerow, 9.1 to 12.3 m for gmelina in block and 15 to 17 m for bagras in both, hedgerow and block (**Table 4.1.7**).

4.1.3.5   Diameter at breast height (dbh)

The MAI in dbh for gmelina over the 4-year study period was 4.7 cm yr^{-1} for trees in hedgerow and 4 cm yr^{-1} for trees in block. These are within the range of MAI (3.3 to 5 cm yr^{-1}) for average sites reported by DENR-ERDB (1998). At the age of 4.5 years, average dbh of gmelina in hedgerow was 16% greater than in block plots (19.9 vs. 17.1 cm) (**Figures 4.1.8 and 4.1.9**).

For bagras, MAI in dbh over the 4-year study period was 3.4 cm yr^{-1} for trees in hedgerow and 3.1 cm yr^{-1} for trees in block. Observed dbh were similar to those reported by Tomboc (1976) for PICOP plantations (13.6 and 14.9 cm) and the MAI in dbh was slightly higher than that of 2 to 3 cm yr^{-1} reported by Francis (1988). The dbh of 4.5-year old bagras trees in hedgerow was 14% greater than in block (15.6 vs. 13.7 cm) (**Figures 4.1.10 and 4.1.11**).
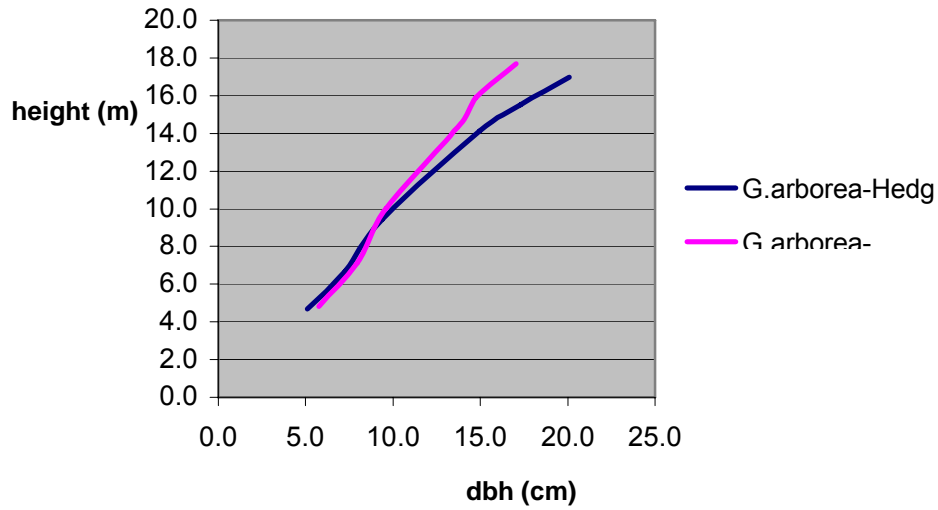
Figure 4.1.8: Diameter and height growth of *Gmelina arborea* in hedgerow (1 x 10 m) and block (2 x 2.5 m) arrangement at age of 54 months.
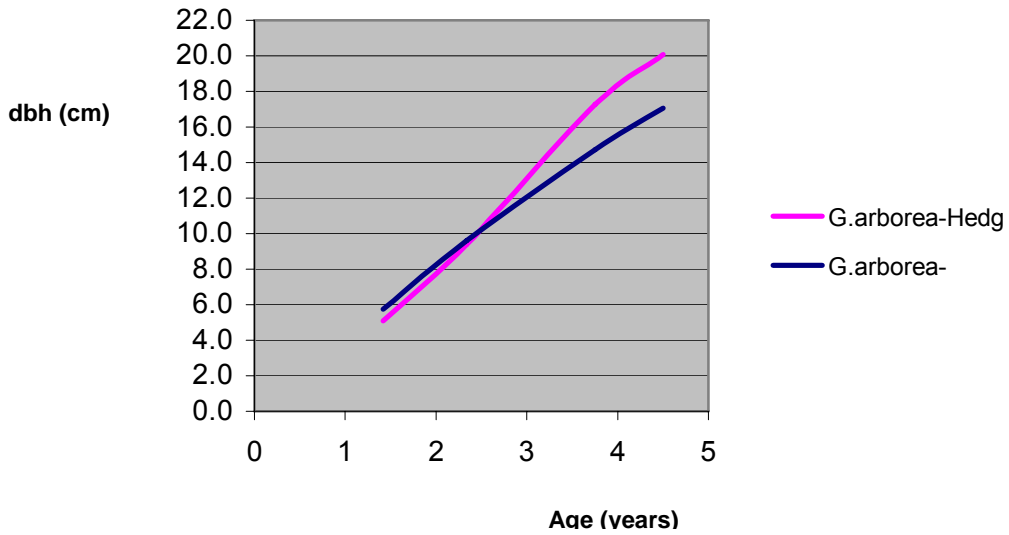
Figure 4.1.9: Diameter at breast height as a function of age of *Gmelina arborea* planted in hedgerow (1 x 10 m) and block (2 x 2.5 m) arrangement.
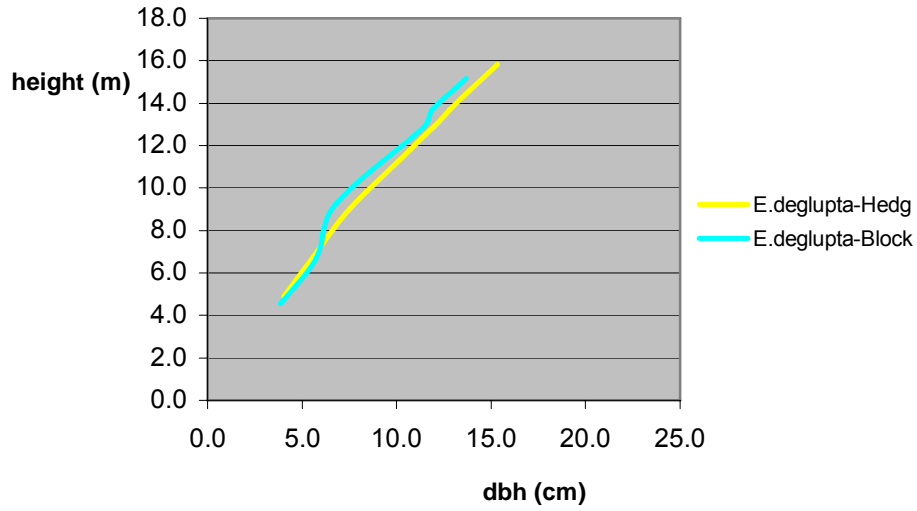
Figure 4.1.10: Diameter and height growth of *Eucalyptus deglupta* in hedgerow (1 x 10 m) and block (2 x 2.5 m) arrangement at age of 54 months.
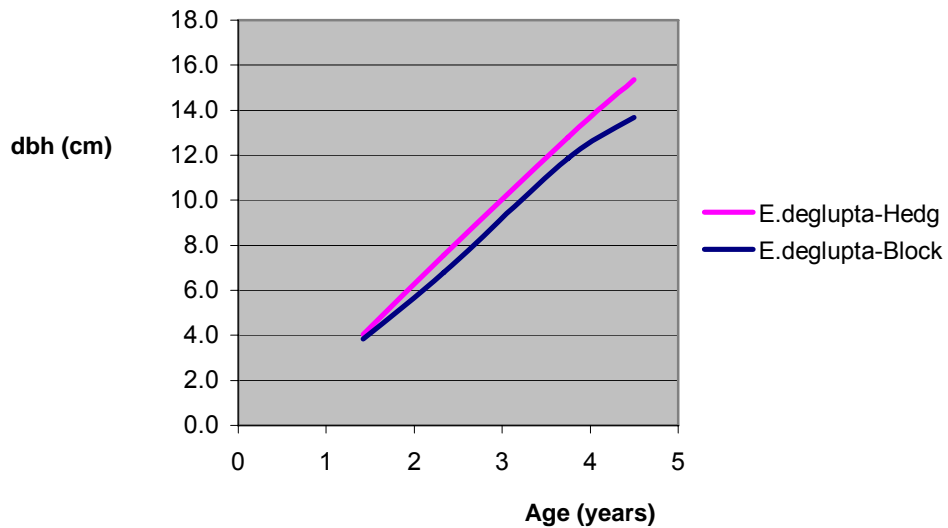
Figure 4.1.11: Diameter at breast height as a function of age of *Eucalyptus deglupta* planted in hedgerow (1 x 10 m) and block (2 x 2.5 m) arrangement.

For both tree specie, the difference in average dbh between trees on hedgerow and trees on block increased with age. However only gmelina showed convincing evidence that at the age of 4,5 years, trees on hedgerows attain a larger dbh than trees planted in blocks (**Tables 4.1.5 and 4.1.6**). The plausible values for the difference given by the 95% confidence interval for the mean are (0.6, 5.2) for gmelina and (-0.4 and 4.1) for bagras.

Table 4.1.5: Increased dbh growth with age of *Gmelina arborea* planted in hedgerow as compared with block planting.

Tree arrangement	17 mo		34 mo		54 mo	
	N	dbh (cm)	N	dbh (cm)	N	dbh (cm)
Hedgerows (1 x 10m)	147	5.0	74	14.1	65	19.9
Blocks (2 x 2,5 m)	156	5.7	86	12.7	70	17.1
SED		0.36		0.43		0.72
F-test probability		0.146		0.052		0.028

N: total number of trees (excluding border trees)
SED and p-values have been correctly calculated based on plot averages, not individual tree values

Table 4.1.6: Suggestive but inconclusive evidence of increased dbh of *Eucalyptus deglupta* planted in hedgerow as compared with block planting.

Tree arrangement	17 mo		34 mo		54 mo	
	N	dbh (cm)	N	dbh (cm)	N	dbh (cm)
Hedgerows (1 x 10 m)	141	4.1	79	10.6	61	15.6
Blocks (2 x 2,5 m)	139	3.8	82	10.4	62	13.7
SED		0.26		0.33		0.70
F-test probability		0.438		0.451		0.079

N: total number of trees (excluding border trees)
SED and p-values have been correctly calculated based on plot averages, not individual tree values

It would be plausible to expect an increase with age of the difference in dbh between trees planted in hedgerow and trees in block, as previous studies showed the long-term benefits for tree growth of planting trees at wide spacing and/or in association with crops. In Costa Rica, Kaap and Beer (1995) found that at the age of 5 years, the dbh of trees in association with crops (3 x 6 m) was greater by 24% for *Acacia mangium* (21.1 cm vs 17.0 cm) and 61% for *Cordia alliodora* (hereafter referred to as cordia) than the dbh in pure tree plots (3 x 3 m). In Rwanda, 12-year old *Grevillea robusta* showed increasing dbh with increasing planting distance: dbh was 8.5 cm when planted at 1.5 x 1.5 m, 10 cm at 2 x 2 m, 11 cm at 2.5 x 2.5 m and 12 cm at 3 x 3 m distance (Habiyambere and Musabimana, 1990). Recently, Beer et al., (2000) presented evidence from Central America on the benefits of growing trees at wide spacing in association with crops for timber production. Based on these and the result of this study, it seems reasonable to assume that at the end of the rotation period, average dbh of trees in hedgerow system will be notably greater than dbh of trees in block.

The measurement of 175 logs of gmelina at 4 mini-sawmills resulted in an average dbh at harvest ranging from 30 to 35 cm. A small-end diameter of 14 cm was estimated as the minimum merchantable diameter at the top end required at harvest. These results are used below to estimate the volumes of gmelina and bagras at the end of their respective rotation periods of 8 and 12 years.

4.1.3.6   Tree basal area and intercrop yield

This section was elaborated following Nissen and Midmore (2002) suggestion of using the stand basal area as a simple parameter to evaluate competitiveness in intercropping systems, and to provide an estimation of the economic value of the tree component. For both tree species tested in this study intercrop yields declined as stand basal area increased. Maize intercropped between gmelina experienced a rapid yield decline as stand basal area increased up to 6 m^2 ha^{-1}. Thereafter, crop yields gradually declined up to 40% of that of maize monocropping **(Figure 4.1.12)**. Intercrop yield decline caused by bagras was more gradual. At the age of 4.5 years and with a stand basal area between 8 to 10 m^2 ha^{-1}, bagras reduced maize grain yield by 40% **(Figure 4.1.13)**. With the same stand basal area, grain yield reduction by gmelina was 15 to 20% higher than reduction caused by bagras, indicating the stronger competition of gmelina for above-and below- ground resources. Therefore, it would be possible to maintain higher tree densities of bagras than gmelina with the same level of maize production. This is probably due, as farmers in Claveria reported, to the small branches, self-pruning habit and the narrower and ligther crown of bagras. Kang et al.,

(1994) found similar results when comparing cordia with gmelina in agroforestry plots in Nigeria, suggesting that cordia is more suitable for mixed agroforestry systems.
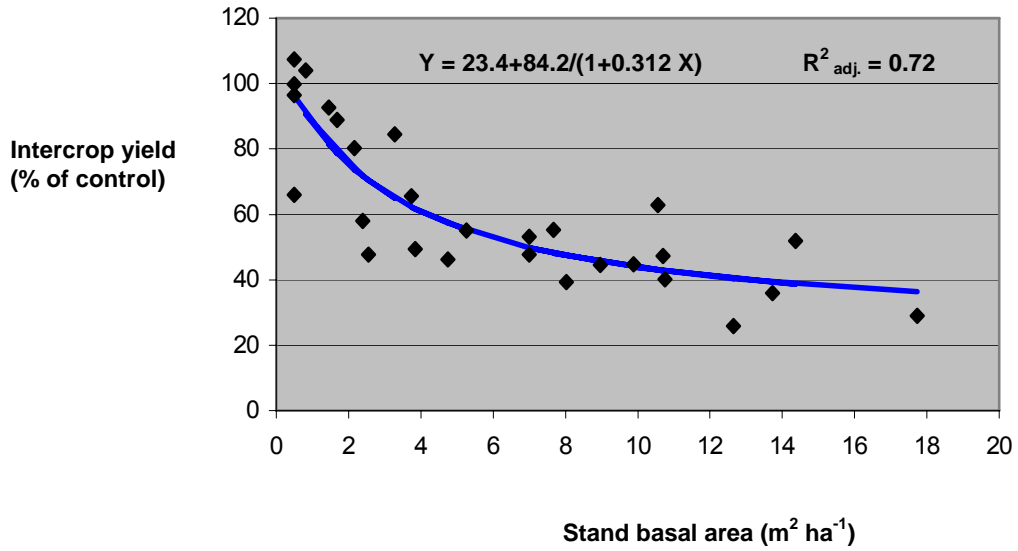
Figure 4.1.12: Maize grain yield decline as stand basal area of *Gmelina arborea* increases.
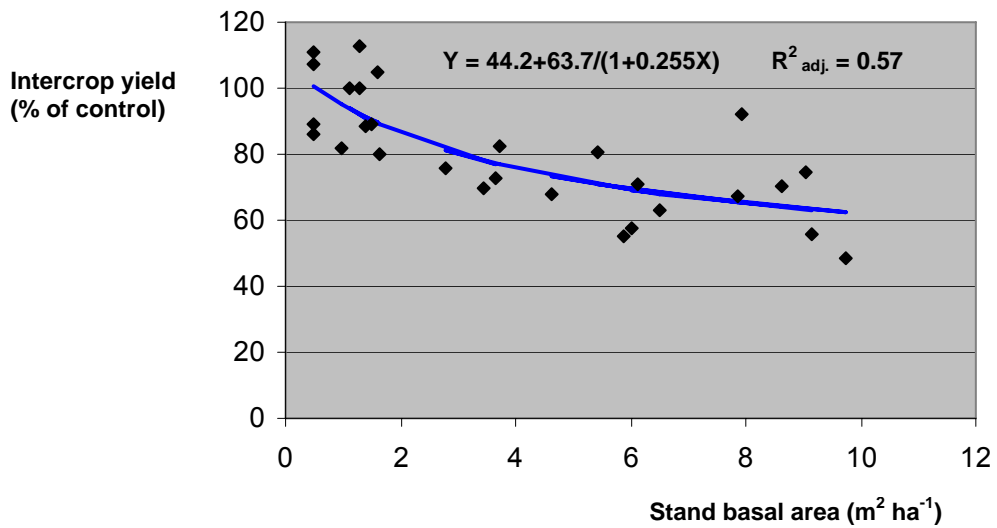
Figure 4.1.13: Maize grain yield decline as stand basal area of *Eucalyptus deglupta* increases.

Although bagras was less competitive than gmelina, both species reduced maize grain yields substantially. The high degree of competition shown in Figures 4.1.12 and 4.1.13 suggests that in intercropping systems with fast-growing timber trees and light demanding crops the tree basal area should be notably low if crop production is the priority. Other studies indicated that basal areas as large as those obtained in this study at the age of 4 should be maintained only when planting shade-tolerant understorey crops. According to Somarriba and Beer (1987), as cited by Kaap and Beer (1995), in traditional agroforestry systems with coffee and cocoa (two shade-tolerant perennial crops) the basal area of cordia should not be greater than 10 m^2 ha^{-1}. Based on the results of this study, if a maize grain yield decline of 20% (i.e., 1.6 ton over an average yield of 8 ton yr^{-1} in two cropping seasons) were acceptable, a farmer should only maintain a basal area between 2 to 4 m^2 ha^{-1}. This is equivalent to a density of 41 to 81 trees ha^{-1} when average dbh is 25 cm, or 28 to 57 trees ha^{-1} when trees are 30 cm in diameter. Other studies have arrived to similar conclusions. In China, planting the fast-growing timber *Pawlonia elongata* more densely than 5 x 20 m (100 trees ha^{-1}) will reduce crop yields drastically. But if trees are planted within the range from 5 x 50 m (40 trees ha^{-1}) to 5 x 20 m, crop yield decline is acceptable as the net economic returns increase to a large extent (Yin and He, 1997). However, this recommendation should be taken cautiously as the degree of tree-crop competition depends on many other factors such as the upperstorey tree, the specie intercropped, microclimatic conditions, management regime, etc. In Lantapan, Philippines, Midmore et al., (2001) found that bagras reduced by 40% the yield of intercropped vegetables when basal area was 2 to 4 m^2 ha^{-1}. It may be more advisable, therefore, to segregate fast-growing timber trees from crops by planting them in different farm niches.

Plate 4.1.2: Even if planted at wide distance, the growth and yield of light-demanding intercrops are substantially reduced as tree stand basal area increases. Intercropping would be viable only if the stand basal area is kept below 4 m^2 ha^{-1} and tree density ranges from 30 to 50 trees ha^{-1}.

4.1.3.7   Pole taper and quality

At the age of 4, taper was 2 cm per meter (SE = 0.08) for gmelina planted in hedgerows and 1.5 cm per meter (SE = 0.05) for gmelina planted in block. These values are in accordance with the average taper of 1.7 cm (SE = 0.05) measured on a sample of 175 harvested logs at several mini-sawmills. Taper of bagras was similar in both arrangements and equal to 0.8 cm (SE = 0.03) for trees planted in hedgerows and 0.76 cm (SE = 0.02) for trees in block.

Table 4.1.7 presents the results on the visual inspection of log quality (form and branchiness). Although block planting is commonly regarded as the arrangement most favourable to produce straight logs with few branches, the results suggest that with close intra-row distance and proper and frequent pruning, quality logs can be produced in widely-spaced tree hedgerows as well.

Table 4.1.7: Stem form and quality of 4-year old *Gmelina arborea* and *Eucalyptus deglupta* planted on farms in hedgerow (1 x 10 m) and block arrangement (2 x 2.5 m).

Stem form and quality	G. arborea (%)		E. deglupta (%)	
	Hedgerow (n = 74)	Block (n = 86)	Hedgerow (n = 79)	Block (n = 82)
1: crooked or knotty	16	18	11	13
2: average, medium form	58	50	57	47
3: excellent, straight and cylindrical	26	32	32	39

4.1.3.8   Total stem volume

Although the dbh of 4-year-old gmelina in hedgerow was 1.9 cm greater than in block (18.9 vs 17 cm), the merchantable wood volume of tree hedgerows was smaller (36.7 m^3 ha^{-1}) than in blocks (45.9 m^3 ha^{-1}) because of the smaller taper (and thus larger merchantable height) and higher stocking in the latter. For bagras, even if stocking was higher in block arrangement, at the age of 4 the merchantable wood volume[48] of tree blocks was lower than in hedgerow (56.8 m^3 ha^{-1} vs. 58.3 m^3 ha^{-1}). This suggests that some factor(s) were limiting growth of trees in blocks.

Based on the taper and the dbh of harvested trees found in this study, at the end of an eight-year rotation period timber volume of gmelina was estimated to range from 60 to 110 m^3 ha^{-1}. For bagras, the final volume at harvest after a 12-year rotation period was calculated to range from 146 to 185 m^3 (**Table 4.1.8**). Timber yields in the low productivity scenario are similar to those used in the financial analysis of tree plantations by the Department of Environment and Natural Resources (60 m^3 ha^{-1} for gmelina and 144 m^3 ha^{-1} for bagras) (DENR-ERDB, 1998).

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[48] Volume estimated by using a merchantable height up to 10 cm small-end diameter.

Table 4.1.8: Harvest scenarios for *Gmelina arborea* in an 8-year rotation and *Eucalyptus deglupta* in a 12-year rotation period.

Timber yield scenarios		N (stems ha^{-1})	Dbh (cm)		H$_m$ (m)		V$_m$ (m^3/ha)	
			Hedg	Block	Hedg	Block	Hedg	Block
G. arborea	Low	250	30	27	8.6	9.1	69	61
	High	250	35	32	11.0	12.3	110	104
E. deglupta	Low	250	28	28	15.0	15.0	146	146
	High	250	30	30	17.0	17.0	185	185

H$_m$: merchantable height, assuming a small-end diameter of 14 cm and taper as reported in this paper.

V$_m$: merchantable volume using the tree volume equations:

Log V$_m$ = -3.8579 + 1.6844 log Dbh + 0.8671 log H$_m$ for gmelina (Virtucio, 1984)

Log V$_m$ = 0.030318 + 2.049154 log$_{10}$ Dbh + 0.739098 log$_{10}$ H$_m$ for bagras (Tomboc, 1976).

4.1.4 Conclusion

This paper has presented evidence on the growth of fast-growing timber trees and their impacts on grain yields of maize intercropped over a 4-year period in an upland environment in the Philippines. In the two agroforestry systems tested (trees on hedgerow at 1 x 10 m and trees on block at 2 x 2.5 m), both gmelina and bagras performed well, showing dbh and height growth rates within the range of averages reported in previous studies from the Philippines and elsewhere. Therefore, in smallholder conditions both tree species can produce sufficient volumes of sawn timber, ranging from 60 to 110 m^3 ha^{-1} for gmelina in 8 years and 146 to 185 m^3 ha^{-1} for bagras in rotation of 12 years.

Because of its straight stem, self-pruning habit, small-diameter branches and narrower and less dense crown, bagras is more suitable than gmelina in mixed agroforestry systems. However, after a short period, both species have shown to drastically decrease maize intercrop yields below tolerable levels. Even if tree lines were planted 10 meters apart, all maize rows experienced grain yield decreases after the first year. Overall, by the seventh cropping season gmelina reduced maize grain yields by 60% and bagras by 40%. These levels of tree-crop competition are not acceptable to small-scale farmers, as the common practice of planting trees on farm boundaries away from crops and farmer's interest in less competitive, slow-growing timbers (see Chapter 3) demonstrates. If mixed agroforestry systems with fast-growing timbers are to produce acceptable levels of intercrop yields, tree basal areas should be within the range of 2 to 4 m^2 ha^{-1}. This is equivalent to a final tree crop ranging from 28 to 57 trees ha^{-1} (9 x 20 to 18 x 20 m), assuming trees are harvested when dbh is 30 cm. For higher tree

densities and if viable crop yields are to be produced, fast-growing trees should be planted in other farm niches, such as home gardens, farm boundaries, pastures or fallows, rather than on cultivated land. Another option may be, as observed in Claveria, to plant shade tolerant crops in the proximity of tree rows and light-demanding crops in the centre of the alleys. Future agroforestry research could focus on this management aspect and its economic implications for the smallholder farmer.

4.1.5   References

Ahn, P. M. (1993): Tropical Soils and Fertiliser Use. Essex, England: Longman Scientific & Technical.

Beer, J., Ibrahim, M. and Schlönvoigt, A. (2000): Timber production in tropical agroforestry systems of Central America. Proceedings of ' The XXI IUFRO World Congress 2000: Forest and Society: The Role of Research. Sub-plenary sessions Vol. 1'. 7-12 August, 2000, Kuala Lumpur, Malaysia: IUFRO:777-786.

Beer, J. F. (1994): Consideraciones basicas para el establecimiento de especies maderables en linderos. Agroforesteria en las Americas (Enero-marzo 1994): 21-23.

Braza, R. D. (1992): Varicose borer infestation and effects on native bagras Eucalyptus deglupta Blume growth condition. Sylvatrop Technical Journal for Philippine Ecosystems and Natural Resources 2 (1): 53-59.

DENR-ERDB (1998): Development and Management of Forest Plantations: A Guidebook. College, Laguna, Philippines: Ecosystems Research and Development Bureau (ERDB).

DTI and PKII Engineers (1996): General land use plan. Municipality of Claveria. Cagayan de Oro, Philippines: Department of Trade and Industry (DTI)-Region 10.

FPRDI (undated): Technical information on Bagras (*Eucalyptus deglupta* Blume). College, Laguna, Philippines: Forest Products Research and Development Institute (FPRDI).

Francis, J. K. (1988): *Eucalyptus deglupta* Blume. Kamarere. New Orleans, L A, US: Department of Agriculture, Forest Service, Southern Forest Experiment Station. 5 p.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

Garrity, D. P. and Agustin, P. C. (1995): Historical land use evolution in a tropical acid upland agroecosystem. Agriculture, Ecosystems and Environment 53: 83-95.

Gonzal, D. G. (1997): Annual crop-Gmelina arborea interactions in contour hedgerow agroforestry systems for smallholder farm forestry. In: Developments in Agroforestry Research. Los Baños, Laguna, Philippines: ICRAF, FAO-APAN, PCARRD and DOST: Book Series No. 160/97: 106-126.

Habiyambere, T. and Musabimana, F. (1990): Effect of spacing on the growth and production of *Grevillea robusta* in the semi-arid Region of Bugesera in Rwanda. In: Hardwood, C. E. (ed.): *Grevillea robusta* in Agroforestry and Forestry. Nairobi, Kenya: ICRAF: 99-102.

Hossain, M. K. (1999): *Gmelina arborea*: A popular plantation species in the tropics. Morrilton, Arkansas, US: Winrock International.

Huxley, P. (1999): Tropical Agroforestry. Oxford, UK: Blackwell Science Ltd.

Kapp, G. B. and Beer, J. (1995): A comparison of agrisilvicultural systems with plantation forestry in the Atlantic lowlands of Costa Rica. Part I. Tree survival and growth. Agroforestry Systems 32 (3): 207-223.

Kang, B. T., Akinnifesi, F. K. and Ladipo, D. O. (1994): Performance of selected woody agroforestry species grown on an alfisol and an ultisol in the humid lowland of west africa, and their effects on soil properties. Journal of Tropical Forest Science 7 (2): 303-312.

Kenmore, Z. F. and Flinn, J. C. (1987): An ethnohistory of an upland area: Claveria, Misamis Oriental. Manila, Philippines: International Rice Research Institute (IRRI).

Lamb, A. F. A. (1968): Fast Growing Trees of the Lowland Tropics: *Gmelina arborea*. Department of Forestry. University of Oxford, Oxford, UK. Commonwealth Forestry Institute.

Lawes Agricultural Trust (2001): GenStat-4.2. Fifth edition. Oxford, UK. VSN International Ltd.

Magbanua, R. D. and Garrity, D. P. (1988): Acid upland agroecosystems: a microlevel analysis of the Claveria research site. In: Proceedings of the 1988 Acid Upland Research Design Workshop. Los Baños, Philippines: International Rice Research Institute (IRRI): 1-20.

Miah, M. D. G. (1993): Performance of Selected Multipurpose Tree Species and Field Crops Grown in Association As Affected by Tree Branch Pruning. PhD dissertation, Central Luzon State University, Muñoz, Nueva Ecija, Philippines.

Midmore, D. J., Nissen, T. M. and Poudel, D. D. (2001): Making a Living Out of Agriculture: Some Reflections on Vegetable Production Systems in the Manupali Watershed. In: Coxhead, I. and Buenavista, G. (eds.): Seeking sustainabililty: challenges of agricultural development and environmental management in a Philippine watershed. Los Baños, Laguna, Philippines: PCARRD: 94-111.

Nair, K. S. S. (2001): Pest outbreaks in tropical forest plantations: is there a greater risk for exotic tree species? Bogor, Indonesia: Center for International Forestry Research (CIFOR).

Nissen, T.M. and Midmore, D. J. (2002): Stand basal area as an index of tree competitiveness in timber intercropping. Agroforestry Systems 54: 51-60.

Ong, C. K., Black, C. R., Marshall, F. M. and Corlett, J. E. (1996): Principles of Resource Capture and Utilization of Light and Water. In: Ong, C. K. and Huxley, P. (eds.): Tree-Crop Interactions: a Physiological Approach. Wallingford, UK: CAB International: 73-158.

Philip, M. S. (1994): Measuring Trees and Forests. Wallingford, UK: CAB International.

PCARRD (1995): Pest and diseases of forest plantation trees in the Philippines: a guidebook. Los Baños, Laguna, Philippines: PCARRD and DENR.

Santiago, R. G. (1997): Livelihood Enhancement Thru Agroforestry (LEAF) Program. In: Developments in Agroforestry Research. Los Baños, Laguna, Philippines: ICRAF, FAO-APAN, PCARRD and DOST: Book Series No. 160/97: 45-56.

Somarriba, E. J. and Beer J. W. (1987): Dimensions, volumes and growth of *Cordia alliodora* in agroforestry systems. Forest Ecology and Management 18: 113-126.

Stark, M. (2000): Soil Management Strategies to Sustain Continous Crop Production between Vegetative Contour Strips on Humid Tropical Hillsides. Technology development and dissemination based on farmers' adaptive field experimentation in the Philippines. International Centre for Research in Agroforestry. Southeast Asia Regional Research Programme.

Tomboc, C. C. (1976): Growth, yield and economic rotation of bagras pulp timber in PICOP plantations. MSc Thesis. University of the Philippines, Los Baños, Laguna, Philippines.

Virtucio, F. D. (1984): Determination of taper, bark thickness and volume of commercial tree species. Terminal Report. FORI.

von Uexkull, H. R. (1986): Efficient fertilizer use in acid upland soils of the humid tropics. FAO Fertilizer and Plant Nutrition Bulletin. Rome, Italy: FAO.

Watanabe, H. (1992): Tree-Crop Interactions in Taungya Plantations. In: Jordan, C. F., Gajaseni, J. and Watanabe, H. (eds.): Taungya: Forest Plantations with Agriculture in Southeast Asia. Wallingford, UK, CAB International: 32-43.

Yin, R. and He, Q. (1997): The spatial and temporal effects of Paulownia intercropping. The case of northern China. Agroforestry Systems 37 (1): 91-109.

4.2   Smallholder timber-based agroforestry systems on sloping lands in Claveria, northern Mindanao, Philippines: Financial returns and farmers' evaluation

Abstract

In the Philippines, timber production on small farms has become profitable as a result of extensive deforestation and increasing timber demand. In the 1990s, when the price of timber was high farmers were promised huge returns from tree farming. But widespread planting of few fast-growing timber species has led to oversupply and subsequently, a sharp decline in the price of farm-grown timber. In addition, low crop and timber yields caused by competition of vigorous fast-growing trees and poor tree management contribute to reduce even more the net economic returns from tree farming systems. In spite of these setbacks interest in tree farming is still high, as evidenced by farmers' willingness to plant other timber species which are more compatible with annual crops and command higher price. This chapter examines the private profitability of smallholder timber-based agroforestry systems and the alternative maize monocropping option. It also presents the result of farmers' evaluation of common timber production systems and tree species. Based on the on-farm trials reported in Chapter 4.1 and surveys conducted in Claveria, I developed realistic farm budgets and compared the profitability of two tree-maize systems, trees in woodlot arrangement (2 x 2.5 m) and hedgerow system (1 x 10 m), with maize monocropping. The financial analyses showed that at the prevalent low timber price maize monocropping provides higher returns to land but significantly lower returns to labour than the maize-tree systems tested. This suggests that tree farming is a more attractive option for labour- and capital-constrained households or those with off-farm opportunities that compete with their labour. These farmers may raise productivity and income by planting trees on the excess land that cannot be devoted to annual crops. Using a wide range of criteria, farmers' evaluation of timber production systems broadly pointed to the need, in small farms, of segregating timber from crop production enterprises as the most preferred systems were trees in boundaries, line planting and small-scale woodlots away from crops. However, the financial analysis also indicated that widely-spaced tree hedgerows (the third most preferred system) are superior to tree blocks or woodlots. The benefits of planting tree hedgerows relative to woodlots or blocks being lower establishment and management costs, longer periods of viable intercropping and faster tree growth. We propose, therefore, widely-spaced tree hedgerows as an alternative system to tree blocks for timber production in small farms.

Widely-spaced hedgerows of timber trees would increase economic returns from harvested crops and timber, provide fuel wood and animal weight gain, and ecological benefits including enhanced soil fertility build-up during the fallow period, soil erosion control and windbreak.

4.2.1   Introduction

In the late 1980s, diminishing timber supplies from natural forest and strong market demand led to a high increase in the price of timber in the Philippines. Farmers seized this economic opportunity by planting fast-growing timber trees, such as *Gmelina arborea* (hereafter referred to as gmelina), *Paraserianthes falcataria*, *Acacia mangium* and others, as a cash crop (Garrity and Mercado, 1993). Tree planting has been so widespread that farm forestry has been proposed as a viable alternative to expensive government-driven reforestation projects (Pascicolan et al., 1997). Nowadays, trees planted on farms account for an increasingly important share of the wood industry output (ITTO, 2001).

Since the rise of timber prices, tree planting began to be promoted as an exceptionally profitable farm enterprise[49]. This promise was based on overoptimistic timber yields of fast-growing trees and the high timber price prevalent in the past. For example, a local newspaper reported that one *Eucalyptus deglupta* tree (hereafter referred to as bagras) would yield in 10 years 1.5 m^3 (636 board foot, bd.ft.) of lumber and produce returns of Ph P 14,000 or Ph P 10.5 million per ha (US $ 400,763 ha^{-1}, exchange rate in 1996 of US $ 1 = Ph P 26.2) (Fonollera, 1996). Just recently, it was reported in the First Visayas Tree Farmers Congress that one hectare of gmelina would give a net income of Ph P 769,011 at a price Ph P 20 bd ft^{-1} (Tree Farmers Congress, 2000). Unfortunately the reality was that as many planted trees reached harvestable age, by mid 1990s timber prices fell drastically due to market saturation. In 1997, the price of stumpage timber averaged Ph P 4 bd. ft.$^{-1}$ (US$ 48.5 m^{-3}; US$ 1 = Ph P 35), or a threefold decline as compared with the price in the late 1980s. This price has caused disenchantment among upland farmers (Caluza, 2002).

The low price of farm-grown timber is not the only reason for diminishing returns from tree farming systems. When fast-growing timber trees are planted on crop land, tree competition for above- and below- ground resources reduce yields of intercrops below economic levels. If strongly competitive tree species are involved, such as gmelina, this may happen as early as one year after tree planting (see Chapter 4.1).

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[49]. The popular saying among Philippinos in northern Mindanao "Kahoy karon, bulawan ugma" (trees today, gold tomorrow) reflects the high expectations put on tree farming.

Furthermore, farmers' practice of severe pruning to control tree's competition effects on crops also leads to low timber price and returns, since this practice reduces timber yield and quality. Other poorly implemented practices leading to low returns are the lack of thinning in woodlots due to farmers' reluctance to get rid of immature trees, and the use of low quality planting materials (Chapter 3.1).

In spite of these setbacks, interest in tree farming is still high. Although dissatisfied with price, gmelina planters in Claveria still showed interest in growing this specie (Magcale-Macandog et al., 1999). Many smallholders are also willing to plant bagras and *Swietenia macrophylla*, even if rotations are longer than that of gmelina, because of their compatibility with associated crops and the higher market price of these quality timbers (see survey results in Chapter 3.1). Planting timber trees may be also a more attractive option for labour-constrained farming households as maximizing returns per unit of labour would be their primary concern (Netting, 1993; Arnold and Dewees, 1997; Franzel and Scherr, 2002). These farmers may raise productivity and income by planting trees on excess land that cannot be put under annual crops (Midmore et al., 2001). Even in smaller farms with a priority on crop production, planting timber trees on boundaries away from crops or at low densities seems to be an attractive option to enhance income (Chapter 3.2).

The first part of this chapter examines the private profitability of smallholder timber-based agroforestry systems and the alternative maize monocropping option. Based on the results of the on-farm trials presented in Chapter 4.1 and surveys conducted in Claveria, I developed realistic farm budgets and compared the profitability of two tree-maize systems, trees in woodlot (or block) arrangement (2 x 2.5 m) and in hedgerow (or line) system (1 x 10 m), with maize monocropping. We hypothesized that agroforestry systems with timber trees on hedgerows at wide distance (10 m) are more profitable than systems with closely spaced trees (2 x 2.5 m) since in the former:

1. The cropping area lost to trees is minimal.

2. Intercropping is viable for longer periods.

3. Tree establishment and management costs are lower

4. Trees grow faster and timber yields are higher because of the more intensive management and favourable light regime.

In the second part of this chapter, the results of three focused group discussions with experienced tree growers are reported. The objectives of this activity were: i) to elicit farmers' evaluation of common timber production systems and tree species; and ii) to evaluate whether farmers perceive widely-spaced tree hedgerows as a feasible tree

farming system. The evaluation of timber production systems on small farms would not be completed without the involvement of the "real" agroforesters and the analysis of their own experience.

4.2.2   Methods and data

4.2.2.1   Growth and yield data

Data on tree growth and maize yield used in the financial analysis was collected from on-farm experimental plots established to study maize-timber intercropping systems. Two timber species were used in association with maize (*Zea mais*): *Gmelina arborea* R.Br (gmelina) and *Eucalyptus deglupta* Blume (bagras). Both species are fast-growing timber trees popular among farmers in the Philippines. During the late 1980s and 1990s, gmelina was extensively planted across the country, particularly in Claveria. But recently, bagras became more popular for on-farm planting because of its fast growth, straight bole, light canopy, self-pruning habit, and high market demand. The experimental set-up consisted of researcher-designed and –managed on-farm trials (Type 1) with plots laid out in a randomized complete block design with 3 treatments and 4 replications. There were 3 treatments:

- T_1 (NVS): maize mono cropping between narrow strips of natural vegetation 10 meters apart.

- T_2 (Block): timber trees in woodlot arrangement at 2 x 2,5 m (2000 stems ha^{-1}), with 3 rows of maize inter-planted in the 2,5-meter alleys until canopy closure.

- T_3 (Hedgerow): timber trees on hedgerows at 1 x 10 m (1000 stems ha^{-1}), with 15 rows of maize intercropped in the 10-meter wide alleys.

Maize cropping started on October 1997 (dry season crop 1997), immediately after tree planting, and continued for 7 cropping seasons in the NVS and tree hedgerow treatments and for 3 cropping seasons in the tree-block treatment. Detailed information on plot management and data collection is given in Chapter 4.1.

Financial calculations were made for a tree rotation period of 8 years for agroforestry systems with gmelina and 12 years for bagras. Maize grain yield data used in the financial analysis from year 1 to 4 was, for each treatment, the average over replications after discounting the area occupied by the grass strips (NVS). As the first maize cropping was in the dry season crop 1997 (October), maize grain yield for the wet season crop of 1997 (May) was assumed to be the same in all treatments and equal to the average yield of the maize monocropping treatment (4.9 t ha^{-1} for systems

with gmelina and 5.6 t ha^{-1} for systems with bagras) (**Table 4.2.1 and 4.2.2**). Only two (2) maize crops above the break-even yield (3 t ha^{-1} for the wet season crop; 2 t ha^{-1} for the dry season crop) were obtained from the agroforestry plots with gmelina. The experiment with bagras yielded six (6) maize crops in the tree-hedgerow treatment and two (2) maize crops in the tree-block treatment above the break-even yield. For the financial analysis of the tree-maize systems, I assumed maize planting is discontinued once yields fall below the break-even. In the monocropping system, maize grain yield from year 5 until tree harvest was assumed to be equal to the average experimental yield for each season.

Table 4.2.1: Maize grain yield (t ha^{-1}) in two agroforestry systems with *Gmelina arborea* and maize monocropping.

Year	Wet season crop			Dry season crop		
	Maize monocrop	Maize-Tree hedgerow	Maize-Tree block	Maize monocrop	Maize-Tree hedgerow	Maize-Tree block
1	4.9*	4.9*	4.9*	2.9	2.7	3.0
2	5.7	4.8	5.0	2.5	-	-
3	4.6	-	-	3.2	-	-
4	4.5	-	-	2.8	-	-
5-8	4.9	-	-	2.9	-	-

Table 4.2.2: Maize grain yield (t ha^{-1}) in two agroforestry systems with *Eucalyptus deglupta* and maize monocropping.

Year	Wet season crop			Dry season crop		
	Maize monocrop	Maize-Tree hedgerow	Maize-Tree block	Maize monocrop	Maize-Tree hedgerow	Maize-Tree block
1	5.6 *	5.6*	5.6*	3.4	3.4	3.2
2	6.9	6.3	5.6	3.2	3.1	-
3	5.3	4.0	-	4.1	2.6	-
4	4.7	3.7	-	3.0	-	-
5-12	5.6	-	-	3.4	-	-

*Since research trials started with the planting of trees and the first dry season crop (October 1997), maize grain yield for the first wet season crop (May 1997) is assumed to be the same in all systems and equal to the average wet season crop in the maize mono-cropping plots

Based on farmers practice and the literature on the subject, tree rotation periods were assumed to be 8 years for gmelina and 12 years for bagras. As recommended by DENR-ERDB (1998) and GOLD Project (1998), the final tree crop was estimated at 250 trees ha^{-1} for both species. Two timber yield scenarios, "low" and "high", were considered in the financial analyses. Assumptions about tree dbh and merchantable height at harvest in the agroforestry systems tested were made based on the projections reported on Chapter 4.1. Thus, timber volume of gmelina at the end of an eight-year rotation period ranges from 60 m^3 ha^{-1} to 110 m^3 ha^{-1}, and timber volume of bagras in a 12-year rotation period ranges from 146 to 185 m^3 for (**Table 4.2.3**). Timber yields in the low productivity scenario are similar to those used in the financial analysis of tree plantations by the Department of Environment and Natural Resources (DENR) (60 m^3 ha^{-1} for gmelina and 144 m^3 ha^{-1} for bagras) (DENR-ERDB, 1998).

Table 4.2.3: Harvest scenarios for *Gmelina arborea* in an 8-year rotation period and *Eucalyptus deglupta* in a 12-year rotation period.

Timber yield scenario		N (stems ha^{-1})	Tree hedgerow (1 x 10 m)			Tree block (2 x 2.5m)		
			Dbh (cm)	H$_m$ (m)	V$_m$ (m^3 ha^{-1})	Dbh (cm)	H$_m$ (m)	V$_m$ (m^3 ha^{-1})
G. arborea	Low	250	30	8.6	69	27	9.1	61
	High	250	35	11.0	110	32	12.3	104
E. deglupta	Low	250	28	15.0	146	28	15.0	146
	High	250	30	17.0	185	30	17.0	185

H$_m$: merchantable height, assuming a small-end diameter of 14 cm and taper as reported in Chapter 4.1

V$_m$: merchantable volume, estimated with the tree volume equations:

Log V$_m$= -3.8579 + 1.6844 log Dbh + 0.8671 log H$_m$ for gmelina (Virtucio, 1984)

Log V$_m$= 0.030318 + 2.049154 log$_{10}$ Dbh + 0.739098 log$_{10}$ H$_m$ for bagras (Tomboc, 1976)

4.2.2.2   Cost and labour data

Cost of inputs, labour and benefits correspond to 1998 values using local prices for the financial calculations (Appendices Table A 4.2.1). The value of family labour used is the average agricultural wage rate of Claveria in 1998 (Ph P 60 man-day^{-1} and Ph P 120 man-animal day^{-1}). With these values, cost of maize monocropping was estimated at Ph P 25,202 ha^{-1} yr^{-1}. Gmelina-maize intercropping production and management costs incurred over an 8-year rotation period was calculated as Ph P 45,111 ha^{-1} for the tree-hedgerow system and Ph P 47,415 for tree-blocks. Costs incurred for establishment and management of bagras over a 12-year rotation period were Ph P 96,116 for tree hedgerows and Ph P 51,015 for tree blocks. Tree and crop management activities are detailed in Chapter 4.1. Land value was assumed to be equal for the 3 systems tested and thus, it was not included in the analysis. Timber harvesting and transportation costs were not included in the financial calculations either, as farmers in Claveria commonly sell timber on stumpage. Because of the important bias introduced when estimating labour use from small-sized research plots, labour data for all the activities involved in maize cultivation, including the slashing of contour grass strips, was obtained from Nelson et al., (1996). Labour use for tree establishment (hole digging, planting and weeding) and management (pruning and thinning) was derived from Agpaoa et al., (1976), Laarman, et al., (1981), Pancel (1993) and DENR-ERDB (1998), and farmers' interview just after the task was completed (only for tree pruning).

4.2.2.3   Financial analysis tools

The financial net benefits of the tree farming systems described and maize monocropping were assessed by the criterion of the Net Present Value (NPV). The NPV is calculated by discounting benefits and costs to the present. The standard formula is:

$$NPV = \sum_{j=0}^{n}\left[\left(B_j - C_j\right)/\left(1+r\right)^j\right] \qquad \text{where}$$

B_j = benefits in year j,   j = 1, 2,..., n

C_j = cost in year j,   j = 1, 2,..., n

r = discount rate

The NPV value provides indication of the profitability of the investment at the discount rate (interest rate) considered. The investment is profitable and viable when NPV is greater than or equal to zero. The NPV also represents the returns per unit of land. So farmers whose scarce resource is land would choose the system with the highest NPV. The analysis also includes the calculation of the net returns to labour, as this indicator would be relevant for labour-constrained farmers or those with off-farm opportunities that compete with their labour (Franzel et al., 2002). Returns to labour were estimated as:

Returns to labour = Discounted net benefits to labour (1) / Discounted labour days (2)

$$(1) = \sum_{j=1}^{n}\left[\left(B_j - I_j\right)/\left(1+r\right)^j\right]$$

B_j = benefits in year j,   j = 1, 2,..., n

I_j = input costs in year j, j = 1, 2,..., n

$$(2) = \sum_{j=1}^{n}\left[WD_j/\left(1+r\right)^j\right]$$

WD_j = Labour work-days

Annual discount rates of 15 and 20% were arbitrarily selected for the financial evaluation. Although commonly chosen by convention, these rates were assumed to approximately represent the rate farmers from Claveria use to discount future benefits considering the cost of borrowed capital in the area and, as Scherr (1992) suggested, farmer's production objective (cash and/or savings) and the risk of the agroforestry

practice. Finally, sensitivity analyses were carried out to account for variations in the price of labour and outputs and discount rates.

4.2.2.4   Farmers' evaluation

Three focused group discussions were organized to elicit farmers' evaluations of timber production systems and tree species. A total of 42 experienced tree growers, including those collaborating in the management of the on-farm trials, participated in the discussions. In the first discussion, there were 19 farmers from Cluster I villages (lower Claveria), 15 from Cluster II in the second discussion, and 8 participants from Cluster III (upper Claveria) in the third and last meeting. Most of the participants had visited at least once the on-farm trials to observe and compare tree and maize growth.

Preference ranking and matrix scoring were the participatory research methods used for the evaluation following the process as described by Pretty et al., (1995). First, participants were presented 6 charts, each of them depicting a common timber production system. Tree arrangement, planting distance and tree density were indicated in the chart. The systems were presented in two categories: a) trees and crops integrated (intercropping systems); and b) segregated systems. The first category included: i) trees on blocks (2 x 2 m; 2,500 trees ha^{-1}) (block); ii) trees on hedgerows (1 x 10 m; 1,000 trees ha^{-1}) (hedgerow), and iii) trees scattered on cropland (500 trees ha^{-1}) (scattered). Segregated systems were: iv) one half hectare of woodlot (2 x 2 m, 1250 trees) plus one half hectare of monocropping (woodlot); v) trees on farm boundaries (2 m; 100 trees ha^{-1}) (boundary); vi) trees around the homestead (50 trees) (homestead). Then, farmers' criteria for evaluation of the systems were elicited by asking them to select the best and the worst of the systems and the reasons for their choice. Thirdly, farmers ranked the systems according to the criteria (matrix scoring). After, farmers' main preferences were determined by comparing each option with the rest (preference or pairwise ranking). Once timber production systems were evaluated, the process was repeated for common timber tree species. Important comments and topics of discussion that emerged as the matrix was created were properly recorded and taken in consideration in the analysis of results.

4.2.2.5   Limitations of the study

The profitability of timber-based agroforestry systems was studied by using data from Type 1 on-farm trials with a small number of replications (4). These provided limited information about the variability of key variables (labour, yields, NPV, etc). Ideally, financial analysis should have been done with data over a broad range of farm types (20 to 50) which better reflect some of the variability in inputs (e.g., labour), and

outputs (grain and timber yields), allowing to capture the uncertainty for farmers by doing a separate financial analysis for each replication and looking at the variability (standard error) of the profitability (NPV) (Franzel et al., 2002). Unfortunately, this was not possible due to time and resource constraints.

The study is also limited in scope, as it has valued only the main products maize grain and timber. I did not attempt to study environmental and other less tangible benefits derived from tree planting, such as erosion control, boundary demarcation, shade or shelter. For such a study in Claveria refer to Predo (2002). Other benefits with direct market value, such as wood fuel and poles from intermediate thinnings, were not included in the analysis as a previous survey suggested that farmers consider these as by-products rather than the main product from tree planting (see Chapter 3.1).

4.2.3   Results and discussion

4.2.3.1   Financial evaluation

For the economic analysis, four scenarios are presented for each agroforestry system by using low and high timber yields with the current timber price (Ph P 4 bd. ft^{-1}), and two discount rates (15 and 20%) **(Tables 4.2.4 and 4.2.5)**. A detailed budget for maize monocropping and intercropping with gmelina is shown in Appendices Table A.4.2.1. The analysis of returns to land for gmelina-maize agroforestry in the low timber yield scenario shows net present values (NPVs) of maize monocropping 41 to 58% higher than that of tree hedgerows and 53 to 70% higher than for tree blocks. In the case of high timber yields (104 – 110 m^3 ha^{-1}), the NPV of gmelina hedgerows is 2.4 % higher than maize monocropping at discount rate of 15% but 13% lower if the discount rate applied is 20%. Maize monocropping is more profitable than any other agroforestry alternative at a 20% discount rate. Therefore, at current timber price gmelina intercropping is not as profitable as maize monocropping. Besides its low price, the main disadvantage of gmelina is its competitiveness. This specie reduces maize grain yield below the break-even after two cropping seasons, even when tree lines are planted at 10 meters distance. The profitability of gmelina tree blocks is lower than tree hedgerows. The benefits of planting trees in hedgerow relative to tree blocks were reduced cost of seedlings and labour for tree establishment and management.

Table 4.2.4: Returns to land (Net present value, NPV) and returns to labour of agroforestry with *Gmelina arborea* and maize monocropping over an 8-year tree rotation period.

System	Maize (t/ha/9 yr)	Timber (m^3 ha^{-1})	Returns to land: NPV (US\$ ha^{-1})		Returns to labour: net returns (US\$ work-day^{-1})	
			dr = 15%	dr = 20%	dr = 15%	dr = 20%
Maize monocropping	70.1	0.0	1,596	1,348	3.8	3.8
Low timber yield						
Tree hedgerow (1 x 10 m)	12.5	69.1	1,131	852	5.7	4.9
Tree block (2 x 2.5 m)	12.9	60.8	1,040	793	4.6	4.0
High timber yield						
Tree hedgerow (1 x 10 m)	12.5	110.6	1,631	1,192	7.4	6.2
Tree block (2 x 2.5 m)	12.9	104.4	1,564	1,151	6.0	5.1

Timber price = PhP 4 bd ft^{-1} or US\$ 42.4 m^3

Exchange rate for 1998: US \$ = PhP 40 (data from: exchange rate_1990-2002 www.bsp.gov.ph/statistics/exrate/usd/year_htm)

The economic analysis of agroforestry with bagras shows similar results: at current timber prices maize monocropping is more profitable than the agroforestry options studied, even with high timber yields (**Table 4.2.5**). Planting bagras in hedgerows is between 30 – 40% more profitable than in block. The benefits of tree hedgerows are reduced costs of seedlings and lower weeding costs and higher maize yields because of the longer intercropping period. Added costs included labour and inputs for maize cultivation.

Even if rotations are 4 years longer, hedgerows of bagras are approximately 60% more profitable than hedgerows of gmelina in the lower timber yield scenario and almost 30% more profitable in the high timber yield scenario. The benefits of bagras over gmelina hedgerows are the higher timber yields (111% higher in the low yield scenario and 67% higher in the high yield scenario) and the longer period of intercropping (4 cropping seasons more). There is not great advantage of blocks of bagras over blocks of gmelina. In the low timber yield scenario, blocks of bagras are around 30% more profitable than blocks of gmelina only because yields of bagras are almost 2.5 times greater than yields of gmelina. But in the high timber yield scenario, tree blocks with bagras are just as profitable as tree blocks with gmelina.

Table 4.2.5: Returns to land (Net present value, NPV) and returns to labour of agroforestry with *Eucalyptus deglupta* and maize monocropping over a 12-year tree rotation period.

System	Maize (t/ha/9 yr)	Timber (m^3 ha^{-1})	Returns to land: NPV (US$ ha^{-1})		Returns to labour: net returns (US$ work-day^{-1})	
			dr = 15%	dr = 20%	dr = 15%	dr = 20%
Maize monocropping	117.3	0.0	2,749	2,242	4.7	4.7
Low timber yield						
Tree hedgerow (1 x 10 m)	28.7	146.1	1,846	1,355	5.6	4.9
Tree block (2 x 2.5 m)	14.5	146.1	1,387	940	5.9	4.8
High timber yield						
Tree hedgerow (1 x 10 m)	28.7	184.6	2,110	1,507	6.1	5.2
Tree block (2 x 2.5 m)	14.5	184.6	1,652	1,092	6.6	5.3

Timber price = Ph P 4 bd ft^{-1} or US$ 42.4 m^3

Exchange rate for 1998: US $ = PhP 40 (data from: exchange rate_1990-2002 www.bsp.gov.ph/statistics/exrate/usd/year_htm)

Financial analysis of tree plantations conducted in the Philippines by the DENR showed higher NPV values and a more favourable cost-benefit ratio (BCR) than the agroforestry systems of this study (DENR-ERDB, 1998). For a plantation of gmelina in an 8-year rotation period, the DENR estimated at 15% discount rate a NPV of Ph P 105,637 and a BCR (15%) = 2.8 . In contrast, in this study the NPV of gmelina hedgerow intercropping is NPV (15%) = Ph P 45,253 and the BCR (15%) = 2.2. The same could be said for plantations of bagras. For plantations in rotations of 8 years, the DENR reported NPV (15%) = Ph P 216,157 and BCR (15%) = 3.65, whereas this study found a NPV (15%) = Ph P 73, 824 and BCR (15%) = 2.0 for tree hedgerow intercropping in rotation of 12 years. The major reason for the large difference between these financial calculations is not the timber yield, which is similar in both studies (DENR estimated a timber yield in 8 years of 60 m^3 for gmelina and 144 m^3 for bagras), but the timber price used and the thinning revenues accrued. DENR's study considered a price of Ph P 9 bdft^{-1} for gmelina timber and Ph P 10.5 bdft^{-1} for bagras. This is more than twice the current average price of farm-grown timber of gmelina on stumpage. In addition, DENR's study assumed a profitable intermediate thinning amounting to Ph P 150,000, which probably is an overoptimistic assumption.

The estimation of NPV (returns per hectare of land) is relevant when land is scarce. But labour-constrained farmers would be more concerned about maximizing the crop return per unit of labour (Arnold and Dewees, 1997; Franzel and Scherr, 2002). The

analysis of returns to labour is more favourable for maize-tree agroforestry in all scenarios, indicating the superiority of timber-based agroforestry systems for labour-constrained farmers whose objective is to maximize land productivity with scarce labour. Over a tree rotation period, a hectare of maize-timber agroforestry required approximately 70 to 80% less labour than a hectare of maize monocropping. Comparisons between agroforestry systems showed that woodlots of gmelina required 26% more labour than hedgerows because of the higher tree density in the former (**Figure 4.2.1**). On the contrary, because of the extended period of intercropping, bagras planted in hedgerows needed 53% more labour than blocks (**Figure 4.2.2**). Therefore returns to labour were slightly higher for woodlots of bagras, although the difference tended to level off with higher discount rates.

In summary, with current timber prices and low timber yield scenarios, maize monocropping shows higher returns to land than timber agroforestry but lower returns to labour. With high timber yields (100 – 110 m^3 ha^{-1}) returns to land are slightly higher for gmelina hedgerow than maize monocropping at 15% discount rate, but not at 20%. In rotation of 12 years, bagras agroforestry did not show higher NPV than maize monocropping, even if intercropping in the hedgerow system was possible during six cropping seasons.
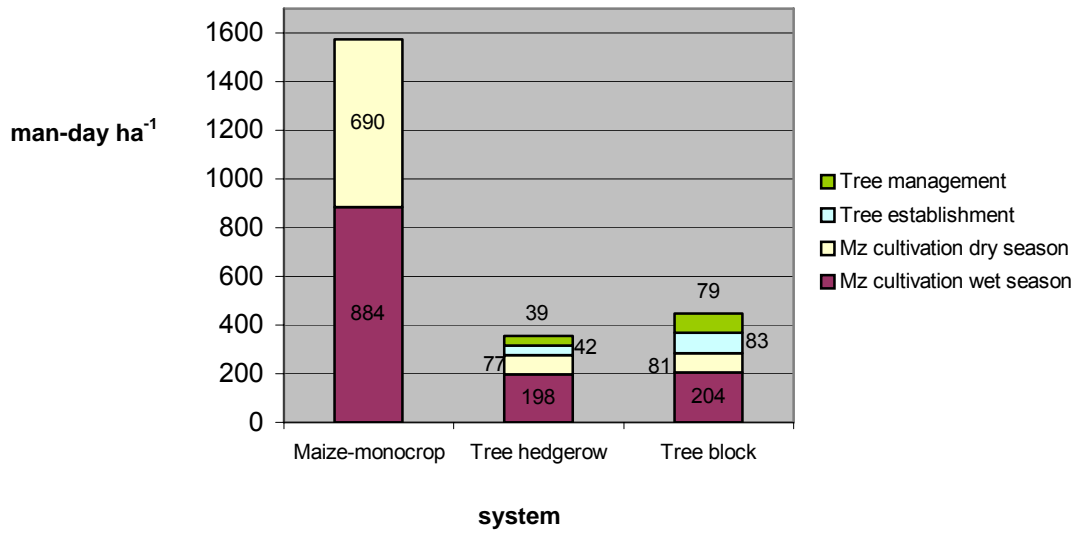
Figure 4.2.1: Labour inputs required for maize monocropping and maize – *Gmelina arborea* agroforestry for an 8– year rotation period.
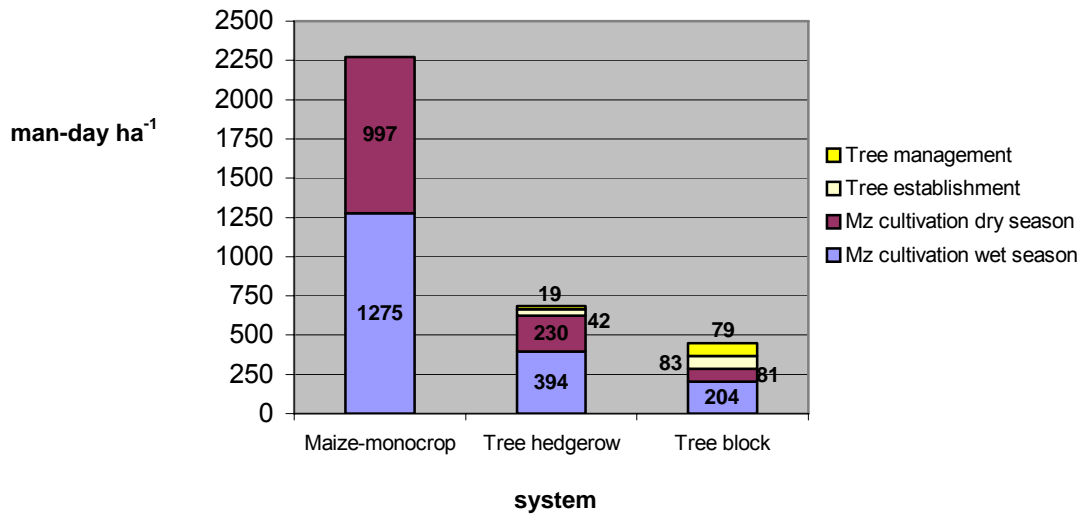
Figure 4.2.2: Labour inputs required for maize monocropping and maize – *Eucalyptus deglupta* agroforestry for a 12– year rotation period.

The sensitivity of the systems to changes in the values of basic parameters is studied following Platen (1991). Figures below present the resulting break-even lines for different pairs of parameters (timber and maize price), discount rates (10, 15 and 20%) and timber yields (low and high). Rather than just estimating the profitability of the systems at a given value of the parameters, these graphs allow us to calculate the range of values that a certain parameter can take before the ranking of the system change (Platen, 1991).

Figures 4.2.3 and **4.2.4** are the result of the sensitivity analysis for maize monocropping and agroforestry with the parameters of maize and timber price, three levels of discount rate, two timber yields and the observed labour cost. All combinations of maize and timber price above the graph indicate economic advantage for agroforestry and the combinations below the line are advantageous for maize monocropping. For example, at current timber price (Ph P 4 bd ft^{-1}) and low timber yields, maize price would have to decrease by 15 to 20% before gmelina intercropping breaks even at 20% discount rate. But if farmers are able to attain high timber yields, a 5% decrease in the price of maize will make timber intercropping at least as profitable as maize monocropping. Overall, the analysis for gmelina agroforestry shows that if the timber price increases by 25% (from Ph P 4 to 5 bdft^{-1}), timber intercropping would be more profitable than maize monocropping at 20% interest rate. This will not be difficult to achieve as some mini-sawmill owners reported to be willing to pay a higher price for straight logs, which are at least 8 feet long and 14 cm in small-end diameter (see Chapter 5).

Results for bagras agroforestry are less favourable. If high timber yields are produced, for tree intercropping to be as profitable as maize monocropping with current maize price and 20% interest rate, the stumpage price would have to increase by 100% (from Ph P 4 to 8 bdft^{-1}). It should be noted however, that although a price increase of such a magnitude is unlikely to occur for gmelina (due to the current oversupply and low quality), the price of round timber of bagras would probably be higher as the sawmill owners manifested in interviews reported in Chapter 5.
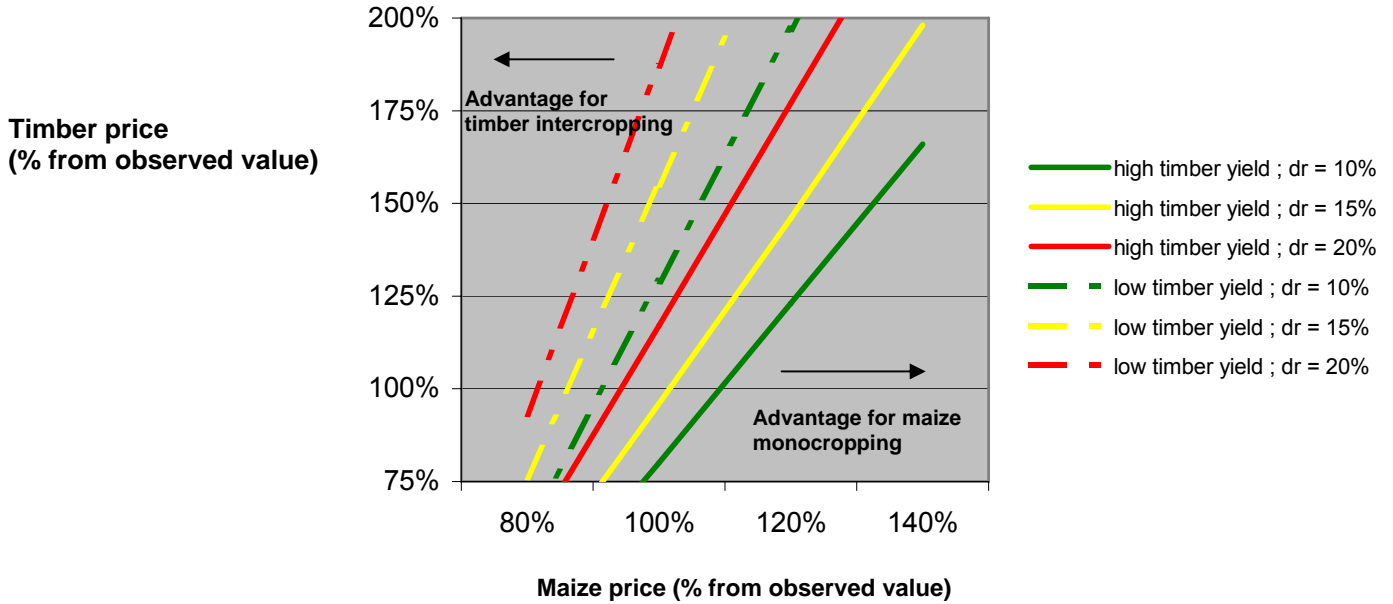
Figure 4.2.3: Break-even line of NPVs of maize monocropping and *Gmelina arborea* intercropping (observed labour cost).
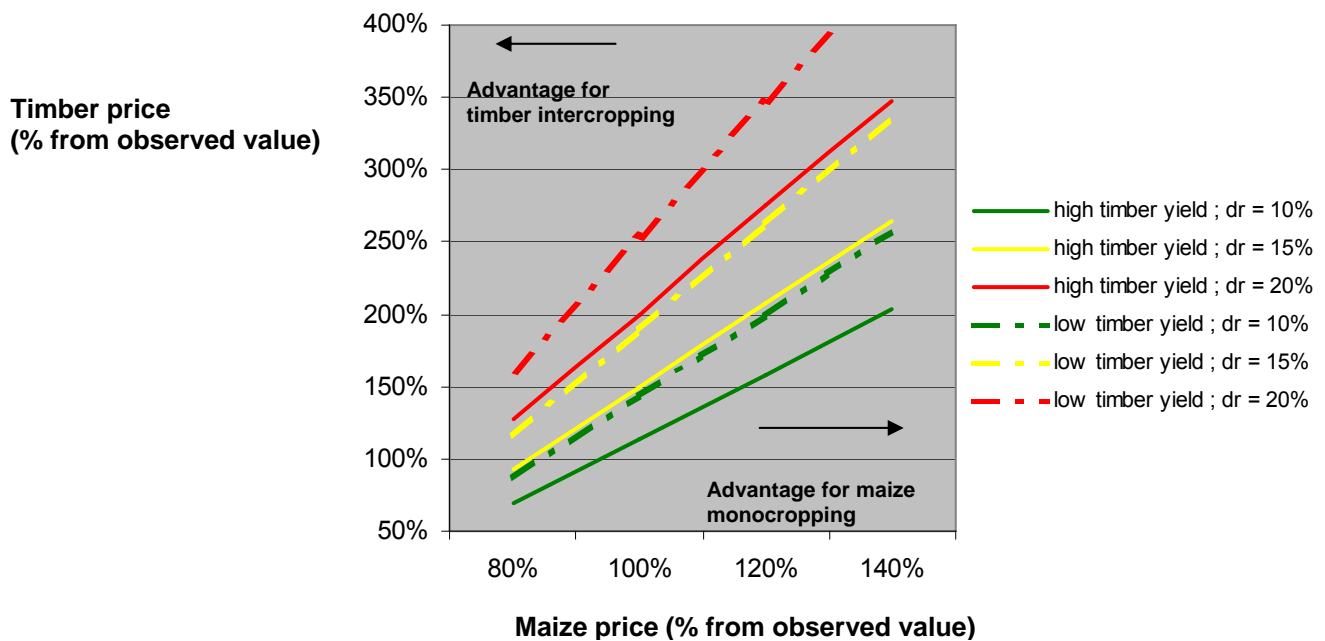
Figure 4.2.4: Break-even line of NPVs of maize monocropping and *Eucalyptus deglupta* intercropping (labour cost as observed).

Not surprisingly, if labour costs increase by 50%, at current timber price, 20% interest rate, and high timbers yields, gmelina agroforestry would be as profitable as maize monocropping even if maize price increases by 10%. In the event of low timber yields and current timber and maize price, gmelina intercropping breaks even at 15% discount rate. For bagras, if labour costs increase by 50%, with current maize price, high timber yields and 20% discount rate, agroforestry would break even only if timber price increases by 50% (from Ph P 4 to Ph P 6 bdft^{-1}) (**Figures 4.2.5 and 4.2.6**).
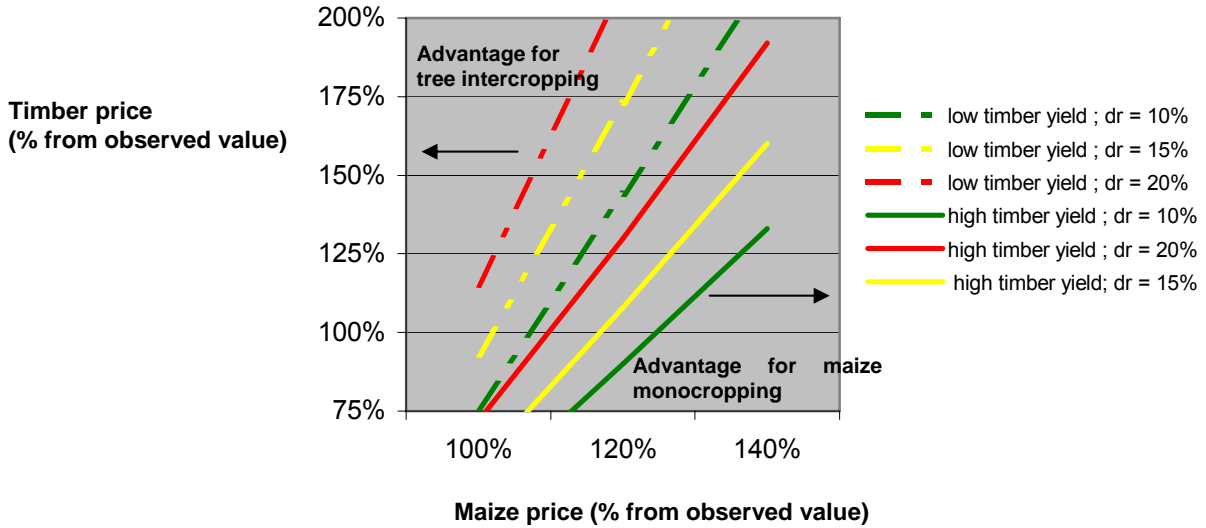
Figure 4.2.5: Break-even line of NPVs of maize monocropping and *Gmelina arborea* intercropping (labour cost + 50 % from observed valued).
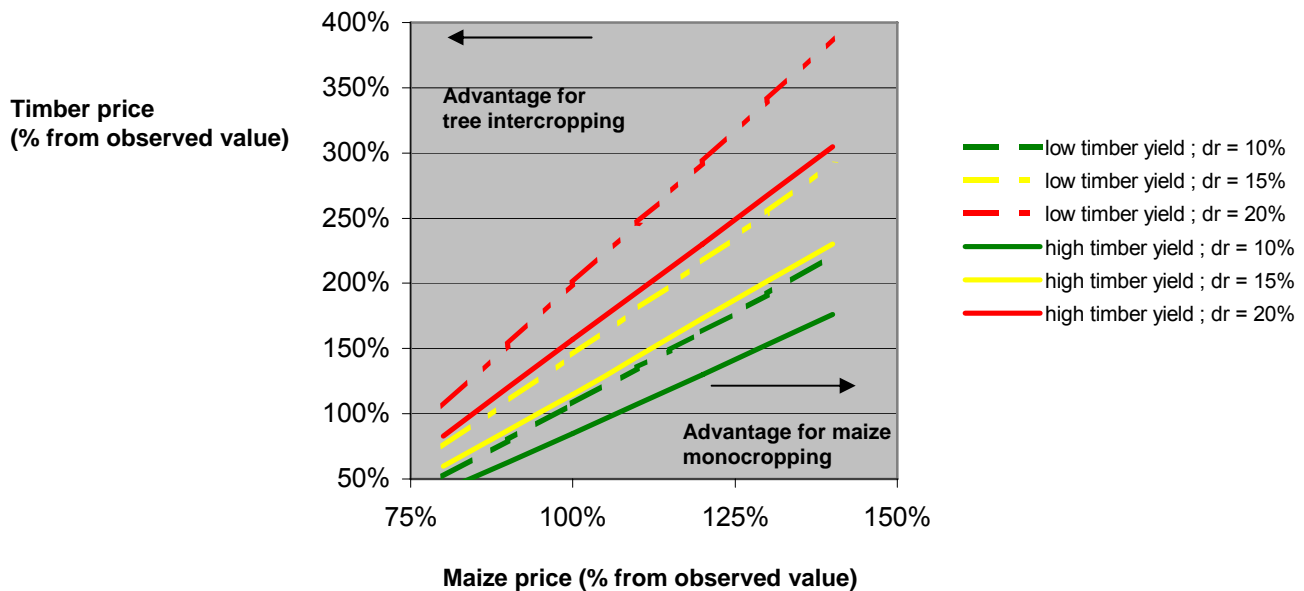
Figure 4.2.6: Break-even line of NPVs of maize monocropping and *Eucalyptus deglupta* intercropping (labour cost + 50% from observed value).

Figures 4.2.7 and 4.2.8 represent the break-even line of returns to labour for maize monocropping and the agroforestry systems studied. None of the results for agroforestry with gmelina are realistic. For example, in the less favourable case of low timber yields and 20% interest rate, returns to labour of maize monocropping would break even only in the unlikely event that timber price decreases by a further 50% (from Ph P 4 to Ph P 2 bd ft^{-1}). In the case of bagras intercropping, with low timber yields and 20% interest rate maize monocropping would break even if timber price is reduced by 11%, or maize price increases by a similar amount.
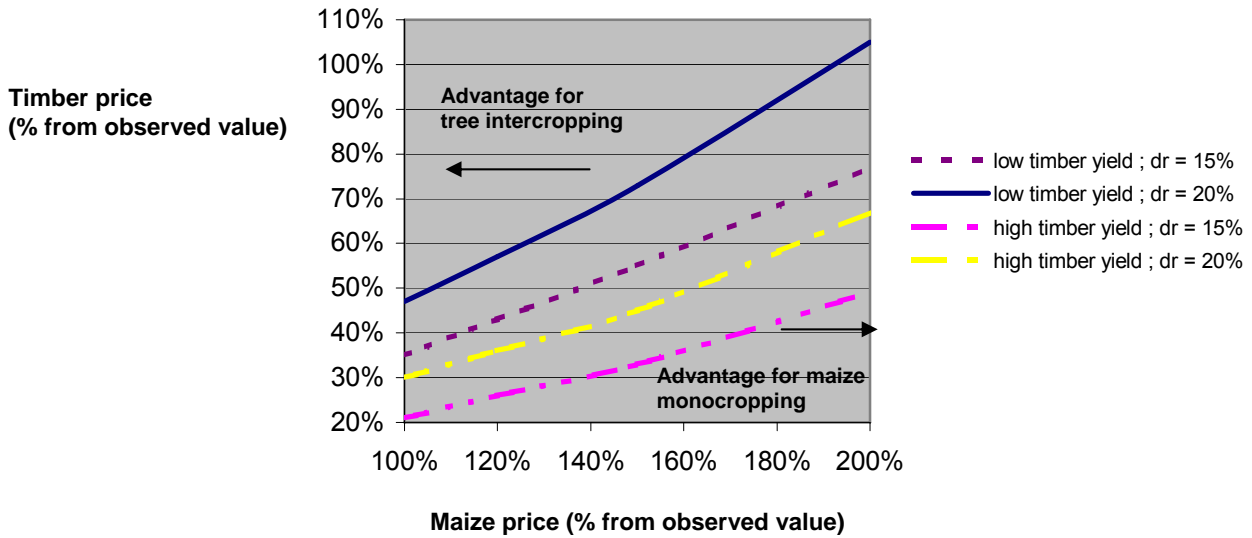
Figure 4.2.7: Break-even line of returns to labour of maize monocropping and *Gmelina arborea* intercropping.
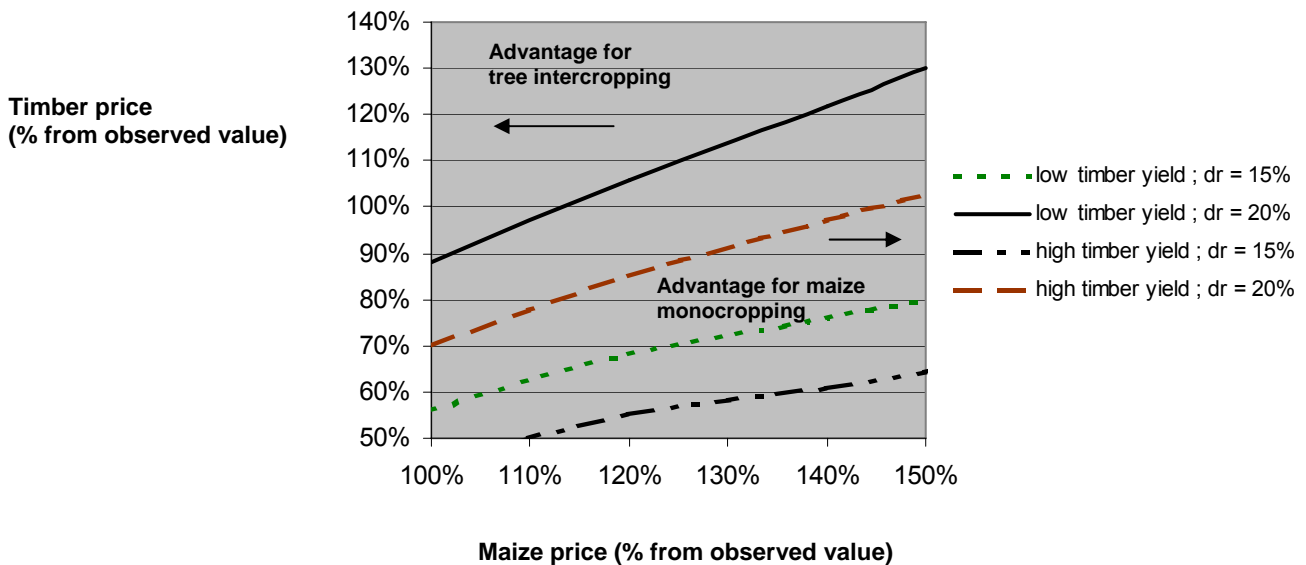
Figure 4.2.8: Break-even line of returns to labour of maize monocropping and *Eucalyptus deglupta* intercropping.

4.2.3.2   Farmers' evaluation

Participants to the focused group discussions cited a wide range of criteria to evaluate the timber-based agroforestry systems presented to them (**Table 4.2.6**). Criteria 1 to 3 were related to tree-crop competition for light, water and nutrients. Farmers seemed to be more concerned with light competition as this factor was mentioned in the three (3) discussions. Not surprisingly, farmers on the villages located at lower elevation (Cluster I) seemed to be also concerned about competition for water, as these areas are more prone to recurrent draught periods than villages at higher elevation. The next group of criteria (4 to 6) concerned tree growth, particularly diameter growth, straightness of the bole, and tree height. Soil erosion control is also another important factor mentioned in the three discussions. This is in line with farmers' perceived benefits from timber tree planting reported in Chapter 3.1. The remaining three criteria concerned the easiness to plough in intercropping systems, profitability and aesthetics.

Results are similar for the three groups. The most preferred systems are boundary planting, woodlot and trees in hedgerows. Ranked from the most preferred (lower score) to the least preferred (higher score), the overall results are:

Boundary > Hedgerows > Woodlot > Homestead > Blocks > Scattered

Not surprisingly, segregated systems, particularly trees on boundaries, were ranked as the less competitive with annual crops. Among the integrated systems, widely-spaced tree hedgerows are seen less competitive than scattered trees because with the same number of trees, the area of interaction between trees and crops (the tree-crop interface) is larger when trees are scattered in the crop field than when planted in lines. This remark shows farmers' considerable understanding of tree-crop interactions and knowledge about how to integrate trees and crops in the same land unit. Another disadvantage of having trees scattered on cropland is that they interfere with ploughing activities. For these reasons, farmers prefer to integrate trees on cropland in neatly designed arrangements such as small woodlots or hedgerows.

As this study hypothesized (Chapter 4.1), line planting systems (boundaries and hedgerows) and scattered trees were cited as more advantageous in terms of tree diameter growth than systems with trees at close spacing. However, farmers recognized that trees grow straighter when they are planted in blocks and woodlots. Thus trees in line arrangement need to be pruned more frequently than tree blocks in order to maintain them straight. Another interesting finding noted by participants of group III is that trees grow taller in intercropping systems than in segregated systems. Farmers noted that this is because trees benefit from improved site conditions when

intercropped. We were not able, however, to prove this hypothesis with the data from the on-farm trials (Chapter 4.1).

Unanimously, farmers indicated tree blocks as the best system for erosion control and preferred for very steep slopes. Interestingly though, tree hedgerows were rated as the second best system for erosion control, before woodlots. Farmers noted that tree hedgerows at regular intervals on the slope, even if at distance as wide as 10 m, are more effective barriers for controlling erosion than just a woodlot on the upper part of the slope.

Participants of group III alleged that the higher number of trees in the block and hedgerow system does not compensate the benefits foregone from reduced crop yields in these integrated systems. Consequently, segregated arrangements (boundary and woodlot), with less trees but with supposedly higher crop yields, are seen as the most profitable systems.

It is also interesting to note that, as in the case of contour hedgerow farming with natural vegetative strips (NVS) in Claveria (Stark, 2000), the importance of the aesthetical value of the plantation was highlighted. In this regard, tree lines along farm boundaries or hedgerows in cropped fields are the most preferred planting system.

It should be also noted that no one mentioned criteria related to labour for plantation establishment or tree management (except for the difficulty in ploughing among scattered trees). This seems to indicate that farmers do not consider tree farming as a labour demanding enterprise.

Table 4.2.6:. Farmers' evaluation of timber production systems through matrix scoring (1 = best; 6 = worst; the lower the score, the better the system).

Criteria	Intercropping systems									Segregated systems								
	Block (2 x 2 m; 2500 trees ha^{-1})			Hedgerow (1 x 10 m; 1000 trees ha^{-1})			Scattered (500 trees ha^{-1})			Boundary (2 m; 100 trees ha^{-1})			Woodlot (2 x 2 m; 1250 trees ha^{-1})			Homestead (50 trees)		
	I[1]	II[2]	III[3]	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
1 Less light competition	6	6	5	3	4	3	5	4	4	1	3	1	2	2	3	2	1	6
2 Less water competition	6			4			5			1			3			2		
3 Less nutrient competition		6	6		4	3		5	4		1	1		2	5		3	2
4 Tree diameter growth		6	6		3	1		2	2		3	2		5	5		4	4
5 Straight bole		1			3				6		5			2				4
6 Tree height growth		1			3				4		6			4				5
7 Prevent soil erosion	1	1	1	3	3	2	4	5	3	6	5	4	5	4	5	6	6	6
8 Less difficult to plough		4			3			6			1			2			5	
9 Higher returns (cash)			6			3			5			1			2			4
10 Aesthetics			4			2			6			2			3			5
TOTAL	13	23	30	10	17	20	14	22	34	8	13	22	10	15	29	10	19	36
GRAND TOTAL		66			47			70			43			54			65	

[1]Group I: participants from Hinaplanan, Cabacugan, Kalawitan and Gumaod

[2]Group II: participants from Patrocenio, Ane-i and Poblacion;

[3]Group III: participants from Lanesi, Luna and Tamboboan

The results of the pair-wise ranking exercise, carried out to determine farmers main preferences and compare the priorities of the 3 different groups, were as follows (ranked in order from the most to the least preferred):

Group 1: boundary > hedgerow > woodlots > scattered > homestead > block

Group 2: woodlot > hedgerow > boundary > block > homestead > scattered

Group 3: boundary > hedgerow > woodlot > homestead > scattered > block

Based on the ranking when all pair of combinations were compared, boundary planting resulted in the most preferred planting system followed by widely-spaced hedgerows. Small woodlots ranked third whereas block planting, scattered trees and trees on homesteads were the least preferred timber production systems.

Farmer's criteria to evaluate the qualities and merits of common timber species were similar to criteria used to evaluate production systems (**Table 4.2.7**). The native specie *Melia dubia* (locally named mangolinaw), commonly found on cropped fields and fallows, had the best score because of its very fast growth in open conditions and low competition with intercrops due to its small leaves and semi-deciduous habit. Farmers also reported the capacity of this specie to improve soil fertility. If this is validated by formal research, and a market niche for mangolinaw timber is found, further research and extension efforts should be put to bring this specie under cultivation.

Even if slow growing as compared to the other common timbers, *Swietenia macrophylla* ranked second because of its straight stem and narrow crown at early age, which make it appropriate for intercropping systems. However, if planted in rows less than 3 m apart, the canopy becomes sufficiently large and dense to prevent intercropping with maize after 2 years, unless trees are regularly pruned (Mayhew and Newton, 1998). Therefore, trees should be planted at wider spacing for prolonged periods of intercropping. Farmers also gave a high score to mahogany as they expect high economic returns from its quality wood. Unfortunately, the high incidence of shoot borer, as observed in Claveria, may severely reduce tree growth and the production of quality timber. As mahogany has increasingly become an important timber specie for agroforestry systems, research should investigate silvicultural and management practices feasible to smallholder farmers to prevent shoot borer attacks.

In the past few years, bagras has become very popular among upland farmers in Claveria. For many years, it has been the flagship specie of the farm forestry program of the Paper Industries Corporation of the Philippines (PICOP) in Surigao del Sur. Farmers have described it as ideal for intercropping systems as it has a straight bole, light canopy, and self-pruning habit that does not shade intercrops excessively. In

terms of economic returns this specie was rated low, probably because plantations have not been harvested yet in the locality and therefore, there is a lot of uncertainty about the market price. However, as sawmill owners manifested, it is likely that bagras will command a high price as demand is high, its timber can be put to the same use as other premium timbers (FPRDI, nd), and stocks, other than those existing at PICOP's plantations, are limited. A major limitation to bagras planting is its susceptibility to stem borer attack (*Agrilus sexignatus* Fisher). This pest has caused serious infestations in the monoculture plantations of PICOP (PCARRD, 1995). Although trees planted in the on-farm trials of this study were not severely affected by stem borer, attacks may probably be more intense and widespread as bagras is planted extensively. In this regard, it will be worth to determine whether the incidence of this pest is as high in pure plantations as in diverse agroforestry systems.

The nitrogen-fixing timber tree *Acacia mangium* has been extensively promoted in agroforestry for its tolerance to poor and acid soils, its capacity to improve soil fertility and its ability to compete and grow well on Imperata grasslands (Mead and Miller, 1991; NFTA, 1996). Upland farmers in the Philippines, and in Claveria in particular, are familiar with this specie. Participants to the discussions highlighted the capacity of mangium to improve soil fertility and low competition for nutrients as its advantages over other species. However, as (Akyeampong et al., 1995) noted, farmers will realize these benefits only when most of the biomass produced is returned to the soil during fallows. Otherwise, fast-growing species such as mangium are very competitive with associated crops (Akyeampong et al., 1995). Moreover, its tendency to form multiple stems, dense foliage and poor stem form on sites with higher fertility (Mead and Miller, 1991), limits the potential of this specie for intercropping systems. On-going research trials at Claveria conducted by ICRAF are now assessing the performance of improved provenance in mixed intercropping systems and its capacity to enhance growth of associated trees and intercrops and improve soil fertility.

From being promoted just few years ago by most private and government development organizations as a "miracle" tree, gmelina have now become very unpopular in the Philippines because of its competitiveness with associated crops and its allegedly enormous water absorption capacity. Although farmers have noted this, they have also indicated its advantages (**Table 4.2.7**). Gmelina has been recommended for farm forestry and *taungya* systems since long ago because of its very fast growth, which enables it to overcome weed growth, its ability to produce dense wood either when grown fast or when grown slow, and its excellent working properties (Lamb, 1968). Even though the current price of gmelina timber is low mainly because of oversupply, market demand is still high. For this reason, gmelina ranked

first in terms of cash returns. Those farmers with fuelwood scarcity have also valued the capacity of this specie to produce large amount of woody biomass. But because of its competitiveness, farmers interested in this tree should plant it on boundaries and other farm niches away from annual crops.

The native premium timber *Pterocarpus indica* (narra) ranked low because of its slow growth and poor stem form. It is, however, one of the most valuable timber species due to its superb wood quality, and in favourable locations growth can be moderately fast (National Research Council, 1979). Farmers' interest in this specie is probably higher than what this study reflects as it is commonly found on farms and fallows, though not in large numbers. Lack of germplasm supply and existing legal restrictions to harvest and use, even if originating from farms, probably prevents farmers from further planting and domestication of this valuable timber specie.

Table 4.2.7: Matrix scoring of selected timber species across farmers' criteria.

	Criteria (1 = best; 6 = worst)	Gmelina arborea	Swietenia macrophylla	Eucalyptus deglupta	Acacia mangium	Melia dubia*	Pterocarpus indica
1	Fast growth	4	5	1	3	2	6
2	Straight bole	4	1	3	5	2	6
3	Less light competition	6	4	2	3	1	5
4	Less nutrient competition	4	3	2	2	1	5
5	Less water competition	6	4	5	3	2	1
6	Improves soil fertility	5	3	3	1	1	2
7	Suitable to the locality	4	3	1	3	2	5
8	Hardwood	3	2	3	4	3	1
9	Fuelwood production	1	4	5	3	2	6
10	Cash returns	1	2	4	6	5	3
11	Shade and shelter	5	1	4	3	6	2
	TOTAL	43	32	33	36	27	42
	RANK	**6**	**2**	**3**	**4**	**1**	**5**

Some farmers did not report on this specie as they have not experienced its cultivation.

4.2.4   Conclusion

In the Philippines, timber production on small farms have become a profitable enterprise as a result of high demand and diminishing supplies from natural forests. Unfortunately widespread planting of few fast-growing species has led to oversupply and subsequently, a drastic decline in the price of farm-grown timber. Financial analyses showed that if current timber price prevails, maize monocropping is more profitable than maize-timber intercropping. However, farmers could realize returns similar or higher than those of maize monocropping in several ways. First, by producing higher timber yields. On-farm trials conducted in Claveria showed that intercropping systems with widely-spaced tree rows, frequent but moderate pruning, and intensive management of alley crops, can produce trees with the size and form required for high timber yields. Secondly, by diversifying tree production with other common timber species that command higher market price. For instance, mahogany or bagras will likely have a farm gate price 50 to 75% greater than that of gmelina. Thirdly, by growing timber trees for high value products (e.g., face veneer). Of course, this will require larger trees with good form and quality. This study also showed that timber intercropping would be more financially attractive than maize monocropping in the event of increasing farm labour wage. In the Philippines, this is likely to occur in the near future, as the economy diversifies and more rural people find work off-farm (Coxhead and Jayasuriya, 2001).

Using a wide range of criteria, farmers' evaluation of timber production systems broadly pointed to the need, in small farms, of segregating timber from crop production enterprises. As on-farm trials showed, intercropping between fast-growing trees cannot be sustained for long periods even if trees with favourable characteristics, such as bagras, are planted in rows as far as 10 m. Therefore, farmers preferred systems with minimal tree-crop interface, such as boundary plantings or small-scale woodlots. But high returns to labour of intercropping systems tested suggests that farmers with scarce labour and/or capital constraints can maximize returns by establishing timber-based agroforestry systems on excess land under fallow. In Claveria, improved fallows of gmelina has shown increased economic returns from harvested timber, fuel wood and animal weight gain, and ecological benefits including enhanced soil fertility build-up during the fallow period, soil erosion control and windbreak (Magcale-Macandog and Rocamora, 1997). Tree hedgerow systems are superior to block because of the lower establishment and management costs, faster tree growth and higher timber yields (as with gmelina) and the longer period of intercropping (as in the case of bagras). Furthermore, as areas commonly used for grazing, timber fallows with widely-spaced trees will probably support more livestock than the 0.6 animal units that,

according to (Mamicpic, 1997), woodlots of gmelina can support. In view of the multiple benefits that timber fallows provide, linear programming is used in the next chapter to develop an optimisation model that find out, considering farmers multiple goals and restrictions, the most profitable land allocation to maize monocropping and tree farming over a tree rotation period and subsequent cycles. The model will allow labour-constrained farmers to determine how much of their land can be devoted to timber production systems in order to maximize net returns without compromising food crop production.

4.2.5   References

Agpaoa, A., Endangan, D., Festin, S., Gumayagay, J., Hoenninger, T. H., Seeber, G., Unkel, K. and Weidelt, H. J. (1976): Manual of Reforestation and Erosion Control for the Philippines. Eschborn, German Agency for Technical Cooperation, LTD. (GTZ).

Akyeampong, E., Hitimana L., Franzel, S. and Munyemana, P.C. (1995): The agronomic and economic performance of banana, bean and tree intercropping in the highlands of Burundi: an interim assessment. Agroforestry Systems 31: 199-210.

Arnold, J. E. M. and Dewees, P. A. (eds.) (1997): Farms, Trees & Farmers. Responses to Agricultural Intensification. London, UK: Earthscan Publications Ltd.

Caluza, D. (2002): Farmers quit planting gmelina in Apayao, women's study says. Philippine Daily Inquirer. April 1, 2002, Manila Philippines.

Coxhead, I. and Jayasuriya, S. (2001): Economic growth, development policy and the environment in the Philippines. Staff Paper Series No. 430, Agricultural & Applied Economics. University of Wisconsin-Madison, USA.

DENR-ERDB (1998): Development and Management of Forest Plantations: A Guidebook. Ecosystems Research and Development Bureau (ERDB). College, Laguna, Philippines.

Fonollera, C. (1996): Agro-forestry micro-enterprises to reforest watersheds. Gold Star Daily. September 12, 1996. Cagayan de Oro, Philippines.

FPRDI (undated): Technical information on Bagras (*Eucalyptus deglupta* Blume). College, Laguna, Philippines: Forest Products Research and Development Institute (FPRDI).

Franzel, S. and Scherr, S. J. (eds.) (2002): Trees on the farm: assessing the adoption potential of agroforestry practices in Africa. Wallingford, UK, CABI Publishing in association with ICRAF.

Franzel, S., Scherr, S. J., Coe, R., Cooper, P. J. M. and Place, F. (2002): Methods for Assessing Agroforestry Adoption Potential. In: Franzel, S. and Scherr, S. J. (eds.): Trees on the Farm: Assessing the Adoption Potential of Agroforestry Practices in Africa. Nairobi, Kenya, CABI Publishing in association with ICRAF: 11-35.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

GOLD Project (1998): Tree Farming Sourcebook. Provincial Government of Palawan, Philippines, Governance and Local Democracy Project (GOLD) and the Palawan Tropical Forestry Protection Program.

ITTO (2001): Annual Review and Assessment of the World Tropical Timber Situation 2001. Yokohama, Japan: ITTO.

Laarman, J., Virtunen, K. and Jurvelius, M. (1981): Choice of technology in forestry. A Philippine case study. Quezon City, Philippines: New Day Publishers.

Lamb, A. F. A. (1968): Fast Growing Trees of the Lowland Tropics: *Gmelina arborea*. Department of Forestry. University of Oxford, Oxford, UK. Commonwealth Forestry Institute.

Magcale-Macandog, D. B., Menz, K., Rocamora, P. M. and Predo, C. D. (1999): Smallholder timber production and marketing: the case of Gmelina arborea in Claveria, Northern Mindanao, Philippines. International Tree Crops Journal 10: 61-78.

Magcale-Macandog, D. B. and Rocamora, P. M. (1997): A Cost-Benefit Analysis of Gmelina Hedgerow Improved Fallow System in Claveria, Northern Mindanao, Philippines. Paper presented at the International Workshop on "Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia", 23-27 June, 1997. Bogor, Indonesia: ICRAF.

Mamicpic, M. A. E. (1997): Livestock in Natural Vegetative Strips (NVS) and Gmelina Cropping Systems. MSc dissertation. School of Environment, Resources and Development, Asian Institute of Technology, Bangkok, Thailand.

Mayhew, J. E. and Newton A. C. (1998): The Silviculture of Mahogany (*Swietenia macrophylla*). Wallingford, UK. CABI Publishing. CAB International.

Mead, D. J. and Miller, R. R. (1991): The Establishment and Tending of Acacia mangium. In: Turnbull, J. W. (ed.): Advances in Tropical Acacia Research. ACIAR Proceedings No. 35, Bangkok, Thailand: ACIAR, Australia: 116-122.

Midmore, D. J., Nissen, T. M. and Poudel, D. D. (2001): Making a Living Out of Agriculture: Some Reflections on Vegetable Production Systems in the Manupali Watershed. In: Coxhead, I. and Buenavista, G. (eds.): Seeking sustainabililty: challenges of agricultural development and environmental management in a Philippine watershed. Los Baños, Laguna, Philippines: PCARRD: 94-111.

National Research Council (1979): Tropical Legumes: Resources for the Future. Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation. Board on Science and Technology for International Development. Commission on International Relations. Washington D.C., USA: National Academy of Sciences. 332 p.

Nelson, R. A., Cramb, R. A. and Mamicpic, M. A. (1996): Costs and returns of hedgerow intercropping and open-field maize farming in the Philippine uplands. Working paper No. 11. University of the Philippines, Los Baños, Laguna, Philippines: SEAMEO Regional Center for Graduate Study and Research in Agriculture and Universtiy of Queensland.

Netting, R. M. (1993): Smallholders, Householders. Farm families and the Ecology of Intensive, Sustainable Agriculture. Standford, California, USA: Standford University Press.

NFTA (1996): Nitrogen Fixing Trees for Acid Soils. Morrilton, Arkansas, USA: Winrock International's Nitrogen Fixing Tree Association and the Taiwan Forestry Research Institute. 110 p.

Pancel, L. (1993): Forestation. Chapter 11, Tropical Forestry Handbook. Berlin, Germany, Springer-Verlag. 1: 645 - 725.

Pascicolan, P. N., de Haes, H. A. U. and Sajise, P E. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forestry Ecology and Management (99): 261-274.

PCARRD (1995): Pest and diseases of forest plantation trees in the Philippines: a guidebook. Los Baños, Laguna, Philippines: PCARRD and DENR.

Predo, C. D. (2002): Bioeconomic Modelling of Alternative Land Uses for Grassland Areas and Farmers' Tree-Growing Decisions in Misamis Oriental, Philippines. PhD dissertation, University of the Philippines, Los Baños, Laguna, Philippines.

Pretty, J. N., Guijt, I., Scoones, I. and Thompson, J. (1995): A Trainer's Guide for Participatory Learning and Action. London, UK: International Institute for Environment and Development.

Scherr, S. (1992): Not out of the woods yet: challenges for economic research on agroforestry. American Journal of Agricultural Economics (74): 802-819.

Stark, M. (2000): Soil Management Strategies to Sustain Continuous Crop Production between Vegetative Contour Strips on Humid Tropical Hillsides. Technology development and dissemination based on farmers' adaptive field experimentation in the Philippines. International Centre for Research in Agroforestry (ICRAF). Southeast Asia Regional Research Programme.

Tomboc, C. C. (1976): Growth, yield and economic rotation of bagras pulp timber in PICOP plantations. MSc Thesis. University of the Philippines, Los Baños, Laguna, Philippines.

Tree Farmer Congress (2000): Small Tree Farms to Save Forests. A Reference Book of the First Visayas Tree Farmers' Congress. November 6-7, 2002. La Paz, Iloilo City, The Philippines: Watershed Management Coalition, The T.R.E.E.S Consortium and West Visayas State University. 58 p.

Virtucio, F. D. (1984): Determination of taper, bark thickness and volume of commercial tree species. Terminal Report. FORI.

von Platen, H. H. (1992): Economic evaluation of agroforestry systems of cacao (*Theobroma cacao*) with laurel (*Cordia alliodora*) and Poró (*Erythrina poeppigiana*) in Costa Rica. In: Sullivan, G. M., Huke, S. M. and Fox, J. M. (eds.): Financial and Economic Analyses of Agroforestry Systems. Proceedings of a workshop held in Honolulu, Hawaii, USA, July 1991. Paia, HI: Nitrogen Fixing Tree Association: 174-187.

4.3   Rotational timber fallows: Improving the adoptability of smallholder timber-based agroforestry systems in the Philippine uplands

<u>Abstract</u>

In the context of smallholder farmers, growing annual crops and timber trees simultaneously in the same land unit may be viewed as incompatible farm enterprises because of the severe reduction of intercrop yields due to intense tree competition. However, commercial crop and timber production in small farms do not need to be mutually exclusive. In Claveria, Philippines, farmers temporarily combine trees, crops, and sometimes livestock, in rotational woodlot fallows. Recent financial assessments of maize-timber agroforestry systems in Claveria have resulted in higher returns to labor and capital invested but lower profitability than the maize monocropping alternative. Tree growers have suggested ways to improve the adoptability (i.e., profitability, feasibility and acceptability) of these timber-based agroforestry systems. For smallholder farmers, cumulative additions of widely-spaced tree hedgerows may have several advantages over even-aged tree woodlots: i) longer periods of intercropping; ii) regular income derived from trees as there would be trees of different ages; iii) higher feasibility and reduced risk since investment costs are spread over several years, and probably; iv) higher carrying capacity for household's livestock because of the increased production of understorey groundcover between widely-spaced trees. Using linear programming (LP), we developed in this chapter a simple model for the optimal allocation of land to monocropping and tree intercropping that maximizes the net present value (NPV) of these farm enterprises over an infinite time horizon and satisfies farmers' labor constraints and regular income requirements. Then, the model is applied to the case of an average smallholder farmer in Claveria and solved using the LINGO computer software. The LP model showed that cumulative additions of tree hedgerows provides higher returns to land and reduce the risk of agroforestry adoption by spreading over the years labor and capital investment costs and the economic benefits accruing to farmers from trees. Incremental planting of widely-spaced tree hedgerows can make timber fallow systems more adoptable and thus, benefit a larger number of resource-constrained farmers in their evolution towards more diverse and productive agroforestry systems.

4.3.1   Introduction

The Philippines was once one of the major timber producers of the tropical world. But since the virtual disappearance of most of its natural forests, increasingly larger amounts of industrial timber are being produced on small farms. Compared with large-scale forest plantations, farmers possess several unique advantages in timber production: i) intensive management which ensures tree survival and growth; ii) reduced risk of fire as cropped alleys act as firebreaks; and iii) minimal establishment and management costs (Garrity and Mercado, 1994). Consequently, small upland farms have been proposed as land management units for reforestation (Pascicolan et al., 1997).

But in the context of smallholder subsistence farmers, whose priorities are the production of food and income on a regular basis, growing annual crops and timber trees in association may be viewed as incompatible farm enterprises. In fact, when planted on cropland most fast-growing timber species promoted for farm forestry in the Philippines severely reduce intercrop yields after few cropping seasons. On-farm trials conducted in Claveria, Misamis Oriental, showed that grain yield of hybrid maize inter-planted between 10 m- spaced tree rows was reduced below the break-even just after two cropping seasons when the tree species was *Gmelina arborea* (hereafter referred to as gmelina) and after 6 cropping seasons when the tree planted was *Eucalyptus deglupta* (Chapter 4.1). Tree growers have developed management practices, such as intensive tree branch and root pruning, to reduce substantially tree-crop competition and prolong the period of intercropping. Unfortunately, these management practices are detrimental to tree growth (Watanabe, 1992; Miah, 1993; Gonzal, 1994), and probably, incompatible with profitable timber production. Consequently, farmers practicing intercropping may eventually abandon commercial tree farming or simply, opt for planting fewer trees on a farm niche away from annual crops (e.g., farm boundaries).

There is, however, an intermediate option in which trees and crops can be temporarily combined in the same land unit to maximize farmers' benefits and produce timber in a commercial scale. For more than a decade now, farmers in Claveria have been establishing and managing small-scale woodlots of gmelina as improved fallows. Typically, tree blocks (i.e., an arrangement with small and similar inter-row and intra-row spacing, as for example, 2 x 3 m or 3 x 3 m) are planted at once on small portions of the farm (0.2 to 1 ha), intercropped with maize for 1 or 2 years and then used as cattle grazing areas. Once trees are harvested, farmers may begin a new cycle by coppicing tree stumps and/or by cultivating the area again (Magcale-Macandog et al.,

1999; Magcale-Macandog et al., 1999). Several forms of this system of timber production are also being practiced in many of the Pacific islands and have been described as sequential cropping, improved fallow or woodlots (Elevitch and Wilkinson, 2000).

In recent years in the Philippines, timber production on farms has become less profitable because of a drastic decline in the price of farm-grown timber. Financial analyses conducted in Claveria, indicate that with average timber yields and current price, returns to land for maize monocropping are higher than for maize-timber agroforestry. However, farmers with labor constraints or limited capital will probably prefer timber intercropping systems as returns to labor used and returns per dollar invested (B/C) are greater than in maize monocropping **(Table 4.3.1)**.

Table 4.3.1: Financial analysis of maize monocropping and maize-*Gmelina arborea* intercropping over a tree rotation cycle of 8 years, Claveria, Misamis Oriental, Philippines.

	Maize monocropping	Agroforestry practice	
		Maize-tree hedgerow	Maize-tree block
Maize grain yield (t/ha/9 yrs)	70.2	12.5	12.9
Timber (m^3/ha /8 yrs*)	-	69.1	60.8
Costs (US $/ha)	5,674.5	1,127.8	1,185.4
Returns (US $/ha)	8,671.4	4,405.5	4,114.5
NPV (15%) (US $/ha)	1,596.2	1,131.3	1,040.2
Returns to labor (US $/work day)	3.8	5.7	4.6
Benefit–Cost ratio (B/C)	1.5	2.2	2.1

* It is assumed that trees are planted at the end of year 1

Based on the results of this economic analysis and on farmers' evaluation of timber-based agroforestry systems (Chapter 4.2), and building on the concept of improved timber fallows as practiced in Claveria, we propose in this paper cumulative additions of widely-spaced intercropped tree hedgerows as the most adoptable[50] system of timber production for smallholder farm forestry. Besides higher economic returns

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[50] For agroforestry technologies to be adoptable, they must be profitable, feasible and acceptable. Feasibility refers to farmers' ability to plant and maintain an agroforestry technology. This depends on available resources (land, labour and capital), farmers' information and skills and farmers' ability to cope with any problem that arises. Acceptability includes profitability, feasibility, risk, compatibility with farmers' values and farmers' valuation of benefits (Franzel et al., 2002).

because of lower production costs and faster tree growth (Chapter 4.2), incremental or staggering planting of tree hedgerows have several advantages over even-aged tree blocks: i) longer periods of intercropping (although this not necessarily true for all tree species as reported in Chapter 4.1); ii) provision of income on a more regular basis as there would be trees of different ages; iii) higher feasibility and reduced risk since investment costs are spread over several years; iv) higher carrying capacity for household's livestock because of the increased production of under-storey groundcover between widely-spaced trees. This continuous small-scale adoption of agroforestry systems has been reported to be more appropriate for smallholder farmers elsewhere (Current et al., 1995).

Linear programming (LP) is a powerful analytical tool that can be used to determine an "optimal" combination of several production systems while considering farmers' constraints and requirements (Betters, 1988). Using LP techniques, we developed a simple model for the optimal allocation of land to monocropping and tree intercropping that maximizes the NPV of these farm enterprises over an infinite time horizon and satisfies farmers' labor constraints and regular income requirements. Then, for demonstration purposes, the model is applied to the case of an average smallholder farmer in Claveria with an interest to grow gmelina. By illustrating how monocropping and tree farming enterprises can be gradually integrated into the same land unit, we aim to assist farmers' decisions in their evolution towards more diverse and productive agroforestry systems and to help farm forestry extensionists to facilitate this transition.

4.3.2   Methods

4.3.2.1   Description of the site and farming systems under study

Research on smallholder timber production systems began in October 1997 at the World Agroforestry Center (ICRAF) research site in Claveria, Misamis Oriental, Philippines. Claveria is an upland municipality located 42 km northeast of Cagayan de Oro City, in northern Mindanao. It covers an area of 112,175 hectares and has a mountainous topography, with 62% of the land area having slopes of 18% or greater and elevation ranging from 390 - 2,000 m a.s.l (DTI and PKII Engineers, 1996). Soils are derived from volcanic parent material and classified as deep acidic (pH 3.9 - 5.2) Oxisols with texture ranging from clay to silty clay loams, with low available P, low CEC, high Al saturation and low exchangeable K^+ (Magbanua and Garrity, 1988). Average rainfall is 2,500 mm with a wet season from June to December (> 200 mm rainfall per month) and a short dry season from March to April (< 100 mm rainfall per month) (Kenmore and Flinn, 1987). Temperatures experiment little variation

throughout the year, with an average maximum of 28.6 °C and average minimum of 21.3 °C.

At lower elevations (400 to 700 m), maize (*Zea mays* L.) is the dominant crop, cultivated twice a year or in rotation with cassava (*Mahinot esculenta* Crantz) or upland rice (*Oryza sativa* L.). Typically, farmers plant a wet season crop on the onset of the rainy season (May) and a dry season crop on September or October. Tomato and other vegetable cash crops are commonly grown on the higher elevations (700 to 900 m a.s.l). Draught animal power is commonly used for land preparation (plowing, harrowing and inter-row cultivation). All other farming operations (i.e., fertilizing and weeding) are performed manually. Average farm size is 2.5 to 3 hectares with farmers commonly cultivating two or more parcels of land.

In the past 50 years, land use in Claveria has experienced a rapid transformation from natural forests to grasslands to a mosaic of intensive cash and food cropping and perennial-based systems (Garrity and Agustin, 1995). Recently, the use of grass strips of natural vegetation (NVS) along contours as a measure to control soil erosion has become common among farmers in the area. This practice is also the base for the incorporation of fruit and timber trees (Stark, 2000).

4.3.2.2   Model development and application

Linear programming techniques were used to develop a model that will determine the "optimal" combination of intercropping and monocropping systems that maximizes the net present value (NPV) over an infinite time horizon while considering simultaneously farmers' labour constraints and minimum yearly income requirement. The model assigns each year throughout the planning horizon (i.e., the time period necessary to achieve the optimal combination of the monocropping and intercropping systems that will be maintained in perpetuity) a portion of the farm to monocropping and tree intercropping systems. Then for demonstration purposes, the model is applied to the case of an average smallholder farmer in Claveria. The farmer wants to estimate the area that should be devoted each year to gmelina timber production and to maize monocropping while maximizing returns to land over an infinite time horizon with his limited land, labour and capital resources. Based on the results of the financial analysis and farmers' evaluation of timber production systems (Chapter 4.2), we identified widely-spaced tree hedgerows as the best tree-maize combination for small-scale farm forestry.

In the application of the model, the NPV values of the objective function were calculated for an infinite number of rotations of both monocropping and tree

intercropping systems. This NPV, which corresponds in forest economics to the classic 'Faustmann principle', is commonly called 'land value' or 'soil value' as it implicitly considers the opportunity cost of land [Romero, 1994]. Data on tree growth and maize yield used in the calculation of the NPV was collected from on-farm experimental plots established to study maize-timber tree intercropping systems. Further details on plot size and management, maize grain and timber yields are given on Chapter 4.1 and 4.2. It was assumed that trees are planted right before sowing the dry season crop of maize (September) and harvested once the rotation period is completed. The optimal rotation of gmelina was considered to be 8 years. The annual discount rate of 15% was selected for the calculation of the NPV of maize monocropping and tree-maize intercropping enterprises. This rate was assumed to approximately represent the rate farmers from Claveria use to discount future benefits considering the cost of borrowed capital in the area. Finally, we used the computer program LINDO (LINDO Systems Inc., 1998) to solve the problem.

The following notation is used in the formulation of the model:

Constants:

r = tree rotation period (years)

npv_{ij} = net present value per hectare of system j in year i

A = farm size (hectares)

l^1 = annual labour requirements per hectare of monocropping

l_t^2 = annual labour requirements per hectare of tree intercropping in year t of rotation period

wd = annual available work days

m^1 = net margin per hectare of monocropping

m_t^2 = net margin per hectare of tree intercropping in year t of rotation period

I = annual income requirements

Decision variables:

x_{ij} = area (hectares) of system j planted in year i

Other variables:

M_{r+2} = area (hectares) allocated to monocropping in perpetuity from year r+2 on

TM_{r+2} = area (hectares) allocated to tree intercropping in perpetuity from year r+2 on

F_{r+2} = fallow area from year r+2 on

Assuming two possible production systems: j = 1 denotes monocropping system and j = 2 denotes tree intercropping system, the whole structure of the model reads as follows:

Objective function:

$$Max \quad \sum_{i=1}^{r+2} \sum_{j=1}^{2} npv_{ij} x_{ij} \tag{1}$$

subject to

- *land constraints*:

$$x_{i1} + \sum_{k=1}^{i} x_{k2} \le A \qquad i = 1, 2, ..., r+2 \tag{2}$$

- *labor force constraints*:

$$l^1 x_{i1} + \sum_{k=1}^{i} l_{i-k+1}^2 x_{k2} \le wd \qquad i = 1, 2, ..., r+1 \tag{3.1}$$

$$l^1 x_{r+2,1} + \sum_{k=1}^{i-(r+1)} l_k^2 x_{i-k-r,2} + \sum_{k=i-r}^{r+1} l_k^2 x_{i-k+1,2} + l_{i-(r+1)}^2 x_{r+2,2} \le wd \qquad r+1 < i \le 2(r+1) \tag{3.2}$$

- *family consumption constraints*:

$$m^1 x_{i1} + \sum_{k=1}^{i} m_{i-k+1}^2 x_{k2} \ge I \qquad i = 1, 2, ..., r+1 \tag{4.1}$$

$$m^1 x_{r+2,1} + \sum_{k=1}^{i-(r+1)} m_k^2 x_{i-k-r,2} + \sum_{k=i-r}^{r+1} m_k^2 x_{i-k+1,2} + m_{i-(r+1)}^2 x_{r+2,2} \ge I \qquad r+1 < i \le 2(r+1) \tag{4.2}$$

- accounting rows:

$$M_{r+2} = x_{r+2,1}$$

$$TM_{r+2} = \sum_{i=1}^{r+2} x_{i2} \qquad\qquad (5)$$

$$F_{r+2} = 2.5 - x_{r+2,1} - \sum_{i=1}^{r+2} x_{i2}$$

- decision variables domain constraints:

$$x_{ij} \geq 0 \qquad \forall i, j \qquad\qquad (6)$$

As the series of net incomes are assumed to continue indefinitely for an infinite number of periods, the coefficients npv_{ij} corresponding to variables x_{i2} are the net present values calculated over an infinite rotation period. For variables x_{i1}, only the npv attached to $x_{10,1}$ has been calculated in perpetuity.

Constraints (2) guarantee that the total area allocated any year to both production systems does not exceed the total farm area. Index i varies from 1 to r+2 (i.e., planning horizon) because the farmer will need r+2 years to establish the optimal combination of monocropping and intercropping systems. From year r+2 on, the farm area allocated to system 1 and 2 would be maintained unchanged in perpetuity.

Constraints (3.1) and (3.2) secure that the farm labor used in any year to both production systems is not higher than the available family labor. Block (3.1) forces the solution to satisfy the labor force constraint for the first r+1 years of the planning horizon, as the area allocated to tree intercropping gradually increases until a complete series of units containing trees of all the individual ages within the rotation period is established. Block (3.2) forces the fulfillment of the labor force constraint from year r+1 to year 2(r+1), when "intercropping" units with trees of all individual ages exist simultaneously. Similarly, block (4.1) imposes the solution to satisfy annual income demands for the first r+1 years, and block (4.2) from year r+1 to year 2(r+1).

Accounting rows have been added just to easily quantify the total final area allocated to each system at the end of the planning horizon. Constraints (6) simply ensure non-negativity for all decision variables.

4.3.3   Results and discussion

4.3.3.1   Application to an average farmer in Claveria, Philippines

Let us now determine the best land allocation to maize monocropping and maize-timber intercropping that would maximize the income of an average farmer in Claveria. This farmer would have a farm area of 2.5 ha. As most children in Claveria go to school or work-off farm when they are older (Stark, 2000), the available family labor for an average household family of five to six members is estimated at just 300 work-days per annum (2 full time family members). To satisfy its daily needs, this family requires a minimum income (I) of Ph P 36,000 yr^{-1} (approximately US $ 2.5 per day at US $ = Ph P 40, Feb 1998).

In Claveria, the labor force required for one hectare of maize monocropping is l^1 = 177 work-days per year (Nelson et al., 1996). Thus, the maximum farm area the farmer can cultivate in a year with his available labor is 1.7 ha. In addition, one hectare of maize-timber intercropping requires the following labor force during the tree rotation period:

$$l_1^2 = 220, \quad l_2^2 = 108, \quad l_3^2 = 21, \quad l_4^2 = 0, \quad l_5^2 = 1, \quad l_6^2 = 5, \quad l_7^2 = 0,$$

$$l_8^2 = 0, \quad l_9^2 = 0$$

The net margin per hectare of maize monocropping (m^1) is estimated to be Ph P 26,330, while the net margin of one hectare of maize-timber intercropping during the tree rotation period is:

$$m_1^2 = 23,990, \quad m_2^2 = 15,475, \quad m_3^2 = 0, \quad m_4^2 = 0, \quad m_5^2 = 0, \quad m_6^2 = 0,$$

$$m_7^2 = 0, \quad m_8^2 = 0, \quad m_9^2 = 116,850$$

Considering these resources, constraints and requirements, and given the objective of maximizing the NPV, we can determine now the optimal land allocation to maize monocropping and maize-timber intercropping using the computer program LINDO to solve the problem (LINDO Systems Inc., 1998).

If the farmer were just interested in maize monocropping, with a labor force of 300 work-days yr^{-1} he could only cultivate every year 1.7 ha and fallow the remaining 0.8 ha. This would provide a net margin of Ph P 44,761, enough to satisfy the annual household demands. However, the solution shows that it is more advantageous to reduce the area planted to maize monocropping and increasingly devote some land and labor to timber intercropping. Therefore, even if maize monocropping is the most profitable system (this can be easily seen by putting on the right hand side of the labor constraints 443, the number of work-days needed to cultivate 2.5 ha, and checking how the model allocates the whole area to maize monocropping), a mix of the two practices is optimal when labor is limiting. The objective function value results in a total NPV of Ph P 162, 686.7 (US $ 4,067.2; US $ 1 = 40 Ph P), and optimal production is achieved when the farmer devotes 1.1 ha to maize monocropping and 1.4 ha to timber intercropping **(Table 4.3.2)**. Every year throughout the first tree rotation period (years 1 to 9) the area devoted to trees increases by planting portions of land of different size, except in year 4 and 9, when the model advised not to increase the area devoted to trees. From the first tree harvest (year 9) on, the model proposes to maintain the area planted to trees indefinitely.

Table 4.3.2: Optimal land allocation to maize monocropping and timber intercropping by incremental tree planting.

Year	Maize monocropping (x_{i1}) (ha)	Tree intercropping (x_{i2}) (ha)	Unused (fallow) (ha)
	Area planted to		
1	1.16	0.43	0.91
2	1.11	0.26	0.7
3	1.33	0.12	0.35
4	1.59	0.00	0.095
5	1.62	0.04	0.018
6	1.59	0.05	0.0
7	1.55	0.04	0.0
8	1.10	0.44	0.0
9	1.10	0.00	0.0
10	1.10	0.00	0.0
11-∞	1.10	1.40	0.0

The analysis of the "slack variables" provides information on other advantages of using rotational timber fallows. For example, during the first five years the farmer will not be able to use the total farm area because of the lack of labor. But from year 6 on, the whole farm area will be under some form of productive system (either maize or tree-maize intercropping or tree fallow) while, at same time, there will be increasingly amounts of labor unused (except for years 10 and 11). In some years these periods of slack labor are as large as 80 to 90 work-days, which the farmer might use for other activities. Also, every year, except for year 12 to 15, the combination of maize monocropping and timber intercropping produces annual net income above the minimum requirement. In some years, the income surplus is substantial, particularly once the farmer begins to harvest timber trees in an annual basis.

Table 4.3.3: Increased land productivity and income, and reduced labour use by adoption of rotational timber fallow systems.

| Year | Amounts unused | | Surplus |
	Land (unproductive fallow) (ha)	Labor (wd yr^{-1})	Income (Ph P yr^{-1})
1	0.91	0.0	4,854.1
2	0.7	0.0	6,081.2
3	0.35	0.0	6,074.8
4	0.095	0.0	7,737.1
5	0.018	0.0	7,808.3
6	0.0	0.0	7,800.6
7	0.0	8.6	6,597.2
8	0.0	0.4	4,407.3
9	0.0	56	50,413.3
10	0.0	0.0	34,063.3
11	0.0	0.0	20,058.6
12	0.0	40	0.0
13	0.0	84	0.0
14	0.0	92	0.0
15	0.0	86	0.0
16	0.0	87	46,874.0
17	0.0	0.4	4,407.3
18	0.0	56	50,413.3

We can also introduce new conditions and/or restrictions to explore the advantages and disadvantages of new optimal land allocations. For example, let's assume that the farmer wants to ensure an even flow harvest of timber by allocating each year portions of the land of equal size to maize-tree intercropping, i.e., $x_{i2} = x_{i+1, 2}$. The solution of the model with this new condition tells us that the farmer should add every year during the first 9 years, 1,343 m^2 of tree hedgerows (or 134 trees per year if planted at 1x10 m). This helps the farmer to ensure a balanced distribution of individual ages on the ground. Then, after the first tree rotation, 1.3 ha will be the total area devoted to maize monocropping and 1.2 ha to tree intercropping. However, in this case the value of the objective function is Ph P 157,824.5 or Ph P 4,862.2 lower than in the case of uneven areas of trees. Also the period of time in which some portion of the farm remains unused extends until year 8, whereas in the previous case it was only until year 5. On

the other hand, the advantages of having areas of equal size devoted to tree intercropping are unused labor of 24 wd and surplus net income of Ph P 18,992.45 per year from the year 8 on.

Detailed sensitivity analyses can be carried out by simply introducing new values for the coefficients of the objective function and/or on the right hand side of the constraints. In our particular case, the value ranges provided by the program in which the solution remains unchanged do not provide additional information on the advantages of rotational timber fallows.

4.3.4   Conclusion

In Claveria timber trees planted on farms and fallow land provide upland farmers with income and important valuable by-products, such as fuelwood, pasture, erosion control and soil fertility restoration. These farm-grown trees are also the main and only source of local timber for the wood industry. Incremental planting of widely spaced tree hedgerows can make timber fallow systems more adoptable and thus benefit a larger number of resource-constrained farmers. The LP model developed showed that cumulative additions of tree hedgerows provides higher returns to land and reduce the risk of agroforestry adoption by spreading over the years labour and capital investment costs and the economic benefits accruing to farmers from trees.

In many upland areas of the Philippines, land use patterns are evolving from monocropping towards productive and more diverse agroforestry systems. Rotational timber fallows appears to be one of such systems, appropriate to smallholders for generating income and other benefits while supplying scarce timber to the local wood industry. But to be acceptable to farmers, transition must be gradual. Instead of simply promoting widespread tree planting, farm forestry programs could help resource-poor farmers to realize considerable benefits by assisting them in making informed decisions in their gradual transition towards agroforestry.

4.3.5   References

Betters, D. R. (1988): Planning optimal economic strategies for agroforestry systems. Agroforestry Systems 7: 17-31.

Current, D., Lutz, E. and Scherr, S. (1995): Costs, Benefits, and Farmer Adoption of Agroforestry. In: Current, D., Lutz, E. and Scherr, S. (eds.): Costs, benefits, and farmer adoption of agroforestry: project experience in Central America and the Caribbean. World Bank Environment Paper No. 14. Washington D.C., USA: World Bank: 1-27.

DTI and PKII Engineers (1996): General land use plan. Municipality of Claveria. Cagayan de Oro, Philippines: Department of Trade and Industry (DTI)-Region 10.

Elevitch, C. R. and Wilkinson, K. M. (2000): Introduction to integrating trees into Pacific island farm systems. Permanent Agriculture Resources, Holualoa, Hawaii, USA. Web site: http://www.agroforestry.net.

Franzel, S., Scherr, S. J., Coe, R., Cooper, P. J. M. and Place, F. (2002): Methods for Assessing Agroforestry Adoption Potential. In: Franzel, S. and Scherr, S. J. (eds.): Trees on the farm: assessing the adoption potential of agroforestry practices in Africa. Nairobi, Kenya: CAB International: 11-35.

Garrity, D. P. and Agustin, P. C. (1995): Historical land use evolution in a tropical acid upland agroecosystem. Agriculture, Ecosystems and Environment 53: 83-95.

Garrity, D. P. and Mercado, A. R. (1994): Reforestation through agroforestry: market-driven small-holder timber production on the frontier. In: Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines. December 6-9, 1993. Bangkok, Thailand: Winrock International: 265-268.

Gonzal, D. R. (1994): Gmelina arborea-annual crop interactions in contour hedgerow systems for smallholder farm forestry. PhD dissertation, University of the Philippines at Los Baños.

Kenmore, Z. F. and Flinn, J. C. (1987): An ethnohistory of an upland area: Claveria, Misamis Oriental. Los Baños, Philippines: International Rice Research Institute (IRRI).

LINDO Systems Inc. (1998): Extended LINGO/PC. Chicago, USA: LINDO Systems Inc.

Magbanua, R. D. and Garrity, D. P. (1988): Acid upland agroecosystems: a microlevel analysis of the Claveria research site. In: Proceedings of the 1988 Acid Upland Research Design Workshop. Los Baños, Philippines: International Rice Research Institute (IRRI): 1-20.

Magcale-Macandog, D. B., Menz, K, Rocamora, P.M. and Predo, C.D. (1999): Gmelina timber production and marketing in Claveria, Philippines. In: Menz, K, Magcale-Macandog, D. B. Rusastra, I. W. (eds.): Improving smallholder farming systems in Imperata areas of Southeast Asia: Alternatives to Shifting Cultivation. ACIAR Monograph No.52: 77-91.

Magcale-Macandog, D. B., Rocamora, P. M. and Predo, C. D. (1999): Gmelina as improved fallow. In: Menz, K, Magcale-Macandog, D. B. Rusastra, I. W. (eds.): Improving smallholder farming systems in Imperata areas of Southeast Asia: Alternatives to Shifting Cultivation. ACIAR Monograph No.52: 121-132.

Miah, M. D. G. (1993): Performance of selected multipurpose tree species and field crops grown in association as affected by tree branch pruning. PhD dissertation, Central Luzon State University, Muñoz, Nueva Ecija, Philippines.

Nelson, R. A., Cramb, R. A. and Mamicpic, M.A. (1996): Costs and returns of hedgerow intercropping and open-field maize farming in the Philippine uplands. Working paper No. 11. University of Queensland, Australia and SEAMEO Regional Center for Graduate Study and Research in Agriculture.

Pascicolan, P. N., de Haes, H. A. U. and Sajise, P.E. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forest Ecology and Management (99): 261-274.

Romero, C. L. (1994): Economia de los recursos ambientales y naturales. Madrid, Spain: Alianza Economia.

Stark, M. (2000): Soil Management Strategies to Sustain Continuous Crop Production between Vegetative Contour Strips on Humid Tropical Hillsides. Technology development and dissemination based on farmers' adaptive field experimentation in the Philippines. Bogor, Indonesia: International Center for Research in Agroforestry. Southeast Asia Regional Research Programme.

Watanabe, H. (1992): Tree-crop interactions in Taungya plantations. In: Jordan, C. F., Gajaseni, J. and Watanabe, H. (eds.): Taungya: Forest Plantations with Agriculture in Southeast Asia. Wallingford, UK: CAB International: 32-43.

Part V: Marketing Farm-grown Timber

5 Sustaining the Philippine wood industry with farm-grown trees: Evidence from northern Mindanao and outlook

Abstract

In many countries and regions of South and South-east Asia trees planted on farms are becoming the most important source of wood. In the Philippines, increasingly larger volumes of the timber traded and consumed come from trees grown on small farms in the sloping uplands. For more than a decade, small-scale farmers in northern Mindanao have been generating a significant marketable surplus of fast-growing timber trees, and viable farm forestry industries have emerged in the region as a result. However, the Philippine government has not duly acknowledged yet the importance of timber production by smallholder farmers and their contribution to sustain the wood industry. Existing policy disincentives constrain the establishment of tree farms and commercialisation of farm-grown timber. This paper has two objectives: first, to describe how timber produced by farmers is reaching the market, the structure of this market and the end uses of farm-grown timber in the province of Misamis Oriental, northern Mindanao; secondly, to estimate the importance of timber production by smallholders and explore its potential to sustain the wood industry. The study was conducted among wood processing plants located in Cagayan de Oro City and its neighbouring municipalities. Although in the past years the forestry sector output in the region has been declining due to depletion of forest resources, the forest- and wood-based industry is the second most important industry sector in the region. Nowadays, there are in Region X[51] 135 active small-scale sawmills (SSS) exclusively supplied with farm-grown timber. These have an estimated log utilization potential of 111,064 m^3 yr^{-1} and a sawn timber production potential of 76,596 m^3 yr^{-1}. Planted trees also represent a large percentage of the national and international production and trade of tropical timber in the country. In 1999, up to 70% (500,000 m^3) of the country log production came from planted trees. This demonstrates that smallholder farmers can produce large quantities of timber and efficiently supply local and national markets. The Philippine government and the wood industry sector should recognize the role of smallholder farmers as land

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[51] Region X of northern and central Mindanao is composed of the provinces of Misamis Oriental, Misamis Occidental, Bukidnon and Camiguin.

managers and efficient producers of many important agricultural commodities, including timber.

5.1   Introduction

Since 1950, the forest area in the Philippines have disappeared at a rate of 2,2% annually. By 1987 only 6,6 million hectares of the country (i.e., 22% of the total land area) remained forested (Kummer, 1992). Rapid deforestation has had dramatic economic and environmental consequences. It is estimated that 5.1 million hectares (i.e., 17% of the country's land area) are grasslands dominated by *Imperata cylindrica* (Garrity, et al., 1997). The forestry sector's contribution to the GDP has dropped from 12,5% in 1970 to just 2,3% in 1988 (PCARRD, 1994), and 1,3% in 1990 (ADB, 1994). The Philippines is now a net importer of timber (ITTO, 1996). Importation is draining the country's foreign currency reserves at a rate of Ph P 14 billion per year (Orejas, 2002).

For more than three decades, tree planting has been promoted as the solution to the negative effects of widespread forest destruction. However, many tree planting efforts have had limited success. Timber License Agreement (TLA) holders did not significantly contribute to the reforestation efforts[52] due to corruption and control of TLAs by the political elite (Vitug, 1993). Large government and foreign donor-funded reforestation and industrial plantation programs over large tracts of land created social conflicts due to farmer evictions and imposed restriction on farmers' livelihood activities on land they traditionally managed (Carandang and Lasco, 1998; Lasco et al., 2001; LTD, 2001). In addition, the wood industries associated with industrial forest plantations have struggled for economic survival (Inquirer, 2000). As with other tree crops, such as coffee, cacao and rubber, scale economies may not exist in the production of timber since "neither large-scale machinery nor central management is required for the production of these tree crops" (Hayami et al., 1993; Barr, 2002). Social forestry programs and initiatives that started in the early 70's have not been more successful. According to Pascicolan (1996), as cited in Pascicolan et al. (1997), between 1988 and 1992 the Contract Reforestation Program successfully reforested only 10% of its 225,000 ha target. The program was very expensive to implement, and its assumptions that the mere participation of rural communities in planning and implementation of time-framed, target-oriented programs would be sufficient for success proved too simplistic.

In contrast, as a result of favourable market conditions and the promotion of a tree planting culture among upland farmers, during the past two decades smallholder tree

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[52] TLA holders were required to reforest an area of denuded land equivalent to that selectively logged, and since 1981 to engage in industrial tree plantation (ADB, 1994).

farming has emerged as a profitable farm enterprise and as a viable alternative to industrial forest plantations and costly government-driven reforestation programs (Garrity and Mercado, 1993; Pascicolan et al., 1997). Paradoxically, small-scale tree farms in the Philippines were first promoted in the early 1970's under the smallholder tree farming contract scheme supported by PICOP[53]. Tree farms developed under this scheme quickly spread. In 1997, there were 15,000 ha of tree farms located nearby PICOP's mill site and another 29,000 ha further away but selling wood to PICOP (Jurvélius, 1997). The high price of timber and the demonstration effect of PICOP's tree farming scheme, as well as the development of other successful tree planting programs, supported the spread of tree farming throughout the country.

Unfortunately, tree farming has been promoted on the promise of huge economic returns[54], based on overoptimistic yields of fast-growing trees in favourable tropical humid conditions and unrepresentatively high timber prices at specific times and locations[55]. In the past few years, lower than expected returns from tree farming, particularly with *Gmelina arborea* R.Br (hereafter referred to as gmelina) and *Paraserianthes falcataria* (L.) Nielsen (hereafter referred to as falcata), has caused disenchantment among upland farmers (Caluza, 2002). As planted trees reached harvestable age, prices fell drastically due to market saturation. In 1997, the price of gmelina on stumpage averaged Ph P 4 per board foot (bd.ft.), (i.e., 33 US $ m^{-3}), a sixty percent decline with respect to prices in the early 1990's. Moreover in the smallholder context, timber yields may be lower than predicted as a result of adverse soil conditions and farmers' poor management practices (e.g., excessive pruning and lack of thinning).

In spite of these setbacks, a field survey conducted in the upland municipality of Claveria, northern Mindanao, among 112 farmers revealed that 55% wanted to plant more trees and were interested in trying new timber species (Chapter 3.1). In addition to the benefits provided to rural families such as fuelwood, construction materials, protection against erosion, shade and shelter, farm-grown timber is taking an increasing share of the timber industry and trade in the Philippines. The existence in Region X of 135 small-scale sawmills (SSS) exclusively supplied with farm-grown timber (DENR,

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[53] The Paper Industries Corporation of the Philippines (PICOP, Inc.) was one of the first major industrial forest plantation initiatives established to supply a pulp and paper mill sited at Bislig, Surigao del Sur. From 1972 up to 1994, a plantation of 33,200 hectares of the fast-growing species *Paraserianthes falcataria* and *Eucalyptus deglupta* were established in its forest concession area (ADB, 1994; Jurvélius, 1997).

[54] The slogan "Kahoy karon, bulawan ugma" (Trees today, gold tomorrow) popular among Philippinos in northern Mindanao exemplifies the expectations put on tree farming.

[55] A local newspaper said that one hectare of Eucalyptus deglupta could yield "Ph P 14,000 per tree or Ph P 10.5 million per hectare" (Fonollera, 1996).

1996b) demonstrates the extent and importance of tree farming in the region and provides evidence that growing timber trees on farms is still considered a viable livelihood alternative and an activity with an importance to the wood industry sector.

In many countries and regions of South and South-east Asia trees planted on farms are becoming the most important, if not the only, source of timber. In Punjab, India, farm trees account for 86% of the province's growing stock. In Sri Lanka, "trees outside the forest" represents over 70% of industrial wood. And in Pakistan trees on farms account for 23% of all timber growing stock. Even in Indonesia, a country that still has vast forest resources, some 20% of the total wood consumed is derived from trees outside the forest (FAO, 1998).

In the Philippines, increasingly larger volumes of timber consumed come from planted trees as well. Most of these are grown on small farms in the sloping uplands. This paper describes first how the marketable surplus of timber produced by farmers is reaching the market, the structure of this market and the end uses of farm-grown timber in the province of Misamis Oriental, northern Mindanao, Philippines. Then, it shows the importance of farm-grown trees to sustain the regional wood industry and outlines timber producers' concerns about the future of the industry. By providing evidence of the contribution of farm-grown trees to the wood industry, I aim to highlight that timber generated on small farms, far from being anecdotal, have the potential to be a viable and reliable supply of timber for the wood industry.

5.2   Materials and methods

The study was conducted among wood processing plants located in Cagayan de Oro City and its neighbouring municipalities. Cagayan de Oro is the capital city of Misamis Oriental, one of the four provinces of Region X in northern Mindanao. Although the forestry sector output in the region has been declining in recent years due to depletion of the resource and the reduction in legal Timber License Agreements (TLA) (Louis Berger International, 1999), the forest- and wood-based industry is the second most important industry sector after the processed foods and beverages (Provincial Capitol, 1997). According to the Cagayan de Oro-Iligan Corridor Master Plan, in 1998 the Agriculture, Fishery and Forestry sector was an important contributor to the Corridor's economy, accounting for a combined share of Ph P 3.3 billion or 18% of the Gross Service Area Product (GSAP) of the two provinces of Misamis Oriental and Misamis Occidental. Consequently, the development of industrial crops, such as forest trees, rattan and rubber, is one of the economic sectors proposed for development (Louis Berger International, 1999). According to the Department of Environment and Natural

Resources (DENR), in 1996 there were in Region X 6 sawmills, 5 re-sawmills, 3 veneer and plywood plants and 135 mini-sawmills. Wood sources to these local industries are TLA from eastern and southern Mindanao, planted trees from Region X and adjacent regions, and imported timber from USA, Malaysia, UK and Singapore (DENR, 1996b).

In March 2000, I carried out a survey among owners and managers of mini-sawmills, wood processors and manufacturers of Misamis Oriental. A total of 16 owners of mini-sawmills and 3 managers of large-scale wood industries were interviewed. The survey technique was structured and semi-structured questionnaires with major topics of discussion concerning timber supply and demand, processing and production, uses of farm-grown timber, marketing system, constraints to the industry and trends, and future expectations (**Appendices Chapter 5**). Important information was also gathered during several study tours to wood processing plants and training and research activities conducted in collaboration with tree farmers and a plywood company at Tagoloan, Misamis Oriental. These activities were part of the Landcare agroforestry extension project funded by the Spanish Agency for International Cooperation (AECI) and implemented by the World Agroforestry Center (ICRAF). Additional data on timber trade and marketing has been collected from published reports, secondary sources, the National Statistics Office and local agricultural statistics.

5.2.1   Limitations of the study

I used the best statistics on timber production available from several sources, including local governments, national agencies and international organizations. However, because of the lack of transparency, common in the forestry sector, and/or the absence of proper market information system, there are probably large discrepancies between the actual amounts on timber produced, traded and consumed and those reflected in the statistics. For example, there are no estimates of the large volumes of timber locally consumed in raw form (i.e., as poles, posts, or lumber), or processed (e.g., furniture, wooden crafts etc.). Also, although small-scale wood processors know well the production capacity of mini-sawmills, including recovery rates, most of them did not keep records of total production or were reluctant to share this information. It should be noted as well that given the species and the size and quality of the logs produced, farm-grown timber cannot be a substitute for wood originating from large diameter and quality logs coming from natural forests. Therefore, comparisons between farm-grown timber and other timber produced, traded or consumed should be interpreted with caution.

5.3   Results and discussion

5.3.1   Supply, demand and uses of farm-grown timber

From late 1980s and throughout the 1990s an increasingly number of small-scale sawmills (SSS) were established in Misamis Oriental for the processing and commercialisation of farm-grown timber stocks. According to the Department of Environment and Natural Resources (DENR), in 1996 there were 135 SSS in the region (DENR, 1996b). All the SSS are mainly supplied with logs of gmelina and falcata mostly grown by smallholder farmers (for a detailed characterization of timber tree producers see Chapter 3.1), although sometimes falcata timber originates from the large-scale forest plantations of eastern Mindanao. Other species milled, though in much smaller volumes, include *Acacia mangium* (mangium), *Swietenia macrophylla* (mahogany), *Eucalyptus deglupta* (bagras), and *Spathodea campanulata* (african tulip).

Fifty percent (50%) of the SSS owners interviewed look themselves for plantations and buy the trees standing "on the stump" and haul the logs to the sawmill. For the other 50%, trees are harvested and delivered to the sawmill by farmers or middlemen. Gmelina is mostly purchased from municipalities within the province of Misamis Oriental, whereas falcata is bought in truckloads coming from localities of the neighboring provinces of Agusan and Surigao as far as 200 kilometers. This shows that farm forestry is a viable option for smallholder farmers even in remote areas of the Philippines.

According to the respondents, there are slight fluctuations in the supply and demand of farm-grown timber throughout the year. Fifty percent of the SSS owners mentioned that there are more plantations for sale during the dry season (i.e., from February to June), as this is the agricultural slack period and farmers need income for household consumption and to pay school fees. Moreover, during the dry season farms are more accesible and hauling and transport of heavy logs easier. The rest of the year, farmers are busy planting and harvesting field crops and therefore, it is more difficult to find timber plantations for sale. By contrast, demand is lower during the first semester of the year and higher in the second as consumers have more cash to spend towards the end of the year due to extra payments and the harvest of agricultural crops. In spite of this, all but two interviewees responded that fluctuations in log supply and timber demand are not as marked so as to make the price of timber fluctuate.

Figure 5.1 depicts the most important transformations and end uses of farm-grown timber in Misamis Oriental. The great bulk of logs produced by farmers are sawn in SSS and either sold for further processing to medium- and large-size wood industries, or sold to retailers (lumber yards, carpentries, furniture shops) and individuals. Wood industries

use falcata planks and veneer as core stock in the production of plyboard (also called block board) and plywood. Gmelina is mostly used for furniture, house construction (window jams, doors, floor and wall tiles) and wooden crafts. Low quality wood and small size pieces are used for pallets, crates and wooden boxes. Because of the smaller size and lower quality, farm grown timber cannot be a substitute for timber originating from natural forests. However, according to the respondents, several premium timber species planted on farms, such as mahogany, have the potential to capture the market niche currently under the premium commercial timbers (veneer and large size, quality wooden planks). Unfortunately, although widely cultivated throughout the Philippines, Mahogany stocks growing on farms are not sufficiently large yet so as to supply the wood industries with sufficient quantities of timber.

The price of farm-grown timber is influenced, aside from the demand and supply, by its end use. This is in turn determined by the size and quality of the log. In the early 1990s, the price of farm-grown timber on stumpage was high, varying between Ph P 7 - 9 bdft^{-1}. But since 1997, the average price is only Ph P 4 bdft^{-1}. According to the owners of SSS interviewed, the price has declined because of the existence of large stocks of undersized and low quality timber. SSS require logs with a minimum length of 4 ft (although 3 ft can be accepted but at an even lower price) and 12 cm small-end diameter. However, thirty seven percent of the respondents reported that they are willing to pay farmers a stumpage price Ph P 1 to 2 bdft^{-1} higher for straight logs with 16 to 18 cm small-end diameter and 8 feet long. Timber planks of this size are used for furniture and house construction. Based on size and quality sawn timber used for furniture and house construction is graded into three categories: A (planks 8 ft long without knots); B (6 ft long with some knots); and C (4 ft long, knotty). Prices vary accordingly: Ph P 11 or 12 for category A; Ph P 9 or 10 for category B; Ph P 7 or 8 for category C. For veneer, timber price also depends on log size. In the year 2002, prices ranged from Ph P 3 bdft^{-1} for logs 26 - 28 cm in diameter, to Ph P 6 bdft^{-1} for logs with diameter 60 cm and larger. There is no price premium for quality for timber that is bought by truckload.

TREE PLANTATION

weeding;   pruning;
thinning; harvesting

weeding; pruning;
thinning; harvesting
sale

POLES

LOGS

STUMPAGE

Processing
(mini-sawmill)
Sale

Chainsawmilling

Harvesting

LOGS

Household
consumption

LUMBER

LUMBER

Sale

Sale

HOUSEHOLD

**LOCAL
MARKET**

Processing
Sale

**PALLETS
CRATES**

**CONSTRUCTION
MATERIALS**

**FURNITURE
CRAFTS**

BLOCKBOARD

POSTS

PLYWOOD
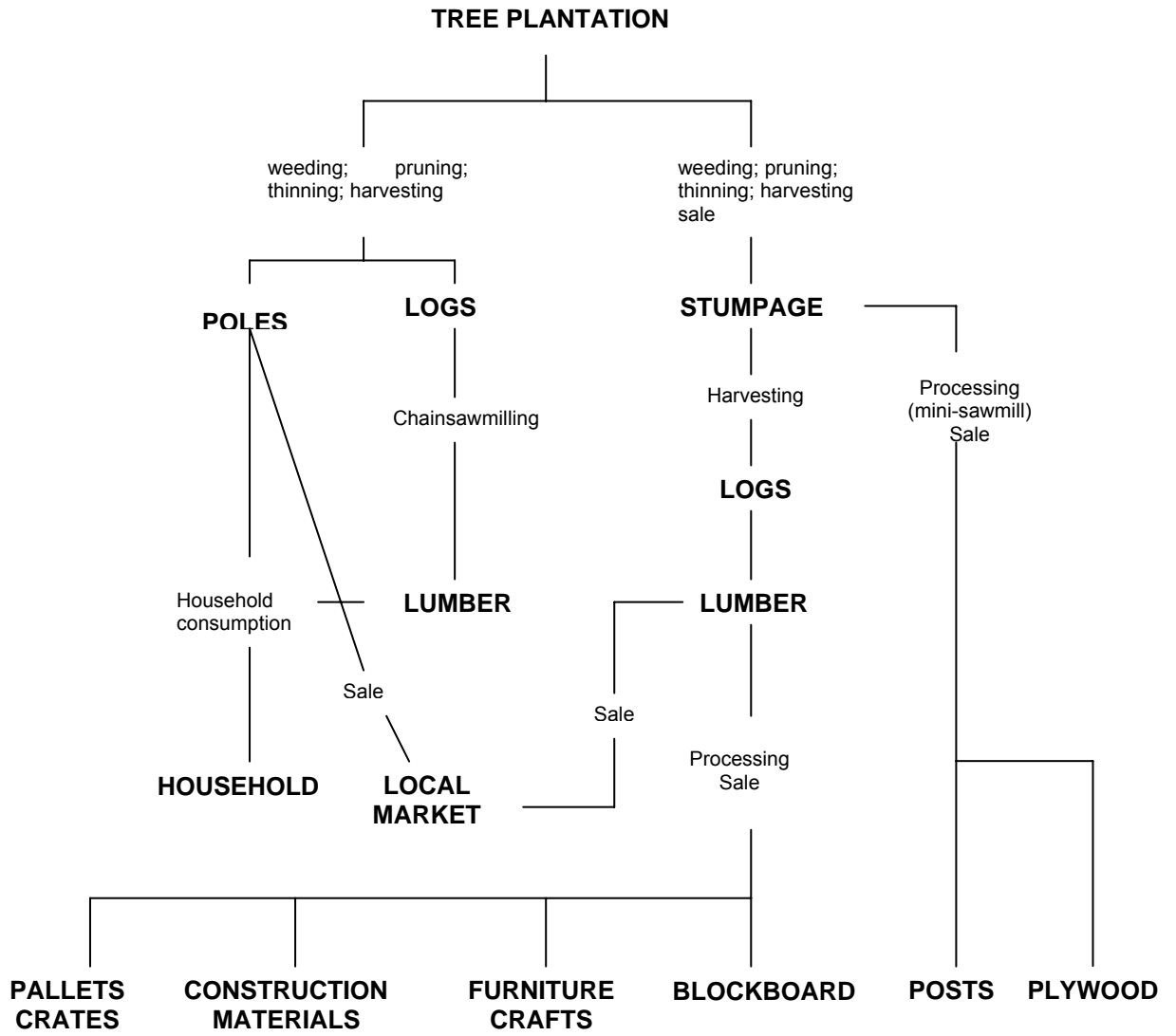
Figure 5.1: Production and marketing system of farm-grown timber in Misamis Oriental, Philippines: producers' decisions, product transformation and end use.

5.3.2   Farm-grown timber: increasing the share of the wood industry

The Philippine government has not duly acknowledged yet the importance of timber production by smallholder farmers and their contribution to sustain the wood industry. For example, The Philippine Year Book 1999 reports the existence in 1996 - 1997 in Region X of only 2 active sawmills with an annual log requirement of 56,800 m^3 (NSO, 1999). However, the 16 SSS surveyed had a total of 65 operational mini-sawmills[56]. The majority of the SSS (56%) had small capacity, with only 1 or 2 mini-sawmills, 32% had 3 or 4 and only 1 SSS was operating on a large scale with 30 mini-sawmills. According to the survey respondents, in a regular 8-hour working day with and with an average recovery rate of 45% a mini-sawmill produces between 700 to 1,000 bd ft of sawn timber of gmelina or 1,000 to 1,600 bd ft of falcata. Considering that of the 16 SSS visited only 45% operate continuously and using an average production of 1,000 bdft of sawn wood per mini-sawmill per day, with the existing sawmill capacity (135 mini-sawmills) an estimated 45,000 to 53,617 m^3 of farm-grown sawn wood was produced every year in Region X since 1996. And with the reported average recovery rate of 45%, a conservative estimate of smallholder log production in Region 10 is that of 65,250 to 77,745 m^3 yr^{-1} . Assuming a continuous operation of mini-sawmills, the potential annual log utilization would be 111,064 m^3 yr^{-1}, and the potential sawn timber production 76,596 m^3 yr^{-1}. If compared to the available statistics of the sawn wood exports from the Cagayan de Oro port (**Table 5.1**) and considering that, unknown, but probably large volumes of sawn timber are consumed locally, we can conclude that these are very conservative estimates of the contribution of smallholder farmers to the wood industry in the region. Nevertheless, it represents about 10 to 14% of the domestic consumption of tropical sawn wood timber in 1996 (539,000 cu m) reported by ITTO (1996).

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[56] Mini-sawmill is a sawmill consisting of a single head rig with a flywheel diameter not exceeding 106 cm, a band saw blade with thickness not exceeding three (3) mm and width of not more than 27mm, with or without a carriage, and a daily rated capacity of no more than 18 cu m or 8000 board feet of lumber per 8 hour shift (DENR, 1996a).

Table 5.1: Exports of Falcata sawnwood from Cagayan de Oro Port, Philippines.

Year	Volume* (m³)	Value (million PhP)
1994	22,863	87.218
1995	30,971	142.614
1996	42,361	237.924
1997	25,175	165.421
1998	1,795	43.144
1999	113	1.127

Source: Regional Statistical Year Book 2000, Neda Region X and 1995-96 Misamis Oriental Provincial Socio-economic Profile.

*Volume adjusted from weight assuming the conversion factor for sawn wood of 1.43 m^3 ton^{-1} (ITTO, 1996).

Smallholder tree farming enterprises are also contributing substantially to employment generation in the region. In the SSS surveyed, for every mini-sawmill an average of 5 workers (considering part time and full time workers) are employed in the various activities involved, from tree harvesting and processing to business management. Thus, around 675 people may be directly employed by the mini-sawmill industry in Region X in 1996. Even if this estimate do not consider the many people involved in associated activities such as transporting and further processing and marketing, it represents 6% of the work force of all processing mills (i.e., sawmills, veneer and plywood mills) in the country reported by ITTO (1996).

Planted trees also represent a large percentage of the national and international production and trade of tropical timber in the Philippines. According to ITTO (2001), "as of 1999, logs coming from plantations made up to 70% of the log production of 712,000 m^3 " (i.e., 500,000 m^3 of the total log production come from planted trees). In 2000, log production registered an increment of 9.6% over the previous year primarily due to harvest of planted trees within private land (Dy, 2002). Considering that in the Philippines sawn wood exports are restricted to those arising from planted trees or from imported logs (ITTO, 1996), between 1995 to 1998, 40 to 45% of the total sawn wood exports would have come from planted falcata trees (Table 5.1). This figure is probably higher considering that 8 owners of SSS and medium size wood industries interviewed reported exporting sawn timber of gmelina to other Southeast Asian countries. Although, it is not clear whether the produce come from industrial forest plantations or from smallholder farms, based on the evidence provided in this chapter, it is reasonable to believe that a

large share of the log production and sawn wood exports comes from smallholder farm forestry.

Table 5.2: Planted trees such as *Paraserianthes falcataria* (falcata) account for a large percentage of the total sawn wood exports of the Philippines.

Year	Volume exported (x 000 cu.m.)		
	Total*	Falcata*	%
1994	38	47	
1995	84	44	52
1996	145	67	46
1997	141	63	45
1998	41	15	37
1999	69	4	6
2000	120	15	13
2001	142	nd	

*Source: ITTO Annual review and assessment of the world tropical timber situation

The Philippines, like many other Asian countries, is a major importer of timber. In the year 2000, imports accounted for 40% of the total supply of logs, 70% in lumber and 20% in plywood and veneer (Dy, 2002). Until recently, growing domestic demand of timber has been met, to a large extent, by imposing low tariffs on imported logs (3%) and protecting wood processors from international competition by high tariffs on sawnwood (30%) and veneer and plywood (50%). But local wood processors interviewed showed concern about competition from imported timber, as the Philippine government is required to substantially reduce tariffs in compliance with the ASEAN Common Effective Preferential Tariff (CEPT) Agreement[57] signed in 1992 (Shimamoto, 1998). Encouraged by new processing technologies that allow timber production from small diameter trees and the use of a wider range of species, the wood industry is realizing that farm forestry has the potential to be an important source of cheap timber. Domestic producers have begun actively looking for other tree alternatives in order to meet domestic demand and reduce their present dependence on imported timber. During the last few years, a plywood company near Cagayan de Oro City has been testing the veneering potential of more than 30 tree species commonly-grown on farms. Of these, 5 native pioneers, *Endospermum peltatum* (gubas), *Artocarpus blancoi* (antipolo), *Octomeles sumatrana*

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[57] Signatories of the agreement are required to reduce tariffs to 20% within 5 to 8 years from 1993 and to 0 - 5% thereafter within a 7-year period (Shimamoto, 1998).

(binuang), *Duabanga moluccana* (loktob) and *Trema orientalis* (anabiong), were identified as suitable for face and back veneer and several others for core stock. In 2001 they also tested, in collaboration with tree farmers from Claveria and Lantapan (Bukidnon), the veneering properties of three exotic species recently introduced for farm forestry, *Maesopsis eminii* (mosizi), *Eucalyptus robusta* and *Eucalyptus torrelliana*. For several years, the company has been already using Falcata for core veneer, again demonstrating the market potential of trees grown on-farms. These initiatives led by farmers and the industry to find new tree alternatives are an indication that facilitating access to a wider range of tree options could prove to be a simpler and more successful reforestation strategy that would satisfy the needs of farmers, the industry and the society.

Domestic demand for sawn wood in the Philippines for the year 2010 has been estimated at 1.646 million cu m, with a log requirement to meet this demand of 3.418 million cu m (Sanvictores, 1994). If fast growing trees were planted on small farms yielding just 6 cu m ha^{-1} year^{-1} on rotation periods of 10 years, the log requirement to meet domestic demand for sawn wood in 2010 could be produced if 56,967 has of tree farms had been established in the year 2000. This represents just a small fraction of the land potentially available for agroforestry and farm forestry in the Philippines.

Unfortunately, existing policy disincentives constrain the establishment of tree farms and the use of trees by the wood processing industry. Although, recent legislation exempt owners of planted trees from paying forest charges, farmers are required to apply for a Certificate of Registration of the plantation and a Certificate of Verification to show that trees are ready to be harvested (GOLD, 1998; DENR, 1999). Moreover, at the village level there exists a lot of confusion on whether fees have to be paid or not (Chapter 3.1). Field inquiries revealed that many farmers are required to pay harvesting fees to local officials, although there is no legal basis for such fees. The owners of SSS interviewed also complained about the many restrictions and permits required to operate. These include, in addition to the licenses required to any business or industrial activity, harvesting permits from Barangay governments, transport permit (Certificate of Origin) (Andin, 2002) and frequent road check points by the DENR, and probably further restrictions to the establishment of SSS as stated in the general objective of the Five Year Mini-sawmill Rationalization Plan (DENR, 1996b). Incentives to encourage forest plantation establishment, like income tax holidays, tax and duty free importation of capital equipment, and exemption from contractors' tax (ITTO, 2001), are, however, better suited for industrial plantations and have limited application to smallholder farmer conditions. By favouring large industrial plantations such incentives function as de facto disincentives for smallholder timber producers. What is required in forestry policy is a

paradigm shift that recognizes the legitimate role of smallholder farmers as contributors to national timber production (Noordwijk et al., 2003).

5.4   Conclusions and recommendations

In the past two decades, small farms in northern Mindanao have generated a significant marketable surplus of fast-growing timber trees and viable farm forestry industries have emerged in the region as a result. The volume of farm-grown timber harvested, processed and traded in the past few years, proves the success of smallholder upland farmers in tree growing and marketing, demonstrating that they can produce large quantities of timber in their smallholdings and efficiently supply local, national and international markets.

However, current produce is not a practical substitute for timber products requiring large diameter and quality logs. Therefore, the Philippines is still largely dependent on imported timber to meet its increasing domestic demand. Wood processors have been protected from international competition by high tariffs on imported processed timber. But presently, in compliance with signed international agreements, the government is required to substantially reduce tariffs on imported timber. The wood industry is realizing that farm forestry has the potential to contribute to import replacement but several constraints remains that limit further development of the wood industry based on locally produced farm-grown timber. First and foremost, the Philippine government should remove policy restrictions curtailing the use of planted trees and provide incentives appropriate to smallholder farmers. At the same time, farm forestry extension programs should provide quality germplasm, promote the use of a wider range of tree species, and invest in training programs aiming at improving management. The Philippine government and the wood industry sector should recognize the role of smallholder farmers as land managers and efficient producers of many important agricultural commodities, including timber.

5.5   References

ADB (1994): Forestry sector study of the Philippines. Manila, Philippines: Asian Development Bank.

Andin, N. A. (2002): Forestry programs and policies in support to Tree Farming. Paper presented at the Second National Tree Farmers Congress, 11-13 July 2002, Butuan City, Philippines.

Barr, C. (2002): Profits on Paper: the Political Economy of Fiber, Finance and Debt in Indonesia's Pulp and Paper Industries. Bogor, Indonesia: Centre for International Forestry Research (CIFOR).

Caluza, D. (2002): Farmers quit planting gmelina in Apayao, women's study says. Philippine Daily Inquirer. April 1, 2002, Manila Philippines.

Carandang, W. M. and Lasco, R. D. (1998): Successful reforestation in the Philippines: technical considerations. In: Mega Issues in Philippine Forestry: Key Policies and Programs. Forest Development Center, UPLB, Philippines: 49-59.

DENR (1996a): Additional Guidelines Governing the Issuance of Permits to Establish and Operate Mini-sawmills. DENR Memorandum Order No. 96-09. Quezon City, Philippines: DENR.

DENR (1996b): Five Year Mini-Sawmill Rationalization Plan for DENR Region 10. Cagayan de Oro City, Philippines: DENR Region 10.

DENR (1999): Supplemental Guidelines Governing the Registration, Harvesting, Transport and Marketing of Timber by Products Coming from Private Plantations Within Private Lands or Tax Declared Alienable or Disposable Lands. DENR Memorandum Circular Order No. 99-20. Quezon, City, Philippines: DENR.

Dy, R. T. (2002): The Philippine Wood Industries. Paper presented at the Second National Tree Farmers Congress, 11-13 July 2002, Butuan City, Philippines.

FAO (1998): Asia-Pacific Forestry: Towards 2010. Executive Summary of the Asia-Pacific Forestry Sector Outlook Study. Rome, Italy: FAO.

Fonollera, C. (1996): Agro-forestry micro-enterprises to reforest watersheds. Gold Star Daily. September 12, 1996. Cagayan de Oro, Philippines.

Garrity, D. P. and Mercado, A. (1994): Reforestation through agroforestry: market driven small-holder timber production on the frontier. In: Raintree, J. B. and de Francisco H. A. (eds.): Marketing of Multipurpose Tree Products in Asia. Proceedings of an international workshop held in Baguio City, Philippines, 6-9 December, 1993, Bangkok, Thailand: Winrock International: 265-268.

Garrity, D. P., Soekardi, M., van Noordwijk, M., de la Cruz, R., Pathak, P.S., Gunasena, H. P. M., van So, N., Huijun, G. and Majid, N. M. (1997): The *Imperata* grassland of tropical Asia: area, distribution, and typology. Agroforestry Systems 36, Special issue Agroforestry innovations for Imperata grassland rehabilitation: 3-29.

GOLD Project (1998): Tree Farming Sourcebook. Provincial Government of Palawan, Philippines, Governance and Local Democracy Project (GOLD) and the Palawan Tropical Forestry Protection Program.

Hayami, Y., Quisumbing M. A. R., Adriano, S. L. (1993): Toward an alternative land reform paradigm: A Philippine perspective. Quezon City, Philippines: Ateneo de Manila University Press.

Inquirer (2000): PICOP to shut down forestry division. Philippine Daily Inquirer. August 5, 2000. Manila, Philippines.

ITTO (1996): Annual Review and Assessment of the World Tropical Timber Situation 1996. Yokohama, Japan: International Tropical Timber Organization (ITTO).

ITTO (2001): Annual Review and Assessment of the World Tropical Timber Situation 2001. Yokohama, Japan: International Tropical Timber Organization (ITTO).

Jurvélius, M. (1997): Labor-intensive harvesting of tree plantations in the southern Philippines. In: Tan, L.C. and Durst, P. B. (eds.): Forestry Harvesting Case Study No. 9. Bangkok, Thailand: FAO.

Kummer, M. D. (1992): Deforestation in the Postwar Philippines. Manila, Philippines: Ateneo de Manila University Press.

Lasco, R. D., Visco, R.G. and Pulhin, J.M. (2001): Formation and transformation of secondary forests in the Philippines. Journal of Tropical Forest Science 13: 652-670.

Louis Berger International Inc. (1999): Cagayan de Oro-Iligan Corridor Master Plan. Volume I - The Report. Republic of the Philippines: Technical advisory services for the Philippine Assistance Program Support.

Nimmo-Bell & Company LTD. (2001). Bukidnon Forests Incorporated. Sustainable Forestry in the Philippines, January 2001. Bukidnon Forests Incorporated (BFI).

NSO (1999): Forestry and Environmental Management. In: 1999 Philippine Yearbook. Manila, Philippines: National Statistics Office.

Orejas, T. (2002): DENR to start cloning native trees. Philippine Daily Inquirer. April 4, 2002. Manila Philippines.

Pascicolan, P. N. (1996): Tree Growing on Different Grounds: an Analysis of Local Participation in Contract Reforestation in the Philippines. PhD dissertation. Leiden Universtity, Centre for Environmental Science. The Netherlands. Quoted by: Pascicolan, P. N., de Haes, H. A. U. and Sajise, P E. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forestry Ecology and Management (99): 261-274.

Pascicolan, P. N., de Haes, H. A. U. and Sajise, P. (1997): Farm forestry: an alternative to government-driven reforestation in the Philippines. Forest Ecology and Management (99): 261-274.

PCARRD (1994): Status of Industrial Timber in the Philippines. Los Baños, Laguna, Philippines: Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and the Department of Science and Technology (DOST).

Provincial Capitol (1997): 1995-1996 Provincial socio-economic profile of Misamis Oriental. Cagayan de Oro City, Philippines: Provincial Capitol.

Sanvictores, E. F. (1994): Demand for Industrial Timber in the Philippines. In: Status of Industrial Timber in the Philippines. Los Baños, Laguna, Philippines. PCARRD and DOST: 14-30.

Shimamoto, M. (1998): Chapter 4: Forest Resources and the Forest Products Industry in the Philippines. In: A Step Toward Forest Conservation Strategy (1). Interim Report 1998. IGES Forest Conservation Project. Available at: http://www.iges.or.jp/en/fc/phase 1/interim-contents.htm.

van Noordwijk, M., Roshetko, J. M., Murniati, M., de los Angeles, M., Suyanto, C., Fay, C. and Tomich, T. (2003): Agroforestry is a form of sustainable forest management. Paper presented at the UNFF Inter-sessional Expert Meeting on the Role of Planted Forests in Sustainable Management. March 24-30, 2003. New Zealand.

Vitug, M. D. (1993): The Politics of Logging. Power from the Forest. Manila, Philippines: Philippine Center for Investigative Journalism.

Part VI: Synthesis

6   Conclusions and recommendations

Widespread planting of fast-growing timber trees on small upland farms and their successful commercialisation evidence the viability and appropriateness of timber-based agroforestry as an alternative for smallholder farming systems and the potential of upland farmers as timber producers. Farmers have accumulated wide knowledge about timber trees and how to cultivate them. They grow timber trees for various reasons: for household consumption of wood products (i.e., lumber and fuelwood); to accumulate capital and generate cash income; for environmental reasons, such as erosion control and soil fertility improvement; and for other benefits like boundary demarcation, shade and shelter. Trees are also planted and managed in response to the resources and livelihood strategies available to satisfy household's requirements. Intercropping between newly planted trees is commonly practiced as a strategy that saves labour, enhance tree growth and provides higher returns to the farmer. This study also suggests that younger farmers, with available draft animal labour, with scarce family labour, and actively involved in village-based organizations are the segment of the rural people most likely to adopt tree farming. Contrary to expectations, the study also found that owning larger farms (i.e., above the average size) and the availability of off-farm income are not major incentives to invest in tree farming. On the contrary, full-time farmers and owners of smaller landholdings are also active tree planters as demonstrated by highest tree densities found on the smaller farms. The availability of off-farm income appears to be an incentive to less labour-demanding tree farming when the allocation of farm family labour to work off-farm limits investments on labour-demanding farm enterprises, such as annual cropping.

The lack of tree options suited to the varied biophysical conditions of the uplands is the most important impediment to widespread adoption of tree farming. But aside from this, tree planters and non-planters alike identified tree competition with field crops as the most important constraint to timber tree planting. Farmers have observed that crop yields can be severely reduced as far as five to seven meters from a row of fast-growing timber trees and reported short intercropping periods when trees are planted at close spacing. Nevertheless, tree-crop competition is not an impediment to tree farming and planters have developed methods to control and reduce it. Severing tree roots spreading into the cropped alley by ploughing close to tree rows, and frequent and severe branch pruning are commonly practiced to reduce below- and above-ground competition and thus prolong the period of intercropping. However, previous

research and tree growers themselves recognized that tree root and branch pruning are detrimental to tree growth. They are also uncertain whether intercrop yield increases can compensate reduced tree growth and increased labour costs of heavy pruning.

The period of viable intercropping depends on the characteristics of the tree specie, the crop requirements (i.e., sun-demanding or shade tolerant), the tree spacing and management of trees and alley crops. Less competitive tree species such as those with small branches and narrow crown (e.g., *Swietenia macrophylla*), or those with a self-pruning habit and light canopy (e.g., *Eucalyptus deglupta*) are preferred for tree farming. But farmers suggestions, supported by field observations of the increasingly popular practice of planting trees on contour grass strips 6 to 8 m apart, led us to hypothesize that planting tree lines at wider distance is another option that will provide higher economic returns because: (a) crops can be planted in the alleys between rows of trees for longer period; (b) trees will grow faster because of the more intensive management and favourable light regime; and (c) farmers would benefit from the reduction of area lost to trees and lower tree establishment and management costs.

On-farm trials showed that intercropping between fast-growing trees could not be sustained for long periods, even if trees with favourable characteristics, such as *Eucalyptus deglupta* (hereafter referred to as bagras), are planted in rows as far as 10 m. After tree establishment, maize grain yields were above the break-even for 6 cropping seasons when intercropping between bagras but only for 2 cropping seasons when intercropping between *Gmelina arborea* (hereafter referred to as gmelina). This supports the claim that bagras is more suitable than gmelina in mixed agroforestry systems because of the straight stem, self-pruning habit, small-diameter branches and smaller and less dense crown of the former. By the seventh cropping season, gmelina had reduced maize grain yields by 60% and bagras by 40%. These results led us to conclude that if mixed agroforestry systems with fast-growing timber trees and sun-demanding crops are to produce acceptable levels of intercrop yields (assuming a threshold of 20% crop yield reduction), tree basal areas should be within the range of 2 to 4 m^2 ha^{-1}. This is equivalent to a density of 41 to 81 trees ha^{-1} (spacing of 10 x 25 and 5 x 25 m) when average dbh is 25 cm or a final crop of 28 to 57 trees ha^{-1} if trees are harvested when dbh is 30 cm. For higher tree densities and if crop production is a priority, fast-growing trees should be planted in other farm niches away from crops, such as home gardens, farm boundaries, or fallows, rather than on cultivated land.

We confirmed the hypothesis, however, that trees grow faster in widely-spaced tree hedgerows than in blocks. With frequent but moderate pruning and intensive management of alley crops, data on tree growth collected during a four-year period

indicated that if planted in hedgerows gmelina would produce in 8 years volumes of timber ranging from 69 to 110 m^3 ha^{-1}, and bagras would produce 146 to 185 m^3 ha^{-1} in rotations of 12 years. Planting trees in widely-spaced hedgerows is, therefore, appropriate for timber production in agroforestry systems.

If the current low price of farm-grown timber prevails and with timber yields in the lower range of those estimated, maize monocropping is more profitable than maize-timber intercropping. Only in the event of a timber price increase (of Ph P 1 bdft^{-1} for gmelina and Ph P 4 bdft^{-1} for bagras) and high timber yields, the profitability of timber intercropping would be similar or higher than that of maize monocropping at a 20% discount rate. Given that nowadays large stocks of small-size timber of low to average quality exist on farms and the limited demand for this type of timber, to improve the financial returns of farm forestry in the Philippines it would be imperative for tree farmers: i) to diversify tree production by planting timber species that command higher market price. Several options are already available, or becoming more available to farmers, such as *Swietenia macrophylla* (mahogany) or bagras; ii) to grow larger trees and of higher quality intended for high-value timber products like for example, veneer. The on-farm trials conducted in this study showed that it is possible to produce in intercropping systems with widely-spaced tree hedgerows logs with the size and form required by the wood industry. Tree hedgerow systems proved to be financially superior than the commonly promoted tree blocks because of the lower establishment and management costs, higher maize yields produced (confirmed only in the case of bagras), and higher timber yields (confirmed for gmelina and probably for bagras).

Timber-based agroforestry systems are, however, superior to monocropping in terms of returns to labour invested. Therefore, they are the best option for labour-constrained farmers aiming to maximize land productivity with scarce labour. Timber intercropping would also turn out more financially attractive than monocropping in the event of moderate increases of farm labour wage. In the Philippines, this is likely to occur in the near future, as the economy diversifies and more rural people find work off-farm.

Farmers' evaluation of timber production systems broadly pointed to the need, in smallholder farm forestry, of segregating timber from crop production enterprises. Because of tree-crop competition, they preferred systems in which the tree-crop interface is minimal, such as line plantings (i.e., trees on boundaries or widely-spaced hedgerows) or small-scale woodlots away from crops. Incremental planting or cumulative additions of tree hedgerows is an intermediate option in which trees and crops can be temporarily combined into the same land unit to maximize farmers' benefits and produce timber in a commercial scale without compromising food crop production. This tree farming system, also called rotational timber fallows, is more

"acceptable" to farmers (i.e., more profitable and feasible, less risky and compatible with farmers' values and farmers' valuation of benefits) because it provides higher returns to land and reduce the risk of agroforestry adoption by spreading over the years labor and capital investment costs and the economic benefits accruing to farmers from trees. We, therefore, propose the gradual planting of tree hedgerows as a strategy that will enhance adoption of tree-based farming systems among smallholder farmers.

The sizeable marketable surplus of fast-growing timber trees generated in small upland farms and the large number of viable farm forestry industries that have emerged in the region as a result, evidence the success of smallholder farmers as timber producers. Farm-grown timber is increasing its share of the wood used and traded in the local, national and even international markets. However, current produce is not a practical substitute for timber products requiring large diameter and quality logs. Therefore, wood processors in the Philippines are still largely dependent on imported timber to meet increasing domestic demand. The wood industry is realizing that farm forestry has the potential to contribute to import replacement but several constraints remains that limit further development of the wood industry based on locally produced farm-grown timber. The Philippine government should remove policy restrictions curtailing the use of planted trees and provide incentives appropriate to smallholder farmers. On the side of the tree farmers, the challenge is to increase production and quality of a variety of timber species. Only by targeting those segments of the wood industry that demand quality timber, would farmers be able to seize the economic opportunity of farm forestry.

This research provided insights on how farmers grow timber trees; it quantified the biophysical performance and profitability of timber production systems, and took into consideration farmers' practical knowledge and perceptions for the design of adoptable tree farming systems. The findings reported in this study also highlight the need of farm forestry extension programs to address three broader issues. First, the lack of quality germplasm of a wider list of timber tree species suited to the diverse environmental and socio-economic conditions of upland farmers. If germplasm is made available, smallholder farmers have already proven to be active and successful tree growers. Secondly, there is a need to demonstrate to farmers the advantages of using quality germplasm and improved tree management practices (e.g., pruning and thinning). A combination of on-farm trials, with active involvement of farmers in design and management, and more training can address this. Thirdly, extension and dissemination methods need to be improved, with a focus on facilitating a gradual transition towards agroforestry instead of planning and promoting standard tree

planting packages. And lastly, there is an urgent need of dialog with government agencies to lift existing policy regulations that prevent the establishment and use of tree resources on farms.

Appendices Chapters 3.1 and 3.2

1   List of questions used in the exploratory household survey among farmer tree planters and non-planters in Claveria (conducted from July to August 1997).

1   Questions related to the farming system

   • Total farm area, number of parcels, size of each parcel and tenurial status

   • Current land use of each farm parcel

2   General questions regarding tree planting and the tree species found on-farm

   • Have you planted trees in your farm? If No, why not?

   • If Yes, What are the important tree species you have planted in your farm?

   • Number of trees of each specie, arrangement and farm niche

   • Farmers' preferences and perceived advantages from common trees

   • If the farmer has not planted timber trees, what things have ever prevented you from planting timber trees?

3   Questions related to tree establishment and propagation:

   • Tree establishment method by reported specie (direct seeding; potted seedling; bare-root seedling; wildling; natural growth)*

   • What are the advantages/disadvantages of the different establishment methods?

   • Source of germplasm: purchased; commercial nursery; trees on-farm; Government agency; NGO

   • If collected, describe collection method and selection of mother trees; number, characteristics and distance between mother trees.

   • Presently, do you have a household nursery? If Yes, what species are you raising? (visual inspection)

   • Have you had a household nursery in the past? If Yes, what species did you grow?; If No, why not?

4   Questions related to tree management practices:

   • Weeding: Did you weed your trees? If Yes, how (describe the weeding operation) and how many times in a year?; If No, why not?

- Pruning: Have you pruned your timber trees? If No, why not?; If Yes, why did you prune the trees?

- When did you conduct the first pruning (age or height of the tree)?

- Did you prune more than once? If Yes, How often do you prune your trees?

- Please, describe how pruning is performed including the pruning height and the tools used

- Should pruning be conducted in any specific time of the year? If Yes, when and why?

- Do you think it is easier to sell pruned than un-pruned trees? If Yes, why?

- Do you think pruned trees will fetch a higher price than unpruned trees? If Yes, why?

- What are the main constraints to pruning?

- Do you think you should improve your pruning method? If Yes, how and why?

- Thinning (for farmers with trees planted in blocks or at close spacing)

- Are you satisfied with the growth of trees planted in this arrangement? If No, why not?

- What could you do to improve growth?

- Have you cut any tree from your plantation? If Yes, please describe the reason for cutting. If No, why not?

5   Other uses of timber trees

- Fuelwood: What is the major source of fuel you use?

- Where do you normally obtain your fuel wood from?

- What changes have you observed in fuel wood availability in the last 10 years? If becoming scarce/available, why?

- Poles: Where do you normally obtain poles from?

- What are the main uses of poles?

- What changes have you observed in availability of poles over time since you live here? If becoming scarce, what have you been doing in response to scarcity?

6   Timber marketing:

- Have you sold timber trees in the past 3 years? If Yes, what species?

- To whom and how did you sell the trees? (indicate unit of measurement)

- Price per unit

- Why do you think the price of Gmelina is lower these days than few years ago?

7   Future plans regarding timber tree planting:

- Do you intend to plant timber trees in the future? If No, why not?

- If Yes, what species, approximate number of trees and where?

- Why do you prefer selected specie?

8   Perceived benefits and constraints to timber tree planting:

- What are the benefits of planting timber trees?

- What are the main constraints to timber tree cultivation? (if necessary please specify specie you are referring to)

9   Farmers' observation of tree-crop competition and strategies to reduce it

- Do you think timber trees affect crop yields? If Yes,

- What negative effects do you perceive? (please elaborate)

- What positive effects do you perceive?

- If trees were planted in lines 10 meters apart, could you predict for how long intercropping would be viable?

- Do you try in any way to reduce tree-crop competition? If Yes, how? (please elaborate).

- What are the effects on crops and/or trees of this practice?

- Other methods or strategies to reduce tree-crop competition

10   About policies regarding tree cultivation

- Are you aware of any law or regulation regarding tree harvesting? If Y, can you explain?

- If you were to sell your logs to a sawmill, do you need to obtain a permit for transportation? If Y, how would you obtain the permit?

- Would you be interested in planting an "illegal tree" (those trees banned from cutting)? If N, why?

2   List of questions and data collected during the survey of household nurseries in Claveria (conducted on July 1998).

1   General information of the respondent: name; land ownership; farm size; membership to village council and/or village organizations

- Why have you decided to have a private nursery?

2   General condition of the nursery:

- Fenced or accessible to stray animals;

- Water availability (distance to water source);

- Exposure to sunlight (direct exposure; partial shade, permanent shade; type of shading material)

- Potbeds and other facilities (description)

3   Information about the tree species raised and propagation practices

- Species and number of seedlings

- Type of germplasm used

- Germplasm: source/origin and procurement

- If germplasm was collected, describe collection (number of mother trees, location and criteria for selection)

- Describe tree propagation methods (seed extraction, pretreatment, fertilizer application, soil media)

- Have you ever sold seedlings raised in your nursery?

4   Problems and constraints to tree propagation

- Have you ever taken part in community nursery activities? If Y, please explain.

- What are the advantages/disadvantages of group nurseries versus household nurseries?

3   Data collected during the inventory of trees on-farm (February-May 2001) (some of the results of this survey are reported in Chapter 3.1).

- Species, number of trees; main use (timber, fuelwood, fodder, fruit, soil conservation, other);

- Tree arrangement (mixed garden; woodlot; linear planting; scattered; isolated)

- Farm niche: external or internal boundary; crop land; pasture or fallow land; homestead

4   List of household and farm explanatory variables hypothesized to influence timber tree planting (survey conducted in Claveria from February to May 2001 among tree planters and non-planters).

Variable name	Description	Response range
Household variables		
BRGY	Village of residence	Cluster I: Hinaplanan; Cabacungan; Kalawitan; Gumaod Cluster II: Patrocenio; Anei; Claveria (Poblacion) Cluster III: Lanesi; Luna; Tamboboan Cluster IV: Rizal; Madaguing
TB	Tribal group respondent belong to	Higaonon (Hig); Visaya (Vis); Tagalog (Tag); Ilongo (Il)
MIGR	If respondent is a migrant to this municipality	Yes (y); No (n)
YRSLIV	Years as resident in the village	0-5 years: (0); 6-10: (1); 11-20: (2); more than 20: (3)
AGEDEC	Age of deciders	20-29: (0); 30-49: (1); 50-59: (2); more than 60 years: (3)
EDLEV	Educational level of household heads (both deciders)	Illiterate: (0); 1-12 years of schooling: (1); 13-20 yrs:(2); >20 yrs: (3)
ORGAN	Level of participation in village organizations (both deciders)	None: (0) Members of 1 organization: (1) Members of 2 or more organizations: (2) Leader of organization: (3) Village Council member: (4)
LNDOWN	Land ownership	Tenant or share-cropper: (0) Owner: (1)

LNDAREA	Land area owned	<1 ha: (0) 1-2,5 ha: (1) 2,6-4 ha: (2) >4 ha: (3)
WLTH	Wealth status of the farmer	Very poor (vp) Poor (p) Wealthy (w)
HSTYPE	Type of house	Bamboo, wooden, nipa roof: (0) Wooden, metal rood: (1) Hollow blocks, cement, metal roof: (2)
ASSTS	Farm assets	Basic tools (bolo, sprayer): (0) Plough and/or kart: (1) Vehicle (motorbike): (2) Vehicle (jeep, truck): (3)
INCOMLEV	Income level of farmer according to interviewer	Low Medium High
OFFINCOM	Off-farm income	None: (0) 1 member: (1) 2 or more members: (2) Business, permanent job: (3)
DISTHOMALLWR	Distance from homestead to nearest all-wheater road	0-100 m: (0) 100-500 m: (1) 500 m-1000m: (2) 1000-2000m: (3) More than 2000 m: (4)
FARMLAB	Farm family labour	Have no man-labour shortage: (1) Have little man-labour shortage: (2) Have much man-labour shortage: (3)
TOTHMEM	Total household members	Number
HIRMANLAB	Hiring labour for farm activities	Never: (0) Sometimes (once/yr): (1) Always (twice/yr): (2)
ANLAB	Availability of draft animal power: define according to variables below	Have no animal power shortage Have little animal power shortage Have much animal power shortage Do not have animal power

ANOWN	Number of draft animals owned	None =0 1 draft-animal: (1) 2 draft-animal: (2) More than 2 draf-animals: (3)
RENTANIM	Hires draft-animals for land preparation	Always hires 2 or more man-animals per cropping: (1) Hires 1 man-animal per cropping: (2) Never hires man-animal: (3)
WAGLAB	Involvement of decider in farm wage labour	Always (permanent): (0) Often (every cropping): (1) Sometimes (one cropping): (2) Seldom (every other year): (3) Never: (4)
AVCASH	Availability of cash to the farmer: how often the farmer avail cash?	Never: n Seldom: s Often: o Always: a
HSOURFIN	Household source of finance	None (own savings): (0) Informal credit (utang): (1) Formal credit from institution: (2) Remittances: (3)
Farm variables		
NPOWN	Number of parcels owned	Number
PARCSIZ	Size of each farm parcel	Number
TOTAREMAN	Total area managed (ha)	Number
LANDRENT	Number of ha rented out	Number
LANDTEN	Number of ha under tenancy or sharecropping	Number
TYPEOWPX	How land has been acquired	Purchased Inheritance Common (land not yet divided among family members: co CARP (Agrarian reform) ISF (Stewardship contract)
DISTPHOM	Distance from parcel to homestead	0-100 m: (0) 100-500: (1) 500-1000: (2)

		1000-2000: (3)
		>2000: (4)
DISTALLWR	Distance from parcel to all-weather road	0-100 m: (0)
		100-500: (1)
		500-1000: (2)
		1000-2000: (3)
		>2000: (4)
YRON	Number of years the farmer has been cultivating that parcel	0-5 years: (1)
		6-10: (2)
		10-20: (3)
		>20: (4)
SLOP	Slope of the parcel	< 3%: (a)
		3-18%: (b)
		18-30%: (c)
		30-50%: (d)
		> 50%: (e)
SWC	Existence of contour grass strips on parcel	Yes (y)
		No (n)

Summary of regression analysis

Household model

	df	deviance	Mean deviance	Ratio	Approx chi pr
Regression	10	31.0	3.099	3.10	<.001
Residual	101	123.0	1.218		
Total	111	154.0	1.387		

Estimates of parameters

	estimate	s.e.	t(*)	t pr.	antilog of estimate
Constant	2.32	1.46	1.59	0.112	10.13
Brgy 2	0.936	0.535	1.75	0.080	2.549
Brgy 3	- 2.95	1.20	-2.47	0.014	0.05243
Brgy 4	- 0.031	0.572	-0.05	0.957	0.9697
Lndarea 2	- 3.22	1.51	-2.13	0.034	0.03995
Lndarea 3	- 2.52	1.63	-1.54	0.123	0.08077
Lndarea 4	- 2.78	1.77	-1.57	0.117	0.06233
Offincom 1	- 3.30	1.73	-1.91	0.056	0.03685
Lndarea 2 .Offincom 1	4.28	1.85	2.31	0.021	72.03
Lndarea 3 .Offincom 1	3.93	1.99	1.98	0.048	50.77
Lndarea 4 .Offincom 1	2.96	2.11	1.40	0.160	19.27

* MESSAGE: s.e.s are based on dispersion parameter with value 1

Parameters for factors are differences compared with the reference level:

Factor Reference level

Brgy 1

Lndarea 1

Offincom 0

Farm model

Summary of regression analysis

	d.f.	deviance	mean deviance	deviance ratio	approx chi pr
Regression	9	39.4	4.373	4.37	<.001
Residual	148	173.2	1.170		
Total	157	212.5	1.354		

* MESSAGE: ratios are based on dispersion parameter with value 1

Estimates of parameters

	estimate	s.e.	t(*)	t pr.	antilog of estimate
Constant	- 0.451	0.364	-1.24	0.215	0.6368
Brgy 2	1.405	0.501	2.80	0.005	4.074
Brgy 3	- 1.93	1.08	-1.79	0.074	0.1455
Brgy 4	0.633	0.530	1.20	0.232	1.883
Anlab 1	3.01	1.15	2.63	0.009	20.33
Brgy 2 .Anlab 1	-3.20	1.38	-2.31	0.021	0.04096
Brgy 3 .Anlab 1	0.00	1.77	0.00	0.999	0.9974
Brgy 4 .Anlab 1	- 3.30	1.74	-1.90	0.058	0.03699
Distallwr 1	- 0.984	0.573	-1.72	0.086	0.3737
Yron 2	- 0.873	0.385	-2.27	0.023	0.4178

* MESSAGE: s.e.s are based on dispersion parameter with value 1

Parameters for factors are differences compared with the reference level:

Factor Reference level:

Brgy 1

Anlab 0

Distallwr 0

Yron 1

Appendices Chapter 4.1

Table A 4.1.1: Chemical soil properties of the portion of the experimental plot with *Gmelina arborea* (rep 4) exhibiting poor growth of maize as compared to the portion of the same plot exhibiting normal growth.

Treatment	Depth (cm)	pH 1:1 H2O	pH 1:1 CaCl2	Avail P Bray 2 mg/kg	Exch K (meq/100g)	Avail Zn mg/kg	Avail Cu mg/kg	Exch Mg meq/100g	Active Mn %	Exch Al meq/100g
Affected part	0-15	4.9	4.5	16.00	0.249	0.96	0.84	0.105	0.091	1.210
	15-30	4.4	4.5	1.90	0.280	1.10	2.00	0.235	0.071	2.140
Control	0-15	5.7	5.2	15.00	0.125	0.89	0.23	0.285	0.113	nil
	15-30	5.0	4.5	2.10	0.158	1.80	1.20	0.255	0.130	0.975

Table A 4.1.2: Maize grain yield (gr lm^{-1}) across a 10-meter alley of *Gmelina arborea*.

Year	Fitted curve	Term	Estimate	Standard error (s.e.)	Adjusted coefficient of determination ($R^2_{adj.}$)	Residual standard deviation
1	A + B/(1 + D*X) + C*X	A	-19634	238529	44.3	41.9
		B	20283.	238571		
		C	-372.	2074		
		D	-0.0153	0.0790		
2	A + (B + C*X)/(1 + D*X + E*X*X)	A	1151.	383.	94.7	26.9
		B	-1493	255.		
		C	-27.1	35.4		
		D	0.420	0.297		
		E	-0.0378	0.0269		
3	A + (B + C*X)/(1 + D*X + E*X*X)	A	-792.	813.	92.6	24.5
		B	741.	763.		
		C	90.7	93.5		
		D	-0.073	0.110		
		E	0.01620	0.00991		

Table A 4.1.3: Maize grain yield (gr lm^{-1}) across a 10-meter alley of *Eucalyptus deglupta.*

Year	Fitted curve	Term	Estimate	Standard error (s.e.)	Adjusted coefficient of determination ($R^2_{adj.}$)	Residual standard deviation
1	A + B/(1 + D*X) + C*X	A	665.9	20.5	51.2	37.2
		B	27.6	26.0		
		C	-19.92	9.08		
		D	-0.09573	0.00670		
2	A + (B + C*X)/(1 + D*X + E*X*X)	A	948	113	94.6	31.6
		B	-1677	461		
		C	36.7	21.9		
		D	1.240	0.900		
		E	-0.1227	0.0862		
3	A + B/(1 + D*X) + C*X	A	2614	1008	91.2	24.5
		B	-2602	952		
		C	-139.8	39.0		
		D	0.1685	0.0777		

Non-linear regression analysis

1. Maize grain yield (% of control) – *Gmelina arborea* stand basal area (excluding border trees)

Response variate: Intercrop Yield (% of control)

Explanatory: Basal area (m^2 ha^{-1})

Fitted Curve: A + B / (1 + D*X)

Summary of analysis:

	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	2	11082.	5541.0	35.71	<.001
Residual	25	3879.	155.2		
Total	27	14961.	554.1		

Percentage variance accounted for 72.0

Standard error of observations is estimated to be 12.5

The following units have large standardized residuals:

Unit	Response	Residual
3	65.9	-2.73

MESSAGE: The curve has a vertical asymptote at X = -3.204

Estimates of parameters

	Estimate	s.e.
D	0.312	0.196
B	84.2	10.2
A	23.4	12.1

2. Maize grain yield (% of control) – *Eucalyptus deglupta* stand basal area (excluding border trees)

Response variate: Intercrop Yield (% of control)

Explanatory: Basal area (m^2 ha^{-1})

Fitted Curve: A + B/(1 + D*X)

Summary of analysis

	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	2	4988.	2493.8	18.68	<.001
Residual	25	3338.	133.5		
Total	27	8325.	308.3		

Percentage variance accounted for 56.7

Standard error of observations is estimated to be 11.6

The following units have large standardized residuals:

Unit	Response	Residual
24	92.0	2.44

The curve has a vertical asymptote at X = -3.917

Estimates of parameters

	Estimate	s.e.
D	0.255	0.284
B	63.7	16.1
A	44.2	22.2

Appendices Chapter 4.2

Table A 4.2.1: Cost-benefit analysis of maize monocropping and *Gmelina arborea*-maize systems ($US per ha).

	Maize monocropping	Agroforestry with Gmelina arborea															
		Trees on hedgerow-fallow (1 x 10 m)								Trees on blocks-fallow (2.5 x 2.5 m)							
	Yr 1-9	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7-9	Total	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7-9	Total
COSTS																	
Maize seed	607.5	67.5	33.8	0.0	0.0	0.0	0.0	0.0		54.0	27.0	0.0	0.0	0.0	0.0	0.0	
Fertilizer	2148.6	238.7	119.4	0.0	0.0	0.0	0.0	0.0		191.0	95.5	0.0	0.0	0.0	0.0	0.0	
Tree seedlings	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0		60.0	0.0	0.0	0.0	0.0	0.0	0.0	
Total cash costs	2756.1	336.2	153.1	0.0	0.0	0.0	0.0	0.0	489.4	305.0	122.5	0.0	0.0	0.0	0.0	0.0	427.5
LABOUR																	
Layout hedgerows	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0		11.2	0.0	0.0	0.0	0.0	0.0	0.0	
Maize cultivation wet season																	
Land preparation	600.4	66.7	66.7	0.0	0.0	0.0	0.0	0.0		53.4	53.4	0.0	0.0	0.0	0.0	0.0	0.0
Maize sowing & fertilizing	71.5	7.9	7.9	0.0	0.0	0.0	0.0	0.0		6.4	6.4	0.0	0.0	0.0	0.0	0.0	0.0
Replanting	28.6	3.2	3.2	0.0	0.0	0.0	0.0	0.0		2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Urea application	85.8	9.5	9.5	0.0	0.0	0.0	0.0	0.0		7.6	7.6	0.0	0.0	0.0	0.0	0.0	0.0
Inter-row weeding	85.8	9.5	9.5	0.0	0.0	0.0	0.0	0.0		7.6	7.6	0.0	0.0	0.0	0.0	0.0	0.0
Hand weeding	228.7	25.4	25.4	0.0	0.0	0.0	0.0	0.0		20.3	20.3	0.0	0.0	0.0	0.0	0.0	0.0

NVS grass slashing	135.0	15.0	15.0	0.0	0.0	0.0	0.0	0.0	42.0	42.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize harvesting	157.2	17.5	17.5	0.0	0.0	0.0	0.0	0.0	14.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-harvest processing	271.6	30.2	30.2	0.0	0.0	0.0	0.0	0.0	24.1	24.1	0.0	0.0	0.0	0.0	0.0	0.0
Maize cultivation dry season																
Land preparation	343.1	38.1	0.0	0.0	0.0	0.0	0.0	0.0	30.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize sowing & fertilizing	71.5	7.9	0.0	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Replanting	28.6	3.2	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urea application	85.8	9.5	0.0	0.0	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Inter-row weeding	85.8	9.5	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hand weeding	171.5	19.1	0.0	0.0	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NVS grass slashing	135.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maize harvesting	157.2	17.5	0.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Post-harvest processing	171.5	19.1	0.0	0.0	0.0	0.0	0.0	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tree establishment																
Hole digging	0.0	25.7	0.0	0.0	0.0	0.0	0.0	0.0	51.4	0.0	0.0	0.0	0.0	0.0	0.0	
Planting and replanting	0.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	0.0	0.0	0.0	0.0	0.0	0.0	
Weeding (cultivation)	0.0	18.8	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	
Tree management																
Weeding (slashing)	0.0	0.0	7.5	22.5	0.0	0.0	0.0	0.0	0.0	21.0	63.0	0.0	0.0	0.0	0.0	
Form pruning and singling	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	
First lift pruning	0.0	0.0	9.4	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.0	0.0	0.0	0.0	
Second lift pruning	0.0	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0	

Third lift pruning	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	
First thinning	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0		0.0	0.0	1.6	0.0	0.0	0.0	0.0	
Second thinning	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0		0.0	0.0	0.0	0.0	7.0	0.0	0.0	
Third thinning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	7.0	
Total labour costs	2918.4	391.9	201.8	31.1	0.0	5.9	7.8	0.0	638.4	453.8	217.7	64.6	0.0	7.0	7.8	7.0	757.9
Total costs	5674.5	728.1	354.9	31.1	0.0	5.9	7.8	0.0	1127.8	758.7	340.2	64.6	0.0	7.0	7.8	7.0	1185.4
Labour work days	1574	220	109	21	0	1	5	0	356	273	125	43	0	1	5	1	447
BENEFITS																	
Maize	8671.4	942.4	541.8	0.0	0.0	0.0	0.0	0.0		983.9	558.8	0.0	0.0	0.0	0.0	0.0	
Timber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2921.2		0.0	0.0	0.0	0.0	0.0	0.0	2571.8	
Total benefits	8671.4	942.4	541.8	0.0	0.0	0.0	0.0	2921.2	4405.5	983.9	558.8	0.0	0.0	0.0	0.0	2571.8	4114.5
Net benefit to labour	5915.2								3916.1								3687.0
Net return to labour day^{-1}	3.8								11.0								8.2
Net benefits	2996.8								3277.7								2929.1
Net Present Value NPV (15%)	1596.2								1131.3								1040.2
Discounted days	835.4								290.2								362.7
Discounted net benefit to labour	3144.8								1651.4								1651.3
Discounted net benefit/discounted days	3.8								5.7								4.6
Maize grain yield (t/ha/9 yrs)	70.2	7.7	4.8						12.5	7.9	5.0						12.9
Timber yield (cu.m/ha/9 yrs)	0.0								69.1								60.8

Prices are from local markets for the 1998 cropping season. Exchange rate: US$ 1.00=35 Philippine Peso (PhP), 1998. (In December 1998, 39 PhP per US$)

Appendices

Cash costs

Maize seed rate: 60,000 plants/ha. Maize seed cost: 75 PhP/kg

Tree seedlings cost: Gmelina arborea = 1PhP/seedling; Eucalyptus deglupta = 3 PhP/seedlings (prices at nurseries in Cagayan de Oro City). It is assumed a mortality rate of 20%.

Fertilizer: recommended rate is 80-30-30 kg of N-P-K per ha. Nitrogen (Urea 46-0-0, 46%N) at 7PhP/kg; Phosphorus (Solophos 0-18-0) at 6 PhP/kg; Potassium (Muriate of Potash 0-0-60) at 7PhP/kg

Insecticide-nematicide Furadan applied at sowing at a rate of 16 kg/ha. Furadan purchased at 70PhP/kg

Labour: labour data for maize cultivation obtained from (Nelson, 1996).

Labour data for tree establishment and management are from (Agpaoa et.al., 1976; Pancel, 1993; DENR-ERDB, 1998) and farm surveys.

Labour cost: at the local farm labour wage rate in 1998. Labour cost 60 PhP per man-day and 120 PhP man-animal-day. A work-day is assumed to involve 8 hours of work.

NVS grass slashing and tree weeding: 1 tree ring-weeding and cultivation at planting. Two grass slashing of NVS during each cropping season. 4 grass slashing around trees are assumed from the last cropping season until the end of the third year.

Benefits

Maize price: at an average of 4.5 PhP/kg for the wet season crop and 5.7 PhP/kg for the dry season crop

Timber price: at prevalent 4 PhP/bd.ft

Appendices Chapter 5

1   List of major questions used in the interview surveys among mini-sawmills and wood processors in Villanueva, Tagoloan and Cagayan de Oro, Misamis Oriental (March, 2000)

1. General information

    *   Location sawmill (Municipality, Barangay)

    *   Date of establishment of the sawmill

2. Questions related to actual supply:

    *   Species processed in this sawmill and relative importance

    *   Origin (province, municipality) and suppliers (smallholders, large plantations, farmer cooperatives, middlemen, others)

    *   Log procurement (on stumpage; cut)

    *   Is supply seasonal? If Y, please indicate season for low/high supply and reasons

    *   Is it difficult to find log suppliers? If Yes, why?:

    *   Potential supply

    *   Have stocks increased/decreased/remained the same during the last 5-10 years?

    *   In the near future, what do you think the status of farm timber stocks will be?

3. Sawmill status

    *   # of cubic meter or board feet produced per day/annum?

    *   Estimation of the average percentage of recovery (by specie)

    *   Fixed assets: number of bandsaws, circular saws; chainsaws; kiln drier; other equipment

    *   Number of permanent and temporary employees and wages

4. Price trends

- Prices of logs and sawn timber 5 years ago (by specie)

- Prices of logs and sawn timber today? (by specie)

- Can you give me an estimation of current prices and the prices 5 and 10 years ago:

- Are there seasonal price fluctuations? If Yes, indicate the season with higher/lower prices and reasons

5. Market characteristics and consumer behaviour

- Main uses of the timber you are selling (furniture, packaging, construction, etc)

- Log requirements: minimum diameter (top and dbh) and length

- Size of sawn timber required by consumers

- Is there a premium paid for quality? If Y, explain grading system for logs/sawn timber

- What is the price difference for each grade? And the use?

- Who are the buyers of farm-grown timber? (the industry, individuals, wood processors, etc)

6. Demand

- Is there a season for higher/lower demand? If Yes, indicate the season and reasons for high/low demand

- Does a market information system exists (e.g., to inform about the market demand, requirements, etc)? Y/N.

- Is demand of farm-grown timber increasing or decreasing? If increasing/decreasing, why?

7. Marketing policy

- What are the main government policies that regulate the timber industry? (cutting, transportation, processing permits, others)

- In your opinion, what are the most important factors affecting timber prices?

- What are the main constraints and problems you face in the timber industry?