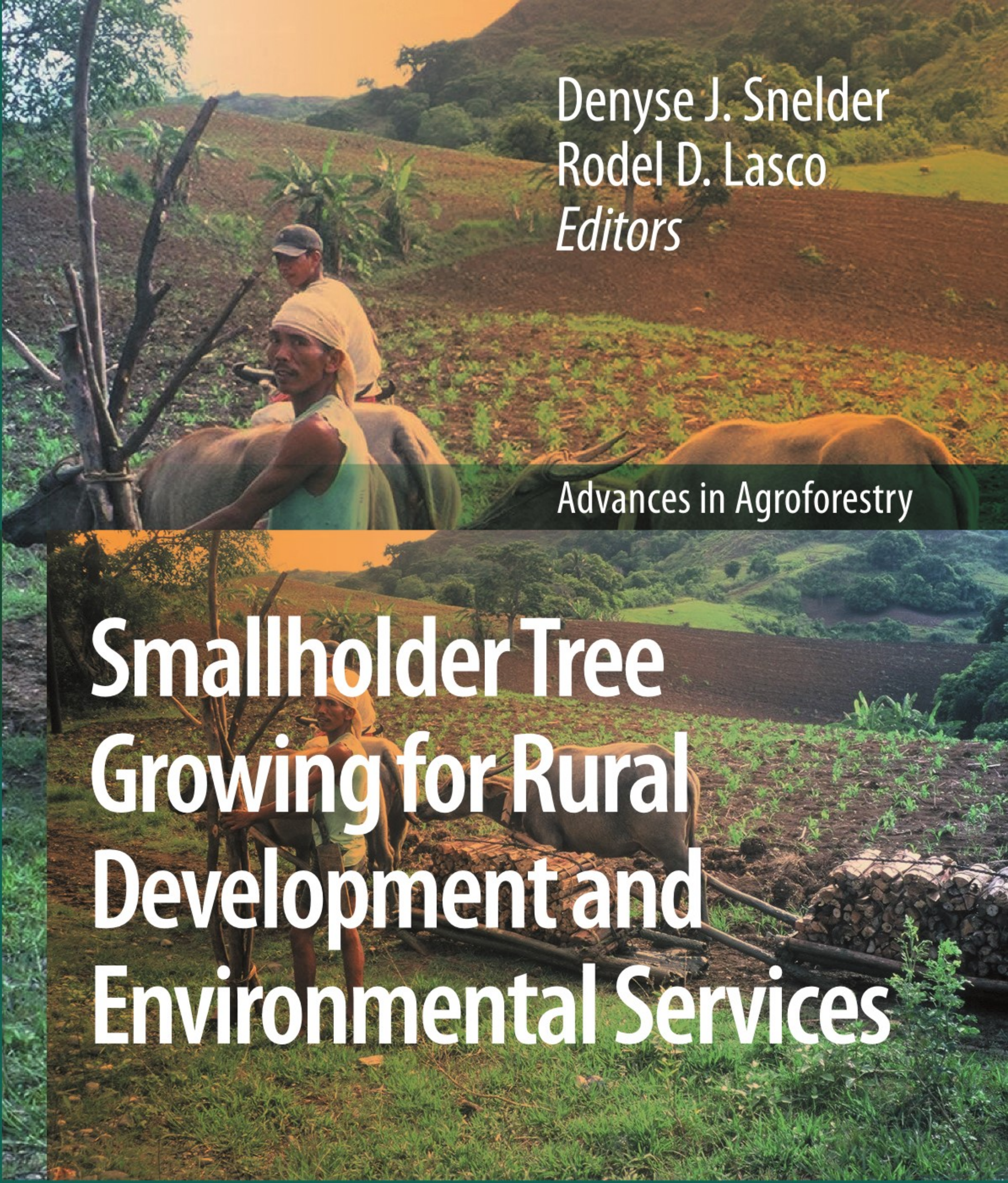

Denyse J. Snelder
Rodel D. Lasco
Editors

Advances in Agroforestry

Smallholder Tree Growing for Rural Development and Environmental Services

Lessons from Asia

Springer

Smallholder Tree Growing for Rural Development and Environmental Services

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Advances in Agroforestry

Volume 5

Series Editor:

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Aims and Scope

Agroforestry, the purposeful growing of trees and crops in interacting combinations, began to attain prominence in the late 1970s, when the international scientific community embraced its potentials in the tropics and recognized it as a practice in search of science. During the 1990s, the relevance of agroforestry for solving problems related to deterioration of family farms, increased soil erosion, surface and ground water pollution, and decreased biodiversity was recognized in the industrialized nations too. Thus, agroforestry is now receiving increasing attention as a sustainable land-management option the world over because of its ecological, economic, and social attributes. Consequently, the knowledge-base of agroforestry is being expanded at a rapid rate as illustrated by the increasing number and quality of scientific publications of various forms on different aspects of agroforestry.

Making full and efficient use of this upsurge in scientific agroforestry is both a challenge and an opportunity to the agroforestry scientific community. In order to help prepare themselves better for facing the challenge and seizing the opportunity, agoroforestry scientists need access to synthesized information on multi-dimensional aspects of scientific agroforesty.

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Foreword

Tree planting has always been considered a noble and respectable activity. In most places around the world, many ceremonious occasions are marked by planting trees to commemorate the event. There is hardly anyone who is famous – from royalty to politicians and movie stars to business tycoons – who has not planted a tree! But, for millennia, ordinary people have been planting trees as part of their routine chores without any external prodding and prompting and, of course, without the accompaniment of the paparazzi and publicity frenzy of the "dignitary tree-planting." Government-sponsored tree planting efforts such as large-scale reforestation and afforestation programs have been the main activity of modern forestry in many parts of the developing world during the past few decades. However, it is not unlikely that the trees planted successfully by ordinary peasant farmers in their (often small) landholdings in the tropics have far outnumbered those planted under such government-sponsored programs. Yet, tree-growing by small holder farmers has received relatively little attention from the scientific and development communities, and is often not even recognized by forestry departments. Any effort in recognizing and encouraging such smallholder tree planting is commendable; for that reason, the publication of this book is very timely and significant.

It is quite appropriate that the book draws from the experience in Asia. Asia is the cradle of agroforestry. The Asian experience of traditional agroforestry systems from shifting cultivation and taungya to homegardens and multistrata systems has paved the way for most of the recent agroforestry innovations and improvements. This book is no exception to this general trend. Presenting a series of case-study papers on tree growing in forest-deprived areas of the Philippines, the book compares the Philippines experience with similar experience in other Asian countries. This comparative analysis then leads to the conclusion that tree growing by smallholder farmers has the potential to play a significant role in sustainable land management. Coming as it does at a time when much of the existing literature about smallholder tree planting is somewhat dated, the new experiences, analyses, and discussions presented in the book are relevant and timely to most other developing countries.

Considering the enormous amount of patient work and persistent efforts needed in bringing out such a multi-authored volume, the editors of the book deserve highest appreciation. I congratulate the editors and all chapter authors on their splendid accomplishment in providing such a valuable contribution to agroforestry literature.

January 2008
Gainesville, Florida, USA

P. K. Ramachandran Nair
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List of Acronyms

ADB	Asian Development Bank
AECI	Spanish Agency for International Cooperation
ANB	Annualized Net Benefits
ANR	Assisted Natural Regeneration
ASB	Alternative to Slash and Burn, programme of the consultative group for international research in agriculture
ATFS	The American Tree Farm System
ATSAL	Agroforestry Tree Seed Association of Lantapan
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BITO	Bakun Indigenous Tribes Organization
BMW	Black Magic Wood
BRASS	Bioeconomic Rubber Agroforestry Support System
CARES	Center for Agricultural Research and Ecological Studies
CARE Thailand	Collaborative Natural Resource Management, Thailand
CBD	Convention on Biological Diversity
CBFM	Community-based Forest Management
CBFMA	Community Based Forest Management Agreement
CBFMP	Community-Based Forest Management Program
CDM	Clean Development Mechanism of the Kyoto Protocol
CENRO	Community Environment and Natural Resources Office of the DENR
CEPT Agreement	ASEAN Common Effective Preferential Tariff Agreement
CHED Program	Program of the Commission on Higher Education
CI	Conservation International
CIFOR	Centre for International Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLT	Certificate of Land Transfer
CML	The Institute of Environmental Sciences-Leiden University
COE	Center of Excellence of Isabela State University-College of Forestry and Environmental Management under the CHED Program
COP	Conference of the Parties

CPPAP	The Conservation of Priority Protected Areas Project
CSA	The Canadian Standard Association
CSC	Certificate of Stewardship Contract
CVPED	Cagayan Valley Programme on Environment and Development
DA	The Department of Agriculture
DAR	Department of Agrarian Reform
DBH	The Diameter at Breast Height
DBP	Development Bank Philippines
DCF	Discounted Cash Flow
DENR	The Department of Environment and Natural Resources, the Philippines
DENR-ERDB	Department of Environment and Natural Resources-Ecosystems Research and Development Bureau
DENR-PAWB	Department of Environment and Natural Resources-Protected Area and Wildlife Bureau
DGIS	The Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs in the Netherlands
EAR	Energy Accumulation Ratio
ECE	Energy Conversion Efficiency
EEPSEA	Economy and Environment Program for Southeast Asia
EFE	Energy Fixation Efficiency
EMS	Environmental Management Systems
ERDB	Ecosystems Research and Development Bureau
ERPA	Emission Reduction Purchase Agreement
ES	Environmental Services
ESCAP	Economic and Social Commission for Asia and the Pacific
EU	European Union
EUREP-GAP	Euro-Retailer Produce working group for Good Agricultural Practices (www.eurep.org)
FAO	Food and Agriculture Organization
FGD	Focal Group Discussions
FMB	Forest Management Bureau, the Philippines
FORRU	Forest Restoration Research Unit, Thailand
FPDP	The Lao Forest Plantation Development Project
FSC	Forest Stewardship Council
FSC-SLIMF	Forest Stewardship Council-Small and Low Intensity Managed Forests
FT	Fruit Trees
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GMPCI	Gabriela MultiPurpose Cooperative Inc
GNI	Gross National Income
GOLD	Governance and Local Democracy Project, the Philippines
GSAP	Gross Service Area Product

HCFV	High Conservation Value Forest
ICEM	International Centre for Environment Management, Brisbane
ICMM	The International Council for Mining and Metals
ICRAF	World Agroforestry Center
IDR	Indonesian Rupiah
ILO	International Labor Organization
Indonesian LEI system	Lembaga Ekolabel Indonesia certification system
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ISO	International Organization for Standardization
ISU	Isabela State University
ITPP	Industrial Tree Plantation Project
ITS	Indigenous tree species
ITTO	International Tropical Timber Organization
IUCN	The World Conservation Union
JBIC	Japan Bank for International Cooperation
JOFCA	Japan Overseas Forestry Consultants Association
KEF	Kalahan Educational Foundation Inc.
KOFFCO system	Komatsu-FORDA Fog Cooling system
LA	Land Allocation
Lao-IRRI	National Rice Research Program, Lao PDR
Lao PDR	Lao People's Democratic Republic
LFPI	Landcare Foundation of the Philippines Inc.
LG	Land Grant
LGU	Local Government Unit
LLDA	Laguna Lake Development Authority
LPA	Lao Plantation Authority
LUP	Land Use Planning
MAF	Ministry of Agriculture and Forestry, Lao PDR
MAFAMCO	The Mt. Apo Farmers Cooperative
MAI	Mean Annual Increment
MANRIS	Manupali River Irrigation System
MBRLC	Mindanao Baptist Rural Life Center
MDF	Medium-Density Fibreboard
MDG	Millennium Development Goals
MMSD	The Minerals, Mining and Sustainable Development project
MPTS	Multi-Purpose Tree Species
MSC	Marine Stewardship Council
MTCC	The Malaysian Timber Certification Council
NAFES	National Agriculture and Forestry Extension Service
NAFRI	The National Agriculture and Forestry Research Institute, Lao PDR
NALCO	Nasipit Lumber Company
NAS	National Academy of Sciences

NCF	Net Carbon Flow
NGO	Non Governmental Organization
NIPAS	The National Integrated Protected Areas System
NIPF	Non-Industrial Private Forests
NORDECO	Nordic Agency for Development and Ecology
NPV	Net Present Value
NSC	National Statistic Centre Committee for Planning and Investment, Lao PDR
NSMNP	The Northern Sierra Madre Natural Park
NSO	National Statistics Office, the Philippines
NTFP	Non-Timber Forest Product
NVS	Natural Vegetative Strips
OM	Organic Matter
PAFO	Provincial Agriculture and Forestry Office, Lao PDR
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAWB	Protected Area and Wildlife Bureau
PCARRD	Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development
PCR	Project Completion Report
PCU	Project Coordination Unit
PEFC	The Programme for Endorsement of Forest Certification
PES	Payments for Environmental Services
PhP	The Philippine Peso
PICOP	Paper Industries Corporation of the Philippines
PLAN (International)	Child focused non-governmental international development agency (www.plan-international.org)
PO	People's Organization
PPTA	Preparatory Project Technical Assistance
PTFI	The Provident Tree Farm Inc.
ReV Chain	Reforestation Value Chain
RFD	The Royal Forest Department Thailand
RMAs	Rapid Market Appraisals
RMI	The Indonesia Institute for Forest and Environment
RUP	Resource Use Permit
RUPES	Rewarding Upland People for Environmental Services
SAFODS	Smallholder Agroforestry on Degraded Soils
SAMAKA Program	Samahan ng Masaganang Kakanin (a united effort to produce ample food for the family)
SCUAF	Soil Changes Under Agroforestry
SFE	Small Forest Enterprises
SFM	Sustainable Forest Management
SLIMF	Small and Low Intensity Managed Forests
SPAs	Seed Production Areas
SPLTP	Special Private Land Timber Permit

SSS	Small-Scale Sawmills
TAO	Tambon Administration Organization
TLA	Timber License Agreement
TRP	The Rainforest Project
TSI	Timber Stand Improvement
TT	Timber trees
UMN	University of Minnesota in the United States
UNDP	United Nations Development Programme
UNDP SGP PTF	The UNDP Small Grants Programme for Operations to Promote Tropical Forest
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UPLB	The University of the Philippines Los Baños
WaNuLCAS model	Water, Nutrient and Light Capture in Agroforestry Systems
WB	World Bank
WCSP	Wildlife Conservation Society of the Philippines
WOTRO	The Netherlands Foundation for the Advancement of Tropical Research
WWF	World Wildlife Fund for Nature

Part I
Smallholder Tree Growing: Introduction

Chapter 1
Smallholder Tree Growing in South and Southeast Asia

D.J. Snelder[1]* and R.D. Lasco[2]

Abstract This chapter sketches the context of this book. It addresses the questions why we focus on smallholder tree growing and why we discuss the Philippines as main case study country. Relevant background information related to the aforementioned questions is given, including a historical sketch on smallholder forest management and the development of concepts on smallholder tree growing in South and Southeast Asia, a review of farmers' motivations and other controlling factors affecting tree growing activities, and a discussion on the need for sustainable land use and, related to this, recognition of farmers' potential to produce wood and provide other forest benefits and ecological services. The chapter ends with an overview of the different sections under which the various chapters in this book have been arranged.

Keywords small-scale reforestation, tree plantation, tree management, forestry concepts

1.1 Introduction

The protection, planting, exploitation and management of forest and tree resources are activities that have a long history in most Asian cultures. Tree growing is part of traditional land use in both tropical dry and wet zones. In recent years, the role of smallholder communities in the management and protection of remaining forests is regaining importance in government policies and programs in Asia and elsewhere.

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D.J. Snelder and R.D. Lasco (eds.), *Smallholder Tree Growing for Rural Development and Environmental Services.*

This tendency is associated with the moral argument that conservation goals should contribute to, and not conflict with, basic human needs and, for that reason, local communities should be more involved in designing and implementing forest conservation policies. The use of such argument is, however, not new but has been emphasized in development issues for the last three decades, especially in the 1980s – by some even called the decade of participation (Chambers 1983; Ingham 1993), when the concept of sustainable development made a great shift towards ‘people centered’ development, community involvement, cooperative management, power sharing, decentralization and devolution, and empowerment. The role of smallholder communities is likewise increasingly recognized in the reforestation of agricultural lands in the form of growing trees on farms and also near settlements and built-up areas, i.e., the so-called “trees outside forests”. The latter are a crucial resource in terms of meeting future needs, both public and private, for timber, woodfuel, other forest products and a variety of environmental services, particularly in developing countries (FAO 1985, 2006a). There is evidence of spontaneous forest product diversification through implementation of tree systems on farms by smallholders who lack easy access to nearby forest resources (e.g., in Cebu, Philippines; FAO 1993; in western Kenya, Scherr 1995). The trees relieve the pressure on remaining forest resources and restore and safe-guard ecological and socio-economic sustainability in agricultural landscapes. Moreover, smallholder tree growing is perceived as a potential strategy for poverty alleviation in various, often agroforestry and community forestry, programs world-wide (e.g., Cacho et al. 2003; ICRAF 2003; Sales et al. 2005; FAO 2005, 2006a). The extent to which tree growing can alleviate poverty and increase food security is however not well documented or clear to policy makers (FAO 2006a).

Yet, research on smallholder tree growing falls behind when compared to research into large-scale forestry and agricultural (tree) crop plantations. Not enough is known about the dynamics of trees on farmlands and their corresponding contribution to the production of wood and other products and services (FAO 2006a). In order to understand current and potential contributions of tree growing to rural development and forest services, extensive research and good statistical data are required. The latter are, however, absent from most official statistics (FAO 2006b). Likewise, data on the actual amount of land occupied by smallholder tree growing systems are still lacking partly because of the multitude of systems that do exist. Generally, no distinction is made for this category of land use by statistics agencies or in case there are distinctions, they are not uniformly perceived (Jensen 1995). Smallholder tree growing systems may be included in several of the categories usually applied in land use statistics such as: forest land, wood land, degraded land, agricultural lands, urban areas (homegardens) and “other land use” (e.g. road side plantings). In addition, the statistics should generally be treated with some caution although processes of data gathering and analysis have been improved since the use of satellite imagery.

In this introductory chapter, we will first give a historical perspective on tree growing, community participation and associated policies in Asia and elsewhere in the world, then sketch the context in which smallholder tree growing receives an ever-increasing role in reforestation efforts, which in turn leads us to giving additional explanations for our focus on smallholder tree growing. We will then discuss smallholders' motivations and controlling factors for growing trees on their farms and land elsewhere. We proceed with a review of the rise and development of various concepts related to smallholder tree growing for those Asian countries that will be discussed in the separate chapters of this book. The chapter will be closed off with an overview of the remaining chapters in this book.

1.2 A Historical Sketch

Records on the oldest practices of tree growing mostly refer to the growing of trees near dwellings in order to provide products for subsistence and home consumption, i.e., the so-called homegardens. Soemarwoto (1987) suggests, based on Brownrigg's literature review of 1985, the earliest evidence of homegarden cultivation in the Near Eastern region dates back to 3000 B.C. and possibly 7000 B.C. Yet, in a recent publication Wiersum (2006) relates the origin of homegardening to 13,000 to 9,000 B.C., a period during which fishing communities were living in moist tropical regions.

Early evidences of use and management of forest resources in China also date back to a distant past. For example, oracle-bone inscriptions with graphs of agricultural words from the Shāng dynasty (ca. 1600–ca. 1046 B.C.) suggest trees in Shāng agriculture played a role comparable to that of trees in agroforestry systems today (Menzies 1996). Early scripts written during the Zhāu dynasty (1122–256 B.C.) refer to systems of forest manipulation and tree cultivation directed at the maintenance of forest productivity through, amongst others, carefully scheduled timber harvesting activities (Menzies 1996). At this time, and also later during the Han dynasty (206 B.C.–A.D. 220; Needham 1986), forest-related activities were predominantly controlled by the nobles, i.e., the farmland-owning classes. Much later in the early 20th century, when the first western scientists started to work in the severely degraded forest areas of northern China, Lowdermilk (1926 in Menzies 1996) discovered indigenous systems of silviculture in protected temple forests, in forests owned collectively by villages and temple associations and in densely populated suburban areas.

In the western world it was only in the Middle Ages that forestry practices were formally developed under the rule of the nobility, i.e., the highest social class, and implemented by farmers and laborers of lower social classes in the, at the time, prevailing feudal system (Shepherd et al. 1998). The more systematic forestry practices for timber purposes are believed to have begun in the 16th century in the German states (James 1996). In the eastern world, plantation forestry started in Japan during the Tokugawa period in the 17th century as a response to the increasing demand for wood and the deterioration of forest resources. It was initially mainly aimed at water conservation and erosion control, for example in the northern part of the main island Honshu (Totman 1985), and in the 18th century increasingly directed at timber production, practiced on both land of feudal lords and common lands managed by farmers (Iwamoto 2002). In Europe, the increasing importance of timber in the 18th century led to the founding of forest science as a specialist discipline in Germany from where it spread to other European countries and their colonies in the 19th century (Shepherd et al. 1998; see also Appendix).

With the technological development in the 20th century, large-scale logging enterprises and monoculture, even-aged forest plantations emerged in rural areas worldwide (Shepherd et al. 1998). Moreover, after the disintegration of most colonial empires around the first half of the 20th century, the Food and Agriculture Organization (FAO) helped forestry departments of former colonies to transform earlier weakly centrally-controlled forests into important timber-producing areas and so-called "political forests", i.e., forests put under state forestry services and affected by both ecological and political processes (Van der Geest and Peluso 2006). Small-scale tree growing activities were still performed by rural communities but received relatively little attention from governments and (inter)national organizations throughout the 19th and most of the 20th centuries. During the second half of the 20th century, forestry laws and binding regulations in support of sustainable land use were being developed and enacted in response to growing environmental awareness. The latter was instigated by the rapid decrease in natural forest cover and associated biodiversity resulting from the excessive rise in timber exploitation rates. Moreover, there was much concern about the ever-increasing gap between demands for fuelwood and availability of supplies in developing countries where local resource-poor farmers used more and more crop residues and animal manure as a source of fuel rather than a source of mulch and fertilizer, affecting soil productivity (Arnold and Dewees 1997; Photo 1.1).

Photo 1.1 Smallholders collecting fuelwood in the uplands in Isabela Province, the Philippines (©DJ Snelder)

The integration of trees into farming systems in the form of agroforestry has been promoted since the late 1970s as a strategy for sustainable land use particularly in support of the rural poor (King 1987, Young 1997, FAO 2005) and, at its earlier stage, as a means to narrow the so-called fuelwood gap (FAO 1997). With the introduction of rural integrated development programs in the 1980s, smallholder tree growing regained recognition because of its potential role in mobilizing rural resources for the generation of a wide range of tree products, for both subsistence and commercial purposes, including timber, wood fuel, fruit, leafy vegetable, fodder, resin, oil, and medicine. In this context smallholder tree growing is also considered in recent times as a policy option addressing the Millennium Development Goals (MDGs; see http://www.un.org/millenniumgoals/). Smallholder tree growing is further linked to environmental services and the agenda on global change. Under the nomenclature agroforestry, it has been identified as one of the thematic areas by the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) in 1996. The CBD refers to agroforestry as a form of adaptive management, being “a method of sustainable agriculture that employ management practices and technologies that promote positive and mitigate negative impacts of agriculture on biodiversity” (Decision V/5 2.3). Likewise, there is a clear link to agrobiodiversity being described as having “all components of biological diversity of relevance to food and agriculture and all components that constitute the agro-ecosystem, i.e., the variety and variability of animals, plants and micro-organism, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes” (Decision COP III/11 in 1996). More recently, the role of tree farming including agroforestry in mitigating climate change primarily through carbon sequestration has also been highlighted (IPCC, 2000, 2007).

1.3 From Deforestation to Reforestation: An Urgent Need for Sustainable Land Use

The state of forest resources in countries world-wide has reached a critical point; never before have forest ecosystems been so greatly and rapidly affected by human activities as during last decades. Large stretches of the world’s forests, that have served in the subsistence and development of humankind, have been converted to other uses particularly agriculture or are severely degraded. The global net change in forest area approximated −8.9 million hectares per year in the period 1990–2000 (FAO 2001, with corrected data in FAO 2006b; Table 1.1). Deforestation still continues at a high rate today.

Most forest losses occur in tropical countries, particularly Africa, South America and Asia. The highest rate of forest reduction in South and Southeast Asia has been recorded for Indonesia with a loss of 1.9 million hectares (or 1.7 percent reduction) per year for the period 1990–2000 followed by Myanmar and the Philippines with losses of, respectively, 0.5 million hectares (−1.3 percent) and 0.3 million hectares

Table 1.1 Forest resources distribution and changes for the period 1990–2005 in South and Southeast Asia (FAO 2006a)

Country/ area		Forest area 2005				Forest area change 1990–2005			
	Land area	Natural forest	Forest plantation	Total forest		Total forest		Forest plantations	
						1990–2000	2000–2005	1990–2000	2000–2005
	000 ha	000 ha	000 ha	000 ha	% of land area	000 ha/year	000 ha/year	000 ha/year	000 ha/year
Bangladesh	13,017	592	279	871	6.7	n.s.	−2	3.7	0.6
Bhutan	4,700	3,193	2	3,195	68.0	11	11	0	0.2
Brunei	527	278	–	278	52.8	−2	−2	–	–
Cambodia	17,652	10,388	59	10,447	59.2	−140	−219	0.5	−2.6
East Timor	1,479	755	43	798	53.7	−11	−11	1.4	0
India	297,319	64,475	3,226	67,701	22.8	362	29	85.1	84.2
Indonesia	181,157	85,096	3,399	88,495	48.8	−1,872	−1,871	79.3	79.4
Lao PDR	23,080	15,918	224	16,142	69.9	−78	−78	9.5	25.0
Malaysia	32,855	19,317	1,573	20,890	63.6	−78	−140	−29.7	−17.2
Maldives	30	1	–	1	3.0	0	0	–	–
Myanmar	65,755	31,373	849	32,222	49.0	−466	−466	30.2	30.6
Nepal	14,300	3,583	53	3,636	25.4	−92	−53	0.3	0.2
Pakistan	77,088	1,584	318	1,902	2.5	−41	−43	6.2	4.4
Philippines	29,817	6,542	620	7,162	24.0	−262	−157	−92.8	−46.4
Singapore	61	2	0	2	3.4	0	0	0	0
Sri Lanka	6,463	1,738	195	1,933	29.9	−27	−30	−2.1	−5.1
Thailand	51,089	11,421	3,099	14 520	28.4	−115	−59	43.7	4.4
Viet Nam	32,550	10,236	2,695	12,931	39.7	236	241	108.3	129.0
S & SE Asia	848,952	266,492	16,634	283,127	33.4	−2,578	−2,851	239.9	286.7
Total World	13,063,900	3,801,848	150,177	3,952,025	30.3	−8,868	−7,317	–	2,800

(−2.8 percent) per year (Table 1.1). For the period 2000–2005, the rate of forest loss remained unchanged for Indonesia and Myanmar but decreased to −0.2 million hectares (−2.1 percent) per year for the Philippines.

Efforts to counteract these losses have been directed at the establishment of large-scale forest plantations. Plantation forests have in fact increased throughout the world, at an estimated rate of 2.8 million hectares per year during the period 2000–2005, and tempered – together with natural forest expansion – the annual rate of net forest loss from 8.9 to 7.3 million hectares (Table 1.1). Yet, forest plantations have not been equally successful in the region. For example, Asia (with a net forest loss in the 1990s), experienced a net gain in forest area over the period 2000–2005, but this was mainly as a result of large-scale afforestation reported by China (FAO 2006b). Moreover, forest plantations still comprise only a small percentage, i.e., 3.8 percent (or about 150 million hectares), of the total forest area world wide (FAO 2006b). It is unclear how much of this percentage is accomplished by smallholder tree growers, if at all included in the country records on which this figure is based.

Remaining forest resources are unevenly distributed over different continents and countries world wide. In South and Southeast Asia, large-sized countries like Indonesia and India with, respectively, 88 and 68 million hectares of forest account for over half of the total forest area in the region (2005 records; Table 1.1). Yet, when looking at the distribution of percentage land surface covered by forest, Indonesia is grouped among countries with intermediate coverage (48.8 percent) whereas India has to be categorized under countries with relatively low coverage (22.8 percent). Lao Peoples' Democratic Republic and Malaysia have well over 50 percent of their land area under forest. Pakistan and Bangladesh hold only small patches of forests covering respectively 2.5 and 6.7 percent of the country's total land area. Vietnam, Thailand, Nepal, and the Philippines take an intermediate to low position with, respectively, 39.7, 28.4, 25.4 and 24.0 percent of forest coverage.

In addition to declining forest areas, suitable areas for the production of food for present and future generations are dwindling as well. Mainly marginal lands remain, the fertile lands traditionally being utilized for various forms of crop cultivation. Consequently, agricultural intensification is currently being practiced in many parts of the world in order to increase crop production and provide food security. However, agricultural intensification has not automatically led to sustainable forms of land use; on the contrary, it has been accompanied by serious forms of land degradation, particularly in the developing world where roughly one quarter of all farmland has been degraded (Garrity 2004). Farmland is affected by soil nutrient depletion and soil physical degradation due to repeated cultivation and harvesting practices without periodic application of fertilizers or manure. The much needed farm inputs, or fallowing time, for restoring the soil are lacking whereas the knowledge on alternative, cost-effective methods of sustainable land use is limited.

The urgency to stop, or at least control, the destruction of remaining forests and the degradation of agricultural land and look into a wide spectrum of solution-oriented measures of sustainable land use has nowadays been recognized as crucial to our survival. This recognition has triggered projects and programs on forest conservation, reforestation, and agroforestry worldwide aimed at the integration of trees in denuded and predominantly agricultural landscapes and funded by institutions like the World Bank, the Asian Development Bank, the European Commission (EU), and FAO.

1.4 Why Focus on Smallholders?

Since the 1980s, there have been clear signs of a paradigm shift in the forestry sector throughout Asia and elsewhere in the world: whereas large-scale timber-oriented industrial estates and reforestation projects dominated past forestry approaches, there is a trend towards small-scale and multiple use systems of tree growing and community forestry (see also Harrison et al. 2002). Environmental concerns and various processes of rural development have facilitated this shift in the forestry sector as will be outlined below.

Firstly, the rate of success among large-scale reforestation projects has been less than expected as discussed earlier. In addition, environmental degradation and social problems associated with large-scale reforestation projects have raised much debate (Sawyer 1993; Carrere and Lohman 1996; Cannell 1999). For example, native longhouse communities in Sarawak resisted the establishment of a 200,000 ha *Acacia mangium* plantation in a former concession area partly claimed by about 20,000 mainly Iban people under Native Customary Rights (Barney 2004). The plantation, to be managed in intensive seven-year rotations, was initiated in 1996 as a joint venture between the Sarawak state government and the Singapore-based Asia Pulp and Paper. Key to the social conflict was the displacement of longhouses and the unconditional resettlement packages, raising also protest among various Sarawakian non-governmental organizations (NGOs). However, an exclusive emphasis on resistance to forest plantations, as practiced by some NGO networks, may undermine the fact that there is also widespread smallholder participation in plantation production; a tendency that is likely to increase in the future (Barney 2004). In addition, in-depth analysis of some of the previously adverse environmental assessments of tree plantations with species such as *Eucalyptus* proved to be unfounded (e.g., Sayer et al. 2004).

In addition to forestry plantations, smallholders have increasingly been involved in on-farm tree growing through the establishment of agroforestry systems. However from the start of its promotion in the 1970s, smallholder tree growing has received considerably less attention from the (less) developed and scientific worlds, when compared to large-scale tree planting and reforestation. More recently, with the expansion of small-scale cultivation in many regions of the world, the awareness is mounting that lands controlled by smallholders are of increasing importance in both sustainable food production and safeguarding environmental services, such as biodiversity conservation, watershed protection and carbon sequestration. They more and more determine the environmental, economical and ecological value of the landscape. Whether smallholder tree growing does indeed make a difference, and if so, to what extent it contributes to sustainable development and environmental protection and conservation, needs further investigation.

Another reason for increasing interest in smallholder tree growing is related to the expansion of areas under forest protection. The latter has lead to a ban on logging and restrictive use of natural forest products in countries like Indonesia, Thailand and the Philippines. Smallholders are therefore in search of alternative sources of tree products and ways of integrating trees into their farming systems through on-farm tree growing and forestry plantations. Moreover, it is expected that, with mounting population and land shortage, the number of farmers with smallholdings will remain high or may even increase in the near future.

Yet, the implementation of tree-based farming systems still faces controversy and need further exploration, given for example their contested role in providing profits to farmers under present conditions of increasingly competitive world markets. Whereas a small number of tree crops (e.g., coffee, cacao, tea) played a critical role in setting off economic growth during past three decades in Southeast Asia, at present there is a need to broaden the array of tree products delivered to global markets by developing countries given the current overproduction and decreased profitability of the few traditional tree crop commodities (Garrity 2004). Moreover, smallholder tree production is still inadequately quantified hampering planning and policy development.

1.5 Smallholder Tree Growing: Motivations and Controlling Factors

Smallholder tree growing is often associated with multiple objectives and usages and differ with large-scale industrial tree plantations in terms of motives for tree species selection and protection, attitudes towards risk management and tree scarcity, and approaches towards tree establishment, management, and marketing (e.g., Scherr 1995; Dewees 1995; Arnold and Dewees 1999).

The main hypothesis of this book is that smallholder farmers will grow and integrate a range of tree species in their land-use systems as a means of risk aversion, livelihood diversification and response to restricted forest resources access, and will effectively react to increases in demands for wood, fruit and other tree food and fodder products, under conditions of secure land tenure and market access.

Yet, the rate of success of tree growing will depend on farmers' ability to overcome a number of barriers farmers face when undertaking tree growing activities. These barriers may be related, for example, to the availability of high-quality planting materials, the production of quality tree products for the market, the lack of tree production technologies, and the transport of farmer-grown indigenous tree products to markets due to policies intended to control illegal logging from natural forests.

In addition, tree growing is conducted under different environmental conditions and stages of land use intensification (e.g., Raintree and Warner 1986; Arnold and Dewees 1995; Van Noordwijk et al. 1997). Hence, a distinction can be made between tree growing in forest-rich and in forest-deprived areas (Fig. 1.1). In the former case, conditions of relatively low population density and locally abundant natural forests prevail. Tree management is practiced but primarily in a rather passive way. For example selective forest species may be logged and replaced with other valuable tree species, gradually converting natural forests into agroforests, village forests or jungle tea forests, as is evident from countries such as Lao PDR and Indonesia. In forest-deprived areas, population densities are usually rather high and natural forests have been cleared through logging and 'slash and burn'. Trees are established on farms and field boundaries through intercropping and line planting, like on *Imperata*-infested grasslands in the Philippines, Indonesia, India and elsewhere. Tree planting is practiced under intensive land use pressure and likely to be a more difficult undertaking compared to tree-growing in forest-rich areas i.e., testing more often than not farmers' patience and endurance. Eventually, it may lead to farmers deciding to move out of these areas particularly after experiencing a serious decline in crop yields due to ongoing degradation. (Noordwijk, Chapter 20,

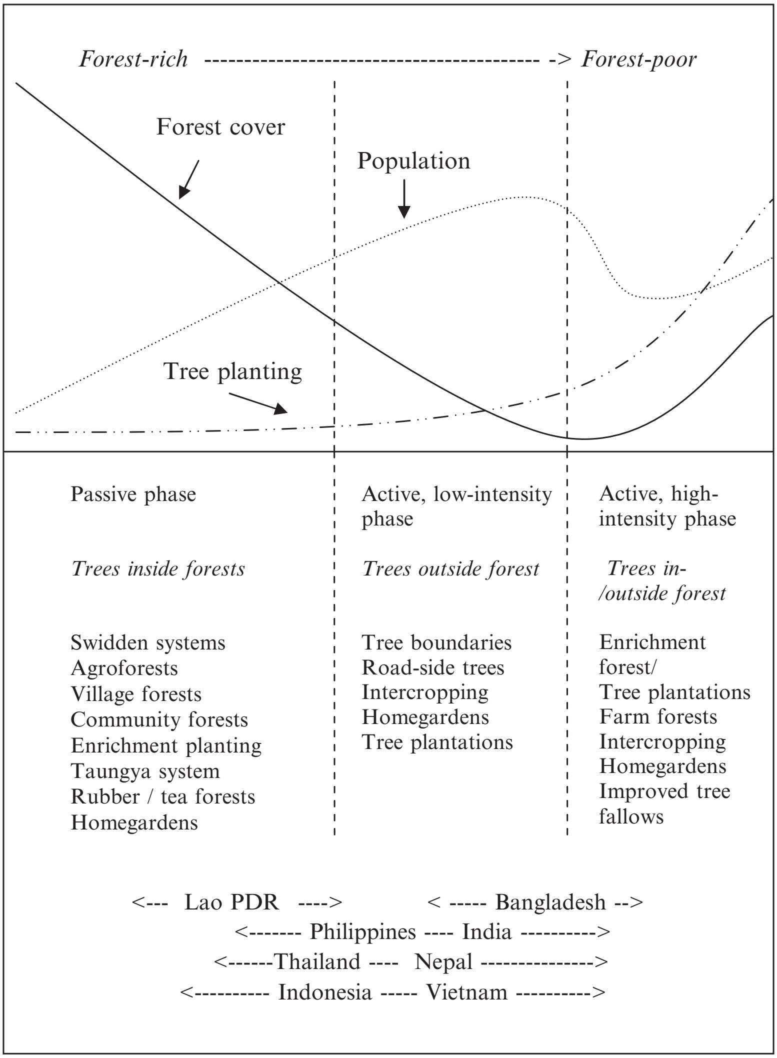

Fig. 1.1 Tree growing activities on (originally) forested land subject to changes in human population number, forest cover and corresponding phases of land use intensification in the countries discussed within the framework of this book, i.e., the Philippines, Indonesia, India, Bangladesh, Lao PDR, Nepal, Thailand, and Vietnam

this volume). The challenge in these areas is to move from an active phase of low-intensity tree growing towards a phase with trees planted at a wider, yet more intensive, scale in farms, blocks, watersheds and zones of forest regeneration, under conditions of increasing population pressure (Fig. 1.1). Farmers' decision making in growing trees on farms and grasslands highly depends on favorable conditions of land tenure security, community fire control, available technology, and marketing channels (Van Noordwijk et al. 1997).

1.6 Development of Concepts on Smallholder Tree Growing in South and Southeast Asia

There exists a variety of land use types with associated terminologies that can be classified under the nomenclature “smallholder tree growing” including small-scale forestry, community forestry, common-property forestry, social forestry, farm forestry and agroforestry. The meanings of these terms differ among countries and regions and can be, in some cases, even conflicting (Harrison et al. 2002), leading to different types of programs and systems of implementation. The first four terms generally refer to forests that are owned – or controlled – and managed by individuals or whole communities whose members share multiple benefits. The latter two terms refer to land use types composed of trees and other woody perennials grown in association with either seasonal crops or livestock, or both, in such a way that the overall system benefits from mutual economic and ecological interactions among the different components. Similarities and differences in concepts of smallholder tree growing, as maintained in various countries in South and Southeast Asia, are discussed in the Appendix. However in this book, the term smallholder tree growers refers to families who (1) have ownership, or at least control over, parcels of farm and forest land and in some cases share in the use of common property land totaling less than 1.0 ha up to a maximum of a few hundred hectares, and (2) grow trees on these lands including species that have been planted and/or those that have been protected after having established themselves spontaneously from (semi-)wild seedlings. Details on the development of concepts on smallholder tree growing for various Asian countries are given in the appendix.

1.7 The Philippines’ Case Study

Within Southeast Asia, the Philippines stand out as a country that has lost most of its original tropical forests. Today, it is classified among those countries with lowest forest coverage in the region (Table 1.2). Whereas deforestation is still on-going, mostly illegally, the rates of forest loss before 1990 were highest throughout

Table 1.2 Classification of South and Southeast Asian countries into forest cover classes, based on data recorded in 2005 (FAO 2006a)

Classes of forest cover*		
75–50	50–25	25–0
Bhutan	Indonesia	Bangladesh
Brunei	Myanmar	India
Cambodia	Nepal	Maldives
East Timor	Sri Lanka	Pakistan
Lao PDR	Thailand	Philippines
Maleisia	Vietnam	Singapore

*: in percentage of country’s land surface

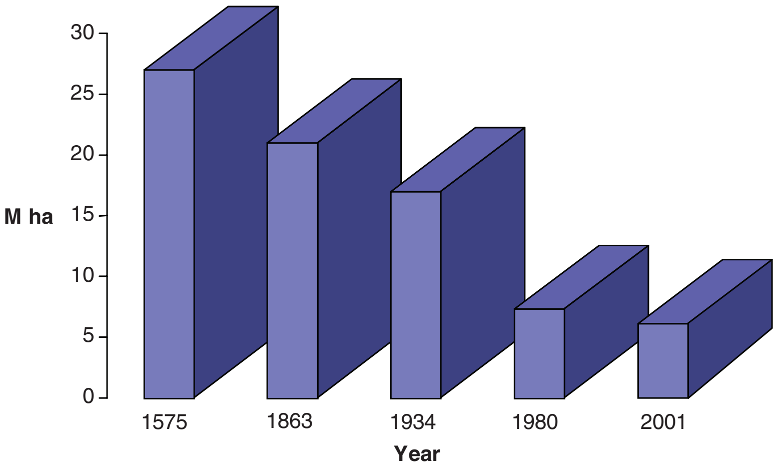

Fig. 1.2 The significant decrease in forest area (in million hectares) between 1575 and 2001 in the Philippines (Forest Management Bureau 2006)

Philippine history. Figure 1.2 shows the decrease in the Philippines forest area for the period before 1990. Remarkable is the period between the 1930s and 1980s when the forest area dropped from about 17 to 6 million hectares. The main cause of deforestation has been large-scale logging operations followed by other, partly associated, causes of forest loss and land degradation including upland migration, agricultural expansion, development policy failures, and inequitable land distribution (Photo 1.2). Although nowadays 15.9 million hectares of land is categorized as forest land based on the Philippines' land cover classification system, Fig. 1.3 shows that in 2005 only about 7 million hectares (or 24 percent) are indeed under forest cover, the remaining being open land, i.e., brushland, grassland or upland farms, and some plantations. The remaining forest cover is largely concentrated in the uplands on the islands of Palawan, Mindanao and Luzon.

An estimated 20 million people live and depend on forested uplands (CIFOR 2005) and face the high risks of severe soil erosion, rain-triggered landslides and flash floods causing hundreds of deaths and casualties on a regular basis. For example in December 2004, four consecutive typhoon and tropical storms caused floods and mudslides in deforested areas in Northeast Philippines leaving 1,060 people dead, 1,023 injured and 559 missing due to floods and mudslides (see: www.inquirer.net, Darmouth Flood Observatory at www.darmouth.edu). The events resulted in a wide public debate on what caused these floods and landslides and who was to blame for these disasters, pinpointing at either loggers or upland farmers in search for cultivable land (e.g., BBC News 2006, http://news.bbc.co.uk/2/hi/asia-pacific/4723770.stm). Then again in 2006, typhoons Bilis (July 2006), Xangsane (September 2006) and Durian (late November 2006) left respectively

Photo 1.2 Land use transition from forest to smallholder tree based and agriculture systems in the Philippines (©DJ Snelder)

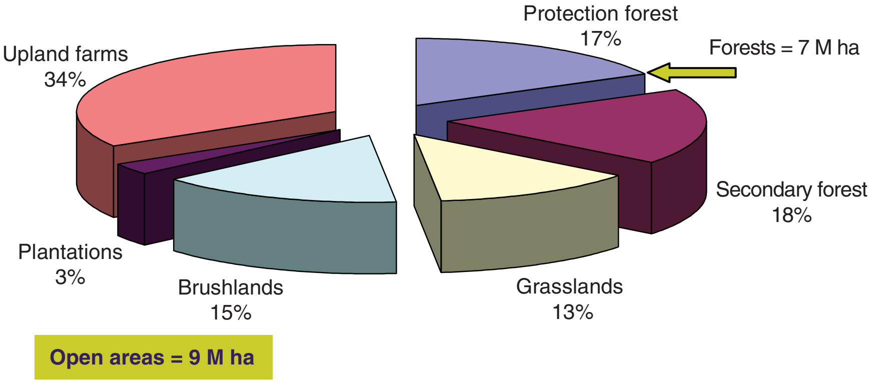

Fig. 1.3 The distribution of the different land use systems over land classified as "forest land" in the Philippines (Forest Management Bureau 2006; FAO 2006a)

626, 260 and 526 people dead. The high human toll and declining wood availability led to logging bans on primary forests and the establishment of protected areas in the 1990s, a reduction in concessions leaving a few sustainable operations, and massive reforestation efforts in the last few decades. After the disastrous storms in November–December 2004, President Gloria Macagapal Arroyo even announced a cancellation of all logging permits and suspension of issuance of other permits (ABC 2004). Earlier efforts of reforestation were not only directed at large-scale forest plantations but, particularly since the 1980s, also at small-scale tree plantations and forest management. In fact, the Philippines are one of the leading countries in on-farm tree growing and decentralized programs of community-based forest management.

The past and ongoing tree growing and reforestation initiatives are summarized by CIFOR 2003 and described as follows:

> The first formal rehabilitation efforts in the Philippines can be traced back to reforestation by students of the campus of the University of Philippines at Los Banos in 1910. This was followed by numerous Government-initiated projects that involved the planting of trees to reforest denuded areas. By 1973, there were 91 government reforestation projects (46 in Luzon, 31 in Visayas and 14 in Mindanao) with reforestation funds derived from timber concessions. Some private companies (such as Paper Industries Corporation of the Philippines PICOP and Provident Tree Farms) reforested via tree plantations within their concession areas. PICOP also pioneered smallholder tree farms among upland farmers near the concession through partnerships.
>
> The 1970s saw the birth of social/community forestry with programs such as Forest Occupancy Management (1971), the Family Approach to Reforestation (1971), Communal Tree Farm (1974), and the Integrated Social Forestry Programme (1982). From the late 1970s-80s, there were numerous community forestry initiatives funded by agencies such as USAID, the World Bank, Ford Foundation and GTZ. There was also major NGO pioneering work on agroforestry and agriculture. In 1986, a 14-year National Forestation Programme was launched with a target area of 1.4 M ha to be reforested by 2000. This programme was given a boost by the ADB/OECF loan for $240 M in 1988 for what became the Forestry Sector Project. Under this project, traditional methods of reforestation gave way to contract reforestation by families, communities, corporations, academic institutions, NGOs and LGUs. It also included watershed rehabilitation and encouragement of industrial reforestation through new agreements.
>
> The 1990s continued to see numerous community-based and integrated development projects funded by Asian Development Bank, Japan Bank for International Cooperation, World Bank, International Tropical Timber Organization, FAO, KFW (Kreditanstalt für Wiederaufbau) development bank and others; and executed by the state, NGOs, Local Government Units (LGUs), and People's Organisations (POs). Community based forest management through different types of tenurial instruments was adopted as the national strategy for reversing the destruction of the Philippines' remaining natural forests and for rehabilitating degraded lands. Besides social and community forestry, reforestation activities have also included large-scale government and industrial plantations and private tree farming. The latter has cropped up spontaneously in response to market demand, particularly in Mindanao, Luzon, and Cebu. It has been suggested that private land reforestation in the last decades may have actually led to increased forest cover in places. New forest cover inventories that are underway could help clarify the situation.

Table 1.3 gives an overview of the reforestation efforts under different forest management and tree growing programs using different types of tenurial instruments from 1980 onwards. Notwithstanding these massive efforts to control deforestation through the establishment of forest and tree plantations, they have had limited success even in more recent times. Remarkable high losses for forest plantations occurred, i.e., 92,800 ha (5.2 percent reduction) per year for the period 1990–2000 and 46,400 ha (5.4 percent) per year for 2000–2005 (FAO 2006b). Besides these records, Lasco et al. 2001 report a success rate of not more than 30 percent for a

Table 1.3 Temporal changes in the number of, and the area covered by, different types of forest and tree farm lease agreements in the Philippines (Forest Management Bureau Statistics Philippines 2006; http://forestry.denr.gov.ph/)

Year	Different types of forest and tree farm lease agreements											
	IFMA/ITPLA[a]		SIFMA[b]		Tree farm lease		Agroforestry farm lease		Community forest management agreements			
									No of beneficiaries			
	No.	Area (ha)	No	Area (ha)	No.	Area (ha)	No.	Area (ha)	household	PO	Individual	Area (ha)
1980	12	88,000	–	–	101	9,000	2	1,000	–	–	–	–
1985	81	291,000	–	–	129	17,000	101	99,000	–	–	–	–
1990	81	304,000	–	–	101	13,000	94	110,000	–	–	8,858[c]	44,222[c]
1995	248	538,000	–	–	128	18,000	84	97,000	–	–	10,620 18,296[c]	106,609 96,906[c]
2000	184	548,000	750	22,387	155	19,000	80	91,000	477,984[d]	–	–	5,482,393[d]
2003	198	702,000	1591	36,237	167	20,000	84	94,000	690,691[d]	2,977[d]	–	5,969,522

[a] Industrial Forest Management Agreement/Industrial Tree Plantation Lease Agreement to enabling private investors to engage in industrial forest management and plantation establishment. IFMA is to encourage logging companies to convert their business from pure timber-cutting into commercial timber plantations. To do this, the government announced that all Timber License Agreements (TLAs, logging permits), would expire in 16 years starting from 1991, while heavily promoting the IFMA as the alternative. Since the government hoped to promote IFMA as a large-scale reforestation programme, the usual area given to TLA holders (on average 10,000 ha) could be doubled, depending on the capacity of the prospective company (http://www.minorityrights.org/Dev/mrg_dev_title4_philippines/mrg_dev_title3_philippines_pf.htm accessed May 7, 2006).

[b] Socialized Industrial Forest Management Agreement enabling individuals, families, co-operatives or corporations to engage in plantation establishment ranging from 1 to 500 ha.

[c] Beneficiaries and total area covered by Community Forest Stewardship Management Agreements in which a portion of the public forest is allocated to a given community to manage, rehabilitate, reforest or develop for a period of 25 years renewable for another 25 years based on performance.

[d] Beneficiaries and total area covered by projects implemented within the framework of the Community-Based Forest Management Programme promoting active and productive partnership between the government and the forest communities in developing, rehabilitating and managing vast tracks of forest areas; communities are being organized and given long term (25 years, and renewable) tenurial instruments over forest areas with the privilege to derive direct benefits through harvesting of forest products, agroforestry and other livelihood programs. However, these privileges and benefits go hand in hand with the corresponding obligation to manage and protect the forest area in the long term. Moreover, benefits derived from production shares and livelihood opportunities are supposed to plow back and be equitably distributed to the POs, their members and families.

total of 1,300,000 ha of fast-growing trees planted between 1976 and 1995 in the Philippines, assuming success is defined as the proportion of area that evolves into secondary forests. Fast-growing tree species such as *Gmelina arborea*, *Eucalyptus* sp. and *Acacia mangium* were, and still are today, most commonly used and planted in the form of government and industrial plantations. As result of the disappointing accomplishments, the rate of reforestation has been lagging far behind the rate of forest loss. Whereas about 70,000 ha of land had been successfully reforested during the period 1916–1987, the average rate of deforestation was estimated at 100,000 ha per year (Forest Management Bureau 1988, Pasicolan 1996). No improvement in forest coverage has been accomplished yet, with the Philippines being ranked at number six on the list of most forest-poor countries (based on the percentage land area under forest cover in 2005) in South and Southeast Asia (with 18 countries in total). However, most efforts directed at community-based forest management and on-farm tree growing are of relatively recent date (with a large area extension from 2000 onwards; Table 1.3) and, hence, the much awaited results still require some time for conclusions to be drawn.

1.7.1 Why the Philippines as a Case Study Country?

The discussion above partly reveals the special status of the Philippines within Southeast Asia in terms of environmental and socioeconomic and political developments. Whereas it is a democratic independent country these days, it has been influenced by foreign administrations being under the colonial rule of Spain, the United States and Japan (occupation of 1941–1945) for more than 400 years (1521–1946). Some of the earliest official tree growing and reforestation activities and research records date back to the American colonial period: the tree planting activities at the campus of the University of Philippines at Los Baños after the foundation of the Department of Agronomy and Forestry in 1910. The Philippines further stands out as a country within Southeast Asia which has lost most of its original tropical forests. However, at the same time, it has a long history in community tree growing or forestry programs and the formulation of policies and laws to create a legal regulatory regime conducive to the implementation of such programs. Compared to other Southeast Asian countries, the Philippine laws and policies in support of community forestry are among the most elaborate and enlightened (Cabarle and Lynch 1996). Yet the implementation lags, political will is limited or absent within many government institutions, and many laws, policies and programs are more than superficially contradictory. The implementation is further complicated by the regular occurrence of natural, or partly man-induced, disasters such as typhoons, earthquakes, floods, mudflows, and land slides. Within the context of such a challenging environment, the Philippines form an excellent case study country for the identification of potentials and constraints of smallholder tree growing.

In addition, the Philippines hold a special status with the main editors of this book. Both are affiliated with Philippine-based institutions for a longer period of time, enabling the accumulation of relevant information on the topic of this book, i.e., Rodel Lasco through his work at the World Agroforestry Centre (ICRAF Philippines Liaison Office) with its regional head office in Bogor, Indonesia and Denyse Snelder through her work with the Cagayan Valley Programme on Environment and Development (CVPED), a university partnership of Leiden University in the Netherlands and Isabela State University in the Philippines. ICRAF started its operations in the Philippines in 1993 in the College of Forestry and Natural Resource Administration building at the campus of the University of Philippines at Los Baños. CVPED started its university programme in 1989 at the campus of the Isabela State University in Cabagan, Northeast Luzon. Both institutions have been building up scientific knowledge on tree and forest resources, with ICRAF conducting research at a wider scale (having offices and field sites throughout the Philippines) and CVPED running an education and research programme at a more local scale (with field sites centered around the office in Cabagan, Luzon).

1.8 Book Overview

This book is partly based on the outcome of an international seminar on tree growing in agricultural landscapes co-organized by CVPED-ICRAF and held in 2002 at the Cabagan Campus of Isabela State University, Philippines, to realistically assess and characterize the status of smallholder tree growing in countries like the Philippines. The seminar further addressed various aspects of smallholder tree growing some of which are integrated within the framework of this book. Questions were formulated such as to what extent have trees been integrated into smallholder farming systems and what evidence do we have that such systems lead to sustainability and enhanced livelihoods? Where is the concept exceptionally promising, and where can it be admitted as a failure? How can we ensure successful implementation of different tree-based farming technologies in terms of adoption, impact on livelihoods and environmental impacts? In short, is smallholder tree growing a viable strategy for sustainable development in rural areas?

The book looks into various questions and aspects of smallholder tree growing that are discussed below including smallholder tree growing and its role in sustainable rural development, its potential for marketing of wood products and contribution to environmental services, and its promotion through employment of various instruments of sustainable management and conservation.

1.8.1 Smallholder Tree Growing for Sustainable Rural Development

Agricultural development and intensification have presented countries throughout South and Southeast Asia with substantial environmental problems over the past decades. Farmers experience a decrease in soil fertility and are forced to apply growing quantities of chemical fertilizers, pesticides and herbicides in order to sustain their cash crop yields, which in turn often result into mounting debts aggravating their poverty status. With increasing awareness of farmers' struggle to maintain adequate yields and escape poverty, initiatives have been undertaken by research institutions, universities, and non-governmental organizations to investigate and promote sustainable land use technologies and livelihood systems. Smallholder tree growing is considered as one of the most promising technologies. Yet, it is still unclear whether tree growing has been practiced in such a way that all aspects of sustainability have been met. If the answer is negative, what can be done to improve sustainability? What is farmers' perception about (newly introduced) tree-based farming systems and to what extent, and under which conditions, have they indeed adopted such systems? What methods of scaling up of smallholder tree growing have been successful and what knowledge and communication gaps do still exist? Tree based farming systems vary in management and productivity, and it is often questioned how these systems compare to other types of land use in terms of profitability. Smallholder bio-crop production and rural processing may be implemented as a way to raise the value of tree products. In this context, sustainable forestry certification will be discussed.

1.8.2 Smallholder Tree Growing for the Market

One of the challenges faced by smallholder tree farmers is marketing their products. There have been anecdotal stories in the past where farmers were lured to plant trees by the prospect of becoming rich upon harvest only to find out later that wood prices are way below their expectations. A case in point is the Philippines where one would expect a healthy market for wood products considering that log importation amounted to US$686 million in 2004 (Forest Management Bureau 2006). However, a recent case study revealed that tree growers in the country are finding it hard to market their products (Calderon and Nawir, 2006). Among the reasons for these are unstable policy environment, policy conflict, lack of marketing plan, poor and unstable markets for tree species, inadequate marketing support from government agencies, and high transport costs (Chokkalingam et al. 2006). An example of unstable policy environment was when the Department of Environment and Natural Resources suddenly suspended in 2004 cutting permits from all community based forestry projects. This was subsequently lifted but such flip flopping policy discourages farmers from planting trees.

1.8.3 Smallholder Tree Growing for Environmental Services

The on-going disappearance of large stretches of forests threatens biodiversity and the natural environment in general throughout South and Southeast Asia. In order to conserve remaining forest, protected areas have been established worldwide. Yet, in recent years, the growing of trees in agricultural areas has become an additional focal point for safeguarding the environment and its services. However, various questions remain to be answered. To what extent do smallholder tree based farming systems indeed contribute to environmental services like biodiversity conservation and watershed protection? What are the most optimal systems, and to what extent do these systems meet the needs of both smallholders and society in general? How can we reward smallholder tree growers contributing to environmental conservation and sustainability that serve society as a whole?

1.8.4 Instruments Facilitating Sustainable Smallholder Tree Growing

Concerns about the fragile relationship between forest use and natural functioning forest ecosystems have led to the establishment of the Forest Stewardship Council (FSC) in 1993. The FSC developed a set of global principles and criteria for environmentally and socially responsible forest practices to be audited for compliance by third parties and certify those operations with a positive audit result (Cashore et al. 2006). The question is, however, to what extent such standard for forest certification is applicable to smallholder tree growing operations. Reports are made of smallholders facing various constraints in their effort to achieve forest certification (Higman and Nussbaum 2002). Moreover, it is questionable whether forest certification will facilitate their excess to markets for wood products. A more recent initiative launched by FSC in 2002 to increase access to certification for Small and Low Intensity Managed Forests (SLMF; FSC 2002) may offer a more relevant instrument within this context. The initiative is directed at woodlot owners, farmers growing trees on farms, family forests, small non-industrial private forests (NIPF), small forest enterprises (SFE), some community forestry operations and non-timber forest product harvesters.

Acknowledgements The book is based on the international seminar on tree growing in agricultural landscapes, April 11–14, 2005, hosted by Isabela State University Cabagan Campus and co-organized by the Cagayan Valley Programme on Environment and Development, a joint undertaking of Leiden University (CML) and Isabela State University (ISU), and the World Agroforestry Center of the Philippines (ICRAF-Philippines). The seminar took place within the frame work of the Junior Expert Programme funded by the Ministry of Foreign Affairs in the Netherlands. The latter programme formed an extension of the Cagayan Valley Programme on Environment and Development and concentrated on two specific fields of research, i.e., agroforestry and indigenous people.

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Appendix: Development of Concepts on Smallholder Tree Growing in Various Countries in South and Southeast Asia

India

People in *India* have been practicing tree growing spontaneously for thousands of years (Puri and Nair 2004), both on farms and around houses for subsistence and, later on, also marketing purposes. Trees played a special role in their daily lives, as they still do today, with various species being valued as sacred trees. At a national level, the management of tree and forest resources was primarily aimed at the production of commercial products such as teak. As early as in 1805, the British government requested the British East India Company to investigate the availability of teak in Madras to meet the needs of British shipbuilding during the Napoleonic war (Barton 2000). Environmental concerns about deforestation (Weil 2006) and a critical timber shortage already by the 1840s (Barton 2000) promoted the establishment of a Forest Department in 1855 by the governor general of India, i.e., Lord Dalhousie. Large areas with forests, the latter being property of the British government in India, were now declared protected areas (Barton 2000). Some considered the annexation of areas for state forest conservation as a way of concealing the real considerations of the British government, i.e., the need for raw materials and the justification of forest expropriation from "traditional" forest users in order to more fully exploit forests resources (Weil 2006). The Indian Forest Act of 1878 subsequently gave the state greater control over forest management.

Nowadays, teak is mainly planted outside forests and still plays a significant role as timber producer (Pandey and Brown 2000). Likewise, there are many other trees outside forests that are crucial in generating fruits and vegetable products but foremost they are important as a main source of fuelwood. In Kerala for example, the most densely populated state of India, trees outside forests account for about 90 percent of the state's fuelwood requirements. Of the 14.6 million cubic meters of timber produced per year, an estimated 83 percent was derived from homesteads (house compounds and farmlands), 10 percent from estates and only about 7 percent from forest areas (FAO 2001). There are a diversity of agroforestry systems directed at smallholder tree growing including trees in farms and on farm boundaries, trees grown in close association with village rainwater collection ponds, crop-fallow rotations, silvopastoral systems, trees within settlements, agroforests, community forests and a variety of local forest management and ethnoforestry practices (Pandey 2007). The promotion of tree growing through agro- and community forestry systems emerged because of concerns over ongoing forest degradation in the 1970s. In 1976, the National Commission on Agriculture (NCA) recommended the creation of 'social forests' on common lands and state forests to provide the local communities fuelwood, small timber and fodder, yet without specifically emphasizing the role of local people (Sekhar and Jørgensen 2003). With projects spread all over the country, the planting of trees for commercial or subsistence purposes was promoted in and around privately owned farms (farm forestry), in combination with agricultural crops on cultivated fields (agroforestry), in the form of woodlots on village common lands or community lands (community forestry), as block plantations on government wastelands and degraded forestlands, and along road sides, canals and railroads (extension forestry). The tree plantations covered areas of 0.1 ha or more in the case of block plantations, less than 0.1 ha in the case of farm forestry, or consisted of lines of individual trees along, for example, road sides (Harrison et al. 2002). However, disappointing results of the social forestry projects and the ongoing deforestation made the Indian government change its forestry policy towards a more people-oriented approach of Joint Forest Management (JFM), i.e., a state-community partnerships in forest management. The Indian National Forest Policy of 1988 (MoEF 1988) together with a government resolution on participatory forest management (MoEF 1990) entrust local communities with legal access to forest resources, encourage communities to set up village forest management committees and ensure a share of the produce from the forest resources (Yadama et al. 1997).

Thailand

Examples of traditional tree growing activities in *Thailand* are the forest gardens on the Kao Luang slopes in southern Thailand and the miang gardens (Werner 1996) or jungle tea agroforests (Thomas et al. 2007) in northern Thailand. The latter refer to tea trees that grow naturally in hill evergreen forests, with *Camellia sinensis L.* being planted and managed as an understory tree and used by villagers to produce green tea or miang. Moreover, various ethnic minority groups have been living as farmers in upland forest for a long period of time, as described by Kunstadter et al. (1978), making use of different types of swidden systems including opium-based systems (Thomas et al. 2007). Traditionally, the management and use of Thai forests has been controlled by relatively autonomous local nobilities, many of whom gained profits from logging contracts with

European companies, until the end of the 19th century. In 1896, the Royal Forest Department was established and tasked with the institution of central authority over regional nobilities (Pragtong and Thomas 1990 in Lakanavichian 2001). The department was further charged with the regulation and control of forest logging, initially operating under absolute monarchy, and from 1932 onwards, under constitutional monarchy. In 1989, a total ban on commercial timber harvesting was declared to stop the rapid deforestation, and major changes in Thai forest policy started (Salam et al. 2006). In 1990, a Community Forest Act was drafted followed by the enactment of a Forest Plantation Act in 1992. Although intentions were there to involve communities in forest plantation and management, the Royal Thai Government rather believed in large-scale private plantations as a way of mitigating deforestation, reviving the forestry sector and supplying wood for domestic consumption (TFSMP5 1993 in Lakanavichian 2001). However, due to the increasing resentment among local communities and NGO's, the promotion of commercial large-scale monocultures of fast-growing trees was halted in 1992. Efforts were subsequently directed at the promotion of small-scale tree farms. Thomas et al. (2007) refer to three main strategies that have been used to promote tree growing in midland and highland areas, i.e., simple agroforestry primarily centered on the planting of fruit trees (temperate fruits like pears, plums, litchee, and Chinese apricots and subtropical fruits like mango and longan) on agricultural fields (e.g., Withrow-Robinson et al. 1998), complex agroforestry in the form of extension or improvement of the jungle tea plantations in the hill evergreen forest (with integration of fruit trees in some areas) and the community-managed forest directed at the maintenance and expansion of permanent forest protected and managed by local communities. However, the results of these efforts are still limited. Farmers face multiple constraints when establishing tree plantations, including no or few incentives, long waiting periods prior to tree sales, lack of legal support for community forest management, lack of legalization for tree felling and selling, lack of specific tree growing technologies and absence of government support, through the Royal Forest Department, in developing marketing channels for small farmers in plantation and wood-product business (Lakanavichian 2001; Salam et al. 2006). Community Forest Management has been debated for quite some time with a number of alternative drafts of proposed community forest legislation prepared separately by the Royal Forest Department (RFD), i.e., the 'ministry version', and the alliance of academics and NGOs, commonly referred to as the 'people's version', since the 1990s (Salam et al. 2006). It is only recently (on the 21st of November 2007) that the Community Forest Bill was passed in the National Legislative Assembly (see Hares, Chapter 19, this volume).

Bangladesh

The forests of *Bangladesh* have been under planned management for over a hundred years, with the first forests being notified as reserved forests after the Forest Act VII of 1865. The Forest Act of 1927 grants the government several basic powers, largely for conservation and protection of government forests, and limited powers for private forests (FAO 2000). After independence in 1971, teak was identified as the main species for plantation and "taungya" agroforestry system (the latter system is comparable to the Indonesian system discussed below). In 1989, the 1927 version of the forest act was amended for extending authority over "any [Government-owned] land suitable for afforestation" (FAO 2000). Bangladesh has further a long tradition of tree growing in homesteads and homegardens like elsewhere in Southeast Asia (e.g., Ahmed et al. 2003). Likewise tree growing in the form of traditional forestry has been practiced in the form of village forests, tea and rubber gardens and shifting cultivation systems in hill forest (Islam 1998). Whereas in present times homegardens cover only about 2.3 percent of the land (1995 data; Jensen 1995), village forests play a more important role supplying 80 to 82 percent of the forest products in villages (Douglas 1981 cited in Forestry Master Plan 1992). It is estimated that these forests cover about 270,000 ha (Forestry Master Plan 1992) containing, amongst others, bamboo, palms, and trees (for fruit, fuelwood, construction, shade, and other multiple purposes). Nevertheless increasing population densities, logging and land use conversion- with shifting cultivation (Islam 1998) and poor people's dependence on natural resources (FAO 2000) being identified as the main cause of deforestation-resulted in a substantial decline in the country's total forest cover. Decades of traditional forest management, based on forest policy guidelines of 1894, 1955 and 1962, proved to be ineffective causing a drastic net loss in forest resource cover (Muhammed et al. 2005). This trend started to change with the introduction of social forestry as a strategy of poverty alleviation and socio-economic development in the early 1980s. In 1994, Bangladesh adopted a new National Forest Policy with emphasis on people-oriented programs to conserve natural resources, preserve existing values and to maximize benefits to local people (FAO 2000). Based on a field survey in 2003, Muhammed et al. (2005) report that thousands of poor farmers have benefited from forest expansion since the mid-1980s through different social forestry plantations including woodlots or block plantations (30,666 ha), agroforestry (7,738 ha), strip plantation (48,420 km), and village afforestation (7,421 ha). Yet, at the same time, they refer to various shortcomings in the social forestry programme making its participants skeptical and, hence, preventing full exploitation of the social forestry benefits. Moreover the area under tree cover further declined from about 14.9 percent under public forest and another 1.8 percent under village forests in 1996 (FAO 2000) to a total of 6.7 percent forest cover in 2005 (FAO 2006b, Table 1).

Indonesia

In *Indonesia*, small-scale tree growing has traditionally been practiced spontaneously by most households throughout the archipelago in the form of village forests (hutan rakyat), village forest gardens (talun) or homegardens (talun-kebun, pekarangan). Yet, forest management and tree growing have also been introduced intentionally particularly in areas where forest resources have been affected by mounting population pressure like on the island of Java. For example, Java's teak (*Tectona grandis*) management system was designed in 1847 and resulted in 1890 in the first forest district management plan, which was based on the principle of sustained yield (Simon 1989). A regeneration taungya system (*tumpangsari*) for teak forests was adopted in 1873, in which all teak-growing activities were performed by farmers living near the teak sites. The farmers had the right to grow agricultural crops between rows of teak and *Leucaena* for a specified period, although the main reason for granting farmers such benefits was to minimize the operational costs of the teak plantations. Intensified taungya systems are still widely practiced as regeneration systems of teak and other species plantations (e.g., *Pinus merkusii*, *Swietenia macreophylla*; see also Kartasubrata and Wiersum 1995), being considered as a form of social forestry since the 1980s. In 1985, the State Forest Corporation Perum Perhutani started the implementation of 13 social forestry projects on Java's public lands with farmers being allowed to plant fruit trees and horticultural crops in between requested timber trees (Kusumanto and Sirait 2000). Similar projects on islands other than Java (e.g., South Kalimantan, South Sulawesi, and West Irian) were initiated at a later stage in 1992. In 1995, the Indonesian government announced a new policy and "community forest" program by issuing the Ministry of Forestry Decree No. 622/Kpts-II/1995, which was revised in 1998 yielding Decree No. 677/Kpts-II/1998 (Inoue 2007). With these decrees, communities – or cooperative groups of people – living within and near the forest can be given the right to use the forest in what is known as Hak Pengelolaan Hutan Kemasyarakatan (HPHKM) or a License to Manage the Forest (Hindra 2005). The license is acknowledged by the government as a Utilization Permit (previously by means of Community Forestry Concession Rights) for timber and non-timber forest products valid for a period of 35 years (Kusumanto and Sirait 2000). Since October 1999, the permits have been granted in the form of Community Forestry Temporary Permits valid for just 5 years but with possible extension. The authority of local administrative units in forestry and tree growing affairs has been extended since the start of the decentralization process in 2001. Moreover, with the issue of Decree No.31/Kpts-II/2001 in 2001, local people have been recognized as the main actors in forest management. However, the decree was counteracted by new regulations on forestry planning in 2002. In 2004, the regulation of the Ministry of Forestry No. 1/Menhut-II/2004 was issued, facilitating the implementation of the Social Forestry Programme launched by the newly appointed minister in 2003. The regulation entails the empowerment of people living within and surrounding the forest through the practice of social forestry (Hindra 2005). By the end of 2004 the Ministry of Forestry declared five priority policies, one of which addressing the empowerment of the economy of communities within and surrounding the forest. Finally a Private Forest Programme (Program Hutan Rakyat) also exists in Indonesia, granting credits to farmers in order to support the development or rehabilitation of privately owned forest lands (Kusumanto and Sirait 2000). These *private* lands are planted with timber species or non-timber species such as fruits and coffee. In various parts of Indonesia, there are various examples of well-managed private plantations that developed spontaneously in response to market demands of various forest-related products (Michon and De Foresta 1997).

Lao PDR

In *Lao PDR*, tree growing is traditionally being practiced in rice-based swidden systems in upland areas home to multiple ethnic minority groups and in homegarden systems (with a variety of fruit and vegetable trees) typically of a more rudimentary form in areas still rich in forest resources and a more developed form in areas where forest resources are (becoming) scarce (Bounthong et al. 2006). In addition to these most common practices, other traditional systems exist including hedges of woody species around agricultural fields (living fences), multistory tree gardens, orchards and plantations, taungya for forest regeneration along river banks in the North and in upland areas, and economically improved fallows (e.g., integration of mulberry or *Broussonetia papyrifera*, cardamom or *Amomum* spp. and benzoin or *Styrax benzoides*; Hansen and Sodarak 1996). Efforts by the Lao government to stop or at least stabilize shifting cultivation have been directed at improvement of swidden systems or facilitation of alternative systems such alley cropping and contour hedgerows using woody species (Hansen and Sodarak 1996). Likewise efforts have been made to implement sustainable forest management on sloping land and in state-owned production forests since the early 1990s. One such initiative was the Lao-Swedish Forestry Programme (LSFP) in 1992–2000 under which villagers participated in production forest management, referred to as Joint Forest Management, in an area of 9,500 ha in the Savannakhet Province (Phanthanousy and Sayakoummane 2005). Natural forests and forestlands all belong to the national community represented by the State in the management and allocation of these resources for rational use by individuals and organizations as stipulated by in the Forestry Law 125 of 11 October 1996. Another initiative concerned the launching of a Forest Management and Conservation Programme (FOMACOP), a national programme implemented by the Department of Forestry of the Ministry of Agriculture and Forestry in 1993, with a Forest Management Sub-Programme (FMSP) focusing on “village forestry” (Fujita et al. 2005). The programme started its field activities in two central provinces of Laos, with local communities leading the management of production forests of 260,000 ha in total through so-called Village Forest Associations in partnership with district and provincial foresters. Under the FMSP, villagers gradually organized themselves and collectively designed and implemented sustainable forest management plans and associated rules. FOMACOP terminated in 2001 and was followed by a project on Sustainable Forestry for Rural Development Project (SUFORD). The latter, covering four provinces but eventually aiming at nation-wide coverage, elaborated on two key aspects of the previous programme, i.e., participatory forest management and training and capacity building. The project further included more components, such as sectorwise policy reform, whereas village development became an integral part of project design and implementation. The concepts of village forestry and community-based management of production forests are also integrated in the government’s *Forestry Strategy to the Year 2020 of the Lao PDR* (MAF 2005). The government issued a PM Decree No. 59/2002 on sustainabale management of production in May 2002 (Phanthanousy and Sayakoummane 2005). The Ministry of Agriculture and

Forestry (MAF) subsequently issued regulation No. 0204/MAF.2003 to effectively implement the above Decree by sustainable management and use of forests, non-timber forest products and forestlands within production forest areas with participation of local authorities and villagers (Phanthanousy and Sayakoummane 2005). Village participation is organized through (Groups of) Village Forestry Organizations ((G)VFO) under a Village Forest Management Agreement signed between the (G)VFO and the respective district's Forestry Management Unit. The agreement specifies the rights and responsibilities of all parties, the scope of village participation, and the revenue sharing arrangement. Other MAF regulations give details on legal prescriptions for logging and harvesting of forest products, including cutting limits for natural trees.

Vietnam

In *Vietnam*, tree growing in the form of agroforestry have existed for a long time and shows similarities with systems of tree growing in Laos discussed above. Typical are the traditional swidden or shifting cultivation systems implemented by ethnic minority groups in the uplands and the homegarden systems in rural areas throughout the country. Research into agroforestry systems has, however, only been initiated in the early 1970s, leading to adaptation of some traditional agroforestry systems (particularly innovated shifting cultivation and swidden systems) and introduction of new systems (e.g., alley cropping, boundary planting and taungya). CARES (2004) refers to different types of traditional agroforestry systems, including intensive perennial (particularly multi-purpose) tree gardens of 0.5 to several hectares, more extensive (planted, high-value fruit/timber) forest gardens of 0.3–0.5 ha per household, three to four-storied fruit gardens close to settlement areas, homegardens, (fruit/timber)garden-fishpond-livestock systems covering about 500–1,000 m^2 per household on average, and related to the latter, the forest-garden-fishpond-livestock systems. In addition, tree growing is practiced within a number of forest-based systems such as (predominantly natural) forest-terrace systems, composite swidden systems, (natural/planted) forest-cash crops-rice systems and the taungya systems to recover natural forests. Traditionally, Vietnamese forests have been managed by upland communities over centuries but the recognition and implementation of the concept community forestry only started to develop in the 1970s (Nguyen et al. 2005). A legal basis for both subsistence and commercial community forestry was achieved again much later with the Land Law (revised) in 2003 and the Forest Protection and Development Law in 2004 (Nguyen et al. 2005). The former specifies the village community as the party to which the State allocates land or whose agricultural land use right is recognized by the State whereas the latter stipulates forest allocation to village communities including their rights and duties. The Civil Law (revised) in 2005 acknowledges the concept of common ownership by the community, based on either traditional customs or a benefit sharing agreement on joint management and utilization of the forest by community members.

The Philippines

The *Philippines* stand out as one of the countries having lost most of its original natural forests but at the same time being one of the first countries that started the decentralization process transferring responsibilities of forestry policies and programs from national to local level, and one of the leading countries in community-based forest management and smallholder tree plantations. These specified conditions, and their associated lessons to be learned, are some of the reasons why the Philippines are selected as a case study country in the first part of this book. More details on Philippine concepts and programs relating to smallholder tree growing have been discussed earlier in this chapter.

Part II
Smallholder Tree Growing for Rural Development: Practices and Adoption

Chapter 2
Smallholder Tree Growing in Philippine Back Yards: Homegarden Characteristics in Different Environmental Settings

D.J. Snelder

Abstract Although Asian homegardens have received fair scientific attention, the Philippine homegardens form an exception to this rule. The objective of this chapter is to explore the dynamics and diversity of 57 homegardens (size: 0.07–0.13 ha) in five villages in the Cagayan Valley. Of the 155 plant species in total (>312 if including ornamentals), 71 are tree species. When moving from forested uplands to densely populated lowlands, homegardens become more diverse, better structured and higher in plant density. Likewise, they show increasing differentiation towards tree crop mixtures with *Mangifera indica* (mango) and *Moringa oleifera* (horse raddish), non-tree crop mixtures with *Solanum melongena* (eggplant) and *Colocasia olotorius* (cocoyam) or *Ipomoea batatas* (sweet potato), and livestock for selling purposes. Farmers' most important reasons for having homegardens refer to household consumption. Yet, the selling of excess crops and livestock products is of increasing importance as income from farms decreases (due to smaller sizes and lower soil fertility) being eventually inadequate to meet households' cash needs. Garden products generate US$281 ± 944 per hectare (median: US$130) – or US$73 ± 123 per homegarden (median: US$27) – at minimal or no input costs. The annual gross income from gardens with livestock is higher, i.e., US$115 ± 72 per household (median: US$98).Yet, corn (major cash crop of farm fields) yields a much higher gross income, i.e., US$676 ± 336 per hectare per year with inputs varying from US$137 (without fertilizer) to US$250 (with) per hectare per cropping cycle.

Keywords Crop differentiation, crop mixtures, economic benefits, land-use intensification, species diversity

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2.1 Introduction

The growing of trees in homegardens is a traditional practice throughout Southeast Asia. It is referred to as the oldest land use activity next to shifting cultivation (Kumar and Nair 2004, 2006), with the earliest evidence of garden cultivation dating back to 7000–3000 BC (Soemarwoto 1987) or even to 13,000–9,000 BC in the case fishing communities in Southeast Asia (Wiersum 2006).

Homegardens in Indonesia and India have received a reasonable amount of scientific attention, being recognized as distinct multi-layered and multi-functional agroecosystems in which trees play an important role (e.g., Michon 1983; Michon et al. 1986; Soemarwoto et al. 1985; Fernandes and Nair 1986; Kubota et al. 2002a, b; Vogl et al. 2004; Peyre et al. 2006; Abdoellah et al. 2006). Yet, nearly all lack scientific evidence of various ecological, economic and social sustainability aspects which in turn obstructs predictions of the gardens' fate under conditions of increasing commercialization (Nair 2001; Wiersum 2004; Nair 2006).

Homegardens can be classified on the basis of a variety of functions and services, including for example gardens for pure survival (survival gardens), subsistence (subsistence gardens), market production (market gardens), hobby (household budget gardens), communal medicine production (village herbal or medicinal garden) or various ecological gardens (bio-gardens; Wiersum 2006). There is a growing awareness that homegardening, combined with nutritional education, can be a viable strategy for improving household food security and optimize nutritional diversity for at-risk populations, particularly women and children (Kumar and Nair 2004). A survey of 40 households in the Philippines showed that most households could meet the recommended daily requirements for vitamin A, vitamin C, iron and calcium with homegarden products. In addition, one in four households could meet their protein and energy requirements (Sommers 1978 in Fernandes and Nair 1986). Homegarden further generate cash income and serve as "reforestation nucleus" or a tree testing site for determining optimal growth conditions and spreading trees more easily to farms and fields of neighbors and others.

Homegarden trees are usually grown together with other crops, and sometimes in association with domestic animals, forming multi-story combinations with overlapping canopy around individual houses or homesteads. With regards to other biophysical and socioeconomic characteristics, homegardens differ in many aspects even if located within the same region. Vegetation structure, in terms of horizontal and vertical stratification, varies with garden age and size (e.g, Kehlenbeck and Maass 2004). Whereas multistoried canopies being most evident in older gardens, stratification can be counteracted by various management practices like trimming of trees, thinning, weeding, and regular sweeping and burning of litter. Homegarden species diversity, crop combinations and plant density likewise significantly vary (Table 2.1) with specific needs and preferences of households, religious beliefs, cultural values and dietary customs, and the availability of other food sources. In addition, climate, seasonality, and soil type control plant density and species composition (e.g., Soemarwoto 1987; Wezel and Bender 2003). Species richness is also influenced by level of commercialization

Table 2.1 Data on species richness and plant density for Asian homegardens of different sizes derived from a selection of literature sources

Source	Country	No. studied homegardens	Total number plant species	Homegarden size (ha)^{a}	No. species/ homegarden^{a}	Plant density (indiv. ha^{-1})^{a}
Black et al. 1996	NE Thailand	49	230	–	15–60	–
Gajaseni 1999	Central Thailand	4	–	0.09 – 0.13	26–53	–
Karyono (1981)	West Java,	351	$501^{\text{dry season}}$	0.02	19	–
in Soemarwoto 1987	Indonesia		$560^{\text{wet season}}$		24	
Kubota et al. 2002	West Java,	–	–	0.03	–	7,330
	Indonesia			0.04		10,420
Kehlenbeck and	Sulawesi,	30	94	0.07 (0.02–0.11)	35 (15–55)	–
Maass 2004	Indonesia		109	0.06 (0.03–0.15)	37 (21–54)	
			84	0.08 (0.05–0.24)	28 (18–41)	
Millat-E- Mustafa et al. 1996	SW Bangladesh	80	67	0.02–>0.2	16 (4)	1,909–2,462
	NW Bangladesh		46	0.02–>0.2	25 (6)	1,189–2,078
	E Bangladesh		54	0.02–>0.2	30 (7)	1,389–2,380
	CN Bangladesh		56	0.02–>0.2	19 (4)	1,754–2,314
Ali 2005	Bangladesh	32	25^{t}	<0.2	12–30	–
			62^{nt}	0.2–1	13–32	–
Kumar et al. 1994	Kerala, India	87	127^{ws}	<0.40	21^{t}	269^{t}
		123		0.40–2.00	26^{t}	1173^{t}
		42		>2.00	20^{t}	561^{t}
Peyre et al. 2006	Kerala, India	30	–	0.14 (0.02)	28 (4)	$1,106\ (138)^{ts}$
				0.24 (0.06)	18 (3)	$621\ (129)^{st}$
				0.40 (0.08)	29 (1)	$449\ (55)^{st}$

-*^{a} data between parentheses represent a range (x–x) or a standard deviation/error (x), single data without parenthesis mean values

CN = Central North; –: not available; t: trees only; nt: no trees; ws: woody species only; ts: trees and shrubs only

(Abdoellah et al. 2006) and homegarden size, with the small-sized (<0.4 ha) homegardens showing the highest crop species diversity (e.g., Kumar et al. 1994; Drescher 1996). If, however, the homegarden is the only land available to the household, food crops like cassava (*Manihot esculenta*) tend to dominate the species composition (Wiersum 1982). Where households avail of other income sources and purchase most of their food like in urban areas, domination by ornamental and aesthetic species is more likely (Drescher 1996). It should be mentioned, however, that apparent variations in species richness in the literature are partly due to uncertainty whether the total numbers of species refer to a sample of homegardens or a single plot (Hoogerbrugge and Fresco 1993). Likewise, it is often unclear whether all species are identified including "wild" and other species that have established themselves spontaneously.

2.1.1 Homegardens in Northeast Luzon: Uncertainties About Their Status and Recent Development

There are only few studies on Philippine homegardens, also referred to as *halamanan sa tahanan* or *halamanan s bakuran*. Among these are some earlier studies discussing traditional homegarden systems (e.g., Sommers 1978) and some recent publications on the establishment of allotment vegetable gardens in urban areas like Cagayan de Oro city (e.g., Potutan et al. 2000; Holmer et al. 2003). Homegardens have been promoted by popular movements like the Green Revolution (a movement for countryside agricultural development) and the SAMAKA Program (Samahan ng Masaganang Kakanin: a united effort to produce ample food for the family; Hoskins 1973; Holmer et al. 2003). In the 1970s, over 70 percent of all Philippine households maintained a homegarden. Yet, field evidence suggests that the Philippine homegardens – particularly those established by migrants more recently – seem less diverse in species composition and structure compared to the Indonesian gardens and those developed under similar climatic conditions elsewhere. No studies have been conducted to confirm this.

The objective of this study is to explore and explain, in terms of biophysical and socio-economic characteristics, the dynamics and diversity among homegardens in the Cagayan Valley. The underlying reason for addressing this objective is to determine whether there is need and potential for (more) species diversification and higher production, as a first glimpse at these gardens suggest. Specific attention will be paid to the proportion of tree and non-tree crop components and the relative importance of subsistence versus commercial crops. Likewise, the study will investigate whether differences in homegarden characteristics are related to distinct diversification in various land use zones, i.e., the remote uplands with a mixture of forest and shifting and semi-permanent agriculture, the hilly grasslands with extensive livestock grazing and increasing mono-cropping of corn and rice and the more accessible lowlands with intensive agriculture. In summary, the following questions will be addressed:

- What types of village homegardens occur in the Cagayan Valley and how do these compare with homegardens elsewhere in Southeast Asia, in terms of tree and non-tree components, species diversity, structure, crop combinations, management, farm activities outside village, and function?
- Do different types of homegardens represent levels of diversification and/or specialization within specific land use zones, i.e., the upland, the hilly grassland and the lowland zones?
- How are homegardens related to cultivated fields outside villages? Are changes in the management of outside farms in specific land use zones also reflected in the homegardens, in terms of species choice and diversity, ratio of tree and non-tree components, and plant densities?
- Is there a gradual change in farmers' main reasons for homegarden cultivation and management when moving from the remote upland zone to the accessible lowlands?

2.2 Methodology

This chapter presents a study of tree-based homegardens in five villages in the Cagayan Valley in Northeast Luzon. The villages are located in three distinct, but neighboring, zones extending in North-South direction: Moldero (Tumauini) and Malibabag (Peña Blanca) in the lowland zone, Namnama (Tumauini) and Baliuag (Peña Blanca) in the intermediate zone of grassland hills and Dy Abra (Tumauini) in the upland zone bordering the Sierra Madre mountain range (see Figure 16.1 in Chapter 16, this volume). The villages differ in accessibility (distance/travel time) to the main markets in the provinces of Isabela and Cagayan (see Table 2.2). A total of 57 homegardens were investigated by means of field observations and measurements, including species identification and individual plant counting.

The households and their respective homegardens were selected at random using population lists: 24 in the lowland villages (the total investigated homegarden area: 14,357 m^2 and 12,829 m^2 for Moldero and Malibabag respectively), 20 in the hilly grassland villages (7,197 m^2 and 8,158 m^2 for Namnama and Baliuag) and another 13 in the upland village (17,005 m^2). Because most homegardens are equally small in size, no distinction was made into different size classes. Of the 57 gardens, 88 percent are less than 0.2 ha. The remaining ones range from 0.24 to 0.38 ha, with each village sample including one garden of this size except for the Dy Abra sample that contains two (for comparison: Peyre et al. 2006 classify homegardens of 0.40 ha or less as "small-sized" and those of 0.72 ha on average as "medium-sized").

Species composition, plant densities and vegetation structure were investigated, including only those species – whether planted or spontaneously growing – that in one way or the other are used by the homegarden cultivators. Seedlings and young trees 50 cm or more in height were also recorded but only included for species richness determination. Ornamental plants were counted but not identified by scientific name and only used for determining differences in plant density between villages. The same single analysis was applied to the livestock data.

Table 2.2 Descriptive information on the study sites and farmers' households (a) and the land use and tenure characteristics (b) in the lowland and upland villages in Northeast Luzon, the Philippines

(a)

Site and household characteristics	Lowlands (150–600 persons km^{-2})		Hilly lowlands (50–150 persons km^{-2})		Uplands (5–50 persons km^{-2})
	Moldero n = 14	Malibabag n = 10	Namnama n = 10	Baliuag n = 10	Dy Abra n = 13
Altitude (m.a.s.l.)	15–25	30–40	50–60	50–60	100–120
Distance to highway (km)	3.3	11	7.8	6.5	15
Members per household	4.9 (2.8)a[a]	7.7 (3.7)b	7.2 (3.0)b	5.8 (2.5)ab	5.6 (2.6)a
Age of homegarden (years)	37 (16)a	38 (22)a	22 (12)b	18 (12)bc	14 (4)c
Homegarden area[b] (m^2)	1026 (782)ac	1283 (967)a	720 (806)b	816 (663)bc	1308 (970)a
Total farm area[c] (ha)	0.73 (0.75)a	1.17 (0.72)b	1.53 (1.03)b	1.65 (1.50)b	2.28 (1.20)c
Large mammals[d]	5 (12)	7 (8)	2 (2)	3 (3)	7 (5)
Small mammals[d]	1 (2)	2 (1)	1 (1)	1 (2)	2 (1)
Fowl[d]	4 (4)	13 (11)	6 (6)	4 (4)	7 (7)

[a] average and standard deviation and values followed by the same letter are not significantly different at 0.05 level

[b] including house and compound; the area of the house with compound is 129 m^2 on average

[c] referring to the total area cultivated by a farmer's household excluding the homegarden area

[d] large mammals: carabao, cow, pig, sheep, goat, horse; small: cat, dog, rabbit; fowl: chicken, duck, goose, turkey, dove (b)

(b)

Land use and tenure characteristics	Number of households (%)				
	Lowlands		Hilly lowlands		Uplands
	Moldero n = 14	Malibabag n = 10	Namnama n = 10	Baliuag n = 10	Dy Abra n = 13
1. Main income from farming	71	50	60	70	31
Major cash products of household:					
Rice/Corn/Tobacco[a]	0/86/64	0/0/0	20/50/0	20/60/0	31/92/0
Livestock[b]/Vegetables[b]/Fruit[b]	14/64/43	90/30/30	40/10/10	80/30/30	67/17/17
Timber	0	0	0	0	54[c]
2. Land tenure arrangement for homegarden – farms:					
Private (titled land)	100–43	80–50	80–70	30–40	31–31
Paying tax, land reform[c]	0–7	10–0	20–0	0–0	31–0
CSC[d] contract	0–0	0–20	0–10	0–20	7–77
Tenancy	0–54	10–20	0–20	20–50	0–15
Squatted land/no land/hired labour	0–14	0–40	0–10	30–10	31–0
Other[d]	0–7	0–0	0–30	20–0	0–8

n = sample size

[a] produced on farm field usually outside village

[b] produced in homegarden; livestock sales in Malibabag, Namnama and Baliuag concerns pigs and in Dy Abra goats and carabaos; vegetables and fruits correspond to, respectively, the non tree crops and the tree crops in Table 5

[c] six of the seven farm households in total earn cash income by (illegally) hauling and logging trees from the natural forest whereas the remaining household only harvests its timber from a *Gmelina arborea* plantation

[c] land in process of being titled, mainly through land reform, i.e., land property rights will be transferred from land lord to tenant farmer

[d] Certificate of Stewardship Contract (CSC) issued for twenty five years and renewable for another twenty five years

[d] Mortgage, leasehold, rent, buying land from owner

For species abundance, three categories are distinguished: (1) low abundance where species are observed only once or twice and did not cover much of the garden area, (2) medium abundance where several plants are recognized but covered less than one fourth of the garden area, and (3) high abundance where many plants occurred or covered more than one fourth than the garden area. The Shannon-Wiever index was calculated to analyze the diversity of homegardens for each study village with $H' = -\Sigma (p_i \ln p_i)$, where p_i is the proportion of the occurrence of species in a study village (expressed as a proportion of the total species occurrence N; Kent and Cocker 1992). From that, the Equitability or Evenness was calculated by $E = H'/H'max$, with $H'max = \ln s$ and where s is the number of species, to estimate the homogenous distribution of plants in homegardens. Finally, the Whittaker's β diversity index was calculated to identify the differences in species composition between plots within upland and lowland villages, using the following formula (Coffey 2002): by $\beta = S/\alpha - 1$, where S is the total number of species in the homegarden sample and α is the average number of species in each subsample.

Semi-structured interviews were conducted to obtain information about plant use, management and planting practices, economic benefits, reason for keeping a homegarden and the cultivators' perception on major constraints in homegardening. A list with 30 major reasons for having a homegarden was composed on the basis of reasons spontaneously referred to by farmers in the field. Interviewees were asked to select the ten most important reasons and to rank these from 10 (most important) to 1 (least important). After completing the interviews, the average rank scores for the ten most important reasons were identified for each village.

Differences among village means for various site and household variables, plant density, evenness, and the Shannon and Whittaker indices were determined by using the non-parametric multiple comparison analysis described by Neter et al. 1996. In order to identify different types of homegardens based on species combinations, a hierarchical cluster analysis was performed with the complete linkage (furthest neighbor) method and the chi-square as distance or similarity measure. Species density (i.e., the number of individuals per species per unit area) was used as main variable in the analysis. For the trees and non-tree species (the latter group including *Musa* sp.), the analysis was made separately given the large differences in species densities between the two groups.

2.3 Study Site and Household Characteristics

The villages are situated in the moist agro-climatic zone with an annual rainfall of 1,500 to 2,500 mm spread over a growing season of seven to eight months. The dry season extends from January up to May or June. The upland village Dy Abra is located in the least densely populated zone (<50 persons per km^2; NSO 2001), along the forest frontier and partly surrounded by hilly grassland and cultivated fields. It is the most remote village among the five, with a travel time of at least one hour to the nearest major (Tumauini) market (Table 2.2). During the wet season, the village is regularly inaccessible because of damaged bridges. The village, with 115 households the smallest of the five, is composed of *Tinguian* families who migrated from the uplands in Abra province from the late 1970s onwards. Many homegardens are relatively young (Photo 2.1), i.e., being established 14 years ago on average (Table 2.2). The garden area is 0.13 ha, i.e., about six percent of the average total farm size of 2.28 ha. Only 31 percent of the farmer respondents have their homegarden and residential lot as private property. Another 31 percent are in the process of acquiring the land (tax payers), whereas yet another 31 percent occupy the land as squatters. Most of the farm land outside the village is cultivated within the framework of an integrated social forestry program. Participants of this program received a certificate of stewardship (CSC) status, meaning the land can be utilized for a period of 25 years, after which the agreement can be extended. Most farmers, 92 percent of those interviewed, use their farms for corn cultivation, whereas another 31 percent cultivate rice every season or in rotation with corn. Moreover, families use a part of the forest for kaingin (shifting cultivation) and timber collection.

The lowland villages Moldero and Malibabag (>300 households per village) are located in the most densely populated zone (150 to 600 persons per km^2; NSO 2001), on the fertile plains of the Cagayan and Pinacanauan de Tuguegarao rivers respectively. Moldero is located along a dirt road at about 3 km distance from the national highway leading to the nearest (Tumauini) market. Malibabag is located along a tarmac road but at a distance of about 11 km from the national highway leading to the regional capital Tuguegarao. Most farmers belong to the group of autochthonous inhabitants of the valley plains, i.e., the *Ibanag*, which means “from the river” referring to their original homeland along the banks of the Cagayan River. The oldest homegardens are found in these villages, some being established more

Photo 2.1 Characteristic homegarden in the Dy Abra uplands in Isabela Province, the Philippines (©DJ Snelder)

Photo 2.2 Ornamental plants within a mixed lowland homegarden in Isabela Province, the Philippines (©DJ Snelder)

than 70 years ago (Photo 2.2). The gardens and residential lots are almost all privately owned and have an average size of 0.10 and 0.13 ha for, respectively, Moldero and Malibabag (i.e., 14 and 11 percent of the average total farm areas; Table 2.2). The tenure status of surrounding farms is rather different: only half, or even less, of all households interviewed has property rights over at least one of their farms (Table 2.2). Other farms are under a tenancy arrangement (54 percent of the households in Moldero), squatted or cultivated by hired laborers. Most farmers in Moldero acquired their farms through land reform in the 1970s and late 1980s. Yet in most cases, land reform was not fully completed. Tenants are still giving one third of their harvest to their (former) landowner. The farms are used for seasonal cash crops, i.e., monocultures of corn and tobacco. Sometimes rice is cultivated for home consumption, whereas homegarden vegetables and fruits also serve as cash crops. In Malibabag, livestock is the main cash-generating product, followed by fruits and vegetables, all mainly produced in the homegarden systems (Photo 2.3). Rice and corn are planted on farms and solely serve for home consumption.

The villages Namnama and Baliuag (200 to 300 households) are both located in the middle of the hilly grassland zone (population density: 50 to 150 persons per km^2; NSO 2001). They are connected to major markets (in Tumauini and Cabagan respectively) along the national highway by a mixed dirt-gravel road of 6 to 8 km long. The households belong to a migrant mixture of Tinguian, Ibanag, and Ilocano ethnic groups, with the first families settling down in 1956 (Baliuag) or earlier (Namnama). Compared to the other villages, Namnama and Baliuag are intermediate in terms of geographic location, altitude, population density, household numbers, accessibility, total farms size, and age of homegardens (Table 2.2). There is, however, one exception: the homegardens are smallest at these sites, having an

Photo 2.3 Integration of cattle in a lowland homegarden in Moldero in Isabela Province, the Philippines (©DJ Snelder)

average size of 0.07 and 0.08 ha. Most homegardens in Namnama are privately owned, and a substantial number of households (70 percent of total) has at least one farm as private property. The tenure conditions for the homegardens in Baliuag are comparable to those in Dy Abra, with only 30 percent of the households owning their garden lot and another 30 percent occupying their lot as squatters. The distribution of tenure arrangements for the farms in Baliuag is however similar to those in Moldero: 40 percent of the households own at least one farm, 50 percent have a tenancy arrangement and another 10 percent just occupy one or more lots. Finally, corn serves as major cash crop for at least 50 percent of the interviewed farmers in both villages. Livestock, vegetables, rice and fruits are also sold at the market but, except for livestock, by less than 50 percent of the households.

2.4 Homegarden Characteristics

When seen from the air, the village homegardens in the Cagayan Valley can be easily identified by their relatively high density of trees and their appearance as (man-made) forest islands in a "sea" of agricultural land. Yet, when wandering within these forests on the ground, it becomes clear that they are not solely composed of trees but comprise various components, i.e., a residential area with a bare yard, tree and non-tree crops, livestock and ornamental plants. The sea of farmland (i.e., the "outside farms") surrounding the gardens are mostly used for monocultures of cash crops and staple food (i.e., corn and rice) but when moving from the lowlands into the uplands mixed subsistence cropping and livestock grazing are also practiced on outside farms.

2.4.1 Homegarden Components

Residential area: A homegarden covers a residential lot with adjacent garden field(s) cultivated by a family composed of one, or sometimes two or three (e.g., parents and grown-up children), households. Except for a few trees (particularly *Mangifera indica*) providing shade, the yard just around the bamboo or concrete house is kept bare and serves as a play ground and place for relaxation, handicraft, processing of crops, and other activities. Aside from a house and bare yard, the homegardens in all villages contain one or more of the following components: store house (on poles where close to river), water pump, bath area, toilet, shed(s) for livestock, concrete platform for drying corn and rice, fishpond, compost pit, fences, cultivated field, and orchard.

Tree and non-tree crop components: A diversity of trees, shrubs and herbaceous plants providing food, medicine, fodder, fuelwood, fence material and timber are found in and around the residential area with yard and houses, as will be discussed in detail at a later stage in this paper.

Livestock component: Households often keep some livestock (Table 2.2) for consumption during special occasions and selling during times of shortage or whenever cash is needed for medicinal or other expenditures. Carabao is kept for plowing wet rice fields and transporting goods and, in the upland village, for hauling of (illegal) logs. Cattle is used for plowing dry fields and, like carabao, sold for meat when needed. Few households have a fish pond in their garden. Meat, eggs and fish are only consumed once a week or on special occasions when money is available.

Ornamental plants: A border with common ornamental plants, including orchids, can be found in almost every garden. In addition, ornamentals are often used in hedgerow fencing, such as, *Hibiscus rosa sinensis*, *Ixora* sp., *Dracena* sp., *Codiaeum* sp., and *Duranta repens*. The most common ornamental plants encountered in this study are described by Madulid (2000).

2.4.2 Tree and Non-tree Crops: Species Diversity and Structure

A total of 155 different plant species (see Table 2.3) are identified, including 71 different tree species, all of which are being used – in one way or the other – by the homegarden cultivators. If including ornamental plants, the total number of species will increase up to at least 312.

The most abundant tree crop species are fruit trees such as mango (*Mangifera indica*) and guava (*Psidium guajava*), leafy vegetable trees like horse raddish (*Moringa oleifera*) and *Broussonetia luzonica*, multipurpose trees like coconut (*Cocos nucifera*) and the timber tree *Gmelina arborea* (see also Table 2.6). Favorite food and vegetable crops are banana (*Musa* sp.), eggplant (*Solanum melongena*), tuber crops like taro (*Colocasia esculenta*) and sweet potato (*Ipomea batata*), and

Table 2.3 Used plant species in homegardens of upland and lowland villages in Northeast Luzon, the Philippines

Species	Species presence (%)		Abundance[a]		Local name	Family	Strata[b]
	Upland	Lowland	Upland	Lowland			
Fruits							
Ananas comosus	4	4	M	M	Pina	Bromeliaceae	H
Annona muricata	27	16	M	M	Guyabano	Annonaceae	LT
Annona squamosa	7	32	L	M	Atis, atti	Annonaceae	LT
Antidesma bunius	0	21		M	Bugnay, vunnay	Euphorbiaceae	LT
Artocarpus heterophyllus	40	47	M	M	Langka, nangka	Moraceae	TT
Averrhoa bilimbi	0	16		M	Piyas, kamiyas	Oxalidaceae	LT
Averrhoa carambola	0	32		M	Balimbing, granatis	Oxalidaceae	LT
Carica papaya	67	77	M	M	Papaya	Caricaceae	LT
Chrysophyllum cainito	13	37	L	M	Kaimito	Sapotaceae	TT
Citrullus vulgaris					Sandiya	Cucurbitaceae	V
Citrus aurantifolia	0	11		L	Dalayap	Rutaceae	LT
Citrus medica	7	0	L		Cidro, sidra(s)	Rutaceae	LT
Citrus grandis	93	68	H	M	Lubban, lukban	Rutaceae	LT
Citrus microcarpa	60	47	M	M	Kalamansi	Rutaceae	LT
Citrus reticulate	7	5	L	L	Dalangita	Rutaceae	LT
Citrus sinensis	0	16		M	Kahel	Rutaceae	LT
Cordia dichotoma					Anonó	Boraginaceae	TT
Diospyrus discolor					Mabolo	Ebenaceae	TT
Lansium domesticum	7	0	L		Lanzones	Meliaceae	TT
Mangifera indica[c]	80	74	H	H	Mangga	Anicardiaceae	TT
Morus alba	7	0	L		Kamoras, mora	Moraceae	TT
Musa sp. [d]	67	84	M	H	Saging, dupo	Musaceae	LT
Muntingia calabura	7	0	L		Manzanitas	Elaeocarpaceae	LT
Nephelium lappaceum	0	5		L	Rambutan	Sapindaceae	LT
Passiflora foetida	7	X	L	L	Masaflora, sipsip ibon	Passifloraceae	V
Persea Americana	27	42	M	M	Abokado	Lauraceae	LT
Phyllantus acidus	0	16		M	Karamay	Euphorbiaceae	LT

(continued)

Table 2.3 (continued)

Species	Species presence (%)		Abundance[a]		Local name	Family	Strata[b]
	Upland	Lowland	Upland	Lowland			
Pouteria campechiana	7	32	L	M	Chesa, tiesa	Sapotaceae	LT
Psidium guajava[e]	53	84	M	H	Bayabas, bayabo	Myrtaceae	LT
Sandoricum koetjape	0	26		M	Santol, santor	Meliaceae	TT
Spondias purpurea	0	32		M	Sineguewelas	Anacardiaceae	TT
Syzygium cumini	13	16	L	M	Lomboy, duhat	Myrtaceae	TT
Tamarindus indica	7	32	L	M	Sampalok, salamagi	Leguminosae	TT
Vegetables							
Abelmoschus esculentus	33	42	M	M	Okra, salyot	Malvaceae	H
Allium cepa	13	16	L	M	Lasona, lasuna	Alliaceae	H/P
Allium porrum	0	11		L	Leek	Alliceae	P
Allium tuberosum	7	16	L	M	Kutsay	Alliceca	P
Amaranthus viridis[f]	7	16	L	M	Kalunay, colitis, alay	Amaranthaceae	H
Amaranthus spinosus	7	5	L	L	Kuwanton, inassi	Amaranthaceae	H
Basella alba	7	16	L	M	Alogbati, cubay	Basellaceae	V
Benincasa hispida	20	0	M		Kandol	Cucurbitaceae	V
Brassica chinensis	20	11	M	L	Petsay, pakchoi	Cruciferae	H
Brassica juncea	7	11	L	L	Mostasa	Cruciferae	H
Broussonetia luzonica	7	63	L	M	Himbabao	Moraceae	LT
Cajanus cajan	13	0	L		Kardis	Leguminosae	LT
Corchorus olitorius	7	5	L	L	Saluyut, salayo	Liliaceae	H
Cucumis sativus	0	16		M	Pepino	Cucurbitaceae	V
Cucurbita maxima	87	42	M/H	M	Kalabasa	Cucurbitaceae	V
Ficus benguetensis	0	11		L	Panpan	Moraceae	LT
Ipomea aquatica	0	5		L	Kangkong	Convovulaceae	H
Lablab purpureus[g]	20	21	L	L	Batao, bataw, basau,	Leguminosae	V
Lycopersicon esculentum	13	47	L	M	Kamatis, kamasi	Solanaceae	H
Momordica charantia	60	58	M	M	Ampalaya, afafe	Cucurbitaceae	V

Moringa oleifera	60	79	M	M	Marunggay	Moringaceae	LT
Oriza sativa[h]	X	0	L		Palay	Poaceae	H
Phaseolus lunatus	7	11	L	L	Patani, gulipatan	Leguminosae	V
Phaseolus vulgaris	7	11	L	L	Bitsuwelas	Leguminosae	V
Psophocarpus tetragonolobus	20	21	M	M	Amale, sigarilyas	Leguminosae	V
Raphanus sativus	7	0	L		Rabanos, labanos	Cruceferae	H
Solanum melongena	93	84	H	H	Tarong	Solanaceae	H
Souropus androgynus	0	21		M	Chinese malunggay	Moringaceae	S
Vigna sesquipedalis	47	16	M	M	Agaya, anta	Leguminosae	V
Zea mays	13	0	L		Mais	Poaceae	S
Roots and tubers							
Alocasia cucullata	7	5	L	L	Gabi China	Araceae	S
Alocasia macrorrhiza	7	16	L	M	Biga, galayang	Araceae	S
Amorphophallus campanulatus	0	5		L	Pungapung, bagabag	Araceae	S
Colocasia esculenta	73	68	H	H	Gabi, taro, awa	Araceae	H
Dioscorea alata	20	21	L/M	L/M	Ube, ubi	Dioscoreaceae	V
Ipomoea batatas	33	21	L/M	L/M	Kamote, kamosi	Convolvulaceae	H
Manihot esculenta	13	42	L	M	Kahoy, kasaba	Euphorbiaceae	S
Solanum tuberosum	0	5		L	Patatas	Solanaceae	H
Fibres							
Ceiba pentandra	27	21	M	M	Kapas, Daddal	Bombaceae	TT
Saccharum spontaneum	40	42	M	M	Sikal, talahib	Poaceae	S
Musa textilis					Abaka	Musaceae	LT
Multipurpose plants							
Bambusa sp.[i]	13	37	L	M	Kawayan, k.kiling	Poaceae	LT
Caryota cumingii	7	0	L		Anibong	Aracaceae	TT
Cocos nucifera	93	84	H	H	Niyog, inyug	Aracaceae	TT
Corypha elata	7	0	L		Bori palm, buri	Aracaceae	LT
Samanea saman	7	0	L		Akasya, rain tree	Leguminosae	TT

(continued)

Table 2.3 (continued)

Species	Species presence (%)		Abundance[a]		Local name	Family	Strata[b]
	Upland	Lowland	Upland	Lowland			
Timber–Fuelwood–Fence							
Acacia auriculiformis	7	0	L		Auri	Leguminosae	LT
Albizia procera	7	0	L		Akleng parang	Leguminosae	TT
Antidesma ilocanum	7	0	L		Arosip	Euphorbiaceae	LT
Calophyllum sp.	0	5		L	Bitaog	Guttiferae	TT
Delonix regia	0	7		L	Fire tree	Leguminosae	TT
Ficus benjamina	7	0	L		Balete, gisi	Moraceae	TT
Gmelina arborea	73	58	H	M	(G-)Melina	Verbenaceae	TT
Leucena leucocephala	13	33	L	M	Ipil ipil	Leguminosae	LT
Macaranga tanarius	13	5	L	L	Samac, samar	Euphorbiaceae	LT
Mallotus philippinensis	7	0	L		Banato	Euphorbiaceae	TT
Melanolepis multiglandulosa	33	42	M	M	Alim, alam	Euphorbiaceae	LT
Nauclea orientalis	13	0	L		Bulala	Rubiaceae	TT
Phitecellobium dulce	0	21		M	Kamatsili	Leguminosae	TT/LT
Polyscias nodosa	0	5		L	Malapapaya	Araliaceae	LT
Pterocarpus indica	27	11	M	L	Narra, Antagan	Leguminosae	TT
Swietenia macrophylla	7	0	L		Mahogany	Meliaceae	TT
Tectona grandis	7	0	L		Teak	Verbenaceae	TT
Trema orientalis					Agandung	Ulmaceae	TT
Vitex parviflora	13	0	L		Sagat, molave	Verbenaceae	TT
Shade–Fence							
Alstonia scholaris	7	0	L		Dita, bakja	Apocynaceae	TT
Antidesma pentandrum	53	21	M	M	Bignay-pugo	Euphorbiaceae	LT
Gliricidia sepium	27	32	M	M	Kakawate, madre-de-cacao	Leguminosae	LT
Sterculia cordata					Ubiyan	Sterculiaceae	TT
Streblus asper	7	5	L	L	Kalios, Balaiking	Moraceae	LT
Terminalis catappa	0	11		L	Talisay	Combretaceace	LT

Beverage–spices–stimulants							
Areca catechu	7	11	L	L	Bunga, bua	Palmae/Arecaceae	TT/LT
Bixa orellana					Achote	Bixaceae	LT
Capsicum annuum	20	16	M	M	Makopa, bilog	Solanaceae	S
Capsicum frutescens	40	53		M	Amiling	Solanaceae	S
Coffea arabica	27	5	M	L	Kape	Rubiaceae	LT
Curcuma domestica	0	5		L	Dalaw, tumeric	Zingiberaceae	H
Cymbopogon citratus	7	11	L	L	Barani	Poaceae	H
Nicotiana tabacum	13	0	L		Tabako	Solanaceae	H
Pandanus spp.	7	5	L	L	Pandan	Pandanaceae	S
Piper betle	7	5	L	L	Gok,, gawid	Piperaceae	V
Piper nigrum	0	5		L	Pamienta	Piperaceae	V
Saccharum officinarum	40	42	M	M	Tubo, una(s)	Poaceae	S
Theobroma cacao	7	11	L	L	Kakaw	Sterculicaea	LT
Zingiber officinale	756	26	L	M	Laya, luya	Zingiberaceae	H
Medicine–fence							
Artemisia vulgaris	0	7		L	Erbaka	Compositae	H
Azadirachta indica	5	7	L	L	Neem	Meliaceae	LT
Blumea balsamifera	7	0	L		Subusub, sambong	Compositae	S
Blumea virens	7	0	L		Payokpok	Compositae	H/S
Cassia alata	13	0	L		Andadasi	Leguminosae	S
Chromolaena odorata[h]	X	0	X		Hagonoy	Compositeae	S
Euphorbia hirta	7	0	L		Subi subi	Euphorbiaceae	H
Ficus septica	13	5	L	L	Hawili, liliyaw	Moraceae	S
Helicteres angustifolia[h]	X	0	X		Magmaga	Sterculiaceae	H
Heliotropium indicum[h]	X	X	X	X	Araritus	Verbenaceae	H
Hyptis suaveolens	7	0	L		Bangbangsit	Labiatae	S/H
Jatropha curcas	16	26	M	M	Tawwa tawwa	Euphorbiaceae	LT/S

(continued)

Table 2.3 (continued)

Species	Species presence (%)		Abundance[a]		Local name	Family	Strata[b]
	Upland	Lowland	Upland	Lowland			
Kaempferia galanga	0	5		L	Disul, disol	Zingiberacea	H
Leucas lavandulifolia	7	0	L		Irbaka, kaskasumba	Lamiaceae	H
Melastoma affine[h]	X	X	X	X	Tungaw-tungaw	Melastomataceae	S
Mentha arvensis	0	5		L	Erba	Labiatae	H
Morinda citrifolia	0	16		M	Apatot	Rubiaceae	LT
Premna odorata	7	X	L	L	Alagaw, abgaw	Verbenaceae	LT
Sanserviera trifasciata		0			Dila dila	Agavaceae	H
Vitex negundo	13	11	L	L	Dangla, lagundi	Verbenaceae	LT
Wrightia pubescens	7	0	L		Lanuti, lanete	Apocynaceae	LT
Other							
Ficus ribes (feed)	7	5	L	L	Tibeg	Moraceae	
Ipomea triloba (feed)[h]	X	X	X	X	Marakamote kalamitang	Convolvulaceae	V
Pennisetum purpureum (feed)					Buntot-pusa, napier grass	Gramineae	H
Semecarpus cuneiformis (instecticide)	7	0	L		Ligas, kamiring	Anacardiaceae	TT

[a] abundance of species found in the homegardens: L = low (species observed only once or twice and covering very small part of homegarden), M = medium (species observed several times but covering less than one fourth of the garden area), H = high (species observed many times and covering more than one fourth of the garden area), X = present (species, often weedy plants, observed but not counted)

[b] position of plant in canopy stratum predominated by Tall Trees (TT; >5.00 m), Lower Trees (LT; 1.50–5.00 m), Shrubs (S; 0.75–1.50 m); herbaceous plants (H; 0–0.75 m), vines or climbing plants (V), or in pots on compound (P)

[c] including the native or carabao variety and the Indian and Hawaiian varieties

[d] including various cultivars Damilig, Manila, Gaddato, Tokul, Lakatan, Tordan, Dipig, Camarine, Costa, Bendito

[e] including the native variety with regularly sized fruits and a cultivar with extra large fruits, i.e., “guapol”

[f] Syn. *A. gracilis*

[g] Syn. *Dolichos lablab*

[h] species not planted but growing naturally and often considered a weed

[i] including *B. spinosa* (kawayan) and *B. vulgaris* (kawayan killing)

spices and condiments such as hot pepper (*Capsicum frutescens*). Eggplant is one of the most favorite crops because it can be harvested every three days during a long period of time providing both food and some cash income. The homegarden further supplies all sorts of green leafy vegetables like pechay (*Brassica chinensis*), mustard (*Brassica juncea*), amaranth (*Amaranthus viridus* and *Amaranthus spinoza*) and leaves of vegetables like bitter gourd and sweet potato and flowers of squash (Table 2.3), all of which are species typically used throughout the year and often bartered with neighbors. They form a good source of vitamins (Villareal et al. 1979; PCARRD 1988; Rasco and Maghirang 1989). It should further be noticed that many of the apparently useless weeds have a medicinal value, although not always practiced as such by farm households.

Homegardens contain up to five structural layers or canopy strata (Photo 2.4). The highest (>5.0 m) canopy stratum is composed of about six tree crop species including mango, jackfruit (*Artocarpus heterophyllus*), paper tree (*Gmelina arborea*) and coconut (see also Table 2.3). A larger number of crop species (at least 61) can be found in the second stratum (1.5–5.0 m), including banana, horseradish, guava, and also the younger trees of the first canopy stratum. The third stratum (0.75–1.50 m) includes at least 42 non-ornamental species and is composed of hedgerow species like pruned tawwa-tawwa (*Jathropha curcas*), madre de cacao (*Glidricidia sepium*) and alim (*Melanolepsis multiglandulosa*), but also of crops like hot pepper and several ornamental shrubs. The fourth stratum mainly consists of climbing vegetables (at least 24 species) like beans, gourds, squash and alugbati (*Basella alba*). Vegetables, like eggplants, tuber crops, and herbal plants (at least 140 species, including herbal weeds) form the lowest (<0.75 m) vegetation stratum. Cans planted with spices and seedlings

Photo 2.4 Differential vegetation layers in a lowland homegarden in Isabela Province, the Philippines (©DJ Snelder)

are also common in the lowlands, but are less frequently in the upland village. Overlap between the different strata is often limited to a small part in the back of the homegarden where trees and shrubs form a natural boundary.

2.4.3 Differentiation of Tree and Non-tree Crop Combinations

Six types of tree and non-tree crop combinations can be identified on the basis of a hierarchical cluster analysis performed with data of all homegardens in this study (Table 2.4a). For the tree crops, a distinction can be made between the fruit-tree based mixtures of mango with either papaya or guava as key species (Type 1 and 2) and the vegetable-tree mixtures with *Moringa oleifera* (horse raddish) as single key species (Type 5) or with papaya (Type 4) or the timber tree *Gmelina arborea* (Type 3) as second key species.

The joint occurrence of tree- and non-tree crop mixtures within homegarden fields and the distribution of different types of combinations are shown in Table 2.4b. Only 10.5 percent of all homegardens have solely trees, i.e., thus lack seasonal vegetables and tuber crops (sum of non-tree crop combination Type 7 in Table 2.4b). Another 22.8 percent is composed of a true mixture of both tree and non-tree crops (no dominant species; Type 6 x Type 6 in Table 2.4b), whereas about 25.6

Table 2.4 Different types of tree and non-tree crop combinations (a) as identified by hierarchical cluster analyses, (b) their relative distribution (in percentage) per site and (c) their joint occurrence (in percentage) for all homegardens at the village study sites in Northeast Luzon, the Philippines

(a) Species	Type of crop combination					
	1	2	3	4	5	6
I Trees:						
Moringa oleifera	X	X	V	V	V	X
Cocos nucifera	X	X	X	X	X	X
Annona squamosa	X			X		X
Carica papaya	F			F	X	X
Citrus grandis				X		X
Mangifera indica	F	F				X
Psidium guajava	X	F	X	X		X
Gmelina arborea	X	X	Ti			X
II Non-trees:						
Ananas comosus				X		X
Musa sp.	X	X	F	X	X	X
Abelmoschus esculentus	X					X
Solanum melongena	V	V	V	X	X	X
Phaseolus vulgaris		X		X		X
Colocasia esculenta	Tu	X	X	T	X	X
Ipomoea batatas		T		X	T	X
Manihot esculenta		X				X
Capsicum frutescens		X	X		X	X
Zingiber officinale	S					X

F, V, Ti, Tu, S: fruit, vegetable, timber, tuber or spice crop as dominant (key) species, always present in indicated mixture

X: species not always present in indicated mixture

(b)

		Tree crop combinations[a]					
		1	2	3	4	5	6
Non tree crop combinations[a]	1	1.8[b]	3.5	0	3.5	0	0
	2	0	3.5	3.5	0	0	3.5
	3	1.8	0	0	1.8	5.3	5.3
	4	1.8	1.8	1.8	3.5	0	1
	5	1.8	1.8	1.8	3.5	0	0
	6	1.8	3.5	0	3.5	7.0	22.8
	7	0	0	3.5	0	0	7.0

[a] Tree/non-tree crop combinations 1–5: at least one tree crop or one non-tree crop species predominates (see under a);
Tree/non-tree crop combination 6: true mixture of tree crop or non-tree crop species (see under a);
Non-tree crop combination 7: no non-tree crops present (i.e. only trees).
[b] data presented as a percentage; n = 57.

(c)

Type of crop combination	Lowlands		Hilly lowlands		Uplands
	Moldero n = 14	Malibabag n = 10	Namnama n = 10	Baliuag n = 10	Dy Abra n = 13
Tree crops					
1	7	10	10	10	0
2	14	0	50	0	8
3	7	10	0	40	0
4	22	60	0	0	0
5	14	10	20	10	8
6	36	10	20	40	84
Non-tree crops					
1	22	0	10	0	0
2	7	10	10	20	8
3	42	10	0	10	0
4	0	20	20	10	0
5	0	40	10	0	8
6	22	20	50	60	84
7 (None)	7	0	0	0	8

percent is dominated by one or more species among either the trees (tree-based system Type 1 to 5 with some vegetable or tuber species, i.e., Type 6 non-tree crop combination) or the non-tree crops (vegetable and/or tuber-based system Type 1 to 5 with some tree species, i.e., Type 6 tree crop combination). The remaining 42.4 percent is characterized by a predominance of at least one tree crop and one non-tree crop species (remaining combinations).

The trees and non tree crops are not necessarily planted in one mixture on the same field, as in intercropping systems. Most trees are actually planted along boundaries or in garden sections specifically reserved for trees. Few farmers plant trees within fields with non-tree crops like eggplant, squash (*Cucurbita maxima*), cassava (*Manihot esculenta*) or pineapple (*Ananas comosus*), except when fields will be converted into a pure tree plantation at a later stage. Trees provide shade and will increasingly hamper the production of crops grown underneath as their crown canopy develops. Himbabao (*Brouzonettia luzonica*) and in particular horseradish (*Moringa oleifera*) are exceptions because the leaves of these trees are regularly harvested and eaten and their branches trimmed, which limits their crown and, hence, allows the growth of sun-loving crops. Moreover, the growing of these trees in single stands and at sunny sites will speed up the recovery of their harvested crown. Likewise, coconut (*Cocos nucifera*), with its rather "sun-transparent" crown, and banana (*Musa* sp.), with its tree-like appearance, are observed in vegetable fields, being planted at wide spacing.

2.4.4 Management Aspects

The majority of the farmers practice two planting seasons, or even continuous planting, for vegetable crops. Tree seedlings and ornamental plants are usually watered during the dry season (i.e., in the afternoon or sometimes also in the morning).

Most farmers (except for those engaged in logging) derive virtually all cash income from the agricultural cash crops grown on outside farms (Table 2.2b). An important implication is the seasonality and the variation of production of these crops and, hence, the irregular cash flow. The latter is generally limited to one or two months per year (i.e., March and September), depending on the quality and quantity of harvests per annum. In this context the homegarden products are a valuable source of supplemental income during the rest of the year, given excess yield is within reach. The mixtures of fruit trees are often selected in such as way that they provide fruits throughout the year, with a peak in the dry season when the yields of the seasonal cash crops are lowest.

Planting materials are acquired in several ways, i.e., by gathering and drying seeds from previous harvest or purchased crops (self-production), by gathering seeds or seedlings from wild stands (self-production), by exchange with neighbors, family and friends, by purchasing certified seeds from a shop or the market, and by free distribution through governmental and non-governmental programs. In addition to the seed and seedlings specifically bought or gathered for planting in the homegarden, excess seed and seedlings of outside farms are also utilized in the homegarden.

The majority of the non-tree crops, particularly vegetables, are grown in direct sunlight on clearly marked fields close to or on the yard and every little spot receiving enough sunlight during the rainy season. Plants that are regularly watered are preferably grown closely together. Trees are mainly kept along boundaries, with the exception of some species as explained earlier in this paper.

Fertilizers are mainly applied to non-tree crops, tree seedlings and ornamental plants in the form of manure. Manure is added three times in some cases, i.e., just after planting, during the growing season, and at the time that plants are bearing fruit. In some cases, vegetables are planted on a former kraal or livestock resting place. A compost pit is also present in most homegardens but its content often contains, in addition to a mixtures of plant residues, manure and degradable kitchen waste, non-degradable waste materials such as tins, plastic bags and bottles. Moreover, the content is usually burned and the ashes only sometimes applied to seedlings, vegetable beds and ornamental plants as means of fertilizer application but also for pest and weed control. In many cases, the compost pit materials are burned to reduce the amount of waste rather than to apply it as crop management practice. Chemical pesticides are mainly applied to vegetable crops, eggplant in particular.

The time spent working in the homegarden varies from 30 to 90 minutes per day – before, after and/or in between work on the cash crop farms – by one or two persons, depending on the size of the homegarden and type and number of crops. Households that keep livestock spend an additional 30 to 60 minutes in the morning and the afternoon feeding the animals and cleaning cages. Other chores include sweeping, burning wastes, weeding, fertilizing and watering. Moreover trees are regularly trimmed, not only to provide fuelwood or promote fruit or leaf growth, but also to increase their resistance against wind during typhoon events. The time needed for planting vegetables varies from three to six hours for one or two days, with the job being performed after finishing the planting on outside farms. The work on the farms clearly has priority.

2.4.5 The Main Reasons for Farmers to Have a Homegarden

Farmers maintain homegardens for all sorts of reasons, including those associated with short-term and long-term economic aspects, socio-cultural and aesthetic values, environmental quality, and accessibility. Farmers spontaneously give one to three reasons for having a homegarden. They either refer to "having something to eat for the family" (65 percent of all interviewed), or to "no need to buy" (51 percent) or to "having something to sell" (35 percent). The latter two reasons refer to short-term economic means of respectively saving and generating cash money to purchase household products such as canned or processed food (e.g., sardines, oil, salt, cigarettes and alcohol) and to cover tax, electricity, educational and medical expenses. Environmental functions like limiting damage from strong wind, flooding, runoff and erosion are referred to a few times only.

The interviews revealed that 60 percent of all households in this study sold something from their homegardens, i.e., 28 percent only livestock (raised in homegarden), 16 percent only fruits and vegetables, and another 16 percent both fruits and vegetables and livestock.

The annual gross income generated from homegarden fruits and vegetables varies considerable, with an average of PhP 14,353 ± 48,117 per hectare (median: PhP 6,649; exchange rate at research time: US$1 = PhP 51), or PhP 3,739 ± 6,259 per household (median: PhP 1,385), i.e. 7 or 18 percent of the total household income (based on median or mean value respectively). The variation in gross income is related to the economic value of the crops (Table 2.5) and the ratio between low- and high-valued crops being sold rather than the size of the homegarden. The highest income, i.e., PhP 164,745, PhP 144,158 and PhP 83,333 on a per-hectare basis, is derived from homegardens of respectively 607, 1,840 and 600 m^2 producing banana in combination

Table 2.5 Average yield and market prices for main cash products of most abundant trees, non-tree crops and livestock in lowland and upland village homegardens in Northeast Luzon, the Philippines

Species[a]	Main use	Harvesting period	Average production/ plant or unit area	Average market price (PhP[b])
Tree crops				
Moringa oleifera	Vegetable leaves	Whole year	15 bundles/tree/year	5.00/bundle
	Fruit	4 months	25 fruits/tree/year	1.00/fruit
Broussonetia luzonica	Vegetable	6 months	2.3 kg/tree/year	25.00/kg
	Fruit	Whole year	20–40 fruits/tree/year	10.00/young or dry fruit
Cocos nucifera	Leaves	Whole year	4–9 leaves/tree/year	8.00/broom (=2–3 leaves)
	Fruit		30 fruits/tree/year	15.00–35.00/fruit
Carica papaya	Fruit	Whole year	15 kg fruit/tree/year	40.00/kg
Chrysophyllum caimito	Fruit	2–4 months	500/tree/year	
Citrus grandis	Fruit	6 months	50–100 fruits/tree/year	5.00/fruit
Citrus microcarpa	Fruit	6 months	25 fruits/tree; 2–3 kg/tree/month	25.00/kg
Mangifera indica	Fruit	4 months	200 fruits/tree	0.50/fruit, 7.00–25.00/kg
Pouteria campechiana	Fruit	3 months	100 fruits/tree	1.00/fruit
Psidium guajava	Fruit	Whole year	1.5–3 kg/tree/month	15.00/kg
Sandoricum koetjape	Fruit	July–October	400 fruits/tree	
Spondias purpurea	Fruit	April–June	50 kg/tree, 100 fruits/kg	25.00/kg
Coffea arabica	Beverage, Stimulant	2–3 months		50.00/kg
Gmelina arborea	Timber	Whole year	50 bft (one time harvest)	18.00/bft[c]
Non-tree crops				
Musa sp.	Fruit	Whole year	100–240 fruits/plant	1.00/fruit
Abelmoschus esculentus	Vegetable fruit	4 months	15 fruits/plant	0.70/fruit
	Vegetable leaves			3.30/bundle
Allium cepa	Vegetable leaves	Whole year		5.00/bundle
Curcubita maxima	Vegetable	July–Dec	20–50 fruits/plant	5.00–20.00/fruit
			1–2 kg/fruit	10.00 –20.00/kg
Lagenaria siceraria	Vegetable	July–Dec	12 fruits/plant	10.00–15.00/fruit

Luffa cylindrica	Vegetable	3 months	40 fruits/plant	5.00/3 fruits 25.00/kg
Lycopersicon esculentum	Vegetable	July–August	1.5 kg/plant	15.00/kg
Momordica charantia	Vegetable leaves	3 months	40 fruits/plant	5.00/bundle
	Fruit		5 fruit/kg	25.00/kg
Solanum melongena	Vegetable	July–May	30–100 fruits/plant	5.00/4–7 fruits 10.00/kg
Colocasia esculenta	Vegetable leaves	Whole year	1 bundle/plant	10.00/bundle
	Tuber		0.5 kg/plant	10.00/kg
Ipomoea batatas	Vegetable leaves	4–12 months	15–20 bundles/plant	4.00/bundle
	Tuber		3–4 tubers/plant	2.00/tuber, 10.00–20.00/kg
Capsicum annuum	Spice, Stimulant	August–Dec	0.5 kg/plant	60.00/kg
Capsicum frutescens	Spice, Stimulant	August–Dec	0.25–1.00 kg/plant	25.00/kg
Zingiber officinale	Spice, Stimulant	Whole year	5000 kg/ha	5.00/bundle, 5–7 root pieces/bundle
Livestock				
Goat	Meat	Special occasion		1,800/head
Carabao	Meat	Special occasion		8,000–15,000/head
Chicken	Meat Egg	Regular daily	1 kg/head	80.00/kg
			1 piece/head/day	2.50/piece
Pig	Meat Piglets	Special occasion 2–3 times/year	10–12 heads/time	65.00/kg life weight[d] 1,500.00/head

[a] The most abundant species with a frequency of 50 percent or more for at least one village

[b] US$1 = 51 PhP

[c] Gmelina arborea boardfeet: 2×4×6

[d] PhP 100.00/kg boneless meat

with squash, eggplant, ginger or coconut as cash crop. These data are a promising outcome, indicating the considerably higher potential for the majority of the gardens particularly where fertilizers (either organic or chemical) are added and high-quality seeds used. Input costs are generally low because there is no use of paid labor for homegarden work, whereas fertilizers and herbicides are hardly used and, if applied, mostly left-over from those purchased for application on cash crops in farm fields. Most households with livestock derive the largest part of their homegarden income from livestock products, i.e., PhP 5,869 ± 3,695 per household (median: PhP 5,000). Livestock is mostly fed with household waste and crop residues; if fodder is to be purchased, input costs will be higher but part of these will be compensated through higher output. Yet, compared to the income from cash crops on outside fields, the current contribution of the overall low-input homegardens to the yearly income of the smallholder farmers is small and also variable, even when taking into account the large difference in input costs between both types of land use. The annual gross income from corn fields is PhP 34,457 ± 17,146 per hectare (median: PhP 28,140), with households cultivating on average 1.9 ha of corn (mostly twice) per year. The variation in gross income is attributed to variations in fertilizer application rates (chemical fertilizer application can double the yield), seed quality and the practice of one or two harvests per year (annual input costs vary both among households and between seasons, being estimated for each cropping cycle at PhP 7,600 per ha if not fertilized and PhP 12,762 per ha if fertilized assuming seeds are bought once every four years). The local maximum gross income from rice is PhP 80,500–115,000 per hectare (maximum input costs: PhP 23,625 per ha on average), based on two harvests per year. Whereas these results suggest homegarden income is insignificant compared to rice or corn fields, its crucial role in fulfilling emergency needs and supplementing low income in case of crop failure remains. Estimates of the overall household income vary between PhP 5,000 and PhP 40,000 per year (average is about PhP 20,000).

2.5 Homegarden Types and Levels of Diversification Within Specific Land Use Zones

Variations in homegarden characteristics may be related to diversification practices in remote uplands, hilly grasslands and accessible lowlands. Hence, various tree – and non-tree component characteristics are also discussed for each village and land use zone separately.

Firstly, species richness and associated indices are presented in Table 2.6 for each of the villages and land use zones. Species richness (excluding ornamentals) is highest for the lowland village Malibabag with 32 species per garden on average and lowest for the upland village Dy Abra with 18 species per garden. The Shannon-Wiener diversity indices further indicate that the homegardens in the lowland villages Moldero, Malibabag and Namnama are more diverse than those in Baliuag and the upland village Dy Abra in terms of both tree and non-tree crops. The differences in the eveness index are less pronounced: although Dy Abra has the lowest index for tree crops (0.72 on average), meaning that the distribution of tree

Table 2.6 Species richness, diversity, evenness and similarity indices for homegardens in upland and lowland villages in Northeast Luzon, the Philippines

Indices	Lowlands		Hilly lowlands		Uplands	
	Moldero n = 14	Malibabag n = 10	Namnama n = 10	Baliuag n = 10	Dy Abra n = 13	All n = 57
Plant density[a,b]						
Tree crops	385 (232)a[c]	409 (156)a	387 (178)a	302 (225)b	220 (198)b	
Non tree crops	3296 (2670)a	7591 (11812)b	4436 (3699)ab	3436 (4144)a	2015 (3459)c	
Ornamentals	1246 (1311)ad	2128 (3367)ab	3402 (3274)b	1147 (1710)d	717 (1233)c	
Species richness[d]						
Tree crops	15 (7)a	16 (5)a	14 (6)a	14 (8)a	11 (6)b	14 (6)
Non tree crops	9 (5)a	16 (7)b	12 (6)a	9 (4)ac	7 (5)c	10 (6)
All crops	25 (11)a	32 (11)b	26 (10)a	23 (11)a	18 (10)c	24 (11)
Total	83	94	88	74	86	155
Shannon Wiener[b]						
Tree crops	2.19 (0.40)a	1.98 (0.55)bc	2.07 (0.38)ac	1.57 (0.84)bd	1.39 (0.81)d	1.85 (0.69)
Non tree crops	1.42 (0.67)a	1.50 (0.36)a	1.53 (0.53)a	1.34 (0.53)a	1.18 (0.46)b	1.36 (0.55)
All crops	2.03 (0.46)a	1.87 (0.43)ac	1.96 (0.51)ac	1.80 (0.52)bc	1.81 (0.43)bc	1.90 (0.46)
Eveness[b]						
Tree crops	0.90 (0.06)a	0.79 (0.13)bd	0.94 (0.06)c	0.80 (0.26)ad	0.72 (0.29)d	0.83 (0.20)
Non tree crops	0.67 (0.22)a	0.57 (0.12)b	0.66 (0.11)c	0.68 (0.20)ac	0.66 (0.24)c	0.64 (0.21)
All crops	0.70 (0.13)ac	0.58 (0.12)b	0.65 (0.11)a	0.66 (0.14)a	0.74 (0.13)c	0.67 (0.13)
Whittaker[b]						
Tree crops	3.2	2.8	3.5	3.4	4.6	6.0
Non tree crops	4.5	3.6	3.7	4.2	6.6	8.6
All crops	3.5	3.1	3.4	3.6	5.1	6.7

[a] individuals per hectare

[b] excluding seedlings

[c] average (standard deviation); values followed by the same letter are not significantly different at 0.05 level

[d] including seedlings

species among the homegardens in this village is the least uniform of all villages, the index is not significantly different from those for Malibabag and Baliuag (0.79 and 0.80 respectively). For the non-tree crops, Malibabag has the lowest average (0.57) that is significantly different from the average values recorded for the other villages. Finally the Whittaker β diversity index is lowest for Dy Abra, indicating that the homegardens within this village show the greatest difference in species composition of all villages, for both tree and non-tree crops.

The highest average tree crop densities are recorded for the lowland villages (Table 2.6). The lowest plant densities are recorded for Dy Abra for both tree and non-tree crops and also ornamental plants. In this village, where homegardens and yards are generally larger than those in the lowlands (Table 2.2), only relatively small sections of the homegardens are actually used for the production of crops, firewood and timber. The houses are built close to the road where water taps are available and at the back, the gardens – composed of naturally growing grasses and herbs including a high variety of weeds – gradually convert into pasture or sometimes a small rice field.

Most upland homegardens (in Dy Abra and Baliuag) are characterized by the presence of two or three structural layers whereas most lowland gardens (Moldero, Malibabag, and Namnama) contain up to five layers. The latter are mainly composed of mixtures with fruit and vegetable trees (see Table 2.4c): mango-based mixtures predominating in Namnama and the *Moringa*-papaya mixture in Malibabag whereas in Moldero both types of mixtures occur in 43 percent of all homegardens.

In the upland village Dy Abra no differentiation has been observed, with homegardens mainly containing a true mixture of the tree species (see Table 2.4c) listed in Table 2.4a. Moreover, like in Baliuag, most gardens have a higher diversity – and also density – of species that spontaneously established themselves and are used for timber, fuel wood, shade and fencing.

With regards to the non-tree crops, only the lowland villages show differentiation through predominance of either vegetable (and-tuber)-based mixtures (i.e., Type 1, 2 and 3 in Moldero) or tuber-based mixtures (Type 4 and 5 in Malibabag). For the other villages, a true mixture of the vegetables, tubers, fruits and spice crops in Table 2.4a can be observed in at least 50 percent of all homegardens.

2.5.1 Differences in Management Aspects Among Land Use Zones

In Baliuag and Dy Abra where permanent streams for irrigation are outside reach of most farmers, water shortage usually hampers production during the dry season (Table 2.7). This is generally not true for most households in Malibabag and Namnama, yet the quantities of "home-grown" food crops are limited and need

Table 2.7 Various homegarden management practices and their frequency of implementation by households at village study sites in Northeast Luzon, the Philippines

Homegarden management practice	Percentage of homegarden households				
	Lowlands		Hilly lowlands		Uplands
	Moldero n = 14	Malibabag n = 10	Namnama n = 10	Baliuag n = 10	Dy Abra n = 13
Acquisition of planting materials[a]:					
Self-production	87	90	50	80	83
Shop (purchased)	43	70	60	20	50
Agency (freely distributed)	7	10	20	10	0
Use of fertilizers[a]:					
Chemical fertilizers	36	30	20	0	8
Manure	79	90	50	50	83
Compost/ash	21	70	60	40	0
Fertilizer application to[a]:	50	90	40	30	58
Non tree crops (vegetables)	50	90	40	30	58
Tree crops (fruit trees)	0	40	10	20	0
Ornamentals	14	30	10	20	0
Pesticide application to non tree crops	64	10	70	10	33
Watering during dry season	64	90	90	40	17
Vegetable planting at least two times per year	64	80	90	30	7
Fruits/vegetables for home consumption supplemented by production on outside farm	7	20	50	50	67
Purchase of additional fruits and vegetables[b]	50	80	90	50	50

[a] often more than one option per household

[b] either during part of the year (particularly dry season) or throughout the year

supplementation (particularly during dry seasons but also during wet seasons) with vegetables and fruits purchased at local markets or from neighbors and others in order to meet daily food requirements. In Namnama, Baliuag and Dy Abra at least half of all households supplement their daily diet with crops grown on outside farms (except irrigated rice fields) including fruits and vegetables like mango, citrus, string beans, taro and squash. The crops are planted between the cash crops or in a small area specifically reserved for this purpose. Farmers in Baliuag and Dy Abra report that they grow most of their subsistence crops in outside fields because of goats destroying crops in village homegardens and sufficient space in outside fields for household food production. In addition they gather food products, both for home consumption and sale, from nearby forest patches, such as, palm hart (*Oncosperma tigillarium*), young fern leaves (*Athyrium esculentum*), wild pigs and chicken, small crabs, turtles, fish and shrimp.

In Dy Abra, where various farmers have more than one carabao, manure is not only used for homegarden application but also transported to outside fields. In the lowland villages where chemical fertilizers, and also pesticides, are regularly used for seasonal cash crops on outside farms (Snelder et al. 2008), farmers apply in 30 percent (or more) of all cases these (excess) chemicals also to non-tree crops in their homegardens.

In Dy Abra, households heavily engaged in logging activities often refer to "a lack of time to work in the homegarden" as a main reason for growing just a few trees and planting vegetables only once a year. Moreover, some farmers also refer to stagnant water during the wet season making the planting of vegetables unfeasible.

Whereas most farmers (or at least half of all in Namnama; Table 2.7) are only engaged in self-production and exchange of seeds and crops, those who purchase certified seeds are particularly the farmers in Malibabag and Namnama. Part of the crops derived from purchased seed is kept aside for seed production during the next season. This method is repeated three times, or until harvests decline, after which new seed will be purchased. Yet, there are also many who reproduce seed from harvested crops over a longer period of time due to lack of cash.

Other homegarden production constraints include (listed in order of importance) a-stray animals (particularly goats), soil fertility and productivity, pests, lack of fencing materials and seeds and seedlings in the upland village and in Baliuag, and pests, diseases, drought, lack of fence materials and flooding in the lowland villages and in Namnama.

2.5.2 Differences in Reasons for Homegarden Cultivation Among Land Use Zones

Homegarden functions become clearer by asking farmers to rank, in order of decreasing importance, various pre-listed reasons for having a homegarden (Table 2.8). Most farmers in both upland and lowland villages primarily maintain a homegarden to produce fresh food for daily home consumption (average score: 7.1–9.2). The urgency to "have something to eat during times of shortages" is,

Table 2.8 Farmers' perception on the main reasons for keeping homegardens categorized on the basis of the gardens' economic, socio-cultural and environmental functions at the village study sites in Northeast Luzon, the Philippines

Main reasons for keeping a homegarden	Score[a]				
	Lowlands		Hilly lowlands		Uplands
	Moldero n = 14	Malibabag n = 10	Namnama n = 10	Baliuag n = 10	Dy Abra n = 13
Short-term economic					
Daily fresh food/"no need to buy" mn	9.2 (0.9)	7.7 (4.1)	8.9 (3.1)	7.8 (3.4)	7.1 (3.8)
Production of cash crops	4.7 (4.5)	2.4 (3.7)	0.9 (2.9)	0.7 (1.5)	3.7 (4.4)
No food crops for home consumption on other farms	4.5 (4.0)	1.8 (3.8)	0.3 (1.0)	0	2.3 (3.4)
Little or no income from other farms	3.9 (4.5)	2.0 (3.4)	1.2 (2.9)	1.2 (2.4)	1.3 (3.0)
To produce fuel wood	1.6 (3.4)	1.9 (2.7)	0.6 (1.9)	0.7 (1.6)	0.8 (1.8)
To produce medicinal plants	0.3 (1.3)	2.1 (3.3)	1.1 (2.9)	2.1 (3.5)	0.9 (2.2)
Long-term economic					
To have something to eat during times of shortage	5.1 (3.6)	5.3 (4.3)	1.8 (3.1)	4.6 (4.9)	4.4 (4.1)
To have something to inherit for children in future	0.9 (2.3)	3.6 (3.3)	3.2 (4.2)	1.0 (1.8)	4.8 (4.2)
To have something to sell during times of shortage	3.4 (3.0)	1.1 (2.4)	0	1.6 (2.9)	2.6 (3.4)
Garden permits flexible working times	0.4 (1.6)	3.6 (3.3)	1.7 (2.9)	2.4 (2.7)	2.2 (3.8)
Work can be divided among family members	0.1 (0.5)	2.3 (3.0)	2.9 (3.9)	1.9 (3.2)	0.5 (1.5)
Economic, accessibility					
House is far from market and shops	1.7 (2.3)	1.2 (2.0)	2.2 (3.1)	2.9 (3.5)	2.6 (3.1)
Fresh food close to kitchen	1.6 (2.8)	3.4 (3.4)	3.6 (3.7)	2.1 (2.9)	4.5 (4.1)
House is far away from other farms	0.4 (1.1)	0.9 (2.0)	2.0 (3.2)	0.2 (0.6)	0.3 (0.9)
Crops near house are not easily stolen	1.3 (2.7)	0	1.4 (3.0)	2.9 (3.4)	1.1 (1.4)
Easy to monitor plants close to the house	0.1 (0.5)	0.9 (1.5)	2.3 (3.0)	2.9 (3.5)	0.7 (1.6)
Socio-cultural					
To share food and seedlings with neighbors	1.7 (2.6)	0.6 (1.1)	0.3 (1.0)	0.7 (2.2)	2.6 (3.3)
Because neighbors have nice homegarden	0.5 (1.8)	3.4 (3.1)	1.2 (2.5)	1.4 (3.0)	1.9 (2.8)
Aesthetic, environmental quality					
To create shade	0.2 (0.8)	3.4 (3.8)	2.6 (3.0)	4.4 (4.0)	1.6 (2.9)
To plant flowers and beautify the surroundings	0	0.3 (0.7)	2.2 (2.5)	0.2 (0.6)	0.8 (1.8)

[a] average and standard deviation for each score is given; the higher the average score, the more important the corresponding reason

except for Namnama, another important reason. The selling of excess products is of moderate importance, with 25 percent or more of the total potential score for Moldero, Dy Abra and Malibabag (score: 2.4–4.7). Likewise "lack of income from outside farms" is rated moderately important (score: 1.2–3.9), with at least 20 percent of the total score for Moldero and Malibabag (as opposed to 12 percent for the other villages). Homegarden products are preferably sold by house-to-house sale and not at local markets where prices are generally lower due to competition.

The hilly lowland farmers in Namnama and Baliuag perceive the production of excess crops to generate cash as a minor homegarden role (score: 0.9 and 0.7). Farmers rate "the easy monitoring of crops close to their house" as a more important homegarden function instead (score 2.3 and 2.9 respectively). Like in Dy Abra, farmers (excluding those engaged in logging) derive virtually all their cash income from farms.

In the lowland village Malibabag, 90 percent of all households focus on pigs as homegarden market product. In the other villages, households sell mixtures of homegarden products, particularly pigs, goats, chicken, fruits and vegetables. Yet in Dy Abra and Namnama, garden products mainly serve for home consumption (61 and 80 percent respectively). Whereas farmers in Namnama clearly depend on agriculture for their livelihood, (illegal) logging forms an attractive alternative for farmers in Dy Abra who live near the closed-canopy forest: logging generates a gross annual income of about PhP 14,500 based on the hauling of 48 logs per year.

The convenience of "having fresh food close to the kitchen" is another function of moderate importance (average score: 1.6–4.5). In Dy Abra, this is also partly because "the house is far from markets and shops" (49 percent of total score as opposed to 22 and 21 percent for Namnama and Baliuag, and 12 percent for both Moldero and Malibabag; Table 2.8). Other reasons for "having fresh food close to the kitchen" are related to the *freshness* and the *healthiness* of garden food products. In Malibabag and also Namnama, farmers refer to the importance of having "bio-food", i.e., fruits and vegetables not treated with chemical pesticides. Finally, the convenience of having always fresh food readily available in case visitors arrive is another valuable interpretation.

Other, mostly lower-ranked reasons for having a homegarden refer to socio-cultural, aesthetic or environmental functions (see Table 2.8). Homegarden product exchange can be pre-arranged or not arranged. An example of the former is an arrangement between a farmer and a shop owner, with the former providing fruits to the shop and receiving canned or processed food in return. The latter refers to both "conditional sharing", i.e., the sharing of food with neighbors, family or friends with the expectation to receive something in return during times of shortage or need, and "unconditional sharing", i.e., to come closer to neighbors, help poor friends or create a good image or status as an industrious, hard-working family among fellow villagers. Imitative behavior also plays a role as farmers refer to nice and productive homegardens of neighbors as a major stimulus of making such a garden themselves (score: 0.5–3.4). Being forced to ask neighbors for food during times of shortage is considered an embarrassment for many, as is evident from the "no-need-to-ask-neighbors-for-food" response of households having primarily a garden for daily food consumption.

Branches of homegarden trees removed by trimming or broken by strong winds serve as a small, yet essential, easy-to-get source of fuelwood. This is particularly true for the lowland villages where the function "to produce fuel wood" rated 1.6 to 1.9 on average. Homegarden trees (including bamboo) account for 10 to 30 percent of the total fuelwood utilized by households in these villages, as opposed to less then 10 percent for the hilly lowlands and uplands. In the latter case, most fuelwood is gathered on farms (e.g., ipil ipil or *Leucena leucocephala*), in extensive grasslands (guava or *Psidium guajava*) or in forest patches along creeks and steep slope sections (e.g., arosip or *Antidesma pentandra*). In Malibabag and Moldero, households make use of a variety of fuel sources: in addition to wood from homegardens, farms and forest patches, wood washed ashore on river banks during and after typhoon events, corn cobs and tobacco roots from farms and fuel wood purchased at local markets are used. The wood collected after a typhoon event is partly converted to charcoal by river-side operations, lasting a couple of months as local fuel source. In Malibabag, liquid gas (shellin) is used during the wet season (for about 2 months) and also serves emergency purposes.

The production of fodder crops is not a crucial homegarden function. Yet in Dy Abra, and partly in Baliuag, natural grass and "wild" herbal species covering much of the space around houses are fed to goats and carabao and also used for medicinal purposes. Some of the wild species are harvested for food, like amaranth and bush okra, the consumption of which is more popular in the rainy season when the shoots are soft. In other villages, some tuber crops *Alocasia macrorrhiza* (galayang) and *Ipomoea batatas* (kamote) are planted to serve a dual purpose, with the leaf tops being fed to pigs on a regular basis but at times of food shortage also eaten by households. Kitchen waste and garden residues like rotten fruits (mango, coconut, banana) are likewise fed to livestock but most feed is derived from the residues of crops grown on farms such as rice drag, corn peelings and milled corn. Carabao, cow and goat are further penned along roadsides to feed on grasses or brought to harvested fields to feed on crop residues.

Finally in 40 percent of the Malibabag gardens, additional houses have been built leaving less space for food crop cultivation; in 40 percent of the Moldero gardens, areas reserved for vegetable cultivation are temporarily (three months) cleared for tobacco drying during the dry season.

2.6 Is There Potential for Diversification and Higher Production?

Species richness, totaling 155 tree and non-tree crop species, is less than two-third of all species reported by Soemarwoto (1987) for homegardens on West Java. Likewise, the average number of species per homegarden (i.e., 24) is less than half of the record for West Javanese homegardens (i.e., 56; Table 2.1). Higher species numbers are also reported for homegardens elsewhere in Asia (Black et al. 1996; Gajaseni and Gajaseni 1999; Kehlenbeck and Maass 2004; Peyre et al. 2006; Table 2.1), suggesting there is potential for enhancement of species diversity to augment multiple uses of the homegardens under study. Likewise tree densities are not exceptionally high, with average densities ranging from 220 to 409 trees per hectare, whereas densities of over 1,100 trees per hectare are recorded for similar-sized homegardens elsewhere (e.g., Peyre et al. 2006).

Whether or not farmers will opt for more diversified homegardens also depends on the total area of farmland available to a household. Households with small homegardens tend to have the highest species diversity (e.g., Kumar et al. 1994), yet if the total area of farmland is limited as well, the gardens may be dominated by a small number of food crop species (Wiersum 1982) planted at relatively high density and, hence, resulting in lower species diversity. In Namnama, where the homegardens are smallest in size and function as so-called subsistence gardens (Wiersum 2006), both species diversity and plant density are not the highest or significantly different from those recorded for Moldero and Malibabag. Contrary to the latter villages, at least 50 percent of the farmers in Namnama have sufficient farmland outside their village where, in addition to cash crops, a variety of food crops for home consumption is cultivated. Hence, the lower-than-expected species diversity is not so much attributed to the domination of food crops in the small homegardens but more to the higher-than-expected diversity of food crops for home consumption on cash crop farms.

The tendency towards food crop domination in gardens of households with limited farmland is, however, observed in the lowland villages Moldero and Malibabag. Both the tree and non-tree crop combinations are predominated by food species, i.e., the key species mango, guava, papaya, horse raddish, eggplant, cocoyam and sweet potato, rather than timber or medicinal species. Whereas these food crops are cultivated primarily for home consumption, they are planted at densities higher than needed for solely home consumption in order to have some excess for marketing purposes. This is particularly true for Moldero where farmers suffer from unfavorable land tenure and other socio-economic conditions. According to the classification of Wiersum (2006), these gardens are associated with survival rather than market gardens. Although most farmers have been awarded land through the land reform program, many farmers are still (or again) financially dependent from their previous landowner or a money lender for paying off their land, buying their inputs and covering other high (e.g., medical) unforeseen costs. In various cases, farmers' ever-increasing debts resulted in the loss of ownership of the land and a return to a "tenancy type" of conditions aimed at monocultures with prescribed commercial crops rather than subsistence cropping. Furthermore, unlike in other villages, none of the farmers in Moldero grow rice for home consumption and thus need cash to buy their major staple food. In Malibabag, the conditions are different. Only 50 percent of the households earn their main income through farming (Table 2.2b), i.e., mainly livestock holding, the other 50 percent being engaged in off-farm activities and having gardens comparable to the so-called budget gardens (Wiersum 2006). The latter households usually lack time for planting sufficient food crops and often have limited farmland at their disposal. Hence, they only plant part of their food crop needs in gardens and buy food to supplement their daily diet.

Like in Namnama, predominance by certain crop species is less evident in Baliuag and virtually absent in the upland village Dy Abra. On the whole, the homegardens in Dy Abra, followed by those in Baliuag, are less developed, poorer in structure and inefficient in space and light use compared to the gardens in the

Table 2.9 Data on mean annual income and profit for Asian homegardens of various sizes derived from a selection of literature sources

Source	Country	N	Homegarden size (ha)	Mean net annual income per hg ($US)	Mean gross annual income per hg ($US)	Mean annual profit ($US m^{-2})[a]	Homegarden income as percentage of total income
Mohan et al. 2006	Kerala State, India	24	≤0.26	1,233	1,394	1.79 ± 0.23	n.a.
		14	≤0.52	3,458	3,722	1.46 ± 0.20	
		10	≤0.78	4,784	5,046	1.63 ± 0.24	
		27	≤1.0	5,494	5,862	0.86 ± 0.09	
Dury et al. 1996	Java, Indonesia	54	n.a.	71[b]	n.a.	n.a.	≤15
Ali 2005	Bangladesh	32	0.10	n.a.	76[c]	0.08	52
This study	Philippines, N Luzon	57	0.10	n.a.	73	0.03	18

[a] calculated from mean financial value per homegarden (Mohan et al. 2006) or gross annual income

[b] based on exchange rate of 1995 (data collected in 1993 as reported by Dury et al. 1996).

[c] range: US$49–154 for homegardens of 0.10 ha in four villages studied by Ali (2005).

n.a.: data are not available

other villages. Logging activities competing for labor time, local inferior soil conditions, destruction of crops by goats, and sufficient space on outside farms are some of the explanations given by farmers. There is, however, much potential for timber, fuelwood and perhaps fodder production which, if implemented, will at the same time help to curtail the illegal extraction of wood from nearby forest and restrain uncontrolled grazing, given some form of fencing is being practiced.

From the economic point of view, there is clearly potential to raise the gross income from homegardens to higher levels, even surpassing those from outside fields on a per-one-hectare basis. In a recent financial analysis of the Kerala homegardens in India (Mohan et al. 2006; see Table 2.9), the average net income for small-sized homegardens up to 0.26 ha were estimated at Rs. 57,971 (US$1,233) per household. The homegardens in this study, with minimal or no (cash) input costs and an average size of 0.10 ha, yield a gross annual income averaging less than six percent of the net income of the Kerala homegardens (only PhP 3,739 = US$73 per household; median: PhP 1,385 = US$27), i.e., an income more comparable to those reported for homegardens in Indonesia and Bangladesh (see Table 2.9). A raise in financial garden output can be achieved by concentrating one part of the garden on few relatively high-yielding crop and livestock species like mango, banana, ginger, eggplant, squash, pig and goat and by boosting production through more efficient use of space, and hence, light, water and nutrients.

Likewise, management practices clearly need more attention although various institutions have been active, such as, the Department of Agriculture with programs on organic fertilizers, seed distribution and mango and vegetable growing in Moldero, Baliuag and Malibabag and international and local non-governmental organizations like PLAN International and Payoga active in organic fertilizer production, nursery set up and livelihood programs in Namnama and Dy Abra. Seed and seedling quality still leave much to be desired, particularly if market production is to be improved. The poor quality is partly due to a lack of funds to purchase certified seed and partly a lack of knowledge and information channels to reproduce and exchange better quality seed. Likewise the production and use of organic fertilizers including compost are inadequate, with most organic materials being burned and lost and the omission of separating degradable and non-degradable materials. In the hilly lowland and upland villages, where lack of water hampers production during the dry season, the installation of simple water storage techniques to capture and retain excess water during the rainy season can meet part, if not all, demands for supplemental irrigation. Where implemented, it can significantly increase homegarden production.

2.7 Conclusions

Although the homegardens are small in size and mainly subsistence-oriented, they form an important component of a larger farming system, complementing livestock, farm agriculture and other components of a farm household. When moving from the thinly populated upland zone towards the densely populated lowlands, there is a tendency towards a more diverse structural composition, an increase in plant density and crop species diversity but a decrease in "wild" species. At the same time, differentiation occurs towards livestock and crop mixtures predominated by one or two fruit and/or vegetable species among tree crops and one vegetable and/or tuber species among non-tree crops. As total farm area per household decreases, there is less space for livestock and subsistence cropping. It is expected that, with the increasing shortage of farmland, the future role of homegardens in supplementing farm production and cash income will grow. This expectation needs adequate attention, particularly in the context of poverty alleviation among rural communities with few prospects to alternative farm and off-farm livelihood. In addition, there is still potential for increasing excess crops for sale through species diversification and land use intensification. The role of homegardens in environmental services, such as, carbon sequestration, is another field in need of further exploration, particularly because gardens are some of the few sites where people spontaneously grow trees.

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Chapter 3
Tree Growing on Farms in Northeast Luzon (The Philippines): Smallholders' Motivations and Other Determinants for Adopting Agroforestry Systems

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Abstract The Philippines have been confronted with land use intensification and migrants cultivating marginal areas. This trend has led to the emergence of the 'upland debate' in the early 1980s, seeking to strike a balance between environmental and socio-economic, national and local interests. The quest for sustainable land use systems began, and agroforestry became an important element in this discussion. Despite the amount of research attention paid to the subject, the integration of trees in agricultural areas has been limited. This chapter sets out to understand this perceived lack of agroforestry adoption based on a study of underlying factors influencing farmers to integrate trees in farm fields by using logistic regression and qualitative information of 151 farmer cultivators. The results indicate that over the past 30 years tree integration in farm fields seems to be, though marginally, increasing due to shifting market imperatives in favor of tree products, decreasing competitiveness of alternative seasonal cash crops (mainly yellow corn) and decreasing availability of natural tree product supply. At the household-level on-farm tree growing is affected by age, lack of extension, total farm area, low or no capital, and non-farm labor time and at the farm plot-level, by soil texture, size of farm field, insecure land tenure and distance of field to house. Extension of agroforestry and tree growing technology can benefit from this information by more effectively targeting efforts and limited resources. Policies could be oriented at removing constraints to tree integration or focusing on resource-poor farmers vulnerable to unsustainable farming technologies.

Keywords Asia, fruit trees, land-use intensification, livelihood systems, smallholders, timber trees

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3.1 Introduction

Land-use intensification takes place in many developing countries where a large part of the steadily expanding population still depends on land and agriculture for their livelihood. The process of intensification tends to have a negative effect on the environment and hence sustainable alternatives are being sought. It is generally accepted that the integration of trees in agricultural systems – in the form of various agroforestry systems – on humid sloping land is a road to follow in order to enhance sustainability in the cultivation of marginal lands. For example, Fujisaka and Sajise (1986) propose agroforestry as a sustainable upland farming alternative for sloping land in the Philippines. However, there exists a gap between the theoretical world of opportunities associated with agroforestry, and its actual status in practice. Various researchers have addressed the question why it has been so difficult to translate this concept from theory into practice (e.g., Vosti et al. 1997; Bannister and Nair 2003; Mercer 2004). One explanation is sought in former generalization in terms of the applicability of a given agroforestry practice. Similar practices were introduced at a wide scale in diverse regions during the early years of agroforestry promotion, as it was believed that these were the sole answer to most land-use constraints. Over the years more solid research resulted in the development of more diverse and efficient systems well adapted to local conditions and the disqualification of other previously widely applied systems because of proven unsuitability at household or field level (Sanchez 1999; Adesina and Chianu 2002).

Another reason for limited success of on-farm tree growing is the inadequate understanding of what factors control the adoption of tree-based technologies and how such technologies can be best designed in order to contribute to sustainability and high environmental value and economic performance. Factors that control adoption are likely to vary per tree-based system and with socio-economic and biophysical conditions. In a synthesis of adoption studies, Mercer (2004) point out that particularly factors at household and field levels influence adoption and tree integration patterns. Others refer to farmers' adaptation of researcher-proposed technologies as a common factor in widespread adoption (Adesina and Chianu 2002; Franzel et al. 2004).

Tree systems involving high risks face low adoption potential, given smallholders are profit maximizers and risk minimizers. Farmers' decision-making is clearly controlled by available household assets. Likewise it is influenced by farmers' awareness of specific household and field constraints and their perception of what solutions are most profitable and risk-safe under their socio-economic, institutional, and biophysical conditions of operation (Caveness and Kurtz 1993). Yet, much remains unknown about the risk-levels of integrated tree systems versus other land uses. Recently a study on farmers' risk perception comparing tree plantations to seasonal crops in typhoon-prone areas of Northeast Philippines suggests farmers perceive trees as slightly more risky and lower output-yielding crops (Snelder et al. 2007).

Perz and Walker (2002) show how various aspects of the household life-cycle stages affect land use decision-making such as the duration of residence, the number of elderly or dependent children within a household and the number of working-age adults. Whether or not specific technologies are adopted depends on the way the specific technology fits into the livelihood system of farm households in a given area (Scherr 1995; Bannister and Nair 2003) and the dynamics to which these households are exposed (Vosti et al. 1997).

Mercer (2004) mentions that the biophysical properties of farm fields have often been ignored in adoption studies. But if included, they often turn out to be predictive of adoption patterns even though the type of the relationships is often inconsistent. It remains unclear under what soil conditions farmers prefer to grow trees and whether conservation motivations play a role in farmers' decision. Furthermore, insecure tenure is generally hypothesized as a negative factor in households' willingness to plant trees on their farms. Although this has been confirmed by some empirical evidence, it definitely does not apply everywhere (Mercer 2004).

The literature demonstrates that there are multiple motivations of smallholders to integrate trees in their household economy, including household and market demands, market accessibility, secure marketing channels, technical knowledge about tree crop production and familiarity with a specific species (e.g., Scherr 1995; Arnold and Dewees 1995). To better understand smallholders' reasoning for growing trees, it is crucial to question what contribution trees have to rural households and how trees are valued by smallholders in terms of income, conservation value, and other factors. A study in Panama demonstrates that farmers are aware of the positive contribution of tree-based systems on soil quality and erosion control (Fischer and Vasseur 2002), although their main motivation for growing trees is the production of fruit, fuelwood and wood. Yet, households differ in their perception of the role of trees in their farms and accord different values to different tree species.

Because land use is rapidly changing under current processes of globalization and population growth, it is the more interesting to study the adoption of sustainable tree-based systems in the light of past and current changes. For example in a study in Western Kenya, Scherr (1995) found evidence of past increases in tree cultivation at times of ecological degradation, a decrease in natural tree supplies, and an increase in the demand for tree products for subsistence and marketing purposes. Likewise Arnold and Dewees (1995) describe how, under conditions of declining natural tree resources, private tree management and integration pass through different stages (based on Raintree and Warner 1986). Where land use is extensive and tree cover still vast due to low population pressure, private tree management tends to be passive. Where land and natural tree resources become scarcer and land use intensifies, tree management takes on a more active role. This is confirmed by a study on tree-growing in Nepal (Gilmour in Arnold and Dewees 1995) where tree densities on private land in the Middle Hills increased over past decade because of diminishing forest resources. Trees, particularly those crucial in household economies, had been deliberately planted, or their natural regeneration encouraged, by local farmers. Continuing along this line of land-use intensification and associated tree loss, local farmers devise new strategies to increase their tree resource base. Fairhead and Leach's highly influential publications (1996, 1998) form likewise a good example on how the West-African forest-savanna mosaic landscape has been created by local farmers through tee growing and gradual development, rather than destruction, of forests around villages and towns. Land use intensification is, according to Arnold and Dewees (1995), coupled with increasing sophistication of tree management strategies. For example, extensive *Imperata* grasslands considered infertile and unsuitable for cultivation in the past are increasingly being used for the production of annual and perennial crops through specifically designed tree-based strategies (e.g., Van Noordwijk et al. 1997). Trees gain in market value and start playing a role as cash crop.

The objectives of this study are (1) to examine household and field characteristics of smallholder tree growers and investigate which of these characteristics are crucial determinants for tree growing, (2) to investigate farmers' motivations for growing trees on their farm fields and (3) to study trends in the integration of trees on farm fields among smallholder farmers under current conditions of land-use change in the Cagayan Valley, Northeast Luzon, Philippines. In this study, land-use changes concern a transition from subsistence-oriented farming systems towards systems with a high degree of intensification and integration of market-oriented crops in response to mounting population and associated demand. The market integration creates new and different conditions in which tree-based farming systems can flourish (Snelder et al. 2007). The research area covers three agro-eco-zones, i.e., an upland, an intermediate and a lowland zone (the former or second zone hereafter mentioned as hilly lowland), a set up that corresponds to a transect of increasing land-use intensification to examine tree integration dynamics at different levels of intensification. The term *tree growing* refers to trees that are either actively planted or naturally growing, i.e., after sprouting spontaneously they are retained in smallholders' farm fields.

3.2 Methodology

3.2.1 The Study Area

The Cagayan Valley in Northeast Luzon is a predominantly agricultural area. The lowland areas adjacent to the river are mainly used for the cultivation of seasonal cash crops, with yellow corn, tobacco and rice forming the major sources of livelihood. At the somewhat higher and hilly locations, a vast area of *Imperata-Themeda* grassland stretches out in North-South direction. However with the integration of high-yielding crop varieties over past three decades (i.e., hybrid rice and corn varieties in the 1970s and mid-1980s respectively), land use at these locations has changed. Large tracks of grassland have been converted into farm fields with monocultures of rice along flat intersections, corn on sloping fields, and banana along creeks, field boundaries or other steep slope sections. In the uplands, logging has been an important economic activity from the early 1960s onwards when large-scale logging companies entered the nearby Sierra Madre mountain forests. Although most companies had to close their doors soon after the logging ban and establishment of a natural park (of about 350,000 ha) in 1997, logging still forms an important – but illegal – cash-generating activity. In addition it forms a crucial safety net in case of crop failure for most smallholder communities around the park. The communities are mainly composed of migrants from low- and upland areas elsewhere in the region (see also Van den Top 2003). Attracted by the large-scale logging companies before, but nowadays mostly in search of fertile land for crop cultivation, they are still either directly or indirectly dependent on the forest for part of their livelihood.

Meanwhile, forest and land degradation have become serious issues in the valley and adjacent mountain area. Government and non-governmental organizations put much effort towards park management and conservation of forest and grassland areas. Local and regional measurements encompass tree growing activities directed at watershed rehabilitation and economic development through community-based reforestation, as well as upgrading nutrition and income diversification through farm-level fruit and timber production. These efforts are mainly concentrated in the buffer zone area surrounding the park.

3.2.2 Site Selection and Data Collection

The study area covers five village sites located near the boundary of the Sierra Madre Mountain Range with a Natural Park to the east and the Cagayan valley lowland with commercial centers at a 1-hour ride to the west. The area is characterized by humid tropical conditions with rainfall ranging between 1,500 and 2,500 mm year^{-1}. Yet, seasonal drought is rather common particularly during the period February–May. In the remaining months, rainfall is strong but unevenly distributed due to, amongst others, regular typhoon occurrence. The area faces severe agricultural intensification, i.e., a process that already has taken place in the lowland area but gradually shifts towards the uplands as indicated by disappearing fallow periods, opening of new lands for agriculture at the forest frontier, and declining land areas per household through intergenerational land transmission. While the five selected villages hardly differ in terms of market access and distance, they vary in terms of biophysiography, land use and land use intensification. Two villages are located in a more elevated and sloping (until 450 m.a.s.l.) area with a mixture of forest patches, grassland and (semi-)permanent agriculture, two are situated in a predominantly flat lowland area mainly used for monocultures of seasonal cash crops (i.e., corn, rice and tobacco), and one is in an intermediate, hilly lowland zone that combines elements of the two other areas being mainly used as grassland for extensive cattle ranging but increasingly converted to intensive corn and rice cultivation.

Projects promoting tree integration have been active in all villages, but their direct impact was limited. Over the past 10 to 15 years two programs promoting tree growing and agroforestry covered the area. On the one hand, two out of five communities were covered by a government reforestation project (Community-based Forest Management or CBFM project). In this project, community members cultivating or claiming public lands were encouraged to plant timber trees (mostly *Gmelina arborea*). The project's direct impact was mainly through workshops and trainings and through the dispersal of tree seedlings. In addition, PLAN international Philippines implemented the Sustainable Agriculture Program, which entailed a tree growing component in all five communities. In this program selected participants were given trainings on fruit-tree management and fruit-tree seedlings for planting in their fields. The direct impact of this program seems limited since only few members per village were included, but for both programs indirect impact is estimated to be much larger.

The respondents in this study were selected by stratified random sampling based on village records of households (n = 151, 76 tree planters and 75 non-planters). Respondents were classified as tree planters when they planted or retained at least seven trees on one of their plots, with a minimum density of 10 trees/ha. Survey data were supplemented with field visits and informal interviews. Respondents were household heads as defined by themselves (96 percent male). All data presented are farmer-based and are derived from the same survey. Sample sizes however, vary throughout the paper as not all respondents were able to answer every question.

3.2.3 Statistical Analysis

Several factors are hypothesized to affect tree growing in the study area based on the exploratory survey and existing evidence in the literature. In order to identify those factors that best explain tree growing in farm fields, binominal (or binary) logistic regression analyses have been applied to the data of the 151 households and associated farm fields. This type of regression is generally used when the dependent relates to a dichotomy (in this study, the dependent at household level is composed of the classes "tree growers" and "non-tree growers" and the one at field level is composed of the classes "fields with trees" and "fields without trees") whereas the independents can be of any type (continuous, categorical or dichotomous; Garson 2006; Hosmer and Lemeshow 1989). Hence, the following models were applied:

Equation for *household* level regression:

$$Ln(\frac{\pi}{1-\pi}) = \alpha + \beta_1 ETHNIC + \beta_2 NFLABOR + \beta_3 EDUC + \beta_4 EXTENSION + \beta_5 LABORAV$$
$$+\beta_6 MEMBER + \beta_7 AGE + \beta_8 TOTLAND + \beta_9 CAPTALAV$$

Equation for the *field* level regression:

$$Ln(\frac{\pi}{1-\pi}) = \alpha + \beta_1 PLOTSIZE + \beta_2 SLOPE + \beta_3 TENADAP + \beta_4 DISTANCE$$
$$+ \beta_5 SOILTEXTURE$$

Where: $Ln(\frac{\pi}{1-\pi})$ represents the logit with π denoting the proportion of success that the dependent variable y equals 1 (= tree growers or fields with trees) and $1-\pi$ the proportion of success that y equals 0 (= non-tree growers or fields without trees); α is a constant and β_i is the partial regression coefficient; ETHNIC = Ethnicity of the household head (0 = non-Ilocano, 1 = Ilocano); NFLABOR = Amount of time spent by household in non-farming activities (days per month); EDUC = Highest education attained by the household head (0 = until primary, 1 = high school and up); EXTENSION = Whether or not the household received extension on tree growing or agroforestry (0 = no, 1 = yes); LABORAV = Number of household members contributing to household income or farm labor (0 = one person, 1 = two or more persons); MEMBER = Whether or not the household is a member of a village-based institution (0 = no, 1 = yes); AGE = Age of the household head; TOTLAND = Total land area owned (both formally and informally) by the household (ha); AGROECOZONE = location of farm (ll = lowland, hl = hilly lowland and ul = upland); CAPTALAV = Aggregate variable for the amount of monetary capital available to the household (0 = none or low, 1 = moderate); PLOTSIZE = Size of individual fields cultivated by a household (ha); SLOPE = Slope of individual fields cultivated by a household (0 = flat, 1 = sloping); TENADAP = Tenure in individual fields cultivated by a household (0 = insecure tenure, 1 = secure tenure); DISTANCE = travel distance between field and house of respondent (minutes); and SOILTEXURE = soil texture in individual fields (0 = fine, clay texture, 1 = medium loam texture, 2 = coarse sandy texture).

Based on analysis of correlations between explanatory variables, some variables were eliminated from the regression analysis, e.g., non-farm labor (NFLABOR) was included and preferred over non-farm income also because the latter resulted in less reliable data. Some categorical variables have been transformed into binary variables in order to better fit the logistic regression model. The variable CAPTALAV has been transformed into ranks, meaning it is an aggregate variable based on the values of several underlying measurements including household savings, income and assets. Each of these observations has been accorded a value (0 = low, 1 = moderate) based on the researchers' assessment of relative importance of each. The variable ETHNIC has been included because of indications that tree growing is associated with certain ethnic groups, e.g., the Ifugao traditionally living in upland areas and accustomed to rice and tree growing and the Ilocano traditionally living in lowlands areas and mostly engaged in seasonal cropping and not so much in tree growing. Most interviewed farmers are Ilocano, explaining the distinction in two ethnic groups: Ilocano and non-Ilocano.

The statistical package SPSS version 12.1 for windows is used for the data quantitative analyses. The means of the several variables describing the household and field characteristics of tree and non-tree growers and their fields have been compared using the χ^2 test for counted data and either the GLIM univariate analysis or the T test with equal variances not assumed for numeric or measurement data. The variables measured at the plot-level are nested within the households and therefore, a general linear model with nested terms was specified.

3.3 Results

3.3.1 Household and Field Characteristics

Tree growing in farm fields is a relatively common phenomenon in the research area, with 47 percent of all households interviewed having integrated trees in at least one of their fields. Since, each household tends to have several fields, 32 percent of the farm fields in the study sample contained a tree component. Table 3.1 presents some key characteristics for households and farm fields of tree and non-tree growers. At the household level, no significant differences can be observed in education level, membership of local organization, time spent on non-farm activities, available capital and number of household members contributing to income and farm work. For the other socio-economic factors the differences are manifest. As opposed to non-tree growers, tree growers are somewhat older in age on average and a higher percentage has been able to make use of extension services. Tree growers mostly reside in upland areas (66 percent) and have large farms, i.e., being 1.75 times larger than the average total farm area of non-tree growers who mostly (64 percent) reside in lowland areas. The latter strengthens the assumption that the pressure on land and – related to this – land use intensity are lower in upland areas. Most non-Ilocano households (i.e., largely the upland ethnic group “Ifugao”) are tree growers, but this group is a minority compared to the large group of Ilocano’s that forms the other part of the tree-growers category. The Ilocano’s constitute, however, also the largest group among the non-tree growers. Most households among non-tree growers have an outstanding debt to a trader but this is not reflected in less capital (difference in available capital between groups is not significant).

Fields with trees prove at least twice the average size of those lacking trees and are more often located on sloping land. Yet, their formal tenure is more often insecure. Trees are further relatively seldom grown on coarse textured soils, fine- and particularly medium-textured soils being preferred by most farmers. There is further no evidence that the distances between tree fields and farm house are significantly longer in terms of travel time than those between farm house and fields without trees

Table 3.2 shows the results of the logistic regression analyses. At the household level, AGE and AGRO-ECOZONE (for lowland and upland) are the sole explanatory variables with significance levels of 0.01. AGRO-ECOZONE correlates with a number of other variables; if AGRO-ECOZONE is excluded as independent variable, eight out of ten variables turn out to be explanatory for the decision to grow trees in at least one of the households’ fields. Age (AGE) and lack of extension ($\text{EXTENSION}_{\text{no}}$) are, respectively, positively and negatively related to tree growing (significant at the 0.01 level). Likewise total farm area (TOTLAND), that is either under ownership or only under cultivation, no or low available capital ($\text{CAPTALAV}_{\text{low}}$) and the amount of time spent in non-farm labor (NFLABOR) have a positive relationship with on-farm tree growing (significant at 0.05 level).

Table 3.1 Household and field characteristics for both tree and non-tree growers in five farmer villages in the Cagayan Valley, the Philippines

Household characteristics	Tree growers n = 76	Non-tree growers n = 75	p-value[a]
Total farm area (ha)	1.95 (1.50)[b]	1.11 (0.94)	0.000[1]
% farms in lowland	20	64	
% farms in hilly lowland	14	24	0.000[2]
% farms in upland	66	12	
Age of household head	47(12)	38(12)	0.000[3]
% Ilocano	71	95	0.000[2]
% non Ilocano	29	5	
% primary school or lower[c]	78	72	0.420[2]
% higher than primary school[c]	22	28	
Number of household members	5 (2)	5 (2)	0.431[3]
Times spent on income generation from non-farming activities (days per month)	10 (15)	7 (8)	0.150[1]
% with capital for input and transport	48	56	0.327[2]
% without capital for input and transport	52	44	
% with debt to trader	55	71	0.043[2]
% without debt to trader	45	29	
% received extension	51	16	0.000[2]
% no extension	49	84	
% with membership to local organization	42	55	0.122[2]
% without membership	58	45	

Field characteristics	With trees n = 137	Without trees n = 241	p-value[a]
Size of field (ha)	1.07 (1.01)	0.47 (0.45)	0.000[1]
Distance field–house (min)	31 (25)	28 (32)	0.414[3]
% flat land	42	73	0,000[2]
% sloping land	58	27	
% fine textured soil	34	32	
% medium textured soil	56	35	0.000[2]
% coarse textured soil	10	33	
% secure tenure	41	77	0.000[2]
% insecure tenure	59	23	

[a] p^1 = p-value of T-test with equal variances not assumed; p^2: p-value of $\chi 2$ test; p^3: p-value of GML univariate analysis for unbalanced designs

[b] Value in brackets represents standard deviation

[c] Highest education level among household members

The results of the field-level regression (Table 3.2) suggest a significant but diverse relationship between fields with trees and SOILTEXTURE: tree growing is positively related to fine-textured soils and negatively related to coarse-textured soils. The fine textured soils refer to clayey soils, including black, cracking clayey soils (*Vertic Luvisols*) and reddish clayey soils (*Ferric Luvisols*; Snelder 2001). The size of a field (PLOTSIZE) and insecure land tenure (TENADAP$_{\text{insecure}}$) are also

Table 3.2 Results of logistic regression analyses at household and field levels based on data gathered in five villages in the Cagayan Valley, the Philippines

Variables	Parameter estimate[a]	Standard error	Significance	Significance incl. AGRO-ECOZONE
Household level[b]				
Constant	−3,709	1,269	0.003	0.003
$\mathrm{AGROECOZONE}_{\mathrm{ll}}$	–	–	–	0.004
$\mathrm{AGROECOZONE}_{\mathrm{hl}}$	–	–	–	0.304
$\mathrm{AGROECOZONE}_{\mathrm{lul}}$	–	–	–	0.001
$\mathrm{CAPTALAV}_{\mathrm{low}}$	0.970	0.494	0.050	0.209
$\mathrm{EDUC}_{\text{up to primary}}$	0.109	0.587	0.853	0.887
$\mathrm{EXTENSION}_{\mathrm{no}}$	−1,400	0.515	0.007	0.066
$\mathrm{ETHNIC}_{\text{non-Ilocano}}$	0.832	0.706	0.238	0.911
TOTLAND	0.529	0.222	0.017	0.225
LABORAV	−0.012	0.459	0.980	0.955
$\mathrm{MEMBER}_{\mathrm{no}}$	0.783	0.478	0.102	0.849
NFLABOR	0.058	0.026	0.024	0.062
AGE	0.058	0.020	0.003	0.001
Field level[c]				
Constant	−1.075	0.514	0.036	–
PLOTSIZE	1.760	0.424	0.000	–
DISTANCE	−0.014	0.006	0.014	–
$\mathrm{SLOPE}_{\mathrm{flatland}}$	−0.566	0.349	0.105	–
$\mathrm{SOILTEXTURE}_{\mathrm{fine}}$			0.007	–
$\mathrm{SOILTEXTURE}_{\mathrm{medium}}$	0.423	0.375	0.260	
$\mathrm{SOILTEXTRUE}_{\mathrm{coarse}}$	−1.019	0.446	0.022	
$\mathrm{TENADAP}_{\mathrm{insecure}}$	0.946	0.383	0.013	–

[a] estimates for model if excluding the dummy variable LOCATION from model at household level

[b] n = 132; Right predictions: 75.8 percent; −2 Log likelihood: 122.536; model Chi-square: 59.970 significant at 0.01 level; Nagelkerke R Square: 0.487

[c] n = 298; right predictions: 79.4 percent; 2 Log likelihood: 233.1442; model Chi-square: 83.554, significant at 0.01 level; Nagelkerke R Square: 0.487

positively related with tree growing (significant at 0.01 and 0.05 levels respectively), whereas the distance of a field to the farm house (DISTANCE) shows a negative relationship.

Table 3.3 shows the different types of tree planting systems specified for the three different agro-eco zones. Boundary planting is by far most common, while the representation of mixed cropping systems (i.e., trees combined with seasonal crops in a non-boundary arrangement) is surprisingly low. For the lowland zone no farm component combinations with livestock were found, as opposed to the hilly lowland and upland zones with 23 percent of the fields falling into these categories.

There is a high variability in tree densities (Table 3.3). The diversity of tree species integrated in farm fields is low, with only five percent of all fields containing more than ten different species (data not shown in table). In most fields (51 percent of total), only two to five tree species are grown. Most trees are planted, i.e., not grown from spontaneously sprouting wild seeds, unlike past times when most trees

Table 3.3 Perennial arrangement, farm system components and tree density for "fields-with-trees", specified for the different agro-eco zones, i.e., uplands (n = 75), hilly lowland (n = 16) and lowland (n = 20), in the Cagayan Valley, the Philippines

Planting systems	Number of fields (%)			
	Upland	Hilly lowland	Lowland	Total (n = 111)
Perennial arrangement:				
Boundary planting	56	69	70	61
Tree plantation	30	25	25	28
Mixed cropping systems	14	6	5	11
System components:				
Agrisilvicultural	48	44	70	51
Pure perennial	29	25	25	28
Agrisilvopastoral	20	31	–	18
Silvopastoral/piscicultural	3	–	5	3
Tree density (individuals ha^{-1}):				
<25	25	47	19	28
25–50	14	27	25	19
51–100	18	13	19	17
>100	41	13	38	36

were of wild origin. Nowadays farmers purposively plant trees in their farms with specific objectives in mind. In upland areas larger stocks of naturally growing trees exist, which corresponds to the idea that natural tree stocks disappear, or are depressed by regular weeding, with increasing land use intensification. The most common species planted in fields, either in single stands or in combination with other tree species and seasonal crops are listed in Table 3.4 (Photos 3.1 and 3.2).

3.3.2 Farmers' Motivations and Perceptions of Tree Growing on Farm Fields

Trees are grown in farm fields for various reasons (Table 3.5). Timber trees (TT) are usually grown for home use, mostly for house construction but also for furniture, and to a lesser extent for commercial purposes. Fuelwood provision is a minor motivation for growing trees in a field except for the lowlands where 11 percent of the fields are grown with trees for a dual purpose, i.e., timber and fuel provision. Fruit trees (FT) are planted to meet household fruit needs and – to a somewhat lesser extent – sell at the market. There are various other, minor reasons for growing trees, i.e., to provide for shade (TT and FT), to diversify household income (TT and FT), to control soil erosion (TT) and to serve as a pension provision (TT and FT). There are no significant differences in motivations to plants trees among the agro-eco zones except for the timber trees in the lowlands, having a second important role as providers of fuelwood.

Table 3.4 Common tree species and associated functions as identified by households growing the species on their farm fields in the Cagayan Valley, the Philippines

Tree species[a]			Percentage of respondents growing tree species for listed purpose												
			Production function								Service function				
	Occurrence[b] (%)	Commercial use[b] (%)	Fuel wood	Charcoal	Timber	Poles	Manure	Fodder	Medicine	Fence	Crop inter	Beautification	Shade	Wind break	Soil conservation
Paper tree	91	27	81	3	94	90	81	2	0	2	47	82	93	88	90
Jackfruit	27	25	0	0	15	10	75	0	16	0	60	85	100	95	100
Mango	64	36	2	2	7	2	77	2	11	0	64	91	96	91	98
Banana	51	43	–	–	–	3	97	3	15	3	63	86	100	56	91
Coconut	30	18	4	0	4	4	74	0	11	0	67	96	100	85	89
Calamansi	26	0	0	0	0	0	84	0	21	0	68	95	95	84	95
Pomelo	31	27	0	0	0	4	87	0	17	0	73	95	100	91	91
Santol	18	31	0	8	8	8	85	8	23	0	85	92	92	85	85
Guyabano	14	22	0	0	0	0	67	0	11	0	78	100	89	100	100
Mahogany	4	67	0	0	100	100	100	0	0	0	67	100	100	100	100
Coffee	10	57	0	0	0	14	71	0	14	0	71	86	71	57	100
Ipil-Ipil	8	33	100	0	100	100	100	17	0	17	67	100	100	100	100
Acacia	3	100	0	0	100	50	100	0	0	0	100	100	100	100	100
Avocado	14	50	0	10	10	0	90	0	50	0	80	100	100	90	100
Mandarin	8	60	0	0	0	0	80	0	60	0	80	100	100	60	100
Guava	4	0	0	0	0	0	100	0	100	0	100	100	100	100	100
Chesa	4	67	0	0	0	0	100	0	0	0	100	100	100	67	100
Ilang-Ilang	3	100	0	0	0	0	100	0	0	0	100	100	50	100	100
Caimito	4	33	0	0	0	0	100	0	0	0	100	100	67	67	100
Narra	5	0	25	0	100	100	75	0	0	0	50	100	100	75	75

Note: all observations of tree species ≤1 have been eliminated from this table

[a] Paper tree: *Gmelina arborea*; Jackfruit: *Artocarpus heterophyllus*: Mango: *Mangifera indica*; Banana: *Musa* sp.; Coconut: *Cocos nucifera*; Calamansi: *Citrus microcarpa*; Pomelo: *Citrus grandis*; Santol: *Sandoricum koetjape*; Guyabano*: Annona muricata*; Mahogany: *Swietenia macrophylla*; Coffee: *Coffea arabica*; Ipil-ipil: *Leucena leucocephala*; Acacia: *Samanea saman*; Avocado: *Persea americana*; Mandarin: *Citrus reticulata*: Guava: *Psidium guajava*; Chesa: *Pouteria campechiana*; Ilang-ilang: *Cananga odorata*; Caimito: *Chrysophyllum cainito*; Narra: *Pterocarpus indica*

[b] The number of fields (expressed as % of total number of fields with trees; n = 74) in which a given tree species is present (occurrence) or used for commercial purposes (commercial use)

Farmers in lowland areas who abstain from planting timber trees give as major reason that their farm area is too small. Other reasons referred to in each of the three agro-eco zones include the necessity to grow seasonal cash crops for immediate income and the need to avoid shading of cash crops by trees. In some fields in the upland areas, timber trees are not grown because the households who cultivate these fields are tenant and have no say about the type of crops to grow. Astray animals are perceived to be problematic only in (hilly) lowland fields. The presence of

Photo 3.1 *Gmelina arborea* tree plot plantation in cultivated area in Isabela Province, the Philippines (©DJ Snelder)

Photo 3.2 Demarcation of agricultural fields by boundary tree plantation in Isabela Province, the Philippines (©DJ Snelder)

Table 3.5 Main motivations of farmers for growing or not growing fruit trees (FT) or timber trees (TT) in fields of different agro-eco zones in the Cagayan Valley, the Philippines

Motivation	Household responses[a] (%)					
	Upland		Lowland		Hilly lowland	
	FT	TT	FT	TT	FT	TT
For growing trees	*n = 85*	*n = 72*	*n = 19*	*n = 24*	*n = 17*	*n = 19*
Home consumption	46	12	52	4	59	11
House construction	–	33	–	43	–	37
Market sale	32	25	36	22	12	11
Fuelwood	–	3	–	4	–	11
Other	22	27	12	27	29	30
Total	100	100	100	100	100	100
For not growing trees	*n = 17*	*n = 9*	*n = 79*	*n = 75*	*n = 27*	*n = 30*
Land area too small	6	–	24	33	22	27
Preference for cash crop for immediate income	12	22	17	13	19	13
Trees will shade the cash crops/crop neighbors	–	22	20	31	11	20
No capital to buy seedlings/inputs	17	11	5	0	22	3
Astray animals	12	–	9	7	15	13
Unavailability of good quality seedlings	23	–	6	4	11	10
Tenant cannot choose what crop to grow	18	22	5	4	–	3
Trees are available in the forest	–	11	–	–	–	–
Other	12	23	14	8	–	11
Total	100	100	100	100	100	100

[a] Responses are given for each of the household fields (not) containing trees and are expressed as a percentage of the total responses in each category

forest, whether or not protected, is yet another remarkable reason for not growing timber trees in upland fields. The main reasons for refraining from growing fruit trees are similar to those mentioned for growing timber, with in addition the lack of capital to buy seedlings and the unavailability of high-quality seeds or seedlings.

Asking farmers about major constraints to tree growing in general (thus not specifically referring to their own fields), they frequently refer to typhoon events (48 percent of both upland and lowland respondents). In addition, the lowland respondents often refer to astray animals destroying tree seedlings and young trees (48 percent as opposed to 25 percent of the upland respondents; see Photo 3.3) whereas the uplanders identify wildfire (18 percent of respondents) as a constraint that in turn is hardly mentioned by the lowlanders (3 percent). The fires are accidental or deliberate (e.g., serving as a management tool; Masipiqueña et al. 2000) and mainly occur during the dry season in grassland areas the majority of which is located in the hilly and upland zone.

Photo 3.3 Protection of *Gmelina arborea* seedlings against astray livestock in Isabela Province, the Philippines (©DJ Snelder)

Farmers underline that tree products most often play a minor, and mostly additional, role in rural household economies (Photo 3.4). Seldom do households completely rely on tree products for their cash income. This is reflected in the data on the function or role that trees have in the eyes of the respondents (Table 3.4). When asked to indicate what role trees have in their farm fields, farmers mentioned: shade (97 percent), soil protection and conservation (94 percent), timber production (93 percent), building poles (91 percent), windbreak (90 percent), fruit production (89 percent), fuelwood (79 percent), organic manure (73 percent), beautification (70 percent), crop interaction (39 percent), medicine (26 percent), animal fodder (4 percent), live fencing (3 percent), charcoal (1 percent). In order to understand which roles farmers value the most, we asked respondents to rank the different roles of trees in their farms. The results are, in order of importance, timber production, fruit production, soil conservation, shade provision, fuelwood provision and windbreak function. This clearly confirms the emphasis farmers put on productive roles of trees, since timber and fruit production consistently rank respectively first and second. It is interesting to note that the role of trees in soil conservation is considered to be highly important.

3.3.3 Farmers' Motivations Under Changing Land-Use Conditions

To study local trends in on-farm tree growing, households were asked whether they made adaptations or conversions in the cropping systems applied to their farm

Photo 3.4 Plantation of mixed natural and introduced fruit, fuelwood and timber tree species supplementing seasonal cash crop cultivation in Isabela Province, the Philippines (©DJ Snelder)

Table 3.6 Different types of land use change and their past and future (planned) occurrence (expressed as a percentage of total number of fields) on lowland (n = 236) and upland (n = 114) fields in the Cagayan Valley, Philippines

Land use change	Lowland fields[a] (%)		Upland fields (%)	
	Past	Future	Past	Future
Non-tree to tees	13	5	30	4
Seasonal crop to other seasonal crop	17	4	5	5
Tree-based to other tree based/ or more trees	1	5	9	25
Tree-based to non-tree-based	2	0	0	2
Add non-tree component to tree based system	–	0	–	5
No land use change	67	86	53	59

[a] In order to simplify the data, the hilly lowlands have been incorporated in the lowland data

fields since they first started cultivation (Table 3.6). The analysis of these land use changes, which spanned a time period of 30 years, reveals that in only 35 percent of all fields some adaptation had taken place. These changes most often entailed the integration of trees into a field that did not contain trees before. The conversion of a field with trees into a field without trees has been relatively rare. Trees have been introduced rather than removed from the farming landscape. Table 3.6 shows remarkable dissimilarities between upland and lowland areas. Tree introduction is more pronounced in upland areas, while in the flat and often most fertile lowlands the emphasis clearly lays on seasonal cropping.

Smallholders derived the idea to integrate trees in their farms from several sources but, in particular, from their social network, including relatives and neighbors, and observations of tree growing in fields of co-farmers (54 percent, n = 78). Often farmers feel it is their own idea to grow trees in their fields (31 percent), which may indicate that tree growing is a traditional practice. Direct influence of extension activities on farmers' tree integration behavior is contradicting; farmers themselves do not often perceive extension as a major source of inspiration to grow trees (12 percent). Yet of all respondents with trees in their fields, a much larger percentage, i.e., 53 percent, had received some form of extension. However, since farmers often imitate what is seen in farms in their surroundings, the impact of farmer-farmer extension may be quite substantial. In 4 percent of the cases farmers reported both extension as well as people from their social network that influenced their decision to plant or retain trees in their farms.

When soliciting farmers' motivations for shifting from their current or past land use into trees, i.e. not only for tree integration, their answers suggest that – in addition to those listed in Table 3.4 – four other factors affect tree integration: (a) changes in profitability and productivity of competing crops, (b) lack of natural tree supplies and (c) changing market imperatives for tree products, and (d) declining soil conditions. In 27 percent of the cases with a planned shift in land use, the planned change was associated with farmers dissatisfaction with seasonal corn production due to declining output prices, rising input prices and lowered productivity. Whereas output satisfaction for yellow corn fields was achieved by only 42 percent of the households, purely perennial fields ranked highest in terms of farmers' output satisfaction (100 percent).

The motivations for growing (more) trees on fields in the future, lie in the benefits that can be derived from trees. Farmers in general mentioned several motivations for their planned land use change, most importantly, the current sale-ability and profitability of fruits (13 percent) and the planting of trees for income diversification (12 percent) and pension provision (6 percent). Advantages associated with tree production, such as, low labor requirements (5 percent) and modest capital investments (5 percent) were also mentioned.

3.4 Discussion

Tree growing on farm fields is particularly common in upland areas and is, though modestly, on the increase. Farmers are interested in growing trees mostly out of economic and partly out of environmental considerations, whereas there is much evidence that both push and pull factors are at work. Decreasing natural supplies of trees coupled with augmenting market demand for farm-grown timber have resulted in favorable prices for tree products (pull). This coincides with observations in Kenya where similar dynamics proved to be an incentive to cultivate trees (Scherr 1995). On the other hand, disappointing productivity and profitability of seasonal crops (mainly yellow corn) have encouraged farmers to orient themselves more on trees (push). The latter is confirmed by another study in the Philippines showing that tree adoption is related to rising prices for tree products (i.e. mango) and decreasing prices for non-tree, seasonal cash products (i.e. corn and rice; Shively 1999). Trees are increasingly part of rural livelihood strategies; they are planted or retained as a means of savings, income diversification and pension provision. Farmers' perception of trees as income-generating crop may well be associated with extension efforts promoting trees as cash crops. Moreover, according to farmers, tree cultivation has some comparative advantages over seasonal crops, such as, low labor and capital requirements (specifically timber trees). Yet, most on-farm tree growing activities take place out of subsistence considerations, i.e. trees are grown to meet household needs.

A main question in the literature refers to whether agricultural intensification necessarily leads to the disappearance of tree cover to make room for intensive seasonal crop production, or whether intensification in itself create a need for sustainable tree-based production systems in order to keep up productivity levels? On the basis of this study, the following observations can be made. Firstly, in the intensively cultivated lowland zone, both the level of tree adoption and planned tree growing are lowest. Similarly, natural tree stocks have almost disappeared while in the upland zone still a reasonable amount of naturally growing trees occur. However, tree growing in the lowlands is more often related to the need for a tree product that cannot be satisfied with naturally growing trees at a reasonable labor and financial investment whereas tree growing in the uplands is more market-oriented. In addition, trees are increasingly grown to counter soil degradation in sloping areas; a role that is valued highly. This indicates that after two decades of progressively more intensive cultivation of seasonal crops, degradation processes are becoming a familiar phenomenon to farm households in sloping or hilly areas. Related to this, the awareness of reduced yields through soil degradation leads in various cases to greater interest in trees rather than seasonal cash crops. These developments coincide with a rising market demand for tree products among both rural and urban communities. Markets that cater the growing urban populations can absorb higher quantities of fruits and fruit products from the agricultural hinterland communities, while also the demand for timber and construction materials increase with the standards of living of parts of the rural and urban populations. Because it is becoming gradually more time-consuming and expensive to harvest trees from the forest, a market for farm-grown trees has come to exist. Timber is increasingly produced from farm fields rather than gathered from surrounding woody patches and nearby forests, as was common in the past. Similar trends in on-farm tree growing are also observed elsewhere in the Philippines. For example, Bertomeu (chapter 8, this volume) refers to land use intensification associated with farm-grown trees in Mindanao in Southern Philippines. Thus, land use intensification produces two opposing trends in tree integration that at the same time contributes to regional specialization: the uplands with lower land-use intensity where trees are preferably grown at increasing densities for both home and market purposes and the lowlands with high land-use intensity where tree integration is limited and usually subsistence oriented.

Adoption studies have been performed to find out what factors explain tree growing patterns in areas under study. Then, the question evolves whether we can distinguish general patterns of tree integration that have worldwide applicability, and if not, if we can understand what causes these relationships to differ. As these studies concern different agroforestry or tree-based systems, the differences in relations found may be contributable to this. In most studies the age of the household head was found to be positively related to agroforestry adoption (e.g. Mercer 2004). In this study, the expected positive relation is explained by reasoning that older-aged farmers grow trees as a pension provision and value trees for their limited labor requirements (compared to seasonal crops). Moreover, the trees or fruits are often harvested by buyers, implying the elderly are still able to make independent transactions even if their physical condition may not allow them to engage in too straining activities. Older farmers are also less cash-oriented since their lifestyle does not require large amounts of cash, for example, to pay their children's education. In stead, "leaving something behind for one's children" is rather an important motive for establishing a timber plantation, assisting offspring in meeting their future wood needs.

Yet, there are exceptions in the literature with studies showing a different relationship between age and tree growing. For example, Thangata and Alavalapati (2003) report that younger households in Malawi more often adopt mixed intercropping of *Gliricidia sepium* with maize because of greater willingness to take risks and thus be more open to venture into the unknown.

As in other studies, extension was found to relate positively to tree growing in farm fields (Mercer 2004). Although the tree projects in the area were not utterly successful (very low survival rates of seedlings dispersed), the free distribution of seedlings and the information and technology dissemination campaigns have increased the adoption rates. Similarly, households with greater land endowments more often grow trees. This also corresponds to findings in the literature where greater endowments imply more willingness by households to engage in new, and therefore insecure, farming activities. Moreover, households in this study are only willing to devote land to long-term crops after having set aside sufficient land for growing short-term commercial crops to fulfill immediate cash needs. Large farms allow households to produce both seasonal and tree crops for diversification, subsistence use and market sale. Surprisingly tree growing is positively related with households having no or limited capital available, given the establishment of a tree plantation usually requires high investment. The latter is particularly true for fruit trees, however, farmers regularly refer to freely distributed fruit-tree seedlings within the framework of various promotional programs as source of planting material. Moreover, they mention low investment needs for timber plantations.

In this study, the time spent on non-farm labor is positively related to tree growing. Tree production is generally perceived as less labor intensive, and thus combining better with non-farming activities, compared to seasonal crop production. In most literature, the total household labor is positively related to tree adoption (Pattanayak et al. 2003). However, in a study on urban wage labor in Pakistan, it was reasoned that this type of labor rather than tree growing itself is less demanding and therefore encouraged farmers to cultivate trees (Dove in Arnold and Dewees 1995).

At the farm field level, tenure is negatively related to tree growing. This contradicts the general positive relationship in other studies (Mercer 2004) suggesting farmers are more inclined to grow trees on land with secure tenure. The latter is explained in terms of the high investments to be made for plantation establishment. The households in this study did not follow this trend because the fields with secure tenure (i.e., titled or CLT-land) are mainly prime agricultural land preferably used for seasonal cropping. The fields with relatively insecure tenure (i.e., squatted lands or land taken into 'position') are preferably used for tree growing and located on sloping land close to the forest boundary. Although officially households have no tenure over these lands, they can use the land with little chance of being evicted. Law enforcement is hardly practiced. The Philippine government generally tolerates the informal land occupancy and, at local level, the informal claims are well recognized. Some farmers use tree growing as a means to claim the land, hoping that tree ownership will eventually lead to secure land rights.

The distance between a field and farmer's house is negatively related to tree growing but no examples have been found in other studies. Trees are preferably grown close to the house where farmers can more easily inspect them and prevent damage or losses by fire, astray animals and theft (in the case of fruits). The size of a field is positively related to tree growing corresponding to the majority findings in the literature (Pattanayak et al. 2003).

Tree growing is further positively related to fine-textured clayey soils and negatively related to coarse-textured soils. Clayey reddish soils are of relatively low fertility and mostly located on sloping land. The soils in sloping areas are generally thinner and affected by the outflow of nutrients (by through flow and overland flow, i.e., erosion) and therefore not very suitable for seasonal cash crop cultivation. Clayey black soils are more fertile and high in base-rich smectites. They are located in concave slope sections, foot slope areas (both locations affected by the inflow of nutrients) or slope depressions. The coarse-textured soils have a relatively high sand content (sandy loam, sandy clay loam) and are often developed in alluvial material. They therefore typically occur in flat areas near rivers and streams, which are preferably reserved for the cultivation of seasonal cash crops, i.e., corn and tobacco.

A major challenge is finally to translate these findings into adaptations of extension programs. What is necessary is to adapt proposed technologies to specific situations of the recipient communities and offer multiple, rather than single, technologies allowing each household to choose whatever fits best within their livelihood strategy. This is the so called 'basket of technology' that Scherr (1995) proposes as extensions strategy. That this has not yet been achieved illustrates that the gap between the research community and actual development practice has as of yet, not been bridged.

3.5 Conclusions

This study gives rise to several conclusions. Firstly, economic incentives play a major role in tree adoption and several tendencies cause tree product prices to increase (with indications of increases in demand for both timber and fruits and decreases in supply of naturally-grown open-access timber). Although farmers now experience difficulties accessing markets for tree products, over time market chains for on-farm produced tree products will develop spontaneously if current economic incentives persist. As these channels develop, more efficient marketing may contribute to higher prices as well as larger markets for tree products. However, in the research area current markets for seasonal crops are much better developed, decreasing marketing risks for peasants. The adoption of trees in farming systems may be increased when clear marketing channels for tree products exist that are accessible for all. This will decrease insecurity and risk related to marketing of output tree products. Policy interventions could aim to speed up this process of market development for tree products.

Secondly, government and non-government extension on agroforestry and tree integration have positively affected tree growing on farms. However, what specific activities (seedling dispersals, environmental education, technological knowledge-sharing, awareness-raising of timber and fruit trees as cash-crop) were most effective remains unclear. Research addressing the question of what specific extension activities have the greatest impact on tree adoption would be highly interesting because financial resources for agroforestry extension are often limited in developing countries. Higher efficiency in targeting extension activities might imply that a wider geographical scope can be achieved, exposing more areas to the potential benefits of agroforestry.

Thirdly, significant constraints hinder farmers' adoption of trees in their farms. These constraints should be addressed in a practical manner, sparking research for tree-based technologies to overcome them. In the specific case of the Philippines, typhoons, seasonal droughts, astray animals and wildfire are mentioned as strong constraints to economically successful tree integration. Additionally, many of the constraints are related to local behavior (free-roaming animals as well as fires that are often of anthropogenic origin). These could be addressed as part of extension strategies. At the local level, various measures can be taken to control these constraints, for example by fining owners of astray animals and devising village-level regulations on fire-damage outside farm fields burned to remove crop residues and weeds.

Fourthly, households differ greatly in their specific needs. From this study it has become evident that households with larger farm areas and 'older' heads more often integrate trees in their farm fields. Although it has been known that rural households are not homogenous in their adoption behavior, in reality extension activities often treat them as if they are. A more diversified extension offering multiple technologies for different groups will be more appropriate and give additional advantages for diversified rural economies. Similarly, farmers are more willing to integrate trees in certain land types. As turned out in this study, sloping lands and fields close to farmers' residence are more often used for trees. Similarly, trees are more frequently grown in fine- and medium textured soils. As such, farm-level factors should also be considered in extension approaches.

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Chapter 4

Dudukuhan Tree Farming Systems in West Java: How to Mobilize Self-Strengthening of Community-Based Forest Management?

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Abstract Dudukuhan are traditional tree farming systems in West Java, Indonesia and can be divided into four types: (1) timber systems, (2) mixed fruit-timber-banana-annual crop systems, (3) mixed fruit-timber systems, and (4) fallow systems. Traditionally dudukuhan are managed on an extractive basis, with few inputs (quality germplasm, fertilizers, labor, etc.) allocated to maintain or improve system productivity. Farmers favour this management approach because of limited land tenure, small landholding size, off-farm employment opportunities, limited market access, or their limited experience with intensive tree management. Depending on the socioeconomic conditions and market opportunities the management of a specific piece of land may shift between the four types of dudukuhan. This transformation occurs gradually over a number of years and affects the tree diversity and total number of trees in the system. A desire for tree products, market opportunities, and land tenure status are the key factors that influence farmers' decision concerning which type of dudukuhan to develop. Positive changes in these factors have a positive influence on tree diversity and tree density. Income generation is the primary factor influencing farmers' choice of tree species. Soil conservation is a secondary but important factor influencing both choices of dudukuhan and tree species. Farmers are interested in intensifying the management of their dudukuhans, but hesitate because they do not know where to focus their efforts. Experience indicates that Nanggung farmers may be best served by transforming their traditional subsistence tree farming systems into semi-commercial enterprises that yield products to meet both home and market demand.

Keywords Talun, tree diversity, transformation process

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4.1 Background

In Indonesia, most agroforestry systems are established through shifting cultivation, which complements relationships between trees and crops, and between forests and farming systems (Michon and de Foresta 1995). Under this relationship natural forests support the livelihoods of local people and at the same time forest vegetation gradually establish on farms (De Foresta et al. 2000). Indonesia boasts a number of agroforestry models that establish gradually and integrate both biophysical and socioeconomic functions. Examples of these models include: the *repong* damar resin producing system of Krui, Lampung; the jungle rubber systems of Jambi and South Sumatra; the *tembawang* (fruit and timber products) system of West Kalimantan; the *pelak* system of Kerinci, Jambi; the durian system of Gunung Palung, West Kalimantan; the *parak* system in Maninjau, West Sumatra; and the *talun* systems of West Java (De Foresta et al. 2000).

The talun system is called *dudukuhan* in Sundanese, the local language of West Java. There is no recognized difference between dudukuhan and talun systems. Dudukuhan systems are divided into four types: (1) timber system, (2) mixed fruit-timber-banana-annual crops system, (3) mixed fruit-timber system, and (4) fallow system. These systems are distinguished from homegardens (*pekarangan*) by location – away from the house – and a lower level of management. Traditionally all types of dudukuhan are managed on an extractive basis, few inputs (quality germplasm, fertilizers, labor, etc.) are allocated to these systems. Farmers favor this management approach because of limited land tenure, small landholding size, off-farm employment opportunities, limited market access, or their limited experience with intensive tree management. Limited management results in low system productivity and low farm income.

A study was conducted to characterize dudukuhans and evaluate their potential to reduce poverty and provide environmental services. Three key points were addressed: (1) tree diversity and dudukuhan profiles (important characteristics), (2) farmers' perceptions regarding tree species selection and tree use in dudukuhans, and (3) identify and analyze options for empowering and mobilizing farmers' self-interest to enhance dudukuhan productivity and profitability and provide environmental services. Results from the study were used by World Agroforestry Centre (ICRAF), Winrock International, the Indonesia Institute for Forest and Environment (RMI) and government extension agency to help farmers improve the productivity and market-orientation of their dudukuhans and recognize the value of the environmental services provided by dudukuhans. This paper presents key results of the study.

4.2 Methods

4.2.1 Site

The study was conducted in Nanggung subdistrict (kecamatan) located at longitude 106° 27′ 35″ to 106° 35′ 26″ and latitude 06° 33′ 25″ to 06° 45′ 45″. Nanggung subdistrict consists of ten villages with an area of around 11,000 km^2 and elevation of 400–1,800 m a.s.l. The study was conducted in three sample villages that were purposively selected according to their watershed location (upstream, mid-stream, and downstream). The villages selected are Cisarua, Curug Bitung, and Parakan Muncang.

4.2.2 *Tree Diversity and Dudukuhan Profiles*

The tree diversity and profiles of dudukuhans were assessed through an inventory of 36 dudukuhans. Three dudukuhans of each type were inventoried in each of three villages. The Dynamic Sample Unit method (Sheil et al. 2002) was used to conduct the inventories. The method uses 40-m long transect lines to measure species richness, tree density, and tree basal area. The transect line is divided into eight tree sampling units as depicted in Fig. 4.1. Within each unit a maximum of five trees are measured. Trees must have a diameter at breast height (dbh[1]) greater than 10 cm. For each sampling unit, the following data were recorded: the number of trees, the species of trees, the dbh of each tree, and distance of the fifth tree from the transect line (d1, d2, d3 … as depicted in Fig. 4.1). The maximum distance a tree can be from the transect line is 20 m (d7). The maximum distance for searching in each cell before deciding it is ‘empty’, is 15 m (d6). Tree diversity in dudukuhan systems was determined using the Shannon-Weiner (H’) Index (Smith 1990).

Multiple Regression analysis was used to describe the relationship between number of species, number of trees and dudukuhan profiles, to understand farmers’ perceptions of the dynamic composition of tree species and number of trees in dudukuhan systems based on dudukuhan size, tree density and tree basal area, elevation of plot, and the number of trees and tree species in dudukuhan systems. Significance level of each regression coefficient is indicated at 1%, 5% and 10% levels. The number of species and the number of trees served as the dependent variables. Dudukuhan size, tree density, basal area, elevation, the number of tree

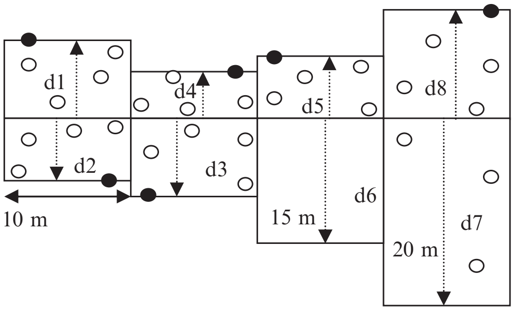

Fig. 4.1 Tree sample units along 40 m of transect line

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[1] Diameter breast height is a trees diameter a height of 1.3 m above the ground.

species, and number of trees served as the independent variables ($\mathbf{x}_1$, $\mathbf{x}_2$, $\mathbf{x}_3$, …, $\mathbf{x}_i$). The four Multiple Regression equations used are:

1. *Number of fruit species (y) = Constant + Dudukuhan size (x_1) + Tree density (x_2) + Basal area (x_3) + Elevation (x_4) + Number of timber species (x_5)*
2. *Number of timber species (y) = Constant + Dudukuhan size (x_1) + Tree density (x_2) + Basal area (x_3) + Elevation (x_4) + Number of fruit species (x_5)*
3. *Number of fruit trees (y) = Constant + Dudukuhan size (x_1) + Tree density (x_2) + Basal area (x_3) + Elevation (x_4) + Number of timber trees (x_5)*
4. *Number of timber species (y) = Constant + Dudukuhan size (x_1) + Tree density (x_2) + Basal area (x_3) + Elevation (x_4) + Number of fruit trees (x_5)*

4.2.3 Farmers' Perceptions Regarding Tree Selection and Uses

Focal group discussions (*FGDs*) were used to collect information regarding farmers' perceptions on tree species selection and use. Discussions considered three variables tree profiles, their landscapes position, and their socioeconomic value. Respondents were asked to identify and rank relevant sub-variables as: less important (1), quite important (2), important (3) or very important (4).

4.2.4 Management of Dudukuhans

Dudukuhan management – including inputs, outputs and financial returns – were documented through a separate farm and household economic study of dudukuhan owners (Budidarsono et al. 2004). In the study 35 households were purposively selected and interviewed in each of the sample villages.

4.3 Results

4.3.1 Tree Diversity and Dudukuhan Profiles

The size of dudukuhans reported by landowners varied between 0.054 and 0.377 ha (Budidarsono et al. 2004). A total of 52 tree species were identified as components of dudukuhan systems. These include 26 fruit species and 26 timber species; with fruit species include those that produce vegetables, spices, medicines, and or other food condiments (they may have other primary wood or non-wood uses). Tree species diversity (H' index) in dudukuhan systems by village (watershed location) is: Cisarua (1.02), Curug Bitung (0.97), and Parakan Muncang (1.19). Statistically, there is no difference tree diversity between the villages.

A large number of maesopsis (Maesopsis eminii Engl.), locally called african timber (kayu afrika), exist in dudukuhans compared to other tree species. Maesopsis is more common at higher elevations and accounts for 34.6% of all trees in Curung Bitung village. The high occurrence of maesopsis causes the tree diversity value for Curug Bitung village to be lower than the values for the other sample villages, even though the number of tree species in Curug Bitung village was higher than either Cisarua or Parakan Muncang villages. Table 4.1 shows that the number of fruit tree species is higher than timber tree species in all sampled villages. The number of trees (per hectare) for fruit tree species in Parakan Muncang village were higher than in Curug Bitung and Cisarua villages. But the number of timber trees (per hectare) in Curug Bitung and Cisarua villages were higher than in Parakan Muncang village.

Tree species diversity is highest in mixed fruit-timber systems, followed by mixed fruit-timber-banana-annual crops systems, fallow systems and then timber systems; the number of trees per hectare is highest in fruit-timber-banana-annual crops systems, followed by timber systems, mixed fruit-timber systems and fallow systems (Table 4.2). Average tree basal area is: 15.2 m^2 ha^{-1} for mixed fruit-timber systems, 12.3 m^2 ha^{-1} for mixed fruit-timber-banana-annual crops systems, 9.3 m^2 ha^{-1} for timber systems, and 6.6 m^2 ha^{-1} for fallow systems.

The differences in species and tree number per hectare influences the tree diversity value for each dudukuhan system type. Shannon-Weiner Index (H') for each dudukuhan system are: 1.31 for mixed fruit-timber systems, 1.18 for mixed fruit-timber-banana-annual crops systems, 1.10 for fallow systems and 0.44 for timber systems. The T-test results for tree diversity show significant differences between the timber systems and both the mixed fruit-timber-banana-annual crop systems and the mixed fruit-timber systems at the 1% level. The differences between the fallow systems and all other systems are significant at the 5% level. There is no significant difference in tree diversity of between mixed fruit-timber-banana-annual crops systems and mixed fruit-timber systems,

The ten most common tree species in dudukuhan systems are: *Musa* sp. (26.8% of total trees), *Maesopsis eminii* Engl. (22.1%), *Paraserienthes falcataria* (L.) Nielsen (14.4%), *Artocarpus heterophyllus* Lam. (4.0%), *Schima wallichii* Noronha (3.8%), *Archidendron pauciflorum* (Benth.) Nielsen (3.6%), *Nephelium lappaceum* L. (3.3%), *Euodia latifolia* DC. (2.9%), *Parkia speciosa* Hassk (2.2%), and *Mangifera odorata* Griff (1.7%). Additionally, *Durio zibethinus* Murr is the twelfth most common species, accounts for 1.5% of all trees in dudukuhan systems and has a very big market demand at the village, district and provincial levels.

Table 4.1 Tree species composition by village

Trees	Cisarua			Curug Bitung			Parakan Muncang		
	Species	Trees/ha	Trees/ha (%)	Species	Trees/ha	Trees/ha (%)	Species	Trees/ha	Trees/ha (%)
Fruit	17	158	38.3	20	229	40.5	20	476	71.0
Timber	12	254	61.7	16	336	59.5	10	194	29.0
Total	29	412		36	565		30	670	

Table 4.2 Tree species composition by dudukuhan type

Trees	Timber system			Mixed fruit-timber-banana-annual crop system			Mixed fruit-timber system			Fallow system		
	Species	Trees/ha	Trees/ha (%)	Species	Trees/ha	Trees/ha (%)	Species	Trees/ha	Trees/ha (%)	Species	Trees/ha	Trees/ha (%)
Fruit	3	130	20.3	20	539	72.0	23	256	56.1	16	227	63.8
Timber	7	510	79.7	12	210	28.0	20	200	43.9	7	129	36.2
Total	10	640		32	749		43	456		23	356	

4.3.2 Farmers' Perceptions of the Selection and Uses of Tree Species

Farmer respondents recognized 14 sub-variables as relevant to tree species selection: (a) biomass production, (b) tree shading, (c) roots system, (d) fast growth and fruiting, (e) tree use value, (f) pests-diseases, (g) dudukuhan size, (h) slope, (i) soil type and fertility, (j) elevation, (k) weather and rainfall, (l) marketing opportunities, (m) land tenure statue, and (n) government policy. They recognized eight sub-variables as relevant to tree use, the species value for: (a) food, (b) income, (c) fuelwood, (d) construction, (e) fodder, (f) medicine and (g) erosion control.

Figure 4.2 illustrates farmers' perceptions regarding tree selection in each village. Tree use value, marketing opportunities and land tenure status are the main factors (very important rank) that influence tree species selection in all villages. Fast growth and fruiting, a lack of pest-disease problems, and garden size are very important or important factors in at least two of the three villages. Tree root system structure (competition for water and nutrients) is considered by farmers in one village, who commented that certain fruit and timber species should not be planted near each other. Government policy is considered very important in one village because the government charges fees on the production of certain timber species (i.e. *Pinus merkusii*). The slope and soil characteristics of the site are of medium importance, particularly when soil erosion is a concern. Elevation, rainfall, biomass production and shading characteristics are of least importance in species selection for dudukuhans.

Figure 4.3 illustrates farmers' perceptions on tree uses. Their main reasons for trees being cultivated in dudukuhan systems is for income generation and food production (fruit species). The production of construction material is an important to medium priority for selecting both timber and fruit species. Erosion control is a medium consideration for species selection in the rainy and steep study area.

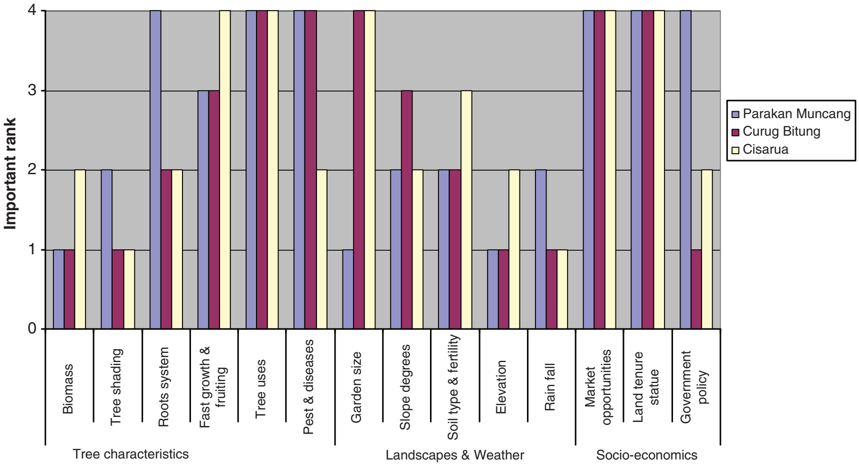

Fig. 4.2 Ranking of farmers' criteria for tree species selection

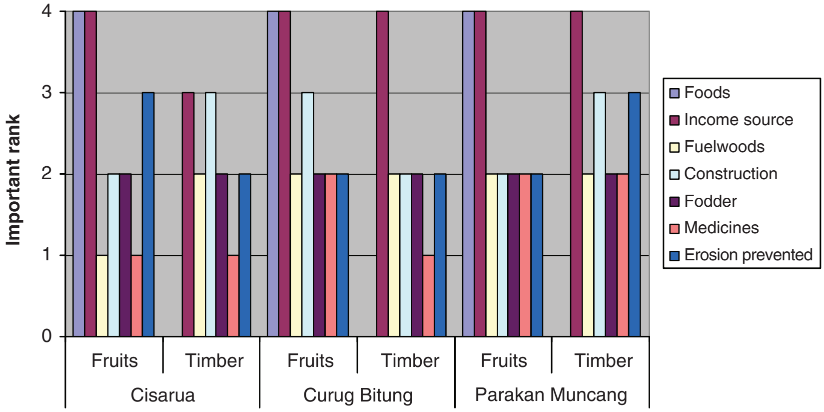

Fig. 4.3 Ranking of farmers' priority for tree uses

The production of fodder and fuelwood are of medium consideration to species selection. The production of medicinal products is of least importance.

4.3.3 Management of Dudukuhans

Table 4.4 summarizes dudukuhan management by farmers as documented by the *farm and household economic study* (Budidarsono et al. 2004). Typically, dudukuhan systems receive little proactive management. Harvesting is the most common activity, conducted in 35.9% of dudukuhans during the period analyzed by the study. Weeding and maintenance of tree or annual crops is the second most common activity, conducted 15.1% of the dudukuhan plots. The number of person-days committed to harvesting (30 ps-day ha^{-1}) was less than the number of person-days used in weeding and maintenance (95 ps-day ha^{-1}). Chemical fertilizer was applied in only 1.4% of dudukuhans; with organic fertilizer applied to 3.1%. The average application of chemical fertilizer was very low, only 30.0 kg ha^{-1}; the average application of organic fertilizer was reasonably high (1.9 t ha^{-1}).

4.4 Discussion

Nanggung has human population of 74,211 people and 17,187 households. Average landholding per household is 0.3 ha of irrigated riceland and 0.25 ha of dudukuhan. Dudukuhan systems cover 16.7% of total area of the subdistrict. While 73.3% of the household heads consider themselves farmers, agriculture provides only 31.2% of household incomes. Trade (operating small shops), the service sector, gold mining, bentonite mining, and plantation work are alternative sources of household income (Budidarsono et al. 2004).

Table 4.3 Economic inputs and returns by dudukuhan type (Budidarsono et al. 2004)

Management system	Mixed timber system	Mixed fruit-timber-annual crops-banana system	Mixed fruit-timber system	Fallow system	All
No. of plot	16	55	129	8	208
Total area (ha)	4.32	13.67	34.5	0.43	52.92
Average area per plot (ha)	0.377	0.263	0.312	0.054	0.251
Tradable inputs					
1. External inputs					
1.1. Chemical fertilizer					
• Plot applying chemical fertilizer (%)		0.7	0.7		1.4
• Average chemical fertilizer application (kg ha^{-1})		43.8	16.2		30.0
1.2. Organic fertilizer					
• Plot applying organic fertilizer (%)	0.3	1.9	1.0		3.1
• Average organic fertilizer application (kg ha^{-1})	714.5	2,009	3,137		1,953.3
1.3. Pesticide					
• Plot applying pesticide (%)		4.9	1.3		6.2
2. Labor inputs					
2.1. Planting					
• Plot with planting activity (%)	0.3	0.7	2.1		3.1
• Total labor (ps-day/ha)	4	9	9		22
2.2. Tree and crop maintaining					
• Plot with tree and crop maintaining activity (%)	0.7	3.3	11.1		15.1
• Total labor (ps-day/ha)	19	58	18		95
2.3. Harvesting					
• Plot with harvesting activity (%)	1.4	11.6	22.9		35.9
• Total labor (ps-day/ha)	4	14	12		30
Returns (Rp 000)					
Fruits (Rp/ha)		18,564	28,581		47,144
Timber (Rp/ha)	3,211	7,173	11,021		21,405
Annual crops (Rp/ha)	382	4,524			4,906
Sum	3,593	30,260	39,602		73,454
Net Returns (Rp 000)					
Total	3,241	28,116	35,148		66,505
Average per plot	954	1,076	655		2,684
Average per hectare	2,223	4,161	2,049		8,432

Tree species diversity (H’= 1.31 to 0.44) in dudukuhan systems is lower than the tree species diversity in nearby Gunung Halimun National Park (H’ = 4.05; Suzuki et al. 1997) which is located in the upstream area of Nanggung at elevations of 1,000–1,800 m a.s.l. The natural forest in the national park is a climax ecosystem; dudukuhan systems still experience dynamic change in tree species composition and tree number as a result of farmer-controlled harvesting and enrichment planting.

This harvesting and enrichment process, opportunistic in response to market demand and household needs, results in tree species diversity lower than natural climax forests.

Tree diversity, tree density, and tree basal area data indicate a transformation process exists between dudukuhan types in the form of dynamic change in tree species composition and number of trees (Table 4.2 and Figs. 4.2, 4.3). This transformation results from farmers' strategy to maintain or enhance the dudukuhan productivity to improve household income and livelihoods. In general, the dynamic change in tree species composition and tree number has a positive impact on biodiversity as well as soil and water conservation. Both indigenous and exotic tree species are planted by farmers. The indigenous fruit and timber species are used for meeting the household subsistence needs; the exotic (introduced) fruit and timber species are planted to meet market demand (and provide household income). The occurrence of indigenous and exotic tree species in large numbers in dudukuhans demonstrates that they are: (a) adapted to the biophysical conditions of the Nanggung area and (b) meet farmers' marketing and subsistence needs.

The dudukuhan transformation process is illustrated in Fig. 4.4 and can be described as follows. A fallow system is cleared by farmers to cultivate annual crops and bananas for 3 to 4 years. Those annual crop-banana systems are called '*huma*' or '*tegalan*'. Farmers continuously enrich the huma with priority fruit and timber species. As the number and size of trees increase huma systems transform to either mixed fruit-timber-banana-annual crop systems or timber systems. As enrichment planting continues and trees mature mixed fruit-timber-banana-annual crop systems transform to mixed fruit-timber systems. Farmers maintain these systems through careful harvesting and enrichment. When mixed fruit-timber systems no longer meet farmers' needs they may be abandoned to transform back to fallow systems or be converted back to huma systems. Depending on management and harvesting intensity, timber systems may transform to mixed fruit-timber-banana-annual crop systems or back to huma systems. The distance of the dudukuhan from the farmers' house also impacts the transformation process. Dudukuhans further from the home receive less management and more quickly transform to fruit-timber systems or remain fallow systems. When market conditions are encouraging distant fallow systems are converted directly to timber systems, without the huma phase. These distant fallow systems may also be given to sons as inheritance near the time of their marriage. Sons convert those fallow systems to timber systems to meet medium-term and long-term livelihood needs.

Table 4.5 summarizes the relationship between dependent variables (number of species and number of trees) and independent variables (dudukuhan size, tree density, tree basal area, elevation) in timber systems. An increase in the number of timber species and trees is associated with an increase in the number of fruit species and trees, and vice versa. Farmers commonly enrich timber system with fruit species such as *Durio zibethinus* and *Mangifera odorata*. To address timber market opportunities farmers prioritize the planting of *Maesopsis eminii* and *Paraserienthes falcataria*. Because these timber species are planted with high densities, dudukuhan size results in significantly great numbers of timber trees. Economic pressures

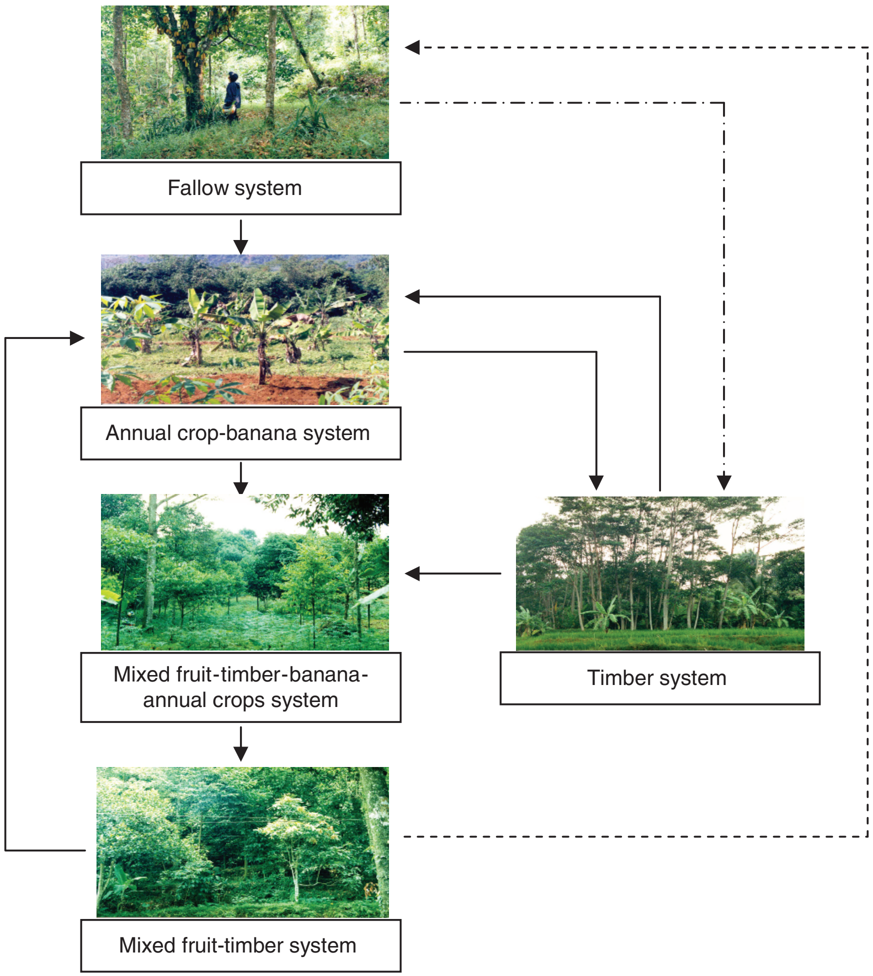

Fig. 4.4 Transformation process between dudukuhan types

cause farmers to start harvesting when timber trees are 3 years old. Farmers frequently fill the gaps created by timber harvesting by planting fruit trees, which are maintained for many years. This process transforms timber systems to fruit-timber-banana-annual crops systems and leads to fruit tree basal area becoming greater than that of timber trees. It also demonstrates farmers' preference for systems that provide for short-term, medium-term and long-term needs. Elevation has a significant influence on the number of fruit and timber species in timber systems. Market opportunities for fruit are higher in downstream areas of Nanggung. Market opportunities for timber are higher in the upstream areas, which support the operation of six sawmills. To address those opportunities, farmers prefer to enrich timber dudukuhan systems with fruit species in downstream areas and with timber species in upland areas.

Table 4.4 Multiple regression analysis results of dependent and independent variables of dudukuhan timber system

Variable	Timber system			
	Number of species		Number of trees	
	Fruit	Timber	Fruit	Timber
Dudukuhan size (ha)	0.100	0.007***	0.671	0.586
Tree density (N/ha)	0.328	0.217	0.105	0.016**
Basal area (m^2)	0.621	0.354	0.086*	–0.042**
Elevation (m a.s.l.)	0.521	0.778	–0.052*	0.012**
Number of fruit species		0.083*		
Number of fruit trees				0.072*
Number of timber species	0.083*			
Number of timber trees			0.072*	

*** indicates significance at 1% level, ** at 5% level and * at 10% level

There are no significant relationships between dependent and independent variables in mixed fruit-timber-banana-annual crops systems (Table 4.6). These systems are very similar with home garden systems; with many mixed fruit-timber-banana-annual crops systems located near farmers' houses. Farmers prefer mixed fruit-timber-banana-annual crop systems because they providing short-term, medium-term and long-term household and income needs. Bananas and annual crops meet short-term needs; *Artocarpus heterophyllus* meets medium-term needs; and other fruit and timber species provide for long-term needs. These dudukuhan systems receive the most inputs and provide the greatest benefit to farmers (see Table 4.4). Net returns from mixed fruit-timber-banana-annual crop systems is IDR 4,161,000 per ha (Budidarsono et al. 2004).

Multiple Regression analysis indicates that in mixed fruit-timber systems all independent variables significantly influence the number of fruit trees (Table 4.7). Farmers tend to plant favor fruit trees over timber trees as the size of the mixed fruit-timber system decreased. Fruit trees are planted at wider spacing, so the tree density decreases when the numbers of fruit tree increased. Basal area increases as mixed fruit-timber systems mature in age, fruit trees are more common in these systems because they are maintained for longer periods than timber trees which are harvested at young age. Elevation has a negative influence on the number of fruit trees in mixed fruit-timber systems because market demand favors timber trees in the upstream area of Nanggung. The numbers of timber species and fruit species in these systems have inversion influences on each other. This data demonstrates farmers' preference for fruit trees as a strategy to maintain or increase their livelihoods.

The Multiple Regression analysis for the fallow system (Table 4.8) show that the number of fruit species increases as dudukuhan size increases. This makes sense as a large area can accommodate many fruit species. Fallow systems are not actively managed; this allows opportunity for natural regeneration of fruit and timber species from surrounding lands and from discarded seed. Because fruit collection from fallow systems is open to all, community members tend to protect and encourage natural regeneration of fruit species in all fallow systems, not just their own.

Table 4.5 Multiple regression analysis results of dependent and independent variables of dudukuhan mixed fruit-timber-banana-annual crops system

Variable	Mixed fruit-timber-banana-annual crops system			
	Number of species		Number of trees	
	Fruit	Timber	Fruit	Timber
Dudukuhan size (ha)	0.782	0.839	0.140	0.286
Tree density (N/ha)	0.856	0.921	0.569	0.964
Basal area (m^2)	0.957	0.846	0.277	0.195
Elevation (m a.s.l.)	0.585	0.679	0.431	0.816
Number of fruit species		0.555		
Number of fruit trees				0.297
Number of timber species	0.555			
Number of timber tree			0.297	

Note: there are no significant results at 1, 5 and 10% levels

Table 4.6 Multiple regression analysis results of dependent and independent variables of dudukuhan mixed fruit- timber system

Variable	Mixed fruit-timber system			
	Number of species		Number of trees	
	Fruit	Timber	Fruit	Timber
Dudukuhan size (ha)	0.785	0.498	–0.046**	0.619
Tree density (N/ha)	0.371	0.722	–0.051*	0.657
Basal area (m^2)	0.740	0.863	0.030**	0.636
Elevation (m a.s.l.)	0.159	0.022**	–0.011**	0.514
Number of fruit species		–0.050*		
Number of fruit trees			0.294	
Number of timber species	–0.049**			
Number of timber trees			0.294	

** indicates significance at 5% level and * at 10% level

Table 4.7 Multiple regression analysis results of dependent and independent variables of dudukuhan fallow system

Variable	Fallow system			
	Number of species		Number of trees	
	Fruits	Timber	Fruits	Timber
Dudukuhan size (ha)	0.099*	0.164	0.221	0.347
Tree density (N/ha)	0.199	0.619	0.146	0.670
Basal area (m^2)	0.165	0.526	0.242	0.342
Elevation (m a.s.l.)	–0.057*	0.325	–0.068*	0.329
Number of fruit species		0.133		
Number of fruit trees				0.393
Number of timber species	0.133			
Number of timber trees			0.393	

* indicates significance at 10% level

The farm and household economic study conducted by Budidarsono et al. (2004) focused on net returns during 2002/2003. The results represent net cash inflow for a single year and do not represent land use profitability. Table 4.4 summarizes the net returns for each dudukuhan type. Results show that, with the exception of fallow systems, dudukuhans provide positive net returns, meaning income exceeds monetary inputs. As this achieved with little proactive planning and management, there is high potential to enhance productivity and profitability of dudukuhans through management intensification.

The potential of tree farming systems has been promoted by many authors. Predo (2002) found that tree farming systems in the Philippines provided annual incomes of Pesos (PhP) 8,860 to PhP 60,996/ha year^{-1}, which greatly exceeds incomes provided by annual crop systems, PhP 5,352 ha^{-1} year^{-1}, and imperata land use system, PhP 69 ha^{-1} year^{-1}. Average annual income from fruit and timber trees in mature damar agroforest systems in Krui, Lampung are Indonesian Rupiah (IDR) 2,410,000 ha^{-1} (De Foresta et al. 2004). Fernandez (2004) reports that benzoin trees (*Styrax benzoin*) contribute as much as 70% of total family incomes, ranges from US$144 to US$216. In Central and East Java, smallholder farmers see tree farming system as a ‘living saving account’ that diversify production, reduce risk, and build assets to enhance family incomes and security (Van Noordwijk, et al., Chapter 20, this volume).

Most smallholder tree farming systems are characterized by limited proactive management and planning. Dudukuhan and others tree farming system are managed on a traditionally extractive basis, few inputs (quality germplasm, fertilizers, labor, etc.) are allocated to these systems. Spacing is irregular and species components often primarily the result of chance. Harvesting products is often the most common management activity, with minimal weeding to control herbaceous and woody competition. As a result, the quality and quantity of products may be far below the systems’ potential. Farmers often occupy weak market positions and are ill prepared to assume an active marketing role. Farmers generally: (i) lack access to market information (product demand, specifications and prices); (ii) lack understanding of market channels; (iii) produce products of unreliable quality and quantity; and (iv) rarely engage in grading or processing to improve product quality (and their profit-margin) (Roshetko et al. 2006).

Farmers are interested in intensifying the management of their dudukuhans, but hesitate because they do not know where and how to focus their efforts. Resource scarcity, a lack of knowledge regarding tree propagation and management, limited access to markets, and governments’ policy disincentives/ambiguities are the key factors that limit farmers’ abilities or incentives to intensify their tree farming systems (Potter and Lee 1998; Carandang et al. 2006). Under conditions of insecure land tenure and poor market access, smallholder farmers can not and will not cultivate a wide range of tree species as a component of their integrated and risk-averse livelihood and land-use systems and will not effectively respond to the increased demand for wood products (Van Noordwijk et al., Chapter 20, this volume).

Mobilizing the self-strengthen of communities to more intensely management tree farming systems can be initiated through the development of a replicable and efficient extension approach designed to reach motivated and innovative farmers who are committed to improve their incomes by increasing the production and market access for their agroforestry products. Such an approach was developed and implemented by ICRAF and Winrock International in Nanggung through the *Agroforestry Innovations and Livelihood Enhancement in West Java Program* (Roshetko et al. 2004). The extension approach is based on providing a series of workshop trainings to farmer leaders and more intensive follow up assistance to farmer groups that these leaders have helped to organize. The workshop trainings provide farmer leaders with the capacity to analyze existing conditions and problems, identify technical options, and set work agendas. Workshops are participatory, relying on the knowledge of farmer and farmer specialists, augmented by input from technical specialists. Farmer leaders identify workshop topics and are responsible to share workshop information and results with their farmer groups. Further follow-up assistance is provide through a number of channels, most commonly the work agendas develop during workshops, weekly farmer group meetings, occasional subject specific farmer group meetings, and informal daily contact between farmers. The approach and activities are based on active farmer participation and leadership that emphasize *farmer to farmer extension* and input from farmer specialists. The approach is flexible and dynamic, adjusting to the actual conditions of and priorities set by farmer participants. It is informal, impact-oriented and avoids wasting resources and time by keeping structure and process simple and straightforward (Roshetko et al. 2006).

Marketing is frequently a priority topic identified by farmer leaders. Rapid market studies are a valuable tool to assist farmers: (i) identify the species and products that hold potential for them; (ii) identify existing and potential market channels for their products; (iii) identify the marketing problems faced by themselves and market agents; (iv) enhance their understanding of market mechanisms; and (v) identifies opportunities to improve the quality and quality of their products and expand their marketing role. These studies could include cross-visits and training activities to develop relationships between farmer groups and market agents (Roshetko et al. 2006).

Extension and market activities are integrated and implemented to develop good management practices to improve system productivity and product marketability to enhance livelihoods and income generation. This process requires farmers to: (1) focus on a limited number of tree species that are appropriate for local biophysical conditions and a high market value/demand; (2) utilize high quality germplasm (provenances, clones, and seed source) to increase productivity and profitability; (3) manage the dudukuhans to yield tree products that meet market specifications and conservation controls; and (4) develop permanent market linkages. Through deliberate management, polyculture tree gardens can be developed based on four or five priority tree species – which yield products with high market values, but also contain a number of other valuable species, both indigenous and exotic, to serve household needs and reduce risks.

Roshetko et al. (2004) noted that utilization of the farmer extension approach discussed above empowered farmers to independently seek assistance and develop solutions to their dudukuhan management problems and marketing challenges. Additionally, farmers have developed an awareness of the importance of high-quality germplasm and deliberate management as means of improving the quality of dudukuhan products and profitability; and begun to incorporate high-quality germplasm and deliberate management into their dudukuhan systems. Farmers are also now aware of the importance of market channels, market information and product specifications; they have begun to develop permanent linkages with market agents and adopt management practices to enhance the quality of dudukuhan products. Developing market linkages with regional traders, instead of waiting for local collectors to visit their farms, helped farmers increase their banana income by 100% (from IDR10,000/bunch to IDR20,000/bunch).

The success of the approach was enhanced through the development of a broad, multidiscipline, multisector partnership with a shared vision. Partners included: local governments (sub-district and village), agriculture and forestry extension officers, non-government organizations (NGOs), the private sector (market traders), university staff, the National Park, research and development institutes (ICRAF and Winrock), and farmer groups. All partners agreed that improving dudukuhan productivity and profitability was a common goal. Roles and responsibilities of each partner were discussed and agreed at the beginning of program; roles and responsibilities continued to evolve throughout the program. Government agencies provided stability by actively supporting the program. Extension officers, university staff, traders and research/development institutes provided technical assistance. Traders and research/development helped develop market linkages. ICRAF and Winrock administered and implemented the overall program. The commitment and participation of local partners was particularly important in providing continuality through the official ending of the program (Roshetko et al. 2004).

4.5 Conclusion

Dudukuhans are traditional tree farming systems which contain high species diversity. Dynamic changes in tree numbers and tree species composition are farmers' strategies to maintain dudukuhan productivity, adjust to evolving market opportunities, enhance their livelihoods (income from market sales plus products for household use), and prevent erosion. Traditional extractive management with low inputs and little planning is the key problem that limits dudukuhan productivity.

Empowering motivated smallholder farmers to enhance and diversify productivity and profitability of their dudukuhan systems may be achieved by transforming traditional subsistence-oriented systems into semi-commercial enterprises that yield products to meet both home and market demand. This process requires that farmers: (1) focus on a limited number of priority tree species that are appropriate for local biophysical conditions and a high market value/demand; (2) utilize high quality germplasm (provenances, clones, and seed source) to increase productivity and profitability; (3) manage the dudukuhans to yield tree products that meet market specifications and conservation controls; and (4) develop permanent market linkages. In addition to the priority species other valuable species should be maintained/included in the dudukuhan to serve household needs and reduce risks.

Integrating collaboration and support with multiple agencies (local governments, extension offices, NGOs, universities, the private sector, and research and development organizations) through a responsive extension approach enhances impact to improve smallholder farmer management skills regarding tree propagation and nursery management, tree and farming system management, post harvest handling, and farmer-operated semi-commercial enterprises.

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Chapter 5
The Adoption of Smallholder Rubber Production by Shifting Cultivators in Northern Laos: A Village Case Study

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Abstract Rubber smallholdings are being established by shifting cultivators in Northern Laos, in response to demand from China and encouraged by government land-use policy. This can be seen as part of a general transition from subsistence to commercial agriculture in the uplands – in particular, from shifting cultivation to tree crop production. This study examines the economics of smallholder rubber production in an established rubber-growing village in Luangnamtha Province. Data were obtained from key informant interviews, group interviews, direct observation, and a farm-household survey. The study shows that, given current market conditions and credit support, investment in smallholder rubber production in the uplands of Northern Laos can be economically rewarding. Hence rubber can be considered one of the potential alternatives for poor upland farmers, in line with the government policy of stabilising shifting cultivation and supporting new livelihood options for poverty reduction. However, there are risks associated with rubber production and emerging constraints of land and labour, hence government should move cautiously in promoting rubber where farmers are uncertain about reducing their dependence on shifting cultivation or where forests are under threat. The recommended role for government is to ensure provision of support services for rubber development, including adaptive research, technical support, extension, credit, road access, and marketing. In particular, maintaining secure access to the China market will be crucial. If carefully managed, the expansion of smallholder rubber in Northern Laos has the potential to contribute to sustainable rural livelihoods.

Keywords Agricultural transition, China market, farm economics, land allocation, upland livelihoods, tree crops

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5.1 Introduction

Lao PDR (hereafter Laos) is a predominantly rural country with 83 percent of the population living in rural areas, of which two thirds relies on subsistence agriculture (Roder 2001). Agriculture accounts for nearly half of GDP and employs 80 percent of the labour force (NSC 2005a). With a total area of 236,800 km^2 and a population of 5.6 million, Laos is the least densely populated country in Asia at only 24 persons per km^2 (NSC 2005b). Yet suitable agricultural land is scarce as around 80 percent of the land area is classified as hilly or mountainous (ICEM 2003). Moreover, with the present annual population growth rate of about 2.5 percent, the agricultural population density will double over the next 25–30 years (Raintree 2002). Laos is one of the poorest nations, with a GDP per capita in 2002 of US$330 and a ranking of 135 out of 175 countries on UNDP's Human Development Index (ICEM 2003; UNDP 2003). The greatest levels of poverty are in the mountainous uplands of the Northern Region, where 50 percent of the land area has a slope of 30 percent or more (Raintree 2002). This mountainous Northern Region is extensively used for shifting cultivation (ICEM 2003).

Shifting cultivation in Laos involves more than 150,000 households (or around 25 percent of rural inhabitants) and may account for up to 80 percent of the land allocated for agriculture, including fallowed fields. Shifting cultivation in the past was recognised as the best land-use alternative for the mountainous regions of Laos because of low population densities, low incomes, little opportunity for trade, and limited access to inputs (Roder 2001). However, this traditional agricultural system has become increasingly unsustainable, reflecting the combined effects of population growth, resource depreciation, and international perceptions of environmental impacts, forcing farmers to shorten their fallow periods. As a result, widespread problems of weed invasion, soil erosion, and declining yields are occurring (De Rouw 2005).

The Government of Laos has made 'stabilisation' of shifting cultivation a priority national program. As stated in its Strategic Vision for the Agricultural Sector (MAF 1999), the Government aims to transform the existing 'harmful' system of shifting cultivation to more ecologically stable cultivation systems with proper land management by villages and individuals. The Government is proceeding with land allocation programs, the promotion of cash crops and livestock production, and the promotion of tree-planting programs with a vision to achieve this aim by 2010. While this policy is controversial and its impacts on rural livelihoods need to be closely monitored (Ducourtieux et al. 2005), there is no doubt that upland farmers are involved in a significant transformation of their traditional subsistence-oriented farming and land-use systems (Thongmanivong and Fujita 2006).

To stabilise shifting cultivation and eradicate poverty in Northern Laos, more sustainable and income-generating agricultural practices have to be identified and adopted. One possible approach to support this transformation is the introduction of tree crops such as rubber to increase farmers' income. Rubber was first introduced into Laos in 1930, with the first rubber plantation established in Southern Laos by French planters during the colonial era. However, smallholder rubber in

Northern Laos is a more recent phenomenon (FRC 2005). In response to the recent growth in market demand, especially from neighbouring China, considerable potential is believed to exist for the expansion of smallholder rubber. Between 1994 and 1996, smallholders in the Hmong village of Hadyao in Luangnamtha Province established rubber over 342 ha and these smallholders started tapping their rubber trees in 2002 (Manivong et al. 2003). By 2004 the total planted area of rubber in the Province was reported to be 4,581 ha, involving 34 villages and 1,559 households. The provincial authorities planned to increase the rubber area by 2,000 ha in the next 5 years (PAFO 2005).

Despite this interest, there is little information available on the potential economic returns to smallholder producers, and on the technical and market constraints they face. Moreover, the impacts of rubber planting on the land-use system and local economy need investigating. To this end, a study of the economic potential and impacts of smallholder rubber in Northern Laos was conducted in Luangnamtha Province in 2005–2006 (Manivong 2007; Manivong and Cramb 2007). This chapter presents selected results from a case study of Hadyao, the pioneer rubber planting village in Northern Laos.

Both qualitative and quantitative data were used to understand the transition from shifting cultivation to rubber production in the case study village. Data were gathered in July–August 2005 through key informant interviews, group interviews, direct observation, and a questionnaire survey of 95 farm-households, which included all the rubber farmers in Hadyao. A pre-tested and modified questionnaire in the Lao language was used. Interviews were undertaken in the Lao language, in some cases assisted by local interpreters. The majority of the interviews were in the respondent's house as this also provided a chance to observe living conditions; however, farm visits were also carried out.

5.2 Theories of Agricultural Transition in the Uplands

Shifting cultivation has been the dominant land use in the sloping uplands of Southeast Asia for many centuries. Integral, rotational, long-fallow systems such as widely practised in the region are considered to be sustainable, provided population pressure is low (Raintree and Warner 1986; Fox 2000). As Boserup (1965) has shown, steadily increasing population pressure in subsistence economies can induce the gradual intensification of such systems from forest-fallow to bush-fallow to short-fallow to annual or even multi-cropping, with necessary changes in crop technology along the way. However, the full intensification sequence proposed by Boserup, with progressively longer cropping periods and shorter fallow periods, is not feasible in much of the steeply sloping Southeast Asian uplands without causing serious land degradation and increasing poverty (Cramb 2005). Raintree and Warner (1986) have elaborated Boserup's theory of intensification, outlining a variety of agroforestry pathways that open up at different stages, such as enriched fallows in the forest- and bush-fallow stages and alley cropping in the short-fallow and annual cropping stages. They highlight that tree crops provide an alternative end-point to the intensification sequence, even at relatively low population densities and labour intensities. Mercer (2004) reviews evidence of such adoption pathways for a variety of agroforestry practices and settings.

Thus with population growth and the improvement of rural infrastructure, shifting cultivators in Southeast Asia have frequently been motivated to incorporate tree crops such as rubber, coffee, and cocoa in their farming systems rather than push shifting cultivation to its ecological limits, thus necessarily moving beyond subsistence production to at least partial engagement with global markets (Cramb 2007). This transition typically occurs in a step-wise fashion as an economy develops. Myint (1973) identifies two stages in the transition from subsistence production to production for the market. The first stage occurs when farmers use the larger proportion of their resources to produce for their own consumption, but use their spare land and labour to produce for the market, thereby minimising the risk involved. The second stage occurs when farmers allocate most of their resources to supplying the market and rely on purchasing commodities and services, with subsistence farming a spare-time activity. The shift is accelerated by the improvement of transportation and market infrastructure and the activities of market intermediaries, encouraging farmers to change from being ‘part-time’ to ‘full-time’ producers for the market. However, smallholders can remain at the semi-commercial stage for many decades, allowing temporary retreat to a subsistence economy when markets experience a downturn (Cramb 1993). For example, Dove (1993) has highlighted how smallholder rubber in particular has provided shifting cultivators in remote areas of Indonesia with both ecological and economic adaptability for nearly a century.

According to Barlow and Jayasuriya (1986), the development of smallholder tree crop cultivation can be classified into three stages, the first two of which correspond to Myint’s schema. The first stage is ‘emergence from subsistence’ when subsistence production is supplemented by a plantation crop. Simple, labour-intensive tree crop technologies are rapidly adopted by smallholders, typically through diffusion from estates. This is followed by the stage of ‘agricultural transformation’ when smallholder farming becomes largely commercialised and new high-yielding tree crop technologies are progressively adopted. Finally, the stage of ‘extended structural change’ is characterised by the increasing significance of the industry and service sectors in the economy, rendering smallholder tree crops less profitable due to the rising cost of land and labour. In a more recent contribution that particularly focuses on the case of rubber, Barlow (1997) further elaborates on this transition, distinguishing between the ‘early’ and ‘late’ phases of the agricultural transformation stage.

Barlow and Jayasuriya (1986) and Barlow (1997) show that the development of smallholder rubber in Malaysia and Thailand has experienced all three stages, whereas in countries such as Indonesia and Vietnam rubber is in the (late) agricultural transformation stage. In this framework, Laos is clearly at the (early) agricultural transformation stage, with rapid diffusion and adoption of simple labour-intensive rubber production technologies – though with the benefit of previous technology development in other countries such as Malaysia and Thailand, and the adaptation of this technology to higher latitudes and altitudes on estates (collective and state farms) in southern China. For Laos to move into the (late) agricultural transformation stage will require further economic growth, more extensive government support, and the development of improved and locally adapted rubber technologies.

5.3 The Case Study Village

Hadyao is situated in Namtha District of Luangnamtha Province around 2 km from the district centre and near the main road to the Chinese border (Fig. 5.1). The village was established in 1975. The first residents were Lao Soung (Hmong) from Oudomxay Province who at first settled in the mountains above the present village site, practising shifting cultivation and opium growing. Two years later they moved down in search of lowland paddy areas. In the first year there were 55 households with a population of 587. From 1975 to 1980, nearly 150 people, mainly children, died of malaria and lack of adaptation to the lowland environment. Many returned to live in the mountains, leaving only 17 households. Then, in 1985, with the encouragement of the district authority, people again started to move down to Hadyao and reconstruct the village, build a school, cooperative, and a state commercial shop, practising group paddy cultivation, and managing livestock grazing areas.

In 1994, 14 Hmong households from China migrated to Luangnamtha Province and requested to live in Hadyao where they had relatives. These people introduced rubber cultivation to the village because they had over 15 years of experience

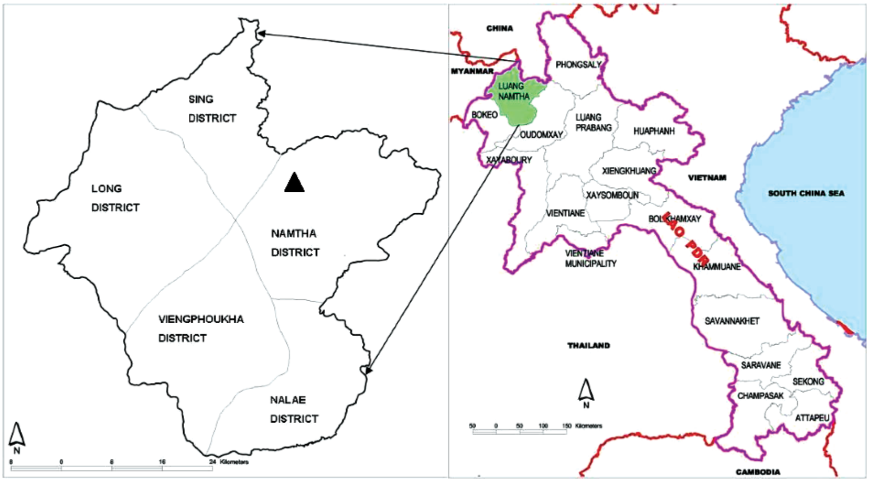

Fig. 5.1 Location of Hadyao village in Namtha district of Luangnamtha province (GIS Unit of NAFRI, 2005)

working in a rubber collective in Yunnan. The village headman and authorities went to Yunnan to explore the possibility of planting rubber and concluded it was the most promising alternative to shifting cultivation. They made a proposal to the provincial authorities and asked for loans for rubber cultivation, which were provided. Many households then faced the problem of having to maintain their immature rubber holdings while cultivating rice for their subsistence. In addition, a heavy frost in 1999 killed numbers of rubber trees. Nevertheless, in 2002 23 households started to tap their rubber, producing 22 t of latex sold to China. Many villagers have since expanded their rubber holdings in their shifting cultivation areas, so the area for shifting cultivation has been substantially reduced.

Currently, the total village population is 964 in 102 households, giving a population density of 21 persons per sq. km. All the villagers belong to the Hmong ethnic group. The average household size in the survey was 7.5 members, with 3.0 full-time workers. The main occupation is agriculture, but there are some government officials, teachers, village traders, and non-agricultural labourers. The level of education varies from primary school to technical college, but the majority did not attend school or have only finished the primary school level.

5.4 Land Resources in the Study Village

Lao farmers who practise shifting cultivation traditionally had usufruct rights to utilise the forest land within their village territory. However, this is now subject to the government's Land Use Planning and Land Allocation (LUP/LA) process, which is being implemented throughout the country (Gansberghe 2005; Tsechalicha and Gilmour 2000). This results in land-use zoning for all the lands within a village territory and the allocation of formal use rights to individual households in the form of Temporary Land Use Certificates and, eventually, Land Titles. In Hadyao LUP/LA was completed in 1997. Each household was provided with three plots of shifting cultivation land, though those with more members could ask for more. The land use zoning defined by the district LUP/LA team is presented in Table 5.1 and Fig. 5.2. The total area of the village is about 4,604 ha. Agricultural land includes limited lowland areas favourable for wet rice cultivation and upland areas that are mainly used for shifting cultivation of rice. The rubber planted since 1994 is located in this area of agricultural land, hence it competes with upland rice and other upland crops. Since land allocation, shifting cultivation has been practised with a three-year rotation, which results in poor soil fertility and weed competition.

With the increasing interest in rubber planting since 2002, many farmers searched for additional land within the village territory to plant rubber or grow upland rice. However, the remaining lands were mostly far from the village settlement, requiring a journey on foot of one to two hours. Therefore, some villagers with kinship or other connections to nearby villages accessible by road obtained land through these connections, mostly under a crop-sharing arrangement.

Table 5.1 Land use zones in Hadyao Village (Hadyao Village, 2005)

Land use zones	Area (ha)	%
Conservation forest	700	15.2
Protection forest	1,300	28.3
Agricultural land	1,700	36.9
Production (plantation) forest	700	15.2
Grazing area	200	4.3
Residential area	4	0.1
Total	4,604	100.0

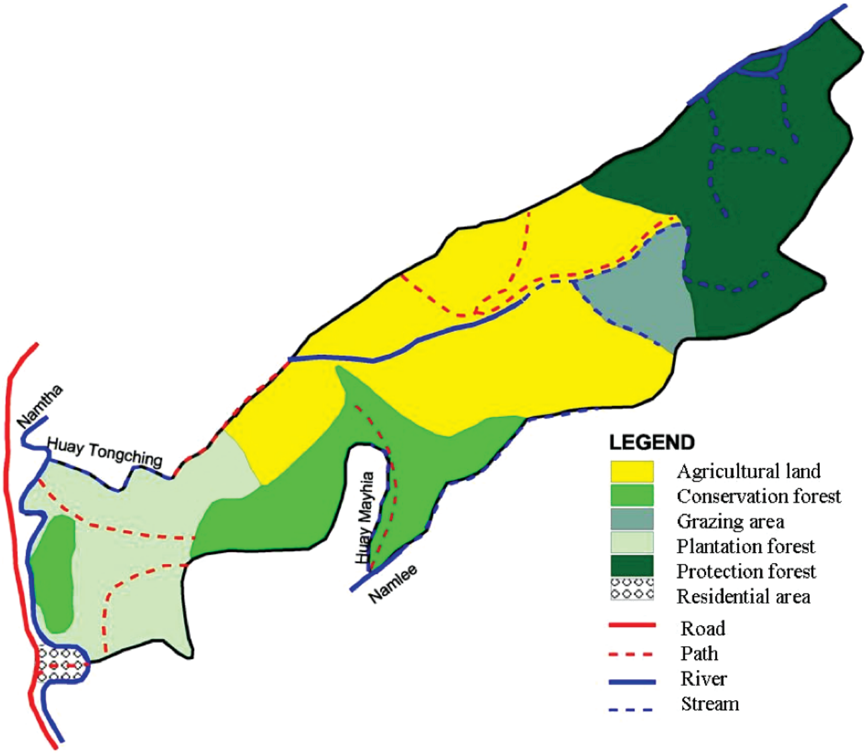

Fig. 5.2 Resource map of Hadyao village (Hadyao Village, 2005)

From the household survey, the average number of cultivated plots per household was 3.5. Over 90 percent of the households had between two and five plots (Table 5.2). The total cultivated area averaged 5.1 ha. Most households were clustered around the mean; 85 percent had from 1.9 to 7.7 ha. Two thirds of the households had all their plots within the village territory, while the remainder had one or more plots in another village's territory (Table 5.3), an indication of the increasing pressure on the village's available land. About 80 percent had land use rights to all the plots they cultivated, while 20 percent had borrowed or rented at least one plot of land because their allocated lands were already planted with rubber (Table 5.3).

Table 5.2 Distribution of land holdings in Hadyao

Number of plots	Households	
	(number)	(%)
1	2	2.1
2	22	23.2
3	27	28.4
4	21	22.1
5	17	17.9
6	3	3.2
7	2	2.1
8	1	1.1
Total	95	100.0

Table 5.3 Tenure status and location of land cultivated by Hadyao households

Land tenure status	Location of cultivated land			Total
	Inside village territory	Outside village territory	Both inside and outside	
Land use rights to all plots	51	5	20	76
At least one plot borrowed or rented	12	0	7	19
Total households	63	5	27	95

Table 5.4 No. of rice-growing households by location and type of rice cultivation

Type of rice cultivation	Location of rice cultivation			Total
	Only inside village territory	Only outside village territory	Both inside and outside	
Only upland	35	16	1	52
Only lowland	1	17	1	19
Both	0	4	7	11
Total	36	37	9	82

5.5 Rice Cultivation

Rice cultivation has been the main livelihood activity of villagers in Hadyao. Farmers normally grow upland rice for subsistence on sloping land by shifting cultivation; however, some with flat land grow rainfed lowland rice as well. In 2004, 86 percent of households in Hadyao cultivated upland rice and/or lowland rice (Table 5.4). As noted, the land available for upland rice cultivation has been decreasing since the advent of rubber planting, hence many farmers grew upland rice in another village territory. Indeed, 45 percent grew rice only in another village's lands. In 2004 about 39 percent of rice-growing households intercropped rice in their immature rubber plantations and in 22 percent of cases intercropping was the only mode of rice cultivation.

The labour requirements for upland rice cultivation are almost 300 person-days per ha, with half of this requirement for weeding alone. The maximum cultivated area per active labour unit is 0.6 to 0.7 ha (Lao-IRRI 1992). Among those who grew rice in Hadyao in 2004, the average area cultivated was 1.0 ha and most households (72 percent) cultivated between 0.5 and 1.5 ha. Given that the average number of full-time workers was 3.0, the area cultivated was about half the maximum area per labour unit, reflecting the degree to which labour had been diverted to rubber.

Of the households who grew rice in 2004, rice production averaged 1,730 kg, but varied from 90 to 10,000 kg. The average yield of upland rice was 1.4 t ha^{-1}, of intercropped rice, 1.0 t ha^{-1}, and of lowland rice, 4.0 t ha^{-1}. The figure of 1.4 t ha^{-1} corresponds well with the figure of about 1.5 t ha^{-1} previously reported for upland rice (Lao-IRRI 2000). The average period of rice self-sufficiency in Hadyao was 8 months; only 30 percent of households produced enough rice for household consumption for the year (Table 5.5). Rice-deficit households obtained additional rice by purchasing and borrowing. Given the above analysis of labour and yields, it appears that the lack of self-sufficiency was more due to the reallocation of labour to rubber rather than to declining yields.

According to respondents, since rubber was introduced to Hadyao, upland rice cultivation had changed significantly. Nearly 75 percent reported that they cultivated a smaller area of upland rice after planting rubber. Around 72 percent reported that the yield of upland rice was lower than before the cultivation of rubber (though this may have been confused with total production). About 78 percent said that the labour used for shifting cultivation had decreased since planting rubber. The reasons given for the decrease in the cultivation of upland rice were that there was less land available so they had to grow rice on the same plot for many years, resulting in lower yields (though the yield figures reported above do not fully support this). Moreover, they did not have enough labour, especially for those who had started tapping. However, the practice of lowland rice cultivation remained unchanged.

To explore the relationship between rice area and rubber planting, total rice area per household in 2004 was regressed on the total number of rubber trees planted, the full-time equivalent household labour force, the age of the household head, and the education of the household head. The model explained only 5 percent of the variance in the total area of rice. The coefficients for both the total number of rubber trees planted and the full-time equivalent household labour force were positive and statistically significant at the 10 percent level, though the coefficients were small.

Table 5.5 Rice self-sufficiency among Hadyao households

Months of rice self-sufficiency	Number	%
0	13	13.7
1–3	5	5.3
4–6	16	16.8
7–9	21	22.1
10–11	12	12.6
12	28	29.5
Total	95	100.0

The results suggest that the area of rice cultivated per household was primarily determined by other factors. Given that most households were clustered around the mean of 1.0 ha and that most households were less than 100 percent self-sufficient, it is likely that there was an *overall* shortage of rice land and individual households were constrained by the land allocation system. Hence the increase in rubber planting was reducing the total area cultivated, as farmers reported, but this was being spread across all households rather than being an individual trade-off. That rice land was being sought outside the village lends support to this argument.

5.6 Rubber Cultivation

5.6.1 Planting Rubber

As described above, rubber was introduced to Hadyao in 1994 by Hmong migrants from China and was planted by individual smallholders (Photo. 5.1). From the first planting in 1994 until 2005 around 253,300 rubber trees have been planted on an area of 562 ha. This represents 12 percent of village land and 33 percent of agricultural land. All the rubber has been planted within the 1,700 ha of village agricultural land shown in Table 5.1. About 120,000 mature trees on an area of 266 ha are currently being tapped and about 133,300 immature trees (296 ha) have been recently planted and are expected to commence tapping in 2011 or 2012. In the immediate future the village leaders have no plan to expand the area of rubber, just to replant dead trees, expressing concern that villagers will not be able to take care of many more trees.

All the surveyed households had planted rubber. On average, one household had planted 2.3 plots of rubber. About 88 percent of households had from one to three rubber plots. About 71 percent of households planted rubber in the first phase (1994–1996), while 94 percent planted in the second phase (2003–2005). Around 76 percent had their rubber plots only inside the village territory while 24 percent had one or more rubber plots outside the village. Almost all households that planted rubber in the first phase planted inside the village, but some that planted in the second phase planted in other village areas. Moreover, almost all of the land planted with rubber in the first phase was located near the village settlement, while many of households that planted in the second phase had their rubber plots far from the village centre, about one to two hours' walking distance. Almost all households (93 percent) had planted rubber exclusively on upland plots used for shifting cultivation. Five of the seven households that had planted rubber on lowland plots had planted in the second phase. These observations again highlight the emerging shortage of land for both rice and rubber, particularly well-located land for rubber.

The total number of rubber trees planted averaged 1,930 trees per household. Most households (65 percent) had planted between 500 and 2,500 trees. On average 426 trees had died, ranging from 0 to 2,300 trees, mostly due to the 1999 frost but some because of poor seedlings, poor planting technique, poor maintenance, and root diseases. Before rubber was tapped, farmers were not sure that they would get

Photo 5.1 A rubber smallholding in Hadyao (August, 2005)

a return so they did not always keep their rubber plots weeded, being busy with rice cultivation. Therefore, the number of surviving trees averaged about 1,510 per household (78 percent) and ranged from 120 to 6,900.

The factors affecting the number of rubber trees planted were investigated through multiple regression analysis. Seven possible factors were included in the model (Table 5.6). The model explained 24 percent of the variance in the total number of rubber trees planted. The coefficients for planting rubber in the first phase and for full-time equivalent household labour force were positive and statistically significant at the 1 percent and 5 percent levels, respectively. The age and education of the household head were not significant factors, nor were access to additional land, labour, or capital (credit). It appears that households with the labour, skills, and initiative to plant first had been able to plant more rubber trees and that, because they now had more experience in rubber cultivation and money from selling their rubber, they were also better able to invest in new rubber plots, compounding their initial advantage.

About 86 percent of the households reported that they planned to increase the area under rubber trees (somewhat contradicting the view expressed by village authorities). The reasons given were to have many trees for their children, to have a permanent job as a rubber farmer and stop growing upland rice, to earn more money because rubber provides a good income, and to claim access to land because

Table 5.6 OLS regression of no. of rubber trees planted on selected variables (n = 95)

Variable	Mean	Estimated coefficients	t value
Constant	na	−496.73	−0.75
Full-time household labour force	3.0	247.47	2.05**
Age of household head (years)	46	11.81	1.09
Education of household head (years)	3.4	13.82	0.35
Credit support (yes = 1/no = 0)	0.8	−53.36	−0.11
Planted in first phase (yes = 1/no = 0)	0.7	1,056.80	2.67***
Access to land outside village (yes = 1/no = 0)	0.5	208.23	0.78
Hire labour for rubber (yes = 1/no = 0)	0.7	426.83	1.23

$R^2 = 0.24$; $F = 5.25$; $p = 0.000$; **significant at 5 percent level; ***significant at 1 percent level

of a fear that there would be no land left to plant in the future. The reasons given for not planting more rubber were that there was not enough labour, or land near the village, or money to invest.

Around 92 percent of the households who planned to increase their rubber area felt they would be able to access the necessary land. The most common way of accessing land was to ask permission from the village authorities for additional plots. Given that the authorities felt that enough planting had taken place and were bound by the land use planning process described above, there was clearly an emerging tension over the future allocation of land resources. The other avenue mentioned was to seek permission to cultivate in other villages, which would defer the problem in Hadyao but export it to those villages.

5.6.2 Rubber Cultivation Techniques

Rubber techniques used in Hadyao were derived from China. During the first period of rubber cultivation in the mid-1990s, all seedlings were imported from China. The clonal varieties were GT1 and RRIM600, the main varieties found in Yunnan province. Hadyao farmers usually planted both GT1 and RRIM600 in the same plot because they have different characteristics. RRIM600 provides more latex but is sensitive to cold and diseases. Farmers said that RRIM600 is not suitable to plant in low terrain, especially near the stream. Conversely, GT1 can resist cold and diseases, but gives lower yield. Hence their combination was a risk-reducing adaptation to the local environment.

Applying inorganic fertilizer was rare, though farmers usually put buffalo or cattle manure into the planting hole. From 1994 until 2005, only one farmer had applied inorganic fertilizer to his rubber, on the recommendation of Chinese rubber experts and buyers. Farmers who never applied fertilizer gave a variety of reasons, not necessarily consistent: (1) the soil was still fertile and their rubber trees grew well; (2) they could not afford to buy fertilizers; (3) the rubber trees would grow too big and fall over in a strong wind; (4) rubber farmers in other countries used fertilizers so Chinese traders wanted to buy from Laos because fertilizer was not used; (5) they had never applied before and did not know how; (6) applying fertilizers caused health problems; and (7) their rubber trees were still young.

All households cleared weeds every year, usually by hand but the use of herbicide had become more common. Households who never applied herbicide reported that they (1) did not have enough money, (2) did not know how to apply it, (3) were still able to control weeds by hand weeding or hiring labour, (4) were afraid of being affected by the chemicals, (5) were afraid that their rubber trees might die, and (6) could not carry water for herbicide application because their plots were far from water sources. Pests were not a serious problem but diseases such as yellow leaf disease and root disease were reported as a serious issue by nearly 80 percent.

Almost all households intercropped their rubber plots for up to 3 years (though pineapple was also intercropped with mature rubber trees). The predominant intercrop was upland rice, followed by maize and pineapple. Raising livestock in rubber plots was not common because farmers were afraid the rubber trees would be destroyed, especially by large livestock. However, some households raised chickens in their rubber plots during the mature phase.

About 71 percent of households were tapping their rubber trees at the time of the survey. Most of these (91 percent) tapped on alternate days, as recommended. The standard of tapping appeared quite high. Tapping on alternate days provided farmers with smaller holdings the opportunity to undertake other livelihood activities when not tapping. Farmers usually tapped in the eight month period from April to November. If tapping on alternate days, this gives a total of 120 tapping days in a year. The latex obtained each day was simply poured into a large plastic bucket or plastic bag and left to solidify for about 24 hours before being removed as a solid lump of 30 to 50 kg and stored for subsequent sale as ‘tub-lump’ rubber.

The main technical problem related to rubber cultivation mentioned by respondents was the difficulty faced in the period before the rubber was tapped, when they had to work harder both growing rice and taking care of their rubber and also faced a rice deficit. Farmers also mentioned their concern about transporting tub-lump rubber from the newer plots to the village because these plots were far from the village and the road. In other respects farmers were technically competent in rubber cultivation.

5.6.3 Rubber Yield, Sales, and Income

An area of 266 ha (120,000 trees), planted between 1994 and 1996, is currently at the tappable stage. The first harvest of rubber began in 2002 with the production of 22 t, increasing to 95 t in 2003 and 150 t in 2004 (Table 5.7). The average rubber production per tapping household was 655 kg in 2002, 887 kg in 2003, and 1,211 kg in 2004. The average yield in the first year of tapping was 904 kg ha^{-1}, but increased to 1,380 kg ha^{-1} in the second year and 1,999 kg ha^{-1} in the third (Table 5.8). This pattern is consistent with the normal yield profile of a rubber plantation. Another reason for the sharp increase in yield may be that tapping was a new skill for

Table 5.7 Production and sale of rubber in Hadyao Village, 2002–2004 (Hadyao Village, 2005)

Year	Households tapping	Production	Price	Total revenue
	No.	kg	Yuan/kg	Yuan
2002	23	22,000	3.5	77,000
2003	67	95,000	4.5	427,500
2004	67	150,000	5.5	825,000

1 Yuan = 1,300 Kip; 1 USD = approx. 10,000 Kip

Table 5.8 Average yields over 3 years of tapping in Hadyao (kg/ha)

Calendar year	Year of tapping			Average
	1	2	3	
2002	1,009 (n = 21)	–	–	1,009 (n = 21)
2003	843 (n = 42)	1,566 (n = 21)	–	1,045 (n = 63)
2004	1,209 (n = 4)	1,295 (n = 42)	1,999 (n = 21)	1,470 (n = 67)
Average	904 (n = 67)	1,380 (n = 63)	1,999 (n = 21)	–

Hadyao farmers, hence yields increased as they improved their tapping skill. The average yields of the initial three years of tapping in Hadyao are consistent with the average annual yields for smallholders in North East Thailand (1,500 kg ha^{-1}) and Southern China (1,200–1,300 kg ha^{-1}) as reported by Alton et al. (2005).

Some of the factors affecting the production of tub-lump rubber were investigated by multiple regression analysis. It was hypothesised that production would be positively influenced by the number of rubber trees tapped, the full-time equivalent household labour force, the education level of the household head, and the year of tapping, and negatively influenced by the total rice area and the age of the household head (Table 5.10). The model explained 39 percent of the variance in production in 2004. However, only the coefficient for the number of trees tapped was significantly different from zero. That is, neither the availability nor quality (age, education) of labour, nor competition for labour from rice production, were affecting rubber output. The likely reason is that, at this stage, the household labour force was able to handle the tapping work as the number of rubber trees tapped was not large. The average labour force of 3.0 equivalent full-time workers was sufficient to undertake tapping and attend to other tasks. Moreover, the restricted area for rice production reduced the degree to which rice competed with rubber for household labour. In the future, when farmers have more rubber trees to be tapped, their available labour may not be enough to do the tapping, and then labour may become one of the main factors determining the production of rubber.

Chinese traders come to the village to buy ‘tub-lump’ rubber usually once a month. In the first two years of selling, rubber was bought using a grading system. In 2004 rubber was bought in one grade only. The Chinese traders were the only source of price information and hence set the price. However, the price offered has increased in line with the world price. Hence the total revenue from rubber for the village increased from 77,000 Yuan in 2002 to 825,000 Yuan in 2004 (Table 5.7). Although there is no formal marketing contract between the rubber farmers and the

Table 5.9 OLS regression of rubber output on selected variables (n = 67)

Definition	Mean	Estimated coefficients	t value
Constant	na	561.97	1.03
No. of rubber trees tapped in 2004	460	2.25	5.13***
No. of full-time equivalent workers	3.0	38.09	0.34
Total area of rice cultivated in 2004 (ha)	1.0	−84.17	−0.61
Age of household head (years)	46	−11.48	−1.05
Education of household head (years)	3.4	34.56	1.11
Second year of tapping (yes = 1, no = 0)	0.7	−44.18	−0.13
Third year of tapping (yes = 1, no = 0)	0.2	503.87	1.29

$R^2 = 0.39$, $F = 5.61$, $p = 0.000$; ***significant at 1 percent level

Chinese traders, every month the village authorities contact the buyers in Yunnan by mobile phone and search for those who offer the highest price. So far there is not seen to be a marketing problem because there is strong demand for rubber from China. However, there is a concern among farmers that if they could not sell their rubber to China, they would have few alternatives and might get a lower price. In 2004 the Lao-SINO company established a rubber processing factory in Luangnamtha Province, but the company offered a lower price than the Chinese traders so farmers continued to sell to the traders.

About 28 percent of households reported that their only source of cash income was selling tub-lump rubber; 29 percent only earned income from other sources (livestock, other cash crops, selling rubber seedlings, working for wages, and from relatives in the USA); the remaining 43 percent received income from both rubber and other sources. About 69 percent of the households mentioned that their highest ranking income source was rubber. Hence rubber had clearly become the major source of income in the village.

5.6.4 Economic Appraisal

In another paper (Manivong and Cramb 2007), we present a discounted cash flow (DCF) analysis of smallholder rubber production in Hadyao. The aim was to assess the long-term profitability of investing in a hectare of smallholder rubber in the conditions faced by a typical farmer in Hadyao. This required modelling the yield of latex over the life of the rubber enterprise, as well as other outputs (intercrops and rubber wood), using the Bioeconomic Rubber Agroforestry Support System (BRASS) (Grist et al. 1998), which was parameterised and calibrated as far as possible to Hadyao conditions. These simulated yields were combined with data on costs and benefits obtained from group discussions with experienced rubber farmers in Hadyao, household survey data, and other relevant sources.

Figure 5.3 shows the predicted latex yield over the likely productive life of a hectare of rubber in Hadyao conditions. It can be seen that the yield increased in the initial period, then levelled off, and finally entered a long decreasing phase.

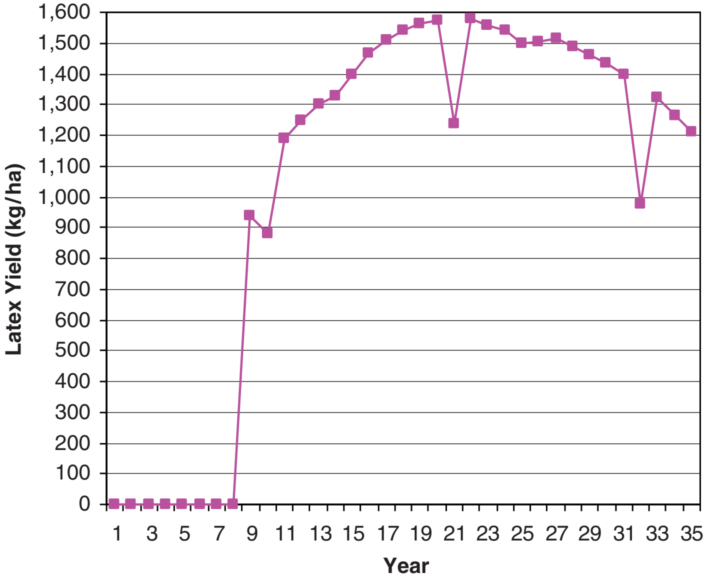

Fig. 5.3 Predicted latex yield in Hadyao over 35 years using the BRASS model

The yield reached a peak of just under 1,600 kg ha^{-1} in Year 22. The fluctuations in yield were largely due to variations in rainfall. It should be emphasised that this estimated yield profile represents the predicted yield pattern which rubber farmers in Hadyao would be expected to achieve given the current state of knowledge, but the actual yields may vary if management practices, weather conditions, or other factors change. Given the initial yields reported in the survey (Table 5.8), the projected yields are likely to be a conservative estimate.

The DCF analysis of a typical hectare of rubber in the study village – using the above yields, the 2005 farm-gate rubber price (7,800 Kip kg^{-1}), a real discount rate of 8 percent, and an estimated opportunity cost of labour of 17,000 Kip/person-day – showed that the investment in rubber was clearly worthwhile (Table 5.10). This was true whether using conventional investment criteria – net present value (NPV), benefit-cost ratio (BCR), internal rate of return (IRR) – as shown in Table 5.10, or perhaps a more accurate criterion such as the net return to the family's own resources of labour and land. The analysis also showed that farmers had little problem paying back credit, whether in nominal or real terms, or at subsidised or commercial interest rates, except for the upper bound rate charged by moneylenders. The key was that repayments of interest and principal were deferred until tapping had commenced.

A sensitivity analysis showed that with a 30 percent decrease in prices, a 50 percent increase in the opportunity cost of labour, or an increase in the discount rate from 8 percent to 13 percent, investment in smallholder rubber in Hadyao is no longer worthwhile (Table 5.10), indicating that farmers may have to re-evaluate

Table 5.10 Results of DCF analysis for smallholder rubber in Hadyao (2005 prices and wage rate of 17,000 Kip/person-day)

Rubber prices (Kip/kg)	NPV (Kip/ha) and BCR at selected discount rates			IRR (%)
	5 %	8 %	13 %	
5,460	–4,958,000 (0.94:1)	–9,361,000 (0.84:1)	–10,847,000 (0.71:1)	3.4
7,800	23,038,000 (1.27:1)	7,048,000 (1.12:1)	–3,347,000 (0.91:1)	10.7
10,140	51,034,000 (1.61:1)	23,463,000 (1.40:1)	4,153,000 (1.11:1)	15.4

1 USD = approx. 10,000 Kip

their investment plans if market conditions change in the future. However, for those with established gardens, for whom the investment is a 'sunk cost', the price would have to fall up to 60 percent from 2005 levels before it would no longer be worthwhile to tap. Even in that case, the rubber plots could be left untended and 'opened up' again for tapping when prices rose sufficiently, which is the practice of smallholders in other countries. The threat of price falls can also be countered to some degree by adopting practices to improve yields in the future, as well as improving the quality of the rubber to obtain a marketing premium. These would translate directly into improved returns to family labour, hence higher household incomes.

There are other risks associated with the investment in smallholder rubber in the uplands of Northern Laos, in particular climate and market uncertainty. The occurrence of heavy frost in 1999, killing many rubber trees in Luangnamtha Province, indicates the foremost climatic risk that farmers face. There is a justifiable concern that this could happen again as most rubber trees in the province are planted at an elevation of almost 700 m above sea level. Another concern is market uncertainty. The sudden but temporary close of border trade with China in late 2006 is one example of market uncertainty that seriously affected Lao rubber farmers as their only market is China. There is also the likelihood of competition as other rubber producing countries are also increasing their production in response to the rising global rubber demand. An improved road network will help to reduce marketing costs and maintain the farm-gate price of rubber, but the pace and extent of this investment in infrastructure is itself uncertain.

Manivong and Cramb (2007) also present a spatial analysis of the potential for the expansion of rubber in other areas within Luangnamtha Province. This shows that the potential for smallholder rubber in the study village is not an isolated case; there are other areas in Luangnamtha Province that appear to be economically suitable for rubber, consistent with the recent expansion in planting activity. There may thus be increasing pressure to reallocate land from forest zones to tree crop production. This demand could perhaps be met from within the areas zoned for plantation forests if rubber is found to compare favourably with timber plantations in terms of economic returns as well as the provision of ecological services. This is an important topic for further research.

5.7 Discussion and Conclusion

The case study of Hadyao shows that farmers are in the middle of a major transition from primary dependence on the shifting cultivation of rice for subsistence to dependence on smallholder rubber and the market economy. Population growth, market demand, improved transport infrastructure, and government restrictions on land use have combined to induce the adoption of rubber planting by almost every household in the village. While these trends in the economic and policy environment have created the context for the adoption of rubber, the expansion of rubber planting has been initiated by smallholders themselves, based on their own assessment of the trade-off between subsistence and commercial agriculture, and with the encouragement of village leaders and local-level officials. Economic analysis shows that, given current and likely future market conditions, investment in smallholder rubber production in this setting is based on good economic returns. Moreover, the potential for rubber in the study village is not an isolated case; there are extensive areas in Luangnamtha Province that appear to be economically suitable for rubber. The transition underway in Hadyao and elsewhere in Northern Laos is broadly consistent with the theories of agricultural transformation briefly reviewed at the outset, supporting Raintree and Warner's notion that, in upland environments such as this, the incorporation of tree crops in the farming system presents an alternative agricultural development pathway to the intensification of food crop production outlined by Boserup.

While rubber is helping farmers increase their income, there are some emerging constraints. Land is becoming a constraint due to a growing demand among farmers to expand their rubber holdings, though less-accessible land is still available and, at least for now, some farmers are able to plant rice and rubber in other villages. Labour is also becoming a constraint; though at this stage family labour can handle the tapping, as more trees come into production this will become an issue, putting more pressure on rice production. Rubber farmers may have to reduce further the area of rice or even stop growing rice altogether if they want to expand their rubber holdings. Even now, the land and labour constraints mean that most households no longer attain rice self-sufficiency. Hence many farmers have now moved into Myint's second and more risky stage in the transition from subsistence to commercial agriculture, corresponding to Barlow and Jayasuriya's stage of 'agricultural transformation', where spare land and labour resources are fully utilised and largely committed to production for the market.

Despite the popularity of rubber and the stated intention of many farmers in the study village to stop shifting cultivation and plant only rubber, it is unlikely that upland rice production will be replaced completely. Farmers still need to grow upland rice or intercrop rice in their rubber plots, especially those whose rubber trees are still immature. Farmers also face the risk that the price of rubber will fall or that they cannot sell to China. Hence they may need to expand rice production again. One advantage of rubber is that, given a major market collapse, it is relatively easy to revert to shifting cultivation, as seen historically among rubber smallholders in Indonesia and Malaysia.

Smallholder rubber in Hadyao is based on simple, labour-intensive technology imported from estates in China, consistent with Barlow's 'early agricultural transformation' stage. The technology has been easily adopted by upland farmers as it readily fits with their current shifting cultivation system. However, the technology is not at the lowest level posited in Barlow's framework, as farmers are planting clones such as RRIM600 and GT1, terracing their hillsides, and maintaining their holdings to a reasonable standard, showing the potential for technological catch-up in 'late developing' regions. Accordingly, Hadyao farmers' yields are comparable to smallholders elsewhere in the region, e.g. Southern China and North East Thailand. However, they do not fertilise their rubber trees and the latex is sold in raw form as 'tub lump' without even processing into sheets. In the future farmers are likely to adopt higher levels of rubber production and processing technology in order to get a better return from their rubber holdings, moving into Barlow's 'late agricultural transformation' stage. However, as in the main rubber-producing countries, various support services for rubber development will need to be established in Laos, including technical support, extension, credit, and marketing.

Research on rubber could be undertaken as part of the development of more diverse agroforestry and livelihood systems, including the incorporation of other crops, non-timber forest products, and livestock, to reduce the risk from the boom-bust cycle of rubber, ensure food security, increase income, and reduce the potential for negative environmental impacts from monoculture rubber (loss of biodiversity, increased soil erosion, and reduced watershed functions).

Improving road access should be considered a high priority for the development of the rubber industry (as well as being part of a general poverty-reduction strategy), given that the economically suitable areas for rubber are mostly concentrated in the more accessible areas along the main roads. When National Road No.3 is completed in 2007, linking China to Thailand through north-western Laos, it will open new marketing opportunities for many Lao upland farmers. However, upgrading village cart tracks to all-weather roads is also needed to make marginally suitable land more profitable for tree crop development.

As more farmers seek to expand their rubber holdings, this will create inevitable pressure to reallocate village lands for tree crop production. Land use policy should discourage farmers from clearing village forests for rubber planting, but instead continue to encourage them to grow rubber on their degraded fallow land. This is consistent with the government goals of reducing deforestation and shifting cultivation. However, the category of 'plantation forest' could be considered as potentially available for rubber planting, requiring further comparative research into the market and non-market costs and benefits.

In general, then, the roles for government, as in other countries where smallholder rubber has played a significant role in rural development, are to provide research and technical support, to assist financially during the long investment period when no income is generated, and to invest in roads and marketing infrastructure. In particular, maintaining secure access to the China market will be crucial for the growth of smallholder rubber in Northern Laos. More generally, the socioeconomic and environmental impacts of the expansion of rubber planting should be carefully monitored. Land use and livelihoods are undergoing rapid change in the uplands due to the expansion of rubber. If carefully managed, this change has the potential to make a significant contribution to sustainable rural livelihoods.

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Chapter 6

Agroforestation of Grasslands in Southeast Asia: WaNuLCAS Model Scenarios for Shade-Based *Imperata* Control During Tree Establishment

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Abstract In the stage of land use evolution where smallholder tree-based systems are desirable as replacement of *Imperata cylindrica* (and similar) grasslands, agroforestry can provide a gradual and rewarding approach to the transition. There tends to be, however, a gap between the last opportunity for food crop interplanting and canopy closure providing shade-based control of grass and weed growth. In such period, regrowth of *Imperata* enhances the risk of fire and failure of tree establishment. We analyzed the duration of this '*Imperata* regrowth window', for a range of planting patterns and choice of tree species in Lampung (Indonesia) and northern Mindanao (the Philippines). Simulations of agroforestation scenarios with the WaNuLCAS model ('water, nutrient and light capture in agroforestry systems') focuss on the *Imperata* regrowth window as the period between 50 percent and 15 percent of ground-level light availability.

The simulation results first of all confirm a well-known fact: young trees of most species are not able to compete with *Imperata* and partial weeding around the tree stem base is absolutely necessary to get most trees started, with the possible exception of *Paraserianthes falcataria*. Although *Acacia mangium* is a fast growing tree, a more intensive weeding regime will double tree growth. The improvement of initial tree growth speeds up tree canopy closure and reduces subsequent *Imperata* regrowth window by two to more than five years according to the model, with periods longer than five years associated with slow initial growth rates. There is, according to the model, only limited opportunity to reduce risk exposure by modifying tree spacing.

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Keywords Indonesia, Philippines, tree-crop interaction, tree plantation, tree spacing, weed control

6.1 Introduction

Imperata cylindrica (and other coarse grasses) dominated vegetation tends to occur as the interlude between the loss of natural tree cover by logging and similar enterprises, and the return of (managed) tree cover, often in forms of agroforestry. Fire maintains the grasslands and slows down succession to woody vegetation (Chazdon 2003; Lavorel et al. 2007). Chomitz (2007) related to three landscape phases as 'core forests', 'forest margins' with rapid loss of forest cover and contests over land use rights, and 'mosaic forests' in the (partial) recovery phase after land rights were established. In the literature on 'forest transitions' (Mather 1992, 2002; Rudel et al. 2005; Geist et al. 2006; Angelsen 2007; Mather 2007; Rudel 2007) two possible pathways are discussed for advancement of tree cover. One is the "economic development route", where the agricultural population declines as industrialisation and urban migration proceed, and abandoned agricultural land is spontaneously reforested (this has happened in parts of Europe and N America; it is less common in densely populated Asia; Chokkalingam et al. 2002; Lamb et al. 2005). The other is the "forest scarcity pathway", where scarcity of forest products drives up price and stimulates tree planting within an agricultural context. In an intermediate form, where urban and service jobs relieve some of the pressure on land, timber-based agroforestry can become an economically attractive land use.

Garrity et al. (1997) estimated that there was about 35 million hectare of *Imperata* (and other coarse grasses) dominated lands in Asia at the time of assessment, and the number has probably increased since. In the Philippines, pure grasslands occupy 1.8 million hectare and another 10.8 million hectare (33 percent of the country's total land area) is under extensive cultivation mixed with grasslands and shrub (Menz et al. 1999). Presently, conversion of these grassland areas into upland farms planted to annual crops and perennial trees is proliferating at a fast rate (Schuren and Snelder, Chapter 3, this volume). This is triggered by interacting factors of rapidly increasing population, the prevailing system of landholdings, scarcity of non-agricultural jobs, and declining arable area in the lowlands. Predo and Francisco (Chapter 14, this volume) analyzed land use options in northern Mindanao and concluded that tree-based systems are profitable but risky for smallholders. Bertomeu (2004; see also Bertomeu, Chapter 8, this volume) showed that profitability depends on the silvicultural management of the trees and the price the lumber can attract. In Indonesia, however, most of the grasslands are in the 'forest zone' where land ownership is contested (Contreras-Hermosilla and Fay 2005) and conversion is constrained by social and political factors. Current interest in increasing terrestrial carbon stocks in the grasslands has lead to renewed attention (Tomich et al. 1997; Menz and Grist 1997; Tomich et al. 2001; Wise and Cacho 2004; Roshetko et al. 2007) to the transformation of grassland into tree-based land use mosaics. The risk of fire, however, remains a concern for such transformations (Wibowo et al. 1997; Murdiyarso et al. 2002; Chokkalingam et al. 2007) and integrative models are needed (Van Noordwijk et al. 2001).

Technically, *Imperata* as a weed can be controlled and *Imperata* grasslands can be converted to more productive systems. However, before any so-called rehabilitation takes place a few questions should be answered: Is land conflict related to current fire frequency (Suyanto 2007) and maintenance of the grasslands? Will anybody currently using the grasslands lose out as a result of rehabilitation? Is labour a constraint for rehabilitation? Is there a lack of market opportunities for the products of intensified systems? Are there any other major policy constraints? If the answer is yes to any of the above, perhaps that issue should be resolved first before proceeding with the *Imperata* rehabilitation per se. The agendas of government and development agencies are often not grounded in a proper understanding of the local human and bio-physical ecology of grasslands or of successful local agroforestry practices; and research on many of the most important dimensions of grassland management is poorly conducted and/or utilized (de Foresta and Michon 1997; Dove 2004).

Imperata cylindrica (alang-alang, cogon grass) is an efficient colonizer of open spaces on a wide range of soils (MacDonald 2004). Once it has established its rhizomes the grass is tenacious and able to survive repeated fires that usually don't kill the growth tips of the leaves at surface level. If they do, *Imperata* still has the capacity to regenerate from buds on rhizomes in deeper soil layers and establish ground cover again, before most other plants. This capacity to rapidly regenerate from rhizomes also allows the grass to survive soil tillage (ploughing), unless a repeated cycle of ploughing, drying the soil and re-ploughing the soil is used. The ecological success of *Imperata* has given it the reputation of being among the worlds ten worst weeds, even though it provides soil cover on soils that otherwise would experience high rates of erosion. While fast-growing leguminious cover crops such as *Mucuna pruriens* can lead to initial control, they may not provide sustained shade to reduce the vigour of *Imperata* rhizomes (Hairiah et al. 1993).

The first steps in technically controlling *Imperata* in the agroforestation of grasslands can be achieved by either mechanical or chemical control. Farmers employ a range of techniques from herbicide or soil tillage to 'pressing', depending on their resources and the current cost of the technique (Purnomosidhi et al. 2005). Food crops can be used in the first few years of most tree crops or agroforestry systems to maintain income and pay for the suppression of *Imperata* regrowth. However, the gap between the last food crop interplanting and canopy closure leads to a major risk of *Imperata* regrowth and fire occurrence (Bagnall-Oakeley et al. 1997; MacDicken et al. 1997; Van Noordwijk et al. 1997).

Four aspects of *Imperata* can influence the growth and performance of trees, although other mechanisms remain debated in the literature (Christopher and Ervin 2006):

1. Light: the capture of light by the grass (1.0 to 2.0 m high) affects small trees.
2. Water/nutrients: the capture of water and nutrients (N, P, K) by the grass reduces what is available for trees (Van Noordwijk et al. 2004b); while the nitrogen

concentration in the foliage is quite low (and thus the competition for N not excessive), the subsequent decomposition of *Imperata* residues (leaf or root litter) involves immobilization of mineral soil nitrogen by microbes, further depleting the generally poor soils (Snelder 2001).

3. Fire: the dry aboveground biomass in dry periods is a well connected, well-aerated fuel that readily burns and in which fire spreads easily. While *Imperata* itself survives such fires (and may benefit from their nutrient mobilizing effects before other plants respond), the trees' survival depends on their size, the height above the ground of the growing tips, the thickness of the bark which protects lateral buds, and the nature of the fire (height of the flames, temperatures reached, spread of the fire to the tree crown).
4. Allelopathy: the roots and rhizomes of *Imperata* release organic compounds that inhibit the germination and early growth of many plant species; the effect of these compounds after the establishment phase of other plants tends to enhance the effects of N-immobilization in *Imperata* soils; enriching the soil with nitrogen tends to reduce the 'allelopathic' effect.

Aspect 3 (fire) is in practice the most problematic consequence of the presence of *Imperata* in agroforestry systems, because a single fire can waste several years of investment in establishment of trees. Control of *Imperata* is thus an important target for tree establishment. Four types of control have been developed in practice:

1. Mechanical control: soil tillage which exposes the rhizomes to the sun and dries them out has to be repeated several times to be effective; part of the rhizomes may survive below the usual depth of hoeing or animal-drawn ploughs, but mechanized ploughing can reach the required depth.
2. Herbicide: the most popular and cheapest currently is glyphosate, available under a range of trade names.
3. Pressing of the aboveground biomass has a remarkable effect on slowing down the regrowth by mechanisms that are not fully understood (Terry et al. 1997). The technique can be used selectively around newly planted trees (Murniati 2002).
4. Shade-based control: reducing the growth rate and, in combination with removal of aboveground biomass, gradually depleting the rhizome capacity for regeneration (Purnomosidhi et al. 2005). *Imperata* biomass decreased drastically when relative light intensity of 20 percent was reached (Hairiah et al. 2000). When more than 20 percent of sunlight reaches the ground, *Imperata* still has a chance in these agroforestry systems.

In practice, a combination of these techniques will have to be used in the various stages of a developing agroforestry system (Fig. 6.1):

A. Land preparation for food crops using tillage, herbicides or (preferably) a combined approach.
B. Close to the tree and in the stage where there is too much shade for profitable intercrops but too little for *Imperata* control, a combination of the pressing technique and/or selective use of herbicides.

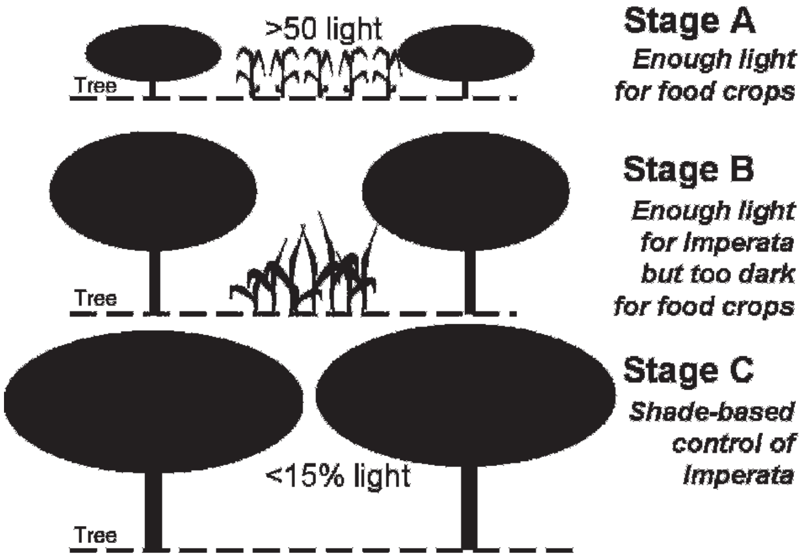

Fig. 6.1 Three stages in the development of an agroforestry system and the consequences for *Imperata* control

C. Reliance on shade-based control once canopy closure has reduced light at the ground level.

In practice this leads to the following three questions:

- What are the thresholds for the end of intercropping (end of Stage A) and the start of effective shade-based control (Stage C) and how can a farmer recognize these stages?
- How can the duration of stage B (*Imperata* regrowth window) be minimized by tree spacing and management for the different tree species?
- How can fire risk in stage B be minimized?

The WaNuLCAS 3.1 model (Van Noordwijk et al. 2004a), a generic tree-soil-crop interaction model calibrated for the experiments of the Smallholder Agroforestry on Degraded Soils (SAFODS) in Lampung (Indonesia) and Claveria (the Philippines), is used here to explore the expected performance of various tree-based systems in achieving shade-based *Imperata* control, especially aimed at reducing the duration of Stage B (question 2).

6.2 Model Scenario Shade-Based *Imperata* Control

6.2.1 Model Scenario for the Indonesia Site

Four tree-based systems were simulated for 10 years with a similar annual rainfall pattern of 2,641 mm per year throughout the simulation. In these systems, *Imperata* grew simultaneously with crops and trees, unless specifically excluded from any or all spatial zones around trees by weeding. Management factors influencing the growth of *Imperata* were tested based on the improvement of tree growth through weeding and tree spacing (Table 6.1). Three tree species were selected: fast growing trees represented by *Paraserianthes falcataria* (albizia) and *Acacia mangium* (black wattle, mangium) and slow growing trees were represented by *Swietenia macrophylla* (mahogany) and *Hevea brasiliensis* (rubber).

Using the above scenarios, simulation results were focussed on:

1. Tree growth in the presence of *Imperata* (using the WaNuLCAS option of continuous regrowth of Imperata as soon as conditions allow).
2. Light available at the crop or *Imperata* level as a function of tree basal area, which reflect how long it will take for the *Imperata* in the shade based systems to die naturally.
3. The effect of trees and tree spacing on *Imperata* growth and crop growth opportunities, including the duration of the initial cropping phase.

6.2.1.1 Model Validity Test for *Hevea Brasiliensis*

The results of simulation of rubber stem diameter growth with the WaNulCAS model with strip level weeding (zone 1, i.e., the spatial zone immediately around the tree – up to 1 m distance – is kept weed-free) showed a good agreement with actual tree diameter measured in farmers field in West Kalimantan as shown in Fig. 6.2 (Mulyoutami et al. 2005).

Table 6.1 Systems and management scheme applied in the shade-based *Imperata* control

Tree Species	Spacing (m × m)	Tree density (ha^{-1})	Weeding
Paraserianthes falcataria	4 × 2	1,250	• Total (clean weeding: all zones)
Acacia mangium	4 × 4	650	• Partial (Zone 1: 1 m around tree)
Swietenia macrophylla	3 × 3	1,111	• No weeding
	4 × 8	313	
Hevea brasiliensis	8 × 8	156	• Total (clean weeding: all zones)
	6 × 3	556	• Partial (Zone 1: 1 m around tree)
	5 × 3	666	• No weeding
	4 × 4	625	
	6 × 6	278	
	6 4× 12	139	

6.2.2 Model Scenario for the Philippines

Two timber *(Eucalyptus deglupta* or mindanao gum and *Gmelina arborea* or white teak, yemane) and non-timber (*Lansium domesticum* or langsat, lansones and *Mangifera indica* or mango) trees were selected for the modeling activity of the shade-based control for *Imperata* grasslands (Table 6.2). The tree-based hedgerow systems were grown in *Imperata* grassland area with an annual rainfall of 1,775 mm (total rainfall recorded in the project area from January to December 2004) and a slope of 18 percent. The soil of the study area is Jasaan clay with 1.98 percent to 2.21 percent organic matter (OM) and a bulk density of 0.93 to 1.05 g cm^{-3}. To determine the relationship between the relative light captured by *Imperata* and the tree canopy width, non-linear regression was done for the simulated data. Based on the above scenarios, the following parameters were analyzed:

1. Tree growth performance (diameter) when grown in an *Imperata* grassland
2. Relative light captured/received by *Imperata* as a function of canopy width of timber and non-timber trees
3. Shading effect of timber and non-timber trees on control of *Imperata* growth

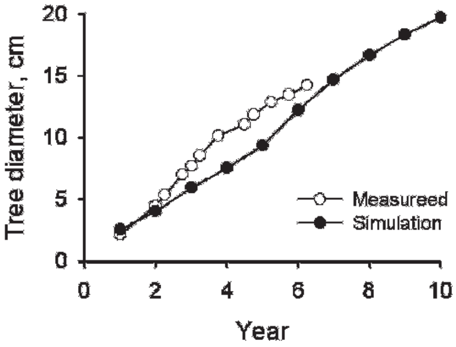

Fig. 6.2 Simulation (with Zone 1 kept free of weeds) and measurement (with strip weeding) of rubber tree diameter in experiments in West Kalimantan (Mulyoutami et al. 2005)

Table 6.2 Systems modeled for the shade-based *Imperata* control

Tree species	Spacing (m × m)	Tree density (ha^{-1})
Eucalyptus deglupta	1 × 3	3,000
	1 × 9	1,000
Gmelina arborea	1 × 3	3,000
	1 × 9	1,000
Lansium domesticum	5 × 5	400
	10 × 10	100
Mangifera indica	5 × 5	400
	10 × 10	100

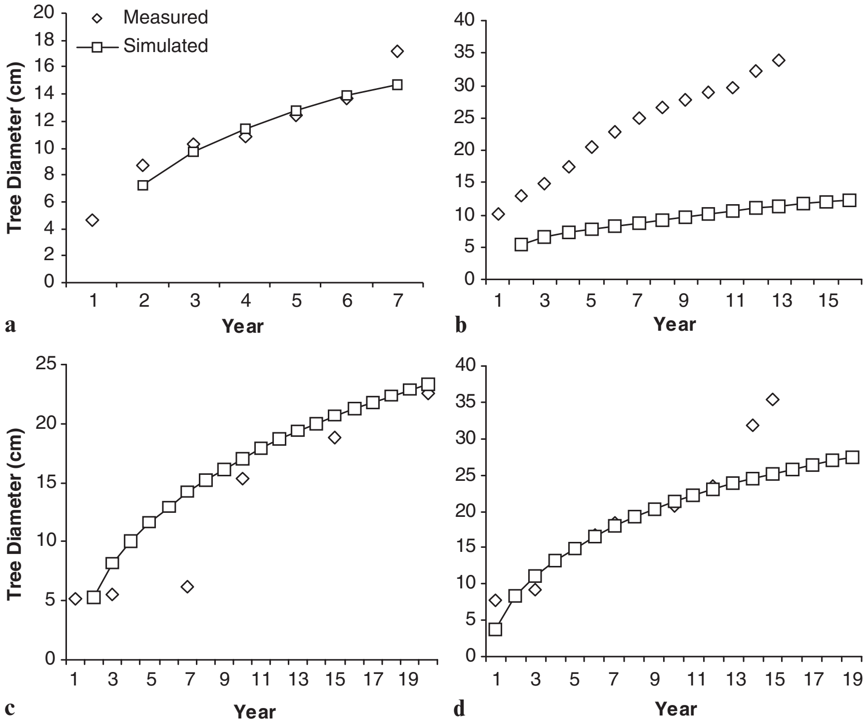

Fig. 6.3 Measured and simulated tree diameter of timber and non-timber trees (a) *Eucalytus deglupta*; (b) *Gmelina arborea*; (c) *Lansium domesticum*; and (d) *Mangifera indica*

There was a good agreement between the measured and simulated growth performance of three tree species (*E. deglupta, L. domesticum* and *M. indica*) as shown in Fig. 6.3. It was only with *Gmelina arborea* that the simulated tree growth performance was much lower than the measured tree diameter.

6.3 Results

6.3.1 Results for the Indonesian Site

6.3.1.1 Tree Growth in *Imperata* Grassland at Different Weeding Intensities

The WaNulCAS simulations first of all corroborated a well-known fact: young trees are not able to overcome competition with *Imperata*, unless their immediate surrounding is kept weed-free. The ‘partial weeding’, i.e., the weeding of zone 1 (adjacent to tree), lead to dramatic improvement of predicted tree growth over the 'no weeding' simulations. *P. falcataria* was the only species predicted to get on top (literally) of *Imperata* without weeding (Fig. 6.4). This effect was largely independent

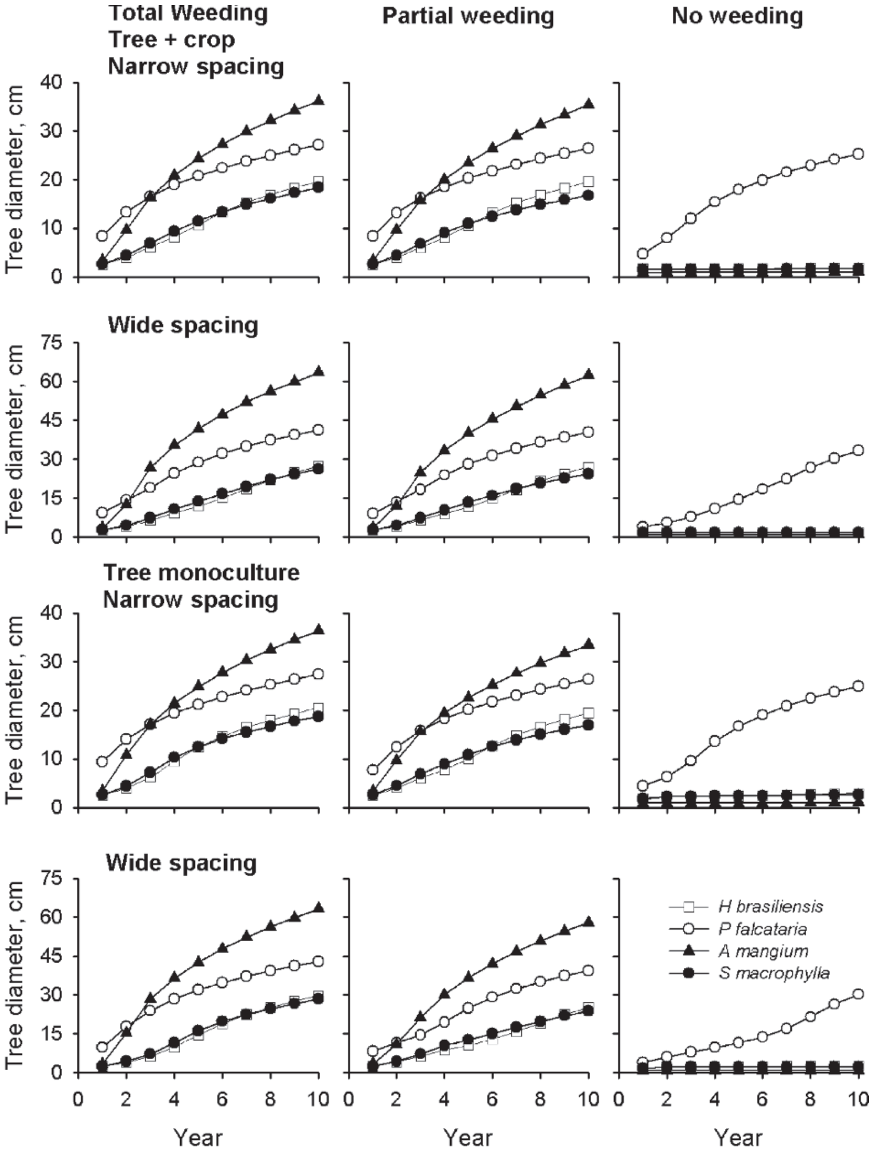

Fig. 6.4 Predicted development of tree diameter of four species from 12 to 120 months after planting at different systems (with and without crop), different weeding regime (total, partial and no weeding) and at different tree spacing, narrow (timber trees: 4 × 2, 3 × 3, 4 × 4 m; rubber: 6 × 3, 5 × 3, 4 × 4 m) and wide spacing (timber trees: 8 × 4, 8 × 8 m; rubber: 6 × 6, 12 × 6 m)

of the tree spacing selected (but the tree stem diameter did depend on spacing, as can be seen by comparing the various Y-axes in Fig. 6.4). The total weeding in tree monocultures (lower two rows in Fig. 6.4) had only a small further improvement of tree growth in most species and planting patterns. Growing crops in the early phase of agroforestation (upper two rows in Fig. 6.4) had no negative effect on predicted tree growth when compared to 'total weeding', and was superior to 'partial weeding' in tree monoculture.

6.3.1.2 Light Received at Crop or *Imperata* Level as a Function of Basal Area

Relative light intensity reached at *Imperata* or crop level was derived from the simulations to allow direct comparison with the data collected by Purnomosidhi et al. 2005. Figure 6.5 shows that increasing stem basal area of all tree species is followed by decreasing relative light intensity at *Imperata* or crop level. The observation points tend to indicate that a slightly larger stem basal area is needed to achieve a certain level of shading than the simulation results show, probably linked to inter-tree variability which is underrepresented in the model.

Predicted light intensity reduces more quickly, not only in time but also with respect to increasing stem basal area, for the fast growing *P. falcataria* and *A. mangium* than for the slower growing trees. For controlling *Imperata* growth under slow growing trees, weeding around the trees is essential and the trees need to be arranged in narrow spacing to have a realistic chance of achieving shade-based control.

When the simulation results across the various plant spacings are compared to the survey results of the smallholder agroforestry systems of *P. falcataria*, *A. mangium* and *H. brasiliensis* conducted in North Lampung by Purnomosidhi et al. (2005) (Fig. 6.6), an acceptable relationship ($R^2 > 0.80$) was found between basal area and relative light intensity for all species (Table 6.3).

6.3.1.3 *Imperata* Regrowth Window

Indications so far are that a light level of about 15 percent of full sunlight is the threshold for *Imperata* growth, while a level of about 50 percent is needed for acceptable yields of light-demanding crops such as maize (Purnomosidhi et al. 2005). Beans and cassava might tolerate light levels down to 30 percent and still be grown profitably. The *Imperata* regrowth window (stage B in Fig. 6.1) is thus operationally defined as the period between 50 percent and 15 percent light availability at crop or *Imperata* level, with the first value as limit to realistic opportunities for intercropping light demanding crops, and the second an estimate of critical light levels for vigourous growth of *Imperata*. The age of trees at which Imperata will be controlled depends on initial weeding regime and tree spacing (Fig. 6.7).

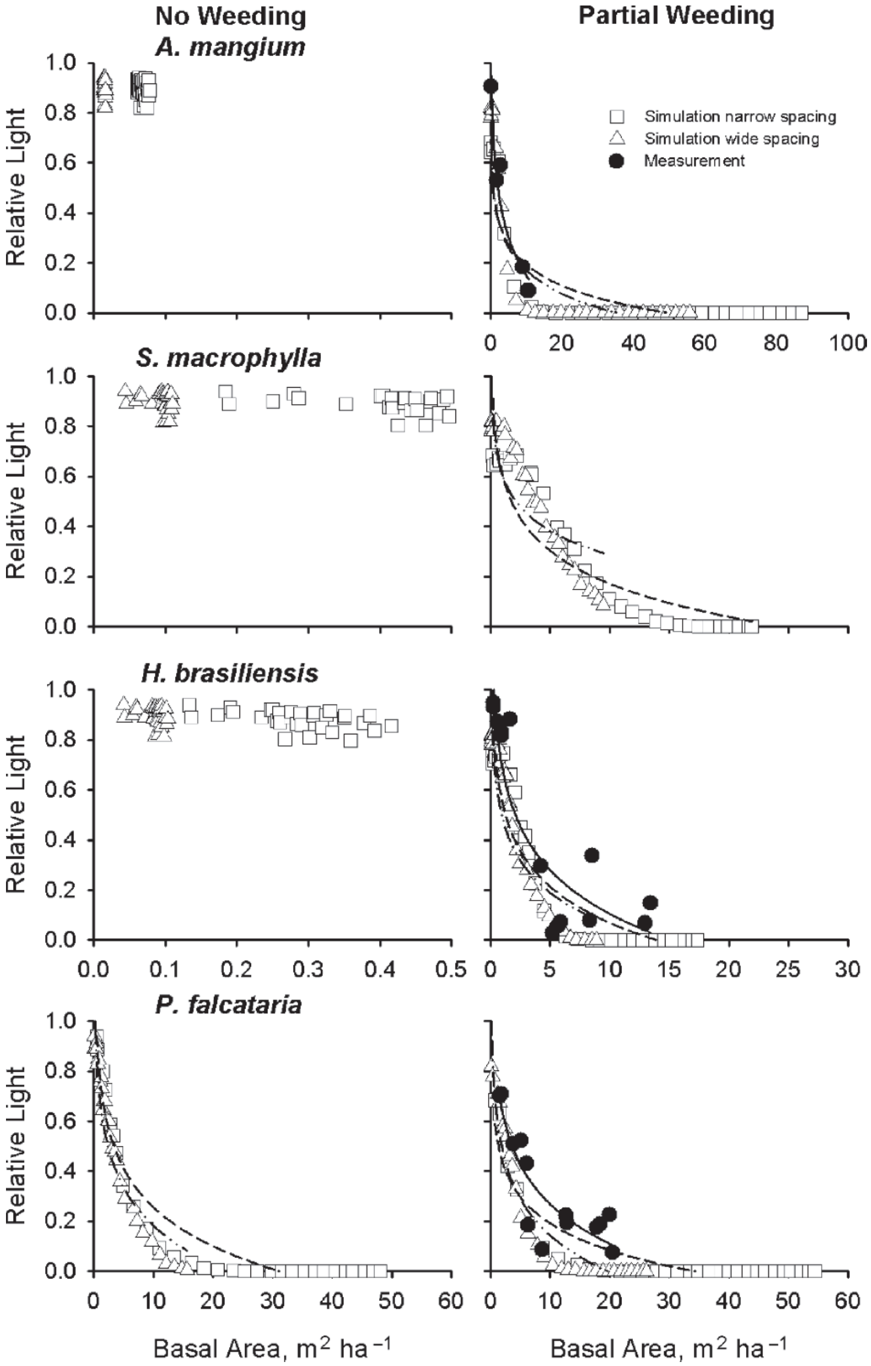

Fig. 6.5 Simulation of relative light received by *Imperata* as a function of basal area of four species at different tree spacing, narrow (timber trees: 4 × 2, 3 × 3, 4 × 4 m; rubber: 6 × 3, 5 × 3, 4 × 4 m) and wide spacing (timber trees: 8 × 4, 8 × 8 m; rubber: 6 × 6, 12 × 6 m)

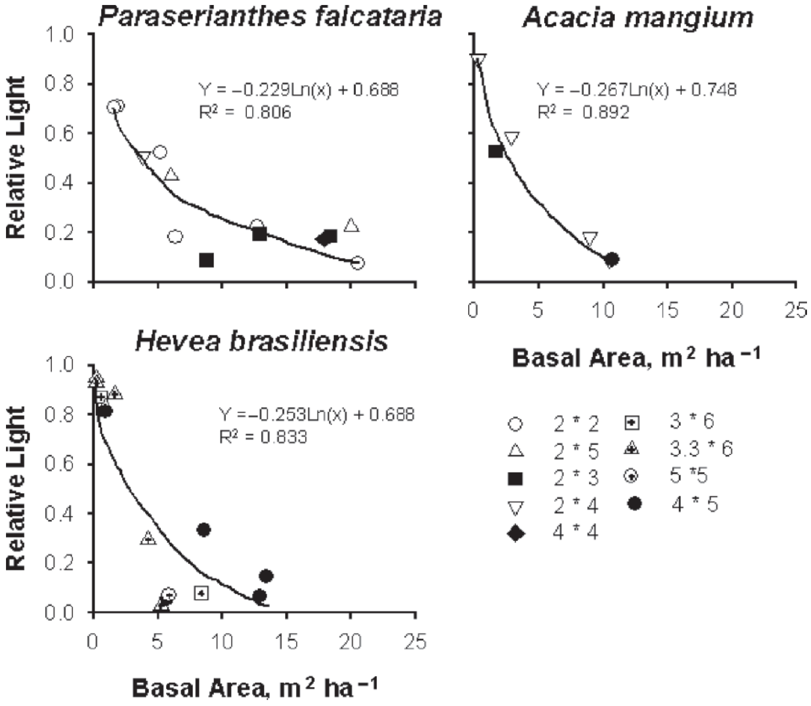

Fig. 6.6 Measure of relative light received by *Imperata* as a function of basal area of *P. falcataria*, *A. mangium* and *H. brasiliensis*

Table 6.3 Regression of simulation and measurement of relative light received by *Imperata* as a function of basal area of four species at different tree spacing

Tree species		Weeding	Tree spacing	Equation	R^2
Acacia mangium	Measurement	–	Narrow	$y = -0.22\mathrm{Ln}(\times) + 0.67$	0.89
	Simulation	No weeding	Narrow	–	–
			Wide	–	–
		Partial weeding	Narrow[a]	$y = -0.12\mathrm{Ln}(x) + 0.44$	0.85
			Wide[b]	$y = -0.13\mathrm{Ln}(x) + 0.45$	0.86
Paraserianthes falcataria	Measurement	–	Narrow	$y = -0.23\mathrm{Ln}(x) + 0.80$	0.81
	Simulation	No weeding	Narrow	$y = -0.21\mathrm{Ln}(x) + 0.72$	0.93
			Wide	$y = -0.21\mathrm{Ln}(x) + 0.64$	0.88
		Partial weeding	Narrow	$y = -0.14\mathrm{Ln}(x) + 0.50$	0.84
			Wide	$y = -0.20\mathrm{Ln}(x) + 0.61$	0.91
Hevea brasiliensis	Measurement	–	Narrow	$y = -0.25\mathrm{Ln}(x) + 0.69$	0.83
	Simulation	No weeding	Narrow	–	–
			Wide	–	–
		Partial weeding	Narrow	$y = -0.19\mathrm{Ln}(x) + 0.51$	0.85
			Wide	$y = -0.18\mathrm{Ln}(x) + 0.46$	0.80
Swietenia macrophylla	Simulation	No weeding	Narrow	–	–
			Wide	–	–
		Partial weeding	Narrow	$y = -0.18\mathrm{Ln}(x) + 0.56$	0.81
			Wide	$y = -0.13\mathrm{Ln}(x) + 0.56$	0.68

[a] narrow (timber trees: 4 × 2, 3 × 3, 4 × 4 m; rubber: 6 × 3, 5 × 3, 4 × 4 m)

[b] wide spacing (timber trees: 8 × 4, 8 × 8 m; rubber: 6 × 6, 12 × 6 m)

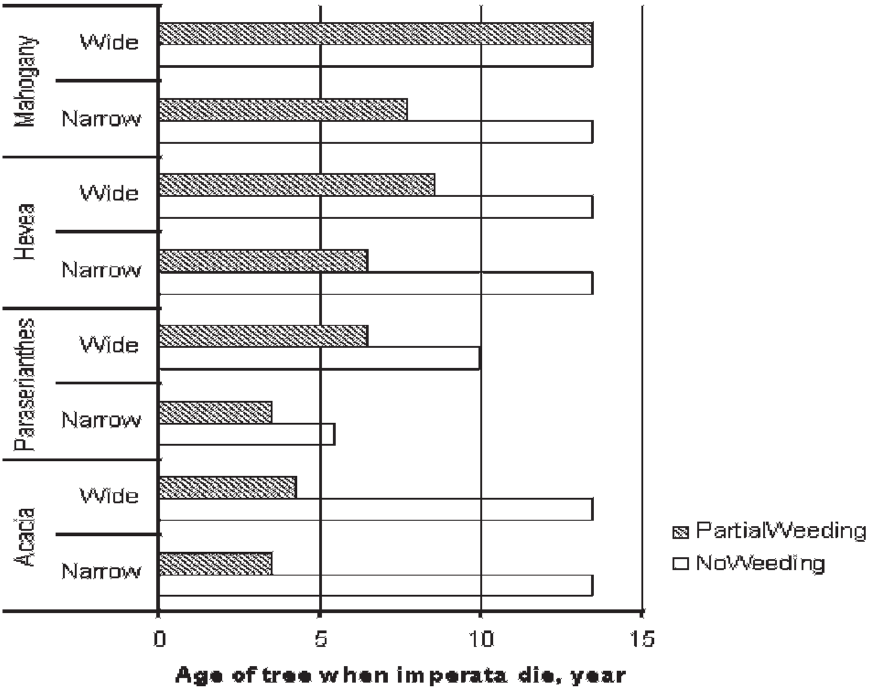

Fig. 6.7 The age of the tree when the simulations predict that *Imperata* dies due to shade of four tree species under different weeding regime (partial and no weeding) and different tree spacing (as defined in Fig. 6.4)

Table 6.4 provides information on the length of the initial cropping period (stage A) and this '*Imperata* regrowth window' for the different tree species and tree spacings shown in Fig. 6.6. The shortest duration of the *Imperata* regrowth window (1.9 year) was obtained for *Acacia mangium* at narrow spacing, with initial strip weeding. The longest period (>10 years) was obtained for *S. macrophylla* at wide spacing and partial weeding. Overall, the trees systems that rapidly close canopy to end phase A also have a short period B (Fig. 6.8); the predicted length of phase B is 1.85 year + 0.5 * length of phase A. However, there is some variation around this relationship. The three points above the trend line refer to: *P. falctaria* and *H. brasiliensis* at wide spacing and partial weeding, and to *S. macrophylla* at narrow spacing.

6.3.2 Results for the Philippine Site

6.3.2.1 Effect of Hedgerow Spacing on Tree Growth

Tree growth performance was lower under closer hedgerow spacing (1 × 3 for timber tree species and 5 × 5 for fruit tree spacing) than when grown under wider

Table 6.4 Length of time available for food crops and *Imperata* regrowth (stage A and B, respectively, in Fig. 6.1) and the stem basal area needed to reduce light at crop level to 50 percent and at *Imperata* level to 15 percent as transition points for phase A and B (the measurements refer to Purnomosidhi et al. 2005)

Tree species	S = simulation, M = measurement	Weeding	Tree spacing	Basal area (m^2 ha^{-1}) at		Time (years)		
				50% light at *Imperata* level	15% light at *Imperata* level	A	B	A + B
Acacia mangium	S	No weeding	Narrow[a]	–	–			
			Wide[b]	–	–			
		Partial weeding	Narrow	0.6	13	0.9	1.9	2.8
	M		Wide	0.7	10.6	1.4	2.2	3.6
		–	Narrow	2.1	10			
Paraserianthes falcataria	S	No weeding	Narrow	2.9	15.4	2.3	2.5	4.8
			Wide	2	11	5.4	3.7	9.1
		Partial weeding	Narrow	1	12.1	0.7	2.0	2.7
			Wide	1.7	9.4	1.9	3.2	5.1
	M	–	Narrow	3.7	16.9			
Hevea brasiliensis	S	No weeding	Narrow	–	–			
			Wide	–	–			
		Partial weeding	Narrow	1.1	6.4	2.8	3.1	5.9
			Wide	0.8	5.9	4.2	4.7	8.9
	M	–	Narrow	2.1	8.4			
Swietenia macrophylla	S	No weeding	Narrow	–	–			
			Wide	–	–			
		Partial weeding	Narrow	1.4	10.5	2.4	4.2	6.4
			Wide	1.6	23.7	4.1	>10	>15

[a] narrow (timber trees: 4 × 2, 3 × 3, 4 × 4 m; rubber: 6 × 3, 5 × 3, 4 × 4 m)
[b] wide spacing (timber trees: 8 × 4, 8 × 8 m; rubber: 6 × 6, 12 × 6 m)

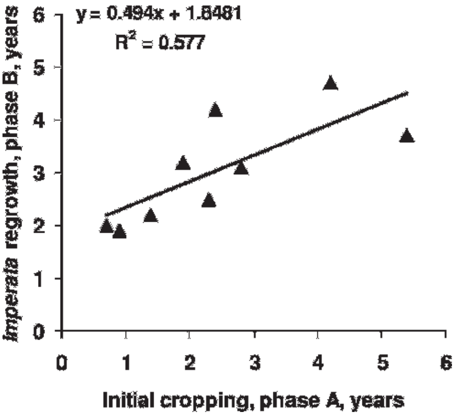

Fig. 6.8 Relationship between predicted length of the *Imperata* regrowth window (Phase B) in relation to the predicted length of initial cropping period (Phase A, as in Fig. 6.1), across different tree species, planting patterns and weeding regimes (data in Table 6.4)

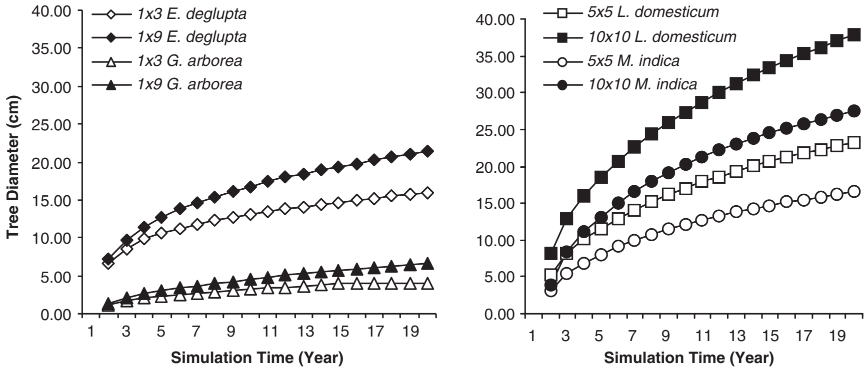

Fig 6.9 Simulated tree diameter of timber and non-timber trees at different hedgerow spacing grown in *Imperata* grassland

hedgerow spacing treatments (Fig. 6.9). This could be attributed to lesser intra-specific competition among the trees for both above- and below-ground resources.

6.3.2.2 Growth Performance and Control of *Imperata* Under Different Hedgerow Spacing

During the first two years of tree growth, the growth performance of *Imperata cylindrica* was not affected as evidenced by the high biomass production of *Imperata* (more than 2.0 kg m^{-2}; Fig. 6.10). On the third year of tree growth, however, *Imperata* growth was greatly reduced, with *Imperata* biomass ranging from 0.12 to 0.13 kg m^{-2}. Reduction of *Imperata* growth was greater under closer hedgerow spacing than wider hedgerow spacing.

Comparing the control of *Imperata* growth under the two timber species simulated, results showed that *G. arborea* hedgerows controlled the growth of *Imperata* on the 5th year under closer spacing treatment (1 × 3) and on the 8th year under wider spacing treatment (1 × 9; Table 6.5). Under *E. deglupta* hedgerows, complete suppression of *Imperata* growth occurred on the 6th year of tree growth under closer spacing (1 × 3) and on the 14th year under wider spacing (1 × 9). Comparing the growth performance of *Imperata* under fruit tree species, the growth of *Imperata* was greatly suppressed on the 8th year under closer hedgerow spacing (5 × 5) and on the 10th year under wider spacing (10 × 10; Table 6.5). Overall, among the four tree species studies, control of *Imperata* growth was faster when *G. arborea* trees were grown in *Imperata* areas. This may be attributed to the large leaf size of *G. arborea* and the possibility of allelopathic effect of *G. arborea* roots.

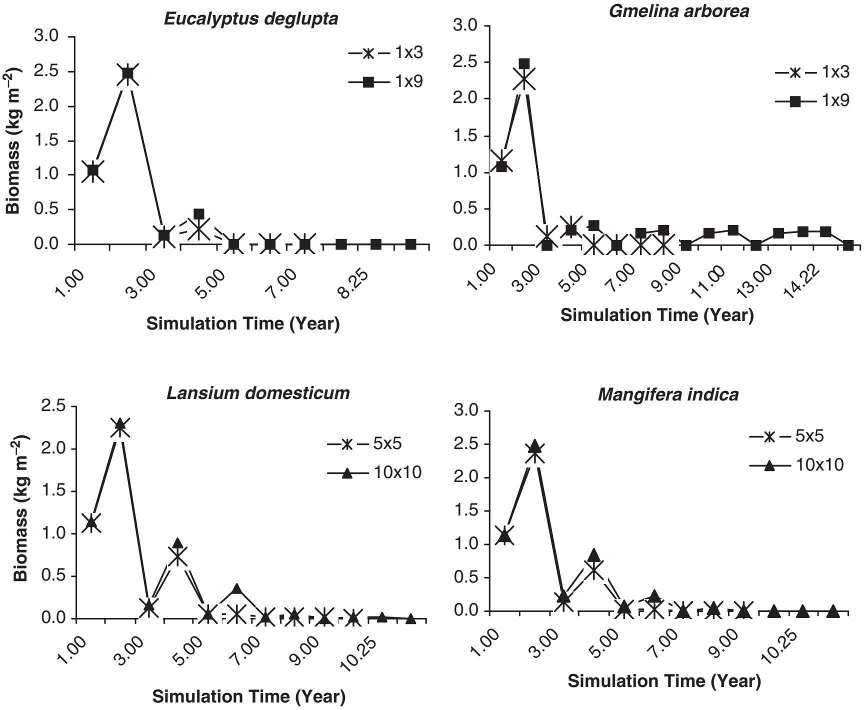

Fig. 6.10 Simulated tree shading effect of timber and non-timber trees on the growth and survival of *Imperata*

Table 6.5 Simulated tree shading effect of timber and non-timber trees on the growth and survival of *Imperata*

Tree species	Spacing (m×m)	Time before *Imperata* dies (years)
Eucalyptus deglupta	1×3	6.2
	1×9	14.2
Gmelina arborea	1×3	5.0
	1×9	8.3
Mangifera indica	5×5	8.3
	10×10	10.3
Lansium domesticum	5×5	8.2
	10×10	10.3

6.3.2.3 Relative Light Captured by *Imperata* Under Hedgerows

The relative light capture of *Imperata* was greatly reduced under *G. arborea* trees. At a canopy width of 1.0 m, the relative light capture of *Imperata* was reduced to nearly zero (under both hedgerow spacing treatments). Under the *E. deglupta* hedgerows, reduction of light capture near zero occurs at canopy with of about 5 m (Fig. 6.11). Due to much wider spacing of fruit trees (5 × 5 and 10 × 10), reduction in light capture of *Imperata* takes place at much greater canopy width. When grown under *L. domesticum*, canopy width of 5.0 and 8.0 m for 5 × 5 and 10 × 0 spacing, respectively, reduced light capture by growing *Imperata* underneath the trees to zero. Under *M. indica* hedgerows, canopy widths of 4.0 and 7.0 m at closer and wider spacing are needed to reduce light capture of *Imperata* to near zero (Fig. 6.11). Light captured by *Imperata* was greatly reduced with increase in canopy width of the different tree species (Table 6.6).

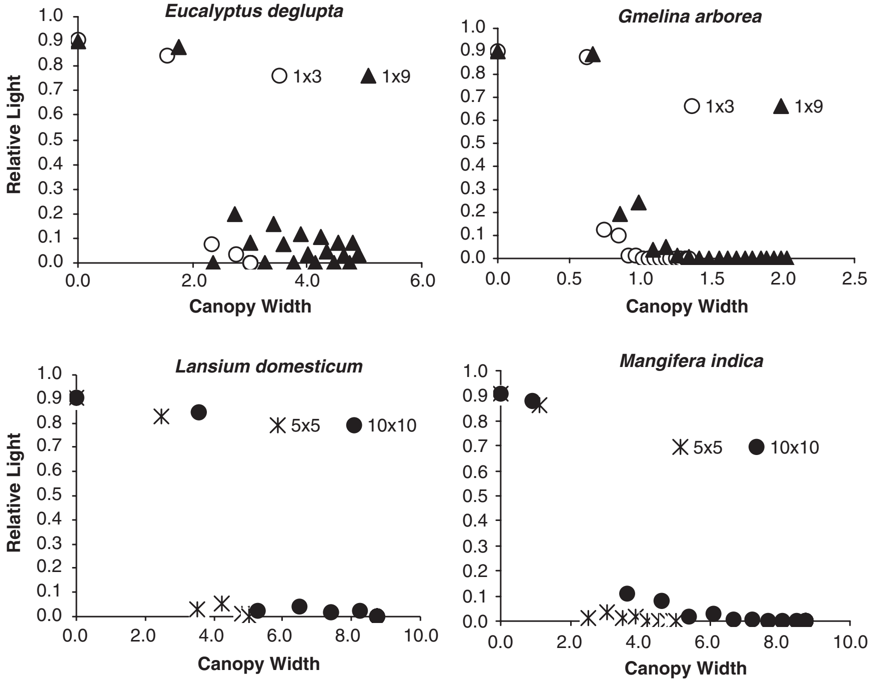

Fig. 6.11 Simulated relative light captured by *Imperata* as a function of the canopy width of timber and non-timber trees

Table 6.6 Regression of the simulated relative light captured by *Imperata* as a function of canopy width of timber and non-timber trees

Tree species	Spacing (m × m)	Equation	R^2
Eucalyptus deglupta	1 × 3	y = −1.16Ln(x) + 1.26	0.86
	1 × 9	y = −0.50Ln(x) + 0.76	0.74
Gmelina arborea	1 × 3	y = −0.66Ln(x) + 0.12	0.93
	1 × 9	y = −0.52Ln(x) + 0.26	0.92
Mangifera indica	5 × 5	y = −0.95Ln(x) + 1.52	0.88
	10 × 10	y = −0.70Ln(x) + 1.49	0.82
Lansium domesticum	5 × 5	y = −0.46Ln(x) + 0.70	0.84
	10 × 10	y = −0.35Ln(x) + 0.71	0.84

6.4 Discussion and Conclusion

The WaNuLCAS model could be used to simulate the various phases of an agroforestation process, including the possible interactions between initial tree growth, the cropping phase till the tree canopy started to capture too much light for the crop and the subsequent *Imperata* regrowth window. For any other tree species with adequate tree parameterization a comparison such as made here can be used to optimize tree spacing.Results for the simulations in the Philippines and Indonesia agree that the length of time required for *Imperata* control varies in the 3 to >15 year range, depending on the growth rate of the tree and the spacing used.

The predicted duration of the *Imperata* regrowth window of two to five years may be linked to the probability of fire-induced tree mortality and tree failure. The probability for trees to survive this period is $(1\text{-p})^n$ where p is the annual probability of fire and n is the number of years. If the fire probability is 0.1, 0.2 or 0.3, the probabilities of surviving the *Imperata* regrowth window of two or four years are 0.81 or 0.66, 0.64 or 0.41 and 0.49 or 0.24, respectively. The probability (p) of fire entering the plot (p) will depend on the landscape context of the plot, the length of time of exposure, n, depends on plot management.

For the trees with a relatively slow growth rate, the benefits of a longer initial cropping period have to be weighed against the longer risk of the *Imperata* regrowth window, as the duration of Phase A and Phase B is well correlated. Wider spacing of trees, similarly has benefits for the cropping period but will lead to slower final closure of the tree canopy. A landscape mosaic with plots in different phases of agroforestation may enhance the overall probability of success, and allow for plots of valuable, slow growing trees to be interspersed with faster growing trees that will reduce fire risk for the surrounding plots.

While there is a wide range of options for the choice of tree species, most farmers opt for a few well-known species. Out of a range of 83 tree species tested, Otsamo et al. (1997) found that the exotics *Acacia mangium*, *A. auriculiformis*, *Gmelina arborea*, *Paraserianthes falcataria* and *Cassia siamea* were among the most hardy survivors when planted in *Imperata* grasslands at low levels of management intensity, while many trees from the local flora failed. *Gmelina arborea* is not as popular among smallholders in Indonesia as *Paraserianthes falcataria*, *Swietenia macrophylla* and *Tectona grandis* (teak; Roshetko et al. 2004). Otsamo (2000, 2002) described that *Acacia mangium* as a ‘framework species’ also provides the best opportunities for regeneration of native tree flora after the early control of *Imperata*. The specific properties of the trees and the dominant weed need to be known, while generic statements about monocultures and biological diversity have low predictive value (Collins et al. 2007).

As recommendations and conclusions we propose:

- The choice of tree species and spacing must balance between benefits of a longer cropping period with wider tree spacing, and the prolonged risks of fire in the *Imperata* regrowth phase.

- Weeding in the zone directly surrounding the tree is essential for tree establishment in nearly all tree species tested.
- Crop growth in the zones with increasing distance to the tree (zones 2–4 of WaNulCAS model; Van Noordwijk et al. 2004a) is less competitive for the tree than allowing *Imperata* regrowth, but clean weeding has no advantage on tree growth.
- Adequate *Imperata* control with the use of medium-to-slow growing tree species is contingent on landscape level control of the risk of fires spreading.
- Agroforestation with fast growing trees with a 70 percent probability of success can be achieved as long as the risk for fires entering the plot is kept below 15 percent.
- A landscape mosaic with plots in different phases of agroforestation may enhance the overall probability of success, and allow for plots of valuable, slow growing trees to be interspersed with faster growing trees that will reduce fire risk for the surrounding plots.

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Part III

Smallholder Tree Growing for the Market: Economics, Policies and Institutes

Chapter 7

Over-Regulated and Under-Marketed: Smallholders and the Wood Economy in Isabela, The Philippines

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Abstract This study explores the relationships between smallholder wood economy, logging of the natural forest and regulatory policies that pertain to these. Major data come from interviews of informants and 42 treegrowing smallholders in the uplands of Isabela province. Three sub-markets appear to operate separately: one in tree-based fruit, one in fuelwood/charcoal and one in timber produced by the exotic *Gmelina arborea* tree. The latter market is of special interest because of its potential importance for the region and because it illustrates a case of outspoken negative interaction between markets and policies. The farmers are overburdened by regulations designed originally to protect the natural forest that is present in the same region. More is at stake than a simple illustration of a well-known dilemma however, since gmelina is well distinguishable from the natural forest species and technical difficulties cannot explain the present imbalance between the underdeveloped legal smallholder market and the well-organized trade in illegal timber, occurring under the wings of the same regulatory agency. The paper discusses the options for a fundamental policy rectification which would lay a basis for a free and fair gmelina timber market that would make wood procurement of the region more sustainable and equitable.

Keywords Forest regulation, Philippines, smallholder forestry, uplands, wood market

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7.1 Introduction

The Philippines is one of Asia-Pacific countries that experienced major deforestation during the second half of the last century, transforming it from a timber exporter nation to a net importer. The main source of timber, primarily high quality tropical hardwoods, traditionally comes from the primary and residual forests. With diminishing forest cover, the global trend is to source wood from industrial tree plantations but in the Philippines, industrial forestry can hardly augment the country's need for wood and sustain the demands of its forest-based industries and increasing population. In recent years therefore, the focus shifted to community-level and individual smallholder plantings for multiple-use forestry.

Tree plantings represent one of the largest income generating assets in rural areas, with the current stock of trees having involved huge investments of about US$3.6 billion equivalent to Philippine pesos (PhP) 140 billion (World Bank 1999). The same report estimated that there are about 4.5 million hectares under tree crops where 70 percent of the rural households have some tree species, either commercial or backyard. Mixed tree systems cover about 1.6 million hectares involving 27 percent of rural households, with 80,000 ha for backyard or home-gardens and 70,000 ha for fruit trees. While forests cover about 19 percent of the total land area of the country, tree crop cover is not far behind at 15 percent.

By and large, farm forestry or agroforesty are probably the only definitive affordable solution for various environmental objectives, creation of jobs in rural areas, and as renewable source of timber and various tree products. Farm forestry in the Philippines tends to be small but with several forms such as woodlots and tree fallows, backyard tree crops, agroforestry in combination with food and cash crops, and fence-line or boundary tree plantings. These multiple combinations in different land-uses whether in public or private lands became widely dispersed throughout the country through government subsidies. Widely grown species include yemane or gmelina (*Gmelina arborea*), mahogany (*Swietenia macrophylla*), bagras (*Eucalyptus deglupta*), falcata (*Paraserianthes falcataria*), and teak (*Tectona grandis*) (Harrison and Herbohn 2000). These exotic species are used in watersheds as well as in production forests and private small-scale wood lots, especially in the case of fast-growing gmelina.

Smallholdings in the rural economy are the lifeline of the people that value agricultural land for sustenance, especially the farmers and workforce in the uplands. Just like the bulk of agricultural production in the Philippines, tree crop production is quintessential private and small-scale, averaging about one hectare. Many upland activities are carried out around protected areas and forest reserves.

As forest resources have become increasingly scarce, wood gradually enters into the local market and link the smallholders to the marketing system and the cash economy. The perspective of policymakers on the markets for forest products will be the key to an increasing contribution of tree-based products sector to reducing the pressure on natural forests (Seve 2001). This is especially so because evidence in agriculture and forestry shows that links between producers and markets are often weakened by bureaucratic politics and organizational processes. Technological innovations require years before they are translated in smallholder's profits, but the effects of policy interventions can be felt quickly in terms of prices and markets at the forest or the farm-gate (Tomich 1996). In the process, trade restrictions that lead to collapse of farm-gate prices can destroy incentives necessary for domestication and commercialization of both timber and non-timber forest products in agroforestry systems. Worse still, well-intended policy measures aimed at the protection of natural forests may also be applied to agroforestry systems that are managed sustainably by small-scale farmers (ASB 2001). The unintended result of treating all timber alike regardless of its origin in forests or farms may be that smallholders who plant and manage the trees are burdened by unnecessary regulations that weaken their motivations to further invest in trees.

The design of institutional structures that address these problems – in other words, institutional structures that stimulate smallholder timber production or at least do not interfere with it – requires knowledge on how smallholders are connected to the wood markets and how this relationship is mediated by regulations. However, very little is known about the decentralized markets for smallholder-produced forest products that operate in many rural areas in general (Veeman 2002), and the Philippines is no exception. Against this background, the aim of the present paper is to address this knowledge gap for the case of the Philippines, with a special objective to elucidate how regulatory policies interface with the relationship between smallholders and the wood market. We will focus on the two legal wood trades that occur in the area, which concern gmelina timber and fuelwood/charcoal. Fruit trees will be mentioned here and there for comparative purposes, given they also represent a tree-based income source.

Due to our explorative and policy-oriented objective, we applied a relatively informal research design that remains close to the life world of the tree growers. In spatial terms, our focus is on an upland area relatively close to a natural forest zone, because many tree growers in the Philippines live in that type of environment, and because we expect that the possible interference of tree growing and forest protection policies may be most likely felt there.

7.2 Description of Study Area

The Sierra Madre mountain range in northern Philippines is an area of many possibilities in tree production and products trade. The forests are counted among the last strongholds of the Philippine forests and recognized as one of the most biodiversity rich ecosystems in Southeast Asia. A big portion of this mountain range stretches in the province of Isabela where a large-scale corporate logging industry used to be a top earner until the imposition of a logging moratorium in 1992, that was intended to keep at least part of the forest for nature and future generations. Nevertheless, the furniture industry continues using *narra* (*Pterocarpus indicus*) and other hardwood species illegally cut in the forest. This well-organized illegal timber flow runs parallel to that of plantation-sourced wood, notably gmelina, grown largely by smallholders that combine the trees with agricultural activities and other livelihood components (sometimes including illegal logging).

The study area covers the northern Isabela watershed area under the jurisdiction of the Community Environment and Natural Resources Office (CENRO) of the Department of Environment and Natural Resources (DENR) in Cabagan town, province of Isabela in northern Luzon. This area comprises the municipalities of Cabagan, San Pablo and Tumauini. The smallholders of the study are to be found within a long stretch of geographically distant communities located at the western foot-slopes of the Sierra Madre Mountain Range at 17°25’34” to 17°48’28” north latitudes and 121°45’45” to 121°48’28” east longitudes. Providing a mixture of grassland, arable lands and secondary forest remnants on often moderate slopes, their landscape is intermediary between the forested mountains of the Sierra Madre in the east and the flat and rice-growing valley lands of the Cagayan River basin in the west. The tree-growing sites are typically at distances of 15–23 km to the highway that runs along the Cagayan River and where the (small-town) capitals of the municipalities are situated.

7.3 Methodology

The study area has been covered by many interdisciplinary research activities under the Cagayan Valley Programme on Environment and Development (CVPED), a partnership institution of the Isabela and Leiden universities (Snelder and Masipiqueña 2003). Data from these studies were used as a general background. Specific data gathering for the present study was conducted in 2006, visiting actors along the product chain between producers and consumers, and the (re)visit of smallholder tree plantings that have been established since the implementation of two community-based forest management programs (see next section).

A purposive two-stage sampling procedure was used. The first step focused on the tree-based enterprise activity (retailing, wholesale, furniture making) and involved some interviews of key informants for overview purposes and interviews of 14 shop-owners and eight furniture makers to gather the detailed data. These respondents were situated in the towns of Cabagan and Tumauini, where trade and manufacture are concentrated. The second step consisted of semi-structured interviews of 42 smallholder tree growers who were pointed out by the first respondent group as suppliers in the wood market. This sampling process was blind; we stopped listing smallholder respondents when we had reached the number we could handle within our time and budgetary constraints.

Note that this procedure assures that we have gathered data only of smallholders that are already connected to the market one way or another and excludes tree growers that are not connected yet. Within the smallholder group, we found a rich variety of livelihoods, ranging between farmers who grow trees as additional source of income to full-time fuelwood gatherers and retailers (see Table 7.1).

Table 7.1 Types of players in marketing farm-grown tree products in Isabela, the Philippines

Category	Frequency
1. Full-time farmer (arable plus trees)	10
2. Private tree plantation owner	3
3. Farmer and part-time fuelwood gatherer	13
4. Farmer and middleman of fuelwood	5
5. Farmer and charcoal maker	3
6. Full-time fuelwood gatherer	4
7. Charcoal maker and buyer of gmelina trees	3
8. Middleman of fuelwood	4
9. Retailer and money lender for fuelwood	11
10. Furniture maker/shop owner	8
Total	64[a]

[a] Total number of respondents from two-stage sampling

Data gathering focused on the following elements:

- Sources of tree-based products and key players involved (supply side)
- Types of wood-based commodities, product flow, market channels, price movement, intermediaries and buyers (demand side)
- Issues related to markets and policies on tree-based product harvesting and marketing
- Secondary data from DENR and former tree planting project implementers

7.4 Findings

7.4.1 *Types of Actors in the Gmelina Timber and Fuelwood/Charcoal Chains*

The two-step sampling procedure yielded a rich variety of actors involved in the gmelina and fuelwood chains. Table 7.1 gives the overview. The classification typifies people by their main outlook. A full-time farmer, for instance, is one who grows different types of crops including trees for timber and fuelwood/charcoal, whereas a full-time fuelwood gatherer earns his income from this activity only. Other variants of entrepreneurship in the area depend on additional income-generating activity such as acting as middleman, value-adding and derived demand such as in the case of furniture shop-owner. Quantitatively in the Table, one might wonder how the 13 timber-growing smallholders (categories 1 and 2) could keep the eight furniture shops in stock. This could be a sampling anomaly but it may also be indicative of that the furniture shops are in fact supplied largely by illegal timber from the forest.

7.4.2 Production Sources of Gmelina Timber and Fuelwood/Charcoal

Communal and private gmelina plantings are the potential production sources of smallholder-grown timber in the study area. The present areas and volumes in the region are very difficult to assess accurately. The communal plantations are part of the tenured areas under six Community-Based Forest Management (CBFM) sites run by local people's organizations, with a total land area of 27,288 ha and 591 farmer-beneficiaries. The sites contained gmelina plantations planted since 1996 including succeeding tree plantings equivalent to, reportedly, approximately 850 ha with varying conditions and quality. Another government program called the 'Grow a Tree for Legacy' initiated a further increase in gmelina plantings by providing seedlings to farmer adopters. Over 200 ha of gmelina were reportedly planted in both public and private land areas under this program in 16 villages within the study area (Fig. 7.1).

The difficulties in trusting these figures may be illustrated by Callitong (1997) who carried out a field inventory and concluded that in the whole of Isabela, only about 42 ha were planted with gmelina. Most of the old gmelina plantations were already harvested and transformed into corn fields. No more recent field inventories are available but it is sure that a good number of the officially present gmelina stands cannot be accounted for, due to poor stocking, low survival rates (through drought, fires, typhoons, etc.) and harvesting or cutting to meet emergency needs. On the other hand, many private tree growers do not register their trees unless when securing permit to cut. These trees may be found in many positions on the farm, e.g. in home gardens, small-scale plantations or along field boundaries. Single-focus tree farms, be it for timber, fruit or fuelwood, are not found in the area. Farmers

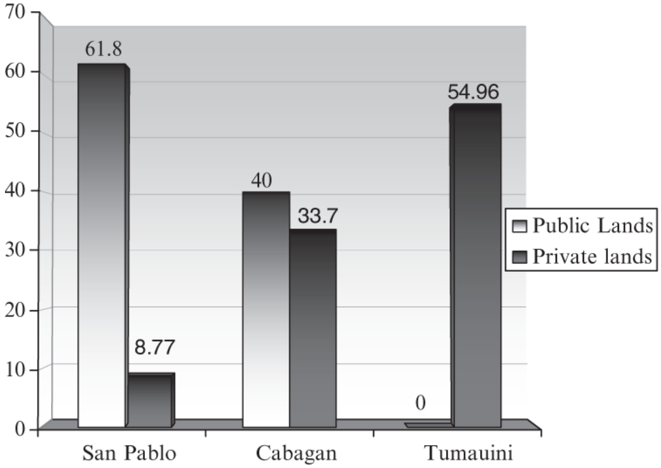

Fig. 7.1 Reported public and private lands (ha) planted with *Gmelina arborea* under the 'Grow a Tree for Legacy' program implemented in the three municipalities under CENRO Cabagan in Isabela, the Philippines (as of 2006)

prefer to integrate timber and fruit trees in a broader livelihood in which annual crops (corn, rice), bananas and off-farm work play major roles.

Fuelwood for home use, direct sale or charcoal making are partly found in the communal plantations but mainly sourced from naturally-growing shrub and trees in patches of secondary re-growth along creeks and in pasture areas (Snelder and Persoon 2008). Felling of trees and gathering dead wood, thinnings and prunings are the routine activities for the fuelwood gatherer.

7.4.3 Sub-markets and the Prices for Gmelina

Fuelwood, charcoal and timber are traded on small-scale and largely independent sub-markets. Local marketing of these commodities are predominantly informal in terms of price discovery and negotiations. As said, there are two major markets in the study area that serve as entry points for rural-based goods, with mean distances from 15 to 23 km from the production sources. Due to long distances from some villages, there are some minor markets for local exchanges. Table 7.2 shows the key economic features of the most frequently traded farm-grown tree products by the farmer-respondents in the study area.

The high number of farmers and weekly selling schedule indicate that fuelwood is a commodity that can easily be traded by smallholders. There are steady markets for woodfuels that provide a stable source of income not only for the smallholder or gatherer but also to shopkeepers due to consistent demand from different types of buyers. The bulk of fuelwood demand comes from households and small-scale enterprises such as bakeries, fish-smoking, eateries and small stores. Peak demand comes during special occasions like town *fiestas*. Yet, the Table shows that average income from firewood are low. Contrary to timber or fruits, it is a product without development potential. Incomes from charcoal can be higher than fuelwood but only few farmers engage in this specialized trade.

Fresh mangoes, especially of the commercial variety, can provide good income for the farmers during the peak season. Fresh fruit is a distinct market for smallholder farmer characterized by profit maximization potential as long as good management practices are followed. This can be a reason why many farmers say they would prefer to plant more fruit trees.

On the other extreme, the market for gmelina timber is highly intermittent, with farmers selling only on incidental orders. Although gmelina timber is becoming more widely used for light construction and furniture making in recent years, there is still low degree of market concentration. Gmelina competes with forest hardwoods for furniture making, and although considerably more expensive, consumers still prefer the forest species for furniture (Siriban 2006). For construction, end users also prefer tree species from the forests. The imperfect market for gmelina can therefore be traced to discontinuities in demand associated with timber volumes sourced from the forests.

The character of the gmelina market creates a high variability of prices. The findings of Cortiguerra (2006) showed that in about 81 percent of the cases, the

Table 7.2 Farm-grown timber and non-timber products traded by farmer-respondents in Isabela, the Philippines

Tree products traded by farmer-respondents (n = 42)	Frequency in the sample (n = 42)[a]	Selling schedule	Ave. volume traded	Selling price (PhP)[b]	Consumer price (PhP)	Ave. annual income derived from sale (PhP)
1. Gmelina timber						
– For furniture making	9	Depends on orders	1,500 bdft[c] per year	8/bdft	17/bdft	12,000
– For construction/poles	6					
2. Fuelwood	36	Weekly for a duration of 8 months/year	120 bundles[d] per month	7/bundle	17/bundle	6,720
3. Charcoal	10	Every 4 months	150 sacks[e] per year	100/sack	120/sack	15,000
4. Fresh table fruits	12	Harvest time	1,125 kg/5 trees/harvest[f]	20/kg	20/kg	22,500

[a] Based on multiple responses
[b] Philippine peso: PhP 49 = US$1 (as of 2006)
[c] bdft = board foot
[d] bundle = small bundle at 12 in. with 7 to 9 wood pieces
[e] sack is 1.17 × 3 ft.
[f] data from fresh mango only

price is set by the furniture makers, with only 13 percent by the middlemen and about seven percent by the producers. Due to long-term nature of timber production, it may be that production costs, as in the case of gmelina, are treated as a sunk cost (Harrison 2003). The result is that the buyer has greater negotiating power than the seller and the price may fall below the profitability level. The selling price is almost doubled at the consumer side, reflecting the high transport cost and the relative power of the buyers.

7.4.4 Market Channels

The market channels for gmelina, fuelwood and charcoal, which are the major farm- grown tree products, are shown in Fig. 7.2. The Figure shows that for charcoal (bottom picture), a fully developed commercial markets exists, with the whole volume flowing through a regular chain of smallholder to wholesaler and then onwards to retailer and consumer. Roughly the same picture exists for fuelwood, although some minor flows are present through contract buyers and direct trading between producer and consumers. This direct trade concerns local contacts, e.g. within the same village. The middlemen in the fuelwood and charcoal trade often provide credit, which the farmers consider as down payment for the goods. This may push farmers into debt bondage to the traders (Hobbes and de Groot 2004).

For gmelina timber, the marketing channels show a very different picture. In fact, only minor flows are directed at the furniture manufacturers and wood or furniture retailers, and most of the timber is traded locally in direct contact between producers and end users (roughly, non-tree owning co-villagers that ask for a tree to be cut for construction or other purposes). In other words, even though a market exists to the extent that gmelina producers could be pinpointed by the shop-owners and traders in our two-step sampling procedure, the market is in fact totally underdeveloped.

7.4.5 Policy Regulations on Farm-Grown Timber and Forest-Sourced (Illegal) Timber

Smallholder tree growing is governed by the Department of Environment and Natural Resources (DENR) policies. A DENR administrative order has already established the ‘Deregulation of Cutting of Forest Tree Species’. According to this Order, the local Community Environment and Natural Resources Office (CENRO) shall invite all concerned private landowners to register tree plantations within private lands. Registration of tree farms will facilitate the processing of documentation requirements for future harvests. The holders of ‘Certificate of Registration’ are exempted from forest charges and require no permit to harvest and transport the registered trees either on private or public lands. The only exceptions are specifi-

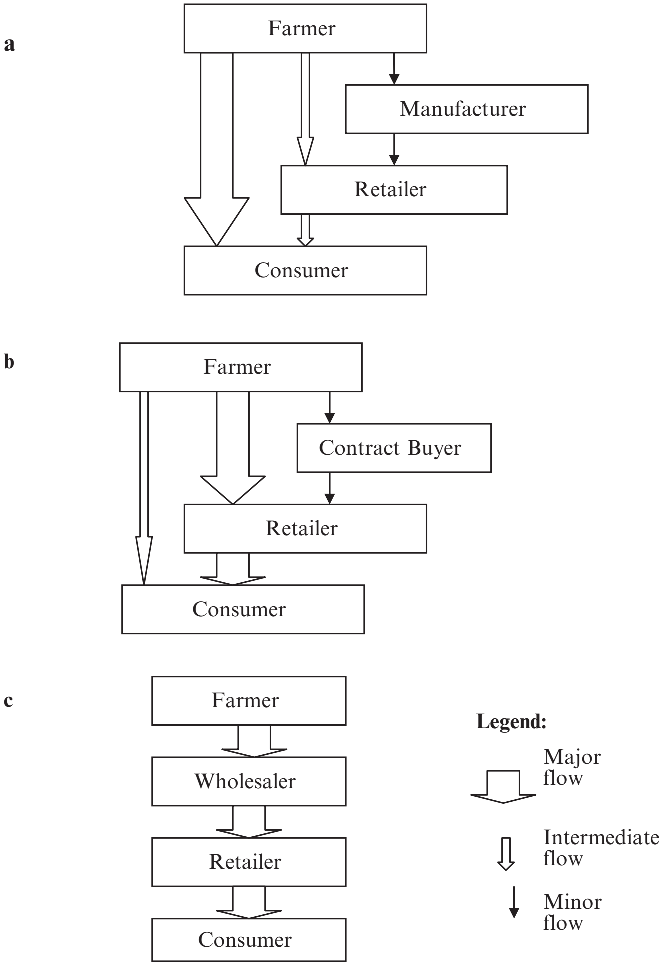

Fig. 7.2 Major, intermediate and minor market channels for *Gmelina arborea* timber (a), fuelwood (b) and charcoal (c) in the northern Philippines

cally listed premium hardwood species, such as narra (*Pterocarpus indicus*), molave (*Vitex parviflora*) and kamagong (*Diospyros philippensis*) that are all sourced from the natural forests.

Findings have shown, however, that most smallholder farmers lack any awareness and understanding of the policies on tree registration, harvesting, transport and marketing. In fact, most farmers when confronted in checkpoints along the roads to show documentation and permits think that their activity is basically illegal and they have to pay fees to make their trade legal.

This situation is perpetuated by the local CENROs who have their own ways of policy implementation (Mangaoang et al. 2005). For instance, proof of ownership is required to transport wood and to make this matter worse, the agency does not accept tax declarations as such proof. Ownership has to be proven by an application filed to the DENR for titling purposes (Calub 2005). There are many private tree plantation owners who are not registered with the DENR. Their existence is known only once the owners request for verification and inventory and issued a ‘Certificate of Tree Ownership’ that serves as a cutting permit. For collective forests planted by social forestry projects on public land, there is a ‘Resource Use Permit (RUP)’ that serves as the permit to cut and sell the logs, lumber and other forest products. Aside from the high cost and cumbersomeness of the required documentation, taxes are imposed by the local government unit (*barangay* tax), the reformed value-added tax and sometimes revolutionary tax in some regions (Cortiguerra 2006). In other words, smallholder tree growers are still heavily burdened by uncertainties, administrative requirements and levies.

Due to the logging moratorium and the exception on deregulation (see above), all cutting and transport of natural forest-sourced timber is basically illegal in the region. One regulatory instrument is noteworthy in this respect, however, namely the ‘Wood Recovery Permit’ that allows anybody to gather, retrieve and dispose abandoned logs, drifted logs, sunken logs, uprooted and fire or typhoon damaged trees, tree stumps, tops and branches. This permit is a major vehicle for the massive cutting and trade of forest species in the region, since for an appropriate payment, any log can be declared abandoned, drifted, sunken or damaged. Organizing such a trade cannot be done by smallholders but requires capital and political involvement. Driven by the large profits to be made, such structures have come into being in the region, however, as smaller-scale re-enactments of the once national-level deforestation machinery.

Overall, then and in spite of all good intentions, the regulations as enforced locally *de facto* largely exclude the smallholders from legal trade of planted wood but allow others to engage in the illegal trade of forest species.

7.5 Discussion

As we have seen, the situation with fuelwood and charcoal in the region is that of a relatively regular market with low profits and development opportunities. The present discussion is therefore fully focused on the timber trade.

The degree of fine-tuning of regulations poses a well-known dilemma in policy design. On the one hand, coarse, across-the-board regulations often tend to create inefficiencies that fine-grained regulations then may rectify. In our case, for instance, a declaration of registration appears rational to ensure that DENR receives information on plantation stands without cost; a declaration of ownership ensures that timber is not extracted from the neighbor’s or state plantations; and a wood recovery permit ensures that fallen or abandoned timber is not left to rot as it would be under a blanket logging ban.

On the other hand, fine-grained regulations increase the regulatory burden on the actors, which distorts markets. Generally speaking, the higher the regulatory burden, the more knowledge, capital and scale are needed to handle it. This tends to exclude smaller and less endowed players. Though this may sometimes be advisable, e.g. when small firms are intrinsically more polluting per unit of product than large enterprises are, the exclusionary effect is strongly perverse in our case. The regulatory burden on the legal gmelina trade is such that the smallholder growers are effectively excluded, while the regulatory burden on the illegal forest species trade is not enough to exclude the capitalist players, once they have organized to grab the windfall profits. The effect of this is aggravated by the fact that gmelina and illegal timber compete on the same furniture and constructions markets. The bad here actively drives out the good. As a result, the gmelina market has remained undeveloped.

As analyzed by Ostrom (1990), fine-graded regulations (or 'graded sanctions' as she calls them) are a characteristic of strong, enduring resource management systems. This rule has its logical flipside too, namely that only strong governments or strong community organizations can afford fine-grained regulations. It is just like a woman in Tanzania once told one of the authors when questioned why her particular community kept up a *total* cattle ban in the area: "Of course, a few cows would do no harm at all. Only, our community simply does not have the capacity to maintain such a [fine-grained] regulation!" If such institutional capacity does not exist, fine-grained regulations become infested by moral hazard and/or overwhelming monitoring problems. In our case, for instance, proof of ownership of gmelina timber – which is a heavy burden to begin with in a country like the Philippines where bureaucracy leaves much to be desired – boils down to papers that the smallholder needs to beg (or pay) off at the DENR. The same holds for the resource use permit for gmelina and the certificate of registration. All these are unnecessary for any rational objective DENR could have with them. No gmelina comes from the natural forest, inventory of gmelina stocks can much better be done with remote sensing or surveys, and DENR has no task in ensuring against wood theft among neighbors. A likewise picture emerges from the 'wood recovery permit' used to transport logs from natural forests out of the region. The permit's fine-grained rationality of preventing a few logs to rot in the forest stands in no balance to the risk of losing the whole forest through this permit.

The reasons behind this state of affairs may be many. First of all, we cannot exclude that our own interpretation here may be incorrect. Possibly too, it is simply a case of temporary administrative confusion. Possibly moreover, it expresses a gut reaction of the agency to remain 'owner' of the 'problem', even if the problem is something else and others might be better positioned to solve it. A final hypothesis is that the prime function served by all these certificates and permits is to maintain a steady flow of extra-legal income to some of those who man the offices and checkpoints. In any case the results, as we have seen, are a disaster for the legal timber market and the natural forest alike.

Addressing the basic imbalance of *de facto* over-regulation of the legal market and under-regulation of the illegal market appears to be the necessary basis for any rectification of the current situation. Different from other cases where farmer-grown (or legal) and natural-forest (or illegal) wood is difficult to distinguish (ASB

2001; Wahyuni 2007), the case study area presents no technical difficulties to do so, since all gmelina is plantation-grown and easy to distinguish from natural forest species. Key to it all, therefore, is for DENR to deeply address the challenges of this situation and to implement a clear and rational policy that conforms to its public mandate of natural forest protection and sustainable wood provision. A blanket logging ban needs to be re-enacted and re-implemented even though this would cost a few non-recovered logs or blocks the establishment of plantations of indigenous species in the region for the time being.

Such a policy rectification would free the smallholders from over-regulation and illegal competition. They would, however, still be ‘under-marketed’. The policy rectification should therefore be seen as the necessary foundation to address the remaining, market-related issues concerning the gmelina market. Our field interviews revealed several of those. Smallholders complained much about the high transportation cost due to poor road conditions, for instance. Other constraining factors are unpredictable demand, lack of access to credit, and low prices fixed by the middlemen especially when the producers are indebted to them. Many farmers expressed a need for more market information and training. Even though there is a paucity of research on the scaling up of agroforestry (Franzel et al. 2001), these problems would not appear to be overwhelming, if we assume that the basic policy rectification is implemented indeed and a free, fair and stable market for gmelina would arise. Farmers in the region have proven to be well motivated and able to invest in new land use if basic circumstances are inspiring (Romero 2006). Well-organized support from DENR, knowledge and development agencies and banks could already help much, especially if reinforced by Local Government Units for political backing, roads maintenance and possibly some tax exemptions.

7.6 Conclusion

This study has explored the institutional-economic interactions between farm-based tree growing, illegal natural forest logging and regulatory policies. We have shown that the present structures in this triangle are detrimental to the forest, the smallholders and DENR’s public mandate alike. At the same time, however, good options exist to rectify these relationships and unburden the smallholders from unnecessary regulations and illegal competition. On that basis, improving the smallholders market situation will be feasible, so that the timber provision of the region may become sustainable (plantation-based) and equitable (smallholder-based), and the region’s unique natural forests may be saved for biodiversity and future generations.

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Chapter 8
Can Smallholder Tree Farmers Help Revive the Timber Industry in Deforested Tropical Countries? A Case Study from Southern Philippines

M. Bertomeu

Abstract In many countries of South and South-east Asia trees planted on farms are becoming the most important source of wood. In the Philippines, forestry statistics indicate that since 1999 between 50 percent to 70 percent of the log production came from planted trees because of misdirected policies on natural forests. Today, there are in northern Mindanao 135 active small-scale sawmills (SSS) exclusively supplied with farm-grown timber. These have an estimated log utilization potential of 111,064 m^3 $year^{-1}$ and a sawn timber production potential of 76,596 m^3 $year^{-1}$. 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 policies disincentive tree planting and the marketing of farm-grown timber. This chapter explores the importance and the potential of smallholder farmers to sustain the wood industry by characterizing the producers and the timber produced, and describing the structure of the market of farm-grown timber. The study was conducted among farmers in Claveria, northern Mindanao and wood processing plants located in Cagayan de Oro City and its neighbouring municipalities. Evidence is provided that most of the planted trees used by the wood industry in the region and sold in national and international markets are produced on-farm. This shows that smallholder farmers can produce large quantities of timber and efficiently supply local and national markets. The Philippine government and the wood industry sector must recognize the role of smallholder farmers as land managers and efficient producers of many important agricultural commodities, including timber.

Keywords *Gmelina arborea*, mini-sawmill, smallholder, timber trees, tree farming, tree marketing, wood industry

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D.J. Snelder and R.D. Lasco (eds.), *Smallholder Tree Growing for Rural Development and Environmental Services.*

8.1 Introduction

Since 1950, forests in the Philippines has declined at a rate of 2.2 percent annually. Likewise the forestry sector's contribution to the GDP has dropped from 12.5% in 1970 to just 2.3 percent in 1988 (PCARRD 1994), and 1.3 percent in 1990 (ADB 1994). The Philippines is now a net importer of timber (ITTO 1996). Timber imports are draining the country's foreign currency reserves at a rate of PhP 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, reforestation efforts have had limited success. Timber License Agreement (TLA) holders, who were required to reforest an area of denuded land equivalent to that selectively logged and to engage in industrial tree plantation, did not significantly contribute to the reforestation efforts due to corruption (Vitug 1993). Large government – and 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; Nimmo-Bell & Company 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 1970s have not been more successful (see also Snelder and Lasco, Chapter 1, this volume).

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 farming has emerged as a profitable farm enterprise (Bertomeu 2006), and as a viable alternative to industrial forest plantations and costly government-driven reforestation (Garrity and Mercado 1994; Pascicolan et al. 1997). Paradoxically, small-scale tree farms in the Philippines were first promoted in the early 1970s under the smallholder tree farming contract scheme of the Paper Industries Corporation of the Philippines (PICOP Inc.), one of the first major industrial forest plantation initiatives established to supply a pulp and paper mill at Bislig, Surigao del Sur.[1] 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.

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[1] From 1972 up to 1994, PICOP established in its forest concession area 33,200 ha of *Paraserianthes falcataria* and *Eucalyptus deglupta* (ADB 1994; Jurvélius 1997).

Unfortunately, tree farming has been promoted on the promise of huge economic returns,[2] based on overoptimistic yields of fast-growing trees in favorable tropical humid conditions and unrepresentatively high timber prices at specific times and locations.[3] In the past few years, lower than expected returns from tree farming, particularly with *Gmelina arborea* (hereafter referred to as gmelina) and *Paraserianthes falcataria* (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 PhP 4.0 per board foot (bd.ft.), (i.e., US\$33 m^{-3}), a 60 percent decline with respect to prices in the early 1990s. 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, interest in tree farming is still high. A field survey conducted in the upland municipality of Claveria, northern Mindanao, among 112 randomly selected farmers (sampling fraction ranging from 1.3 percent to 1.6 percent), of which 75 percent had planted timber trees, revealed that 55 percent (62 farmers) intended to plant timber trees in the near future. Of these, 37 farmers were non-planters and thus farm forestry is new to them, while the remaining 41 percent (25 farmers) were already tree planters who wanted to expand their plantations (Bertomeu 2004). In addition to the benefits provided to rural families, including fuelwood, construction materials, protection against erosion, shade and shelter, farm-grown trees are taking an increasing share of the timber industry and trade in the Philippines. The existence in Region 10 of northern Mindanao of 135 small-scale sawmills (SSS) exclusively supplied with farm-grown timber (DENR 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 percent of the province's growing stock. In Sri Lanka, "trees outside the forest" represents over 70 percent of industrial wood, and in Pakistan trees on farms account for 23 percent of all timber growing stock. Even in Indonesia, a country that still has vast forest resources, some 20 percent 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 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

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[2] The slogan "Kahoy karon, bulawan ugma" (Trees today, gold tomorrow) popular among Philippinos in northern Mindanao exemplifies the expectations put on tree farming.

[3] A local newspaper reported that 1 ha of *Eucalyptus deglupta* could yield "Ph P 14,000 per tree or Ph P 10.5 million per hectare" (Fonollera 1996).

in the province of Misamis Oriental in northern Mindanao. 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 trees planted on small farms, far from being anecdotal, has the potential to be a viable and reliable supply for the wood industry.

8.2 Materials and Methods

The study was conducted among smallholder farmers in Claveria, Misamis Oriental, and 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 10 in northern Mindanao.[4] 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 PhP 3.3 billion or 18 percent of the Gross Service Area Product (GSAP) of the two provinces of Misamis Oriental and Misamis Occidental. Consequently, the establishment of industrial crops, such as forest trees, rattan and rubber, is one of the economic sectors proposed for development (Louis Berger International 1999). The Department of Environment and Natural Resources (DENR) reported that in 1996 there were, in Region 10, six sawmills, five re-sawmills, three veneer and plywood plants and 135 mini-sawmills. Wood sources to these industries are TLAs 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 the year 2000, 17 farmers who harvested trees were interviewed and their plantations surveyed. From these, 14 are commercial tree farmers as they sold their trees to middleman or sawmills, whereas the other three used their timber for house construction. Only the data from commercial tree farmers was included in the calculations reported below. In addition, 16 owners of mini-sawmills and three managers of large-scale wood industries of Misamis Oriental were interviewed. The survey technique consisted of 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

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[4] Region X of northern and central Mindanao is composed of the provinces of Misamis Oriental, Misamis Occidental, Bukidnon and Camiguin.

and trends, and future expectations. 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 the municipality of 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 have been collected from published reports, secondary sources, the National Statistics Office and local agricultural statistics.

8.2.1 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, so common in the forestry sector, and the absence of proper market information systems, there are probably large discrepancies between the actual amount 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.

8.3 Results

8.3.1 Characterization of Commercial Tree Farms and Farmers

The average farm area managed[5] by the commercial tree farmers interviewed was 5.7 ha, with an average number of trees in their plantations of 995 (ranging from a minimum of 30 to a maximum of 4,000 trees) and an average number of trees harvested and sold of 232 (with a minimum of nine trees and a maximum of 2,000). Considering the number of trees harvested and the total number of board feet as

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[5] Farm area managed = farm area owned + farm area rented.

reported by the farmer, the average volume per tree is 46 bd.ft. (i.e., approximately 0.1 m^3 per tree). Although studies conducted in Claveria show that small farm size do not prevent timber tree planting (Bertomeu 2004), results of this survey indicate that smallholders with larger farms (i.e., above the average size in Claveria of 2.5 to 3.0 ha), are more likely to be market-oriented timber producers. The number of trees sold indicates that the size of viable, small-scale commercial plantations varies widely. Among the 14 commercial tree farmers, nine had sold less than 100 trees and five of them less than 30 trees. When asked about the minimum number of mature trees that a small-scale plantation should have to be commercial, sawmill managers indicated that a tree plantation is considered commercial as long as the truck used to transport the logs can be fully loaded with logs of the size required. Accordingly, to be commercially viable small-scale tree farms should have from 11 to 14 m^3 (for the smaller trucks) up to 18 to 20 m^3 of timber (for the larger trucks).

8.3.2 Supply, Demand and Uses of Farm-Grown Timber

From the late 1980s and throughout the 1990s an increasing number of SSS were established in Misamis Oriental for the processing and commercialisation of farm-grown timber stocks. According to the DENR, in 1996 there were 135 SSS in Region 10 of northern Mindanao (DENR 1996b). All the SSS are mainly supplied with logs of gmelina and falcata. Other species milled, though in much smaller volumes, include *Acacia mangium* (mangium), *Swietenia macrophylla* (mahogany), *Eucalyptus deglupta* (bagras), and *Spathodea campanulata* (african tulip). Wood processors indicated that trees are mostly grown by smallholder farmers, although sometimes falcata originates from the large-scale forest plantations of eastern Mindanao.

All farmers interviewed sold their trees on stumpage (i.e., standing "on the stump"). Fifty percent of the SSS owners interviewed look themselves for plantations, buy the trees standing "on the stump", and haul the logs to the sawmill. For the other 50 percent, 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 neighbouring provinces of Agusan and Surigao, as far as 200 km. This shows that at current timber prices farm forestry is profitable even in areas far away from the sawmills.

About 50 percent of the SSS owners reported slight fluctuations in the supply and demand of farm-grown timber throughout the year. There are more trees 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 accessible 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 trees 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. However, these slight fluctuations in log supply and timber demand do not lead to fluctuations in the price of timber.

Figure 8.1 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 (Photo 8.1). Low quality wood and small size pieces are used for pallets, crates and wooden boxes. Due to 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

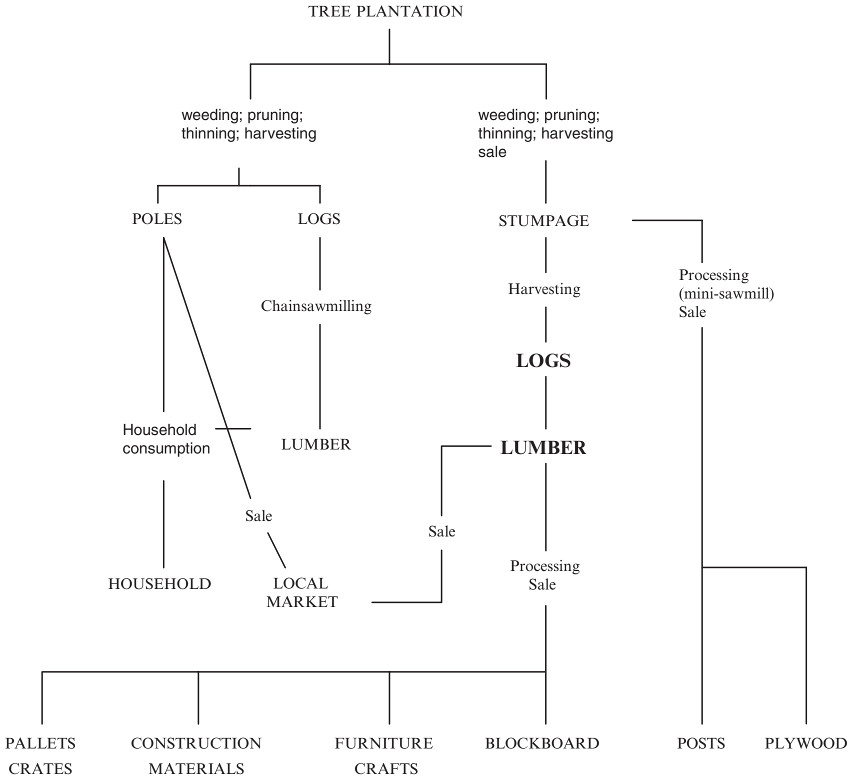

Fig. 8.1 Production and marketing system of farm-grown timber in Misamis Oriental, Philippines: producers' decisions, product transformation and end use

Photo 8.1 Gmelina arborea planks drying and finished product on a smallholder's compound in the Philippines (©DJ Snelder)

the premium commercial timbers (veneer and large size, quality wooden planks). This is already happening in central Philippines, where mahogany trees planted by small-scale farmers are sold to the wood industries of Cebu, the second largest city of the Philippines (Yao et al. 2005). Unfortunately, mahogany stocks growing on farms in northern Mindanao are not sufficiently large yet so as to supply the wood industries in this region with sufficient quantities of timber.

In the early 1990s, the stumpage price of farm-grown gmelina timber was high, varying between PhP 7.0 to 9.0 bd.ft.$^{-1}$. But since 1997, the average price is only PhP 4.0 bd.ft.$^{-1}$. Tree planters have a good understanding of the reasons for the current decline in the price of farm-grown timber. Farmers reported that the market is likely to be saturated as plantation stocks rapidly increased when prices were high. In addition, lower demand for low quality timber is also a contributing factor. Although some farmers indicated market control by exploitative middlemen as the reason for the current low timber price, there is no evidence of the presence of a timber cartel since good market access and the existence of many buyers make the trade of farm-grown timber fairly competitive. 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

4.0 ft (although 3.0 ft can be accepted but at an even lower price) and 12 cm small-end diameter. However, 37 percent of the respondents reported that they are willing to pay farmers a stumpage price PhP 1.0 to 2.0 bd.ft.$^{-1}$ higher for straight logs with 16 to 18 cm small-end diameter and 8.0 ft long. Timber planks of this size are used for furniture and house construction.

Other factors influencing the price of farm-grown timber are the size and quality of the log, which ultimately determine the end use. Sawn timber used for furniture and house construction is graded into three categories: A (planks 8.0 ft long without knots); B (6.0 ft long with some knots); and C (4.0 ft long, knotty). Prices vary accordingly: PhP 11.0 or 12.0 for category A; PhP 9.0 or 10.0 for category B; PhP 7.0 or 8.0 for category C. For veneer, timber price also depends on log size. In the year 2002, prices ranged from PhP 3.0 bd.ft.$^{-1}$ for logs 26 to 28 cm in diameter, to PhP 6.0 bd.ft.$^{-1}$ for logs with diameter 60 cm and larger. There is no price premium for quality timber that is bought by truckload. In the region, there is no active cooperative or local organization engaged in timber marketing. This is unfortunate as farmers and sawmill owners interviewed reported that the price of round timber at mill gate is around 50 percent higher than the current average stumpage price of PhP 4.0 bd.ft.$^{-1}$. As Anyonge and Roshetko (2003) indicated, tree growers would certainly benefit from the development of cooperatives and farmer groups that transfer economies of scale of timber production to smallholdings by facilitating the marketing of farm-grown timber. However, the 16 SSS surveyed had a total of 65 operational mini-sawmills[6] (56 percent of the SSS operates only one or two mini-sawmills and 32 percent have a capacity of three or four mini-sawmills). According to the survey respondents, in a regular eight hour working day and with an average recovery rate of 45 percent a mini-sawmill produces between 700 to 1,000 bd.ft. of sawn timber of gmelina or 1,000–1,600 bd.ft. of falcata. Considering that of the 16 SSS visited only 45 percent operate continuously and using an average production of 1,000 bd. ft. 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 10 since 1996. And with the reported average recovery rate of 45 percent, a conservative estimate of smallholder log production in Region 10 is that of 65,250 to 77,745 m^3 year^{-1}. Assuming a continuous operation of mini-sawmills, the potential annual log utilization would be 111,064 m^3 year^{-1}, and the potential sawn timber production 76,596 m^3 year^{-1}. If compared to the available statistics of the sawn wood exports from the Cagayan de Oro port (Table 8.1) 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 percent to 14 percent of the domestic consumption of tropical sawn wood timber in 1996 (539,000 m^3) reported by ITTO (1996).

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[6] 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 3.0 mm and width of not more than 27 mm, with or without a carriage, and a daily rated capacity of no more than 18 m^3 or 8,000 board feet of lumber per eight hour shift (DENR 1996a).

Table 8.1 Exports of falcata sawnwood from Cagayan de Oro Port, The Philippines (Regional Statistical Year Book 2000, Neda Region X and 1995–96 Misamis Oriental Provincial Socio-economic Profile)

Year	Volume[a] (m^3)	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

[a]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 five 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 10 in 1996. Even if this estimate does not consider the many people involved in associated activities such as transporting and further processing and marketing, it represents six percent of the work force of all processing mills (i.e., sawmills, veneer and plywood mills) in the country as 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 percent of the log production of $712{,}000\,m^3$” (i.e., $500{,}000\,m^3$ of the total log production comes from planted trees). In 2000, log production registered an increment of 9.6 percent over the previous year primarily due to harvest of planted trees within private land (Dy 2002). And in 2002, log production was $398{,}196\,m^3$, of which 46 percent was falcata, 13 percent gmelina and 4 percent mangium (ITTO 2003). 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 percent to 45 percent of the total sawn wood exports would have come from planted falcata trees (Table 8.2). This figure is probably higher considering that eight owners of SSS and medium size wood industries interviewed reported exporting sawn timber of gmelina to other Southeast Asian countries. Although timber trade statistics do not specify whether logs originate from industrial forest plantations or from smallholder farms, responses and data reported in this study support the hypothesis that a large percentage of the logs traded are produced on small farms.

The Philippines, like other former timber exporters in Asia such as Thailand and Vietnam, is now a major importer of timber. In the year 2000, imports accounted for 40 percent of the total supply of logs, 70 percent in lumber and 20 percent in plywood and veneer (Dy 2002). Until recently, growing domestic demand of timber has

Table 8.2 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 1000 m^3)		
	Total[a]	Falcata[a]	%
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	97	2	2
2002	91	10	11

[a] Source: ITTO Annual review and assessment of the world tropical timber situation

been met, to a large extent, by imposing low tariffs on imported logs (three percent) and protecting wood processors from international competition by high tariffs on sawnwood (30 percent) and veneer and plywood (50 percent). 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[7] 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, five native pioneers, *Endospermum peltatum* (gubas), *Artocarpus blancoi* (antipolo), *Octomeles sumatrana* (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 satisfactorily 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 seeds and seedlings of a wider range of tree species could prove to be a simpler and more successful reforestation strategy that would satisfy the needs of farmers, the industry and the society.

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[7] Signatories of the agreement are required to reduce tariffs to 20 percent within five to eight years from 1993 and to zero to five percent thereafter within a seven year period (Shimamoto 1998). Current tariffs are seven percent for sawn wood and veneer and 15 percent for plywood (ITTO 2003).

Domestic demand for sawn wood in the Philippines for the year 2010 has been estimated at 1.646 million cubic metres, with a log requirement to meet this demand of 3.418 million cubic metres (Sanvictores 1994). If fast growing trees were planted on small farms yielding just $6.0\,m^3\ ha^{-1}\ year^{-1}$ on rotation periods of 10 years, the log requirement to meet domestic demand for sawn wood in 2010 could be produced if 569,667 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 a lot of confusion exists on whether certain fees have to be paid or not. 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 village 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 giving large industrial plantations such incentives, they 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 (Van Noordwijk et al. 2003).

8.4 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 are 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 and marketing. The Philippine government and the wood industry sector must recognize the role of smallholder farmers as land managers and efficient producers of many important agricultural commodities, including timber.

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Chapter 9
The Reforestation Value Chain for the Philippines

R.D. Lasco

Abstract The Philippines has almost 100 years of reforestation experience. In spite of this long history, reforestation efforts in the country have not reaped much success. In this paper, we propose that a more holistic and sustainable strategy be adopted for reforestation in the Philippines. We propose that a chain of key activities that add value to the whole reforestation be identified right at the start. This "reforestation value chain" (ReV Chain) can then be used as a guide for reforestation projects, from design to implementation to evaluation. Our main thesis is that the success of a reforestation project should take into account each of the components of the value chain right from the very beginning.

The ReV Chain has several implications. First, reforestation efforts that address only part of the chain are likely to be unsustainable. In other words, each component of the value chain should be well thought of from the outset of a reforestation project. Second, policy makers and stakeholders will be better informed on where in the chain they can contribute best.

Keywords Tree plantation, forest products, production chain, value-adding activities

9.1 Introduction

The Philippines has almost 100 years of reforestation experience. In spite of this long history, reforestation efforts in the country have not reaped much success (Pasicolan et al. 1997; Carandang et al. 2006). Glowing statistics on paper of vast areas supposedly reforested hardly matches what is on the ground. It is therefore timely to ask, how can we reverse this track record?

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The main objective of this paper is to propose a more holistic approach to reforestation and tree planting in the Philippines by adopting the "value chain" approach, first developed for business enterprises by Porter in 1985 and subsequently applied from the firm level all the way to global industry level (Sturgeon 2001; Kaplinksy et al. 2003; Elloumi 2004; Kaplinsky and Morris 2005). For the first time, this paper explores the application of this approach to reforestation. Here I show how the use of value chain analysis could provide a more long term and holistic perspective to reforestation in the Philippines which will help address the often myopic efforts at present. The term "reforestation" is used generically to include all tree planting activities including agroforestry, whether for environmental protection and/or economic gain.

9.2 Deforestation and Reforestation in the Philippines

9.2.1 Deforestation Rate

When the Spanish colonizers first set foot in the Philippines in 1521, 90 percent of the country was covered with lush tropical rainforest (ca. 27 M ha out of 30 M total land area). By the year 1900, there were still 70 percent or 21 M ha of forest cover (Garrity et al. 1993; Liu et al. 1993). However, by 1996 there were only 6.1 M ha (20 percent) of forest remaining (Fig. 9.1). Thus, in last century alone, the Philippines lost 14.9 M ha of tropical forests.

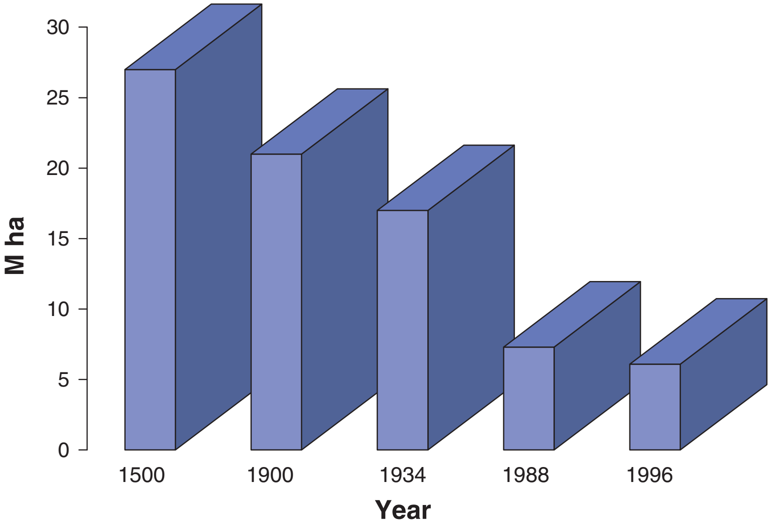

Fig. 9.1 Estimated area (in Million ha) of Philippine forests from the 1500s to the present (FMB 1998)

Historically, the most important driving forces in the conversion of primary forests to secondary forests were logging activities by big companies (Kummer 1992). The main tenure instrument for commercial logging was the Timber License Agreement (TLA). At the height of the logging activities in the 1970s, there were 471 TLA holders in the Philippines controlling an aggregated area of more than 10 M ha, a staggering one third of the total land area of the country. At that time, a few companies (and families) controlled much of the country's natural resources. Since the mid 1980s the number of TLAs has steadily declined and by 1997 there were only 26 TLAs covering an area of 1.31 M ha (FMB 1998).

While logging operations themselves were supposed to be sustainable through the application of the Philippine Selective Logging System, in many cases commercial logging sets into motion a process that eventually leads to deforestation and severe degradation of forest lands (Kummer 1992). That is, logging roads facilitate establishment of communities inside the forest area leading to other activities such as shifting cultivation and further cutting (often illegal). For example, Liu et al. (1993) have shown using GIS analysis the strong correlation between the development of road networks in the Philippines and the formation of highly degraded secondary forests and ultimately to the destruction of these forests resulting to denuded grassland areas. While the area of secondary forests remains more or less the same from 1971 to the present, the area of primary forests declined steeply from more then 4.5 M ha to less than 1 M ha (Fig. 9.2). The difference between the two is the area deforested during the same period or roughly 140,000 ha per year of deforestation.

The ultimate driving forces of secondary forest formation (from primary forests) and their eventual destruction (deforestation) are more complex than

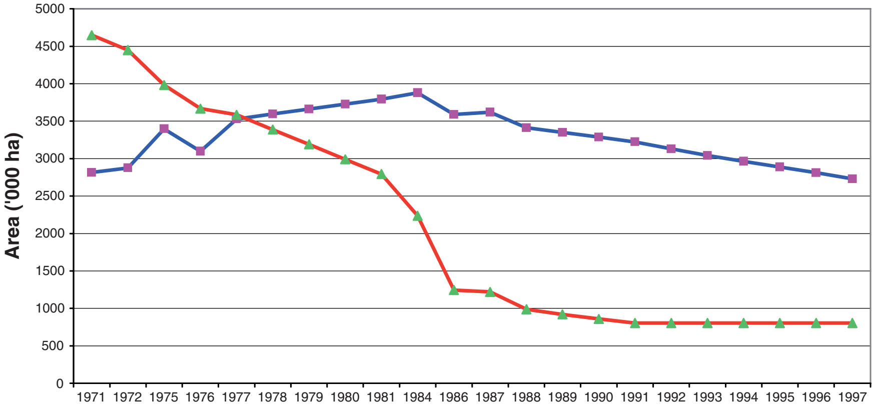

Fig. 9.2 Change in area of primary (triangle) and secondary (square) forests in the Philippines (Lasco et al. 2001)

simply blaming loggers and shifting cultivators. As Kummer (1992) and Van den Top (1998) have shown, deforestation in the Philippines is tied up to the larger issues of corruption, poverty, high population density, and migration to upland areas.

9.2.2 Reforestation Efforts

Reforestation work in the Philippine started during the first decade of the 20th century. A recent review of reforestation in the Philippines showed that reforestation rate significantly lagged behind deforestation rate (Carandang et al. 2004). From 1960 to 2002, the annual average area planted is about 41,000 ha per year (Fig. 9.3) which is less than 50 percent of the annual deforestation rate for the same period. More importantly, the actual success rate of the reforestation effort could be less than 30 percent in many cases. Official statistics report the area planted for the year but do not track what portion still exists. This is validated by the fact that available maps do not show where the reforested areas are.

The cost of reforestation is not cheap. Just between 1988 and 1992 the Asian Development Bank (ADB), the World Bank, and the Japanese government lent US$731 million for forestry projects in the Philippines (Korten 1995). With such a low rate of success, much of these funds have been wasted. In the future, reforestation of the country's 8.4 million hectares of denuded forests could cost the government some PHP 361 billion (US$6.6 billion).

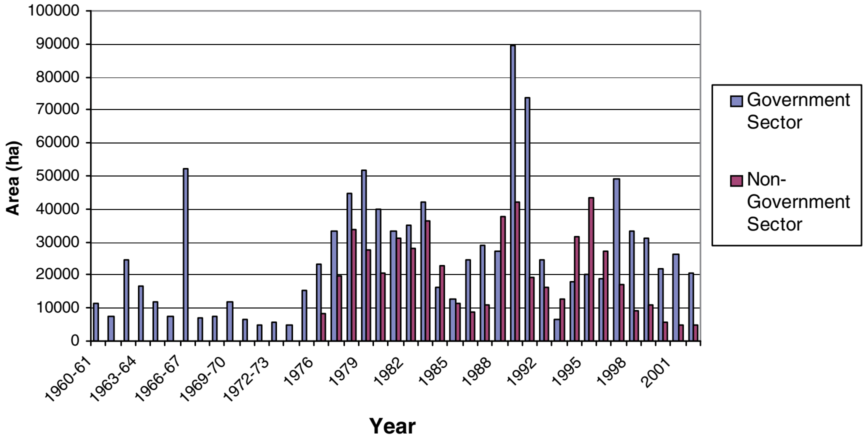

Fig. 9.3 Annual area planted by the government and non-government sectors in the Philippines from 1960 to 2002 (Carandang et al. 2004)

9.3 The Reforestation Value Chain (ReV Chain) Approach

One of the main reasons for the failure of reforestation projects in the Philippines is the short term planning and implementation of a great majority of projects. Tree planting projects typically last for three years from seedling propagation to planting and maintenance. After the three-year period, most of the trees planted eventually die or are cut. Thus, in the long term, areas "reforested" revert back to grasslands or brush lands. Many reasons can be cited why trees do no survive after the project is over. One common reason is that the reforested land is often claimed by farmers. After project staff leaves, the farmer cuts the trees and resumes farming activity. In other cases, the open access nature of reforested land coupled with the high demand for fuel wood results to cutting of trees. It is also not unknown for local people to intentionally burn reforested lands because of real or imagined injustices.

In all of the above, reforestation is viewed as a mere tree planting activity without regard to the other factors that are essential to the long term sustainability of tree planting. For example, many tree planting projects do not have a well-thought out plan for what to do after tree establishment (e.g. marketing).

In this paper, I propose that a more holistic and sustainable strategy be adopted for reforestation in the Philippines based on the "value chain" approach originally conceptualized by Porter (1985) to enhance the competitive advantage of business enterprises. A "*value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use*" (Kaplinsky and Morris 2005). While value chain analysis has been applied in different types of industries and at various scales from firm to nations (Sturgeon 2001; Kaplinksy et al. 2003; Elloumi 2004), it has not been applied to reforestation viewed as an enterprise.

Porter distinguished between two general types of activities, primary and secondary activities. Primary activities are directly concerned with the creation or delivery of a product or a service (Recklies 2001). On the other hand, support activities facilitate primary activities such as human resources management, infrastructure, and research.

The whole series of activities in a reforestation project can be viewed as a chain similar to any enterprise. The difference being that here the output is not a commercial product or service but environmental rehabilitation and socio-economic upliftment through tree planting. Thus, it is proposed that a chain of key activities that add value to the whole reforestation be identified right at the very beginning of the project. This "*reforestation value chain*" (or ReV Chain) can then be used as a guide for reforestation projects, from design to implementation to evaluation.

Figure 9.4 shows the generic reforestation value chain for Philippine reforestation projects. The middle boxes are the key activities that add value to the reforestation process. These correspond to the primary activities under Porter's value chain approach. The left boxes show the key stakeholders who should be involved in each of the value-adding activity (middle boxes). The right boxes show the outputs that

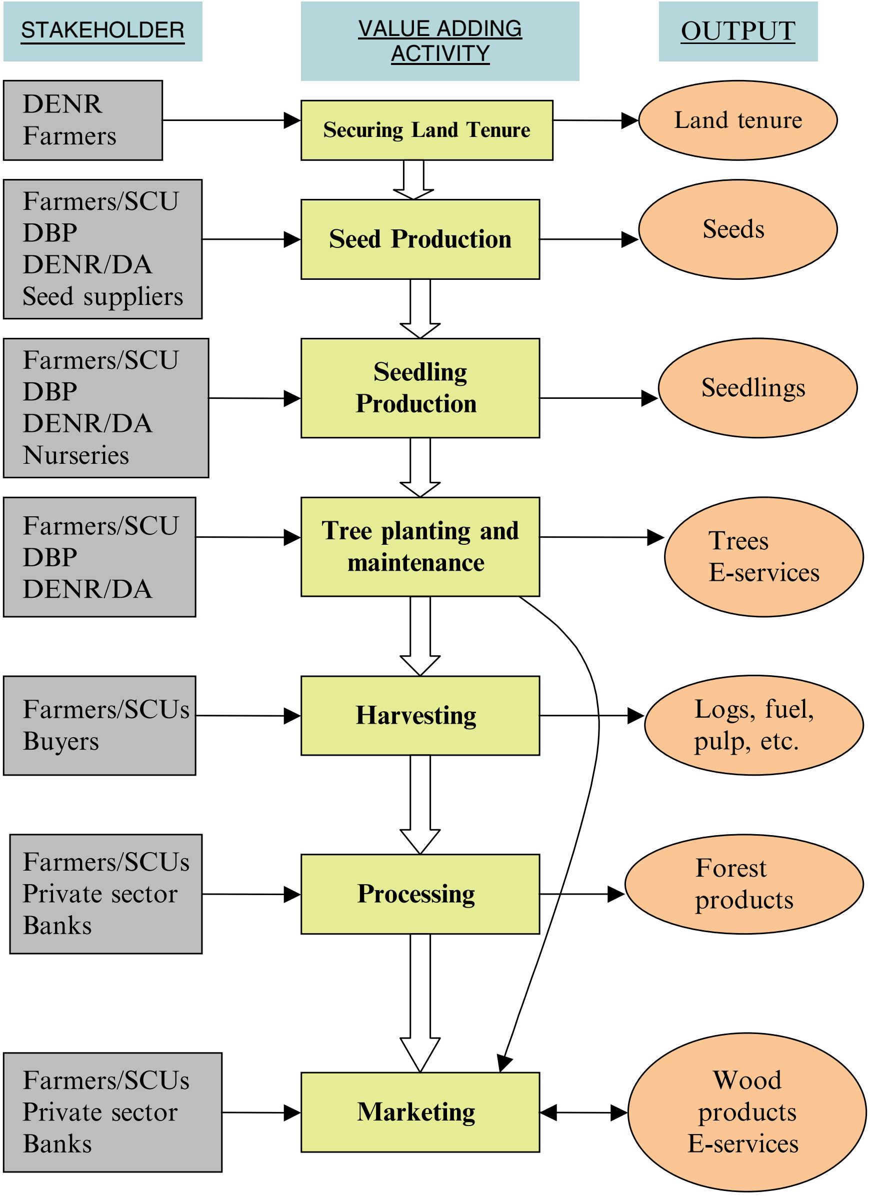

Fig. 9.4 Generic reforestation value chain (ReV Chain) for the Philippines. Legend: SCU – state colleges and universities; DENR – Department of Environment and Natural Resources; DA – Department of Agriculture; DBP – Development Bank of the Philippines

emanate from each value adding activity. The key inputs for each of the value-adding activity are shown in Table 9.1.

Table 9.1 Inputs for ReV Chain

Inputs	Value-adding activity
Mother trees	Seed production
Seed orchards	
Seed suppliers	
Quality seeds	Seedling production
Nurseries	
Quality seedlings	Tree planting and maintenance
Technology	Harvesting
Technology	Processing
Markets	Marketing
Marketing system	

9.3.1 Land Tenure

Legally, upland areas which are the target of reforestation projects are owned by the government. In reality, there are perhaps up to 20 million people in these areas (Cruz and Zosa-Feranil 1988). In 1995, community-based forest management (CBFM) was adopted as the national strategy for sustainable forestry and social equity. The different programs and projects that were implemented in the last two decades were "integrated and unified" into one umbrella program, known as the Community-Based Forest Management Program (CBFMP). A key component of this program was the granting of land tenure to farmers who participate in the government's tree planting program such as reforestation and agroforestry. The main premise of these programs is that a secure tenure is a prerequisite for meaningful participation of local farmers. To date, close to 6 million hectares of forest lands are under some form of community forest management. Of these, about 4.7 million hectares have been issued with various forms of land tenure instruments including around 1.57 million hectares issued with Community Based Forest Management Agreement or CBFMA (FMB 2004).

Thus as a first step, the ReV Chain recognizes the need to ensure that the land tenure arrangement is clear before the start of any reforestation activity. If there is any conflict over land, then chances of success of a reforestation activity are very low. This is borne out of experience (Pasicolan et al. 1997). For example, trees planted by government personnel or contractors on land claimed by farmers are eventually destroyed by the latter.

9.3.2 Seed Production

The aim of this activity is to produce quality seeds. There are a series of measures related to this activity, starting from mother tree selection to seed treatments to seed storage. A value chain can in fact be constructed for seed production. In the

Philippines, technology for seed production is more commonly available for exotic species than for indigenous species (Tolentino, Chapter 15, this volume). The establishment of seed production areas (SPAs) is still in its infancy in the Philippines. There is no nationwide system of seed certification. In many cases, the seeds are simply collected from any seed-bearing trees without regards to phenotypic or genotypic characteristics.

Globally, restricted availability of good quality tree germplasm at the farm, village and municipal level has been identified as a major constraint to the development and scaling-up of improved agroforestry systems in many tropical countries (Cooper and Denning 1999). This is especially true in the Philippines (Gunasena and Roshetko 2000). In view of this, seed production is one of the weak links in the ReV Chain that needs to be addressed to enhance the chances of success of reforestation in the country.

9.3.3 Seedling Production

With the rise of government reforestation projects in the Philippines, there is also a corresponding increase in small nursery operations throughout the country. There are no statistics available on the number and distribution of these nurseries. The government primarily the Department of Natural Resources (DENR) also maintains a network of forest nurseries. The quality of seedlings coming out of private and government nurseries is largely unknown, partly because the seed sources are also of uncertain quality. Low quality planting materials lead to poor survival in the field.

9.3.4 Tree Planting and Maintenance

Reforestation projects in the Philippines use more or less similar methods of site preparation, planting and maintenance. The site is typically prepared for planting by ring clearing or strip clearing which are standard procedures for grassland areas (Weidelt 1975). In the former, grasses are cut in about 0.5 m radius patch. Afterwards, patches are cultivated and all rhizomes removed. Seedlings are planted in the center of these patches. In strip clearing, 1–2 m wide strips are cleared. Patches where seedlings will be planted could be cultivated before planting.

9.3.5 Harvesting

For natural forests, the Philippine government prescribes the Philippine Selective Logging Method which includes very specific guidelines for each activity (Bureau of Forestry 1970 a and b; Weidelt and Banaag 1982). For community-based tree farms, there are no specific guidelines except that labor intensive methods are preferred. In reforestation projects designed mainly for watershed protection and rehabilitation no harvesting is allowed.

9.3.6 Processing

Processing of tree products is typically not included in the plans for reforestation projects. This is especially crucial in agroforestry farms where there could be a number of products from the farm, both wood and non-wood. Processing could really add value to farm outputs. However, in many cases farmers do not have access to even basic processing technology resulting to low prices for their outputs.

9.3.7 Marketing

Just like processing, marketing of forest products is typically not included in government reforestation programs. This may also include the building of roads. This is understandable considering the most reforestation projects last for only three years, much earlier than the time of harvesting which will take place ten or more years after planting. Aside from wood products, new markets have opened up for reforestation activities. For example, under the Clean Development Mechanism (CDM) of the Kyoto Protocol, reforestation projects in the Philippines may qualify (Lasco and Pulhin 2001). The absence of a market strategy in most reforestation projects in the Philippines denies farmers from capturing the true market value of the products and services they provide.

Using the aforementioned key components of the ReV Chain it becomes clear why many reforestation projects fail in the Philippines. In a great majority of cases, the emphasis is given only on seedling production (but still seedlings are of doubtful quality), on actual planting, and to a lesser degree on maintenance for a couple of years. The rest of the value chain is largely ignored. For example, more emphasis should be given on the long-term maintenance of reforested areas. Key questions include: Who will pay for the cost of maintenance? What are the incentives for local farmers to maintain the trees planted? In addition, marketing should also be given more emphasis. The value of tree products could be enhanced greatly if the farmers can take advantage of the market. In reality, it is not uncommon for farmers to get a low price for their products (from middlemen) when the price of the commodity in urban centers is much higher.

In addition to the primary value adding activities described above, secondary activities that will facilitate them are also important including human resource development (e.g. for DENR, LGUs), institution building (e.g. local community organizing), research and technology development, and infrastructure development. For example, an organization like the World Agroforestry Centre/ICRAF could assist in technology development as well as in local institution building. In the Philippines, the use of Natural Vegetative Strips (NVS) was developed by farmers and ICRAF scientists to help reduce soil erosion (Garrity 1995). In local institution building, ICRAF pioneered the use of the Landcare approach in community-based natural resources management (Mercado et al. 2000).

Of course, the ReV Chain approach does not mean that all the components should be present in ALL reforestation projects. For example, a carbon sequestration project may not have harvesting and processing components. Each specific project should prepare its own ReV Chain. In addition, the generic ReV Chain presented here could be modified in terms of its key components depending on the specific project situation.

9.4 Reforestation Value Chain Analysis: Examples

In this section a couple of hypothetical examples are presented to show how ReV Chain can be used in a reforestation project. A typical tree planting project may have the value chain analysis shown in Table 9.2 while a carbon sequestration project may have a value chain analysis shown in Table 9.3. The main difference between these two examples is that the former project allows for harvesting of trees while the former may not. These examples show how ReV Chain can be used to identify the essential stakeholders and their roles in the whole reforestation process from the very beginning rather than as afterthought. Absence of any key stakeholder will generally mean failure of the reforestation project. In addition, the ReV Chain analysis could show the key inputs required and their cost.

Through the ReV Chain, reforestation project managers are forced to plan ahead and anticipate the factors necessary for the success of the project. Moreover, the weaknesses of existing reforestation projects can also be identified. Remedial measures can then be developed to address these weaknesses. For example, if the first case above is already an existing reforestation project, it could be that ReV Chain analysis will reveal that the markets for products are still uncertain. In such a case, efforts will be made to find markets for the expected tree products.

9.5 Conclusions

With millions of hectares of degraded uplands, reforestation will continue to be a critical part in the Philippines environmental agenda. However, current efforts are beset by short-sighted planning and implementation. ReV Chain provides an analytical and planning tool that could help reforestation projects be more holistic and sustainable.

The use of ReV Chain has several practical implications. First, reforestation efforts that address only part of the chain are likely to be unsustainable. In other words, each relevant component of the value chain should be well thought of from the outset of a

Table 9.2 Example of ReV chain analysis for a hypothetical reforestation project in the Philippines where harvesting is allowed

Stakeholders	Inputs	Value-adding activity	Cost[a]	Output
Farmers DENR (issue to tenure instrument)		Land tenure		Tenure instrument
Farmers of Sitio Isidro CENRO-DENR (technical assistance) Green foundation (community organization) ADB (financing)	Seed orchards of narra	Seed production	0.22 per seed	High quality narra seeds
Farmers of Sitio Isidro CENRO-DENR (technical assistance) Green Foundation (community organization) ADB (financing)	Narra seeds (of superior germplasm)	Seedling production	1.42 per seedling	Hardened seedlings for field planting (at least 30 cm tall)
Farmers of Sitio Isidro CENRO-DENR (technical assistance) Green Foundation (community organization) ADB (financing) farmers of Sitio Isidro CENRO-DENR (technical assistance) Green Foundation (community organization) ADB (financing)	Narra seedlings hardened for planting	Tree planting and maintenance	5.47 per tree	
Farmers Cutting contractors DENR (permits)	DENR permits	Harvesting	tbd[b]	Forest products Income for farmers
ABC furniture company (processing) DBP (financing)	Harvested wood	Processing	tbd	Furniture
ABC furniture company (marketing) DBP (financing)	Furniture	Marketing	tbd	Income for furniture company

[a] in Philippine Peso (US$ 1 = about PhP 41)

[b] to be determined

Table 9.3 Example of ReV chain analysis for a hypothetical reforestation project in the Philippines where environmental services (carbon) is the main product (harvesting is not allowed)

Stakeholders	Inputs	Value-adding activity	Cost[b]	Output
Farmers DENR (issue to tenure instrument)		Land tenure		Tenure instrument
Farmers of Sitio Isidro CENRO-DENR (technical assistance) Green Foundation (community organization) WB (financing)	Seed orchards of indigenous species	Seed production	0.22 per seed	High quality seeds
Farmers of Sitio Isidro CENRO-DENR (technical assistance) Green foundation (community organization) WB (financing) farmers of Sitio Isidro CENRO-DENR (technical assistance) Green Foundation (community organization) WB (financing) farmers of Sitio Isidro CENRO-DENR (technical assistance) Green Foundation (community organization) ADB (financing)	Genetically superior seeds Hardened seedlings	Seedling production Tree planting and maintenance	1.42 per seedling 5.47 per tree	Hardened seedlings for field planting (at least 30cm tall)
Farmers ICRAF (carbon stocks measurement)	Carbon assessment methods	Carbon measurement and monitoring	tbd[b]	Amount of carbon sequestered
Farmers DBP (CDM financial intermediary) Japan Fund (carbon buyer)	ERPA (emissions reductions purchase agreement)	Marketing	tbd	Carbon credits Income for farmers

[a] in Philippine Peso (US$ 1 = about PhP 41)

[b] to be determined

reforestation project. Second, policy makers and stakeholders will be better informed on where in the chain they could contribute best. For example, external fund sources (e.g. ADB, WB, USAID) may be in a better position to assist in the early phases on the chain since they have more resources. While local financial institutions (e.g. DBP) may be more effective in assisting in the marketing and processing activities.

The ReV Chain must be tested in an actual reforestation project and the results documented. The specific components could be refined depending on the objectives and resources of a reforestation project.

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Chapter 10
The Potential of Sustainable Forestry Certification for Smallholder Tree Growing

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Abstract This chapter's aim is to investigate the potential of sustainable forestry certification for smallholder tree growing. Certification can be important for different stakeholders in the value chain of timber and timber products. By certification, consumers can choose on the basis of more sustainable behavior. For the manufacturing industry, certification can help to improve its image, and in the long run assure its resource input. For the producers of the timber resources, certification can help in achieving market access and can be the basis for long-term sales agreements. There are a number of certification systems for sustainable forestry, some of them operating on a global level, like particularly the Forest Stewardship Council (FSC) and the Programme for Endorsement of Forest Certification schemes (PEFC). However, certification in developing countries lags behind: in 2006 these countries only comprised two percent of the certified forests. A recent FSC program was aimed at timber production by Smallholders and Low Intensity Forests (FSC-SLIMF). This may alleviate the barriers faced by producers in developing countries, for both individual and community forestry. Before starting a process of certification, the costs and benefits along the chain need to be carefully examined, including market perspectives. In general, certification is only useful to an international market, which with others sets requirements on the choice of tree species and timber quality. As a case study, special attention is paid to the potentials of certification of forestry plantations in the Philippines.

Keywords Developing countries, environmental certification, SLIMF, sustainable forestry certification, tree plantation

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D.J. Snelder and R.D. Lasco (eds.), *Smallholder Tree Growing for Rural Development and Environmental Services.*

10.1 Introduction

The general question in this chapter is what role sustainable forestry certification can play in the conservation of forests by smallholders. Certification is typically a communication instrument, providing information between stakeholders in a given value chain.

Firstly, an overview will be given of the different types of certification, i.e., those related to environmental certification and to the broader sustainability certification. Section 10.3 will outline the potential benefits of certification for different stakeholders in the chain of custody and Section 10.4 will deal with the benefits for forest managers and workers, and a link will be made to the chapter from Lasco (Chapter 9), stressing the need to involve all relevant stakeholders in the value chain of reforestation. Section 10.5 is an overview of global developments in forestry certification, while Section 10.6 goes into the specific requirements set for certification under the authority of the Forest Stewardship Council (FSC), the oldest global initiative in this field. In Section 10.7, specific attention is paid to the development of the requirements set for forest plantations, with an example in an industrialized country (the Netherlands). Section 10.8 discusses the barriers to the certification of smallholders' forests, particularly in developing countries, followed in Section 10.9 by a description of a new FSC program that focuses on small and low-intensity forest management and addresses some of the existing barriers. This chapter concludes with a case study on the prospects for smallholder forestry certification in the Philippines.

10.2 Environmental and Sustainability Certification

Two main types of certification can be distinguished, environmental and sustainability certification. Environmental certification focuses on the environmental performance of production processes of the resources and the resulting products. According to the triple-bottom-line approach (Elkington 1997), sustainability certification has a broader scope, including requirements of social, environmental and economic dimensions.

The best-known environmental certificates are founded on the standards of the International Organization for Standardization (ISO). There is the 14000 series, with the 14001 standard underlying the certification of environmental management systems (EMS) of industrial companies (ISO 1996). The 14020 series deals with three types of product labelling: product labels with third party verification (Type I labels according to ISO 14024 [ISO 1999a]), product claims by the companies themselves (Type II labelling according to ISO 14021 [ISO 1999b]) and product declarations, which are information sheets, comprising the environmental specifications of the product and its upstream processes (Type III labelling according to ISO 14025 [ISO 2000]). There is also the 14040 series dealing with Life Cycle Assessment or LCA, which is required for the underpinning of Type III labelling and can also be used to support Type I labelling, like the Blue Angel in Germany, the Green Swan in the Nordic countries, and the EU eco-labelling scheme (cf. Mungkung et al. 2006).

Sustainability certification can also deal with products, as is the case with products from the Body Shop, but its focus is usually on natural resources. Thus, there are certificates for sustainable forestry (including the certificates under the authority of the FSC; www.fsc.org) and for sustainable fisheries (including certificates under the authority of the Marine Stewardship Council MSC; www.msc.org). There are ongoing activities to bring the mining and metals industries under the framework of sustainable development, initiated by the International Council for Mining and Metals (ICMM) (see the Minerals, Mining and Sustainable Development (MMSD) project (www.icmm.com)). To enhance sustainable agriculture, the best-known certification scheme is organic farming but there are also initiatives within the framework of conventional farming, for example from retailers, such as the EUREP-GAP certification (www.eurep.org) (see also De Snoo and Van de Ven 1999; Manhoudt et al. 2002). Sustainable forestry certification, like that under the FSC, and fisheries certification under the MSC, involves verification by a third party, and can therefore also be regarded as a form of Type I labeling.

These different types of certificates need not be exclusive. There are sound reasons for the larger forestry companies to aim at an FSC certificate combined with an EMS certificate according to ISO 14001 (Hortensius 1999). The focus of the rest of this chapter will be on the sustainability certification of forestry.

Sustainability certification has two principal components: legality verification, that is the assurance that the forestry activities are legal, and sustainable forestry management. Thus, certification of sustainable forestry management, together with the certification of the management of the chain of custody, presupposes legality verification. Sometimes a plea is made for a step-by-step approach: first, realization of legal forestry and the protection of high conservation value forests (HCFVs) and then sustainability certification (cf. Jurgens 2006).

10.3 Benefits of Forestry Certification – The Chain of Custody

The most direct benefits of forest certification concern the forests themselves. This relates to sustainable harvesting of forest products, and the enhancement of biodiversity. Here we will focus on the potential benefits for the different stakeholders in the value chain. These are mainly producers of the timber resource, product manufacturers, retailers and consumers. In fact a major distinction can be made between the forest managers and forest workers who deal with the sustainable forestry management itself and the other stakeholders in the value chain, who deal with the so-called “Chain of Custody” certification, ensuring that certified timber will not become unduly mixed up with non-certified timber. In this section we will discuss the benefits for the main stakeholders of the chain of custody. As Lasco (Chapter 9, this volume), when focusing on reforestation, points out, reforestation can only become a success if all activities in the chain are functioning well, each of them adding value, with each of the stakeholders having his own benefits. We start with the chain-of-custody stakeholders and in the next section will discuss the benefits for the forest managers and workers.

At the end of the chain are the consumers and the general public, who are the real drivers for certification. It is their choice of sustainable production and consumption, which ultimately matters, and the certification of timber products is instrumental in this. In Europe, in countries such as Finland and Austria, they are close to reaching 100 percent certification of their forests but there is often still a lack of demand by consumers (UNECE/FAO 2006). This explains why the potential supply of certified products still exceeds the actual demand in many markets (ibid). In South-East Asian countries, both demand and supply are currently low. The influence of the consumer may be direct or indirect. A direct influence means, it is consumers who choose a sustainable product, whereas an indirect influence is where they choose to go to a retailer who sells sustainable materials and products (Udo de Haes and De Snoo 1996, 1997).

Retailers are the stakeholders who are upstream of the consumer, and product certification is often primarily aimed at them rather than at the ultimate consumers. It then becomes an instrument for business-to-business communication. The benefits to the retailers are mainly related to the improvement of their image, thus supporting their “license to operate”. They are often the prime movers in the value chain (Klooster 2005). Examples of retailers involved in the selling of certified timber include Ikea, Brico, Gamma, B&Q and The Home Depot, the world-largest do-it-yourself (DIY) market.

On the next level are the manufacturers. Societal image is also an important driver for them but these companies can also have a more specific aim, namely the long-term assurance of their resources. This holds true for other natural resources like fish. Thus Unilever contributed greatly to the establishment of the MSC, in part to ensure the long-term availability of their fish resources.

10.4 Benefits of Forestry Certification – The Forest Managers and Forest Workers

We can distinguish between three types of potential benefits of forest certification for forest managers and forest workers, who form the main target group of this chapter. Firstly, there are the direct economic benefits of potentially higher profits for the forest managers. Secondly, there are indirect economic benefits, like market access and sales agreements and thirdly, there are non-economic benefits.

The direct economic effects of certification are a rather ambiguous issue. The main question is whether the public is willing to pay a higher price for certified timber products. Such price premiums are logical and necessary to cover the costs related to certification but they appear to be rather varied in practice. There are the so-called willingness-to-pay studies, in which customers are asked what additional price they are prepared to pay for certified products. These studies give rather variable results but quite a number claim to have identified a positive attitude of customers. For instance, a recent study by Aguilar and Vlosky (2007) on a number of consumer products found a willingness-to-pay, which varied between 10 percent and 25 percent, this mainly depending on the income of the consumers. But similar research indicates that the market for certified products is rather limited; see Kollert and Lagan (2007) for an overview.

Willingness-to-pay studies do not necessarily reflect what consumers will do in reality. Empirical studies must be done to clarify this issue but they are rare. A Finnish study that compared timber certified under PEFC (the Programme for Endorsement of Forest Certification schemes, see Section 10.5) with non-certified timber exported to the UK and Germany, showed that certification leads to better customer satisfaction and a more positive public reputation, but not to improved financial performance (Owari et al. 2006). For most producers, charging a price premium proved impossible. This may well be due to the fact, that the certification market is dominated by a small number of large scale suppliers and buyers, who are not willing to pay such a premium (Taylor 2005).

But there are empirical studies with more positive results. Kollert and Lagan, in a study conducted in Sabah, Malaysia, compared a forest unit certified by FSC (see Section 10.5) with two units without certification. They found a 40 to 56 percent higher price for certified heavy hardwood, a 17 to 30 percent higher price for medium hardwood, a two to eight percent higher price for light hardwood and no premium for mixed types of timber. But the forest units were not strictly comparable: the FSC plantation was the only state owned unit, causing a potentially better market entry. In a study near to Sao Paolo, Humphries and Kainer (2006) found that FSC certified timber obtained the formal market price, instead of the usual local price, which is four times lower. The authors argued that this was caused by better market access due to the certification. Nebel et al. (2005) also found a market price for FSC certified timber in a large-scale project in Bolivia, which was five to 51 percent higher than for non-certified wood. As the certified forests there are managed by only five companies, the authors argued that the effects could not be separated from marketing strategies. Thus, the overall picture in the empirical studies seems to be that price premiums are available to most producers in Asia-Pacific (Cashore et al. 2006), but are obtained only in special situations, particularly linked to a better market access.

Another potentially very important economic factor is donor support. In many case sudies, the transition process was supported by international donor organizations, an example being Nebel et al.'s (2005) case study in Bolivia, dealing with five large forestry companies. A study on certified community forestry conducted by Markopoulos (1998) in the same country even came to the conclusion that the positive economic result was largely due to donor support. In this context, it should be borne in mind that donors will in general support a transition period. They can greatly help a project get off the ground, but they will not guarantee economic sustainability.

Other benefits for forestry managers are the indirect economical ones of better access to markets and long-term sales agreements. The European and, to a lesser degree the North American, markets increasingly demand certification of their imported timber products. The importance of this has already been seen in the discussion of examples of price premiums. The dominance of a small group of large retailers (see Section 10.3) renders long-term sales agreements very important for the economic viability of a forestry company.

There can also be a number of benefits of an even broader nature. These include an improved business culture leading to higher self esteem in the forestry company, the option to become a serious player in forest policies and debate, the improvement of forest management by technical or commercial support, improved labour conditions leading to more safety and better tenure rights for the forest workers, and the benefit from increased employment (see for instance FSC 2003). And there can be benefits facilitated by certification for the local infrastructure, like roads, schools and health centres (Cashore et al. 2006). Interestingly, these additional benefits are often facilitated by international donor organizations supporting the certification process. But care is needed not to generalize, because these benefits will not always be present. For instance, Ahas et al. (2006) found that in Estonia, a consequence of certification was a decline in hectares available for timber production and a lower production pro hectare, resulting in fewer jobs.

Finally, new benefits may arise in connection with the biomass-for-energy and climate policies. Both the US and the EU give much support to the production of ethanol and biodiesel from biomass, although these programs are increasingly challenged because of their rather low effectiveness in CO_2 reduction (Farrell et al. 2006; Johnson and Heinen 2007) and because of their competition with food production and natural forests. Indeed, it can be observed that palm oil plantations are replacing old growth forests in Kalimantan on a large scale (http://www.foe.co.uk/resource/reports/oil_for_ape_summary.pdf). A requirement for biofuels to come from certified plantations may help to militate against this increasing threat to biodiversity and indigenous peoples. In the current first commitment period of the Kyoto Protocol (2008–2012) in the framework of the Clean Development Mechanism, only timber from afforestation and reforestation is eligible for carbon emission rights (Manguiat et al. 2005). It must be ensured that this will only pertain to certified plantations, under the requirement that reforestation does not replace recently converted natural forest.

We conclude that at the level of forest management, the main effects of certification relate to improved market access and sales agreements. Benefits due to price premiums cannot be generally expected, but this may change with the development of well-organized niche markets. International donors can help to facilitate the transition process; they do not provide economic sustainability, but they can provide a number of indirect benefits. Potentials in the framework of sustainable energy and climate policy have to be explored.

10.5 Development of Sustainable Forestry Certification

Forestry certification is a process that developed because it was broadly supported by a number of parties. Although it is first of all a private scheme supported by stakeholders in the value chain, national governments also provide substantial support. Governments can require certification of state owned forests, or can choose certified timber products in their national procurement policies. Major support has also come from NGOs, most strongly from the WWF, which has played a pivotal role in the development of the FSC worldwide.

Globally, there are six important forestry certification initiatives, which work on the basis of independent ("third party") verification. These are the Forest Stewardship Council, the Program for Endorsement of Forest Certification schemes, the Sustainable Forestry Initiative, the Canadian Standard Association, the American Tree Farm System and the Malaysian Timber Certification Council. A short description of these programs and organizations is given below.

The Forest Stewardship Council (FSC) is housed in Bonn and is an international, non-profit, non- governmental organization founded in 1993. It is an association of representatives from environmental and social groups, the timber trade and forestry profession, indigenous peoples' organizations, community forestry groups and forest product certification organizations. It is the only system with global principles and criteria (FSC 2004a). Based on these principles and criteria are 62 national standards, each with their own adapted criteria and indicators (www.fsc.org).

The Program for Endorsement of Forest Certification schemes (PEFC) is also an independent, non-profit non-governmental organization, founded in 1999. It started as a European forest certification program, with the aim of creating a simpler alternative to the FSC but it now has a global reach and has consequently changed its name. It is an umbrella organization that accredits national schemes all over the world and is currently spread over 18 countries. In contrast to the FSC, this program explicitly advocates national sovereignty (www.pefc.org). Another difference concerns its main focus on ecological and market aspects.

The Sustainable Forestry Initiative (SFI) is a program of the American Forest & Paper Association. Adherence to the principles of this program is conditional for the members of this association. It was founded in 1994 and is now endorsed by PEFC (www.sfiprogram.info).

The American Tree Farm System (ATFS) is a program of the American Forest Foundation, a national non-profit organization. The ATFS was founded in 1941, and is the oldest third party forest certification system. It focuses on family forest owners, of whom 51,000 do participate (www.treefarmsystem.org).

The Canadian Standard Association (CSA) is an independent non-profit organization for the development of standards. The CSA Sustainable Forest Management (SFM) Project is part of it and was initiated in 1994, supported by the Canadian forest industry. Its certification scheme is modeled on the ISO 14000 series and is endorsed by PEFC (www.csa.ca). Many of the performance criteria are created at a regional, provincial level, in an interactive process with the stakeholders.

The Malaysian Timber Certification Council (MTCC) is an independent Malaysian non-profit organization for forestry certification. Like the FSC it also has a chain-of-custody certification. The criteria are set up in line with the FSC criteria and were adopted in 2002, but it is not endorsed by FSC. Its board includes representatives from academic and research and development institutions, the timber industry, non-governmental organizations and government agencies (www.mtcc.com.my).

In addition to these certification systems are a number of national certification schemes, which are not independently verified. In South-East Asia, examples include the Indonesian LEI system and Ecoforestry certification in Papua New Guinea. Like MTCC, these national systems are becoming more in line with the requirements of the FSC, with the aim of improving their reputations (Cashore et al. 2006).

Figure 10.1 presents the increase of forests, certified under the six forest certification initiatives mentioned above, for the period 1998–2006. In 2006 about 275 million hectares were certified by one of these six organizations (UNECE/FAO) 2006. This should be compared to the global total natural forest area for the year 2000 estimated at 3,682 million hectares, excluding plantations (FAO 2001). This means that in 2006, 7.5 percent of the natural forest areas were certified by one of the above schemes. But globally, certified timber products represent less than one percent of forest product sales (UNECE 2001). This seems to imply that on the average certification is applied to less productive forests.

The certified areas are not equally distributed throughout the world. At the end of 2000, about 92 percent of all certified forests were located in the United States, Canada, Finland, Sweden, Norway, Germany and Poland. At the same time, only four countries with tropical moist forests (Bolivia, Brazil, Guatemala and Mexico) were listed as having more than 100,000 ha of certified forests. According to FAO (2001) these forests amounted to a combined total area of 1.8 million hectares, which is about one percent of the total certified forest area. Kollert and Lagan (2007) presented a more recent figure of 3.6 million hectares, that amounts to nearly two percent (see Table 10.1). Despite the fact that forest certification started in the South, with the Smartwood Program of the Rainforest Alliance in 1990 in Indonesia, and despite the present increase in developing countries, we

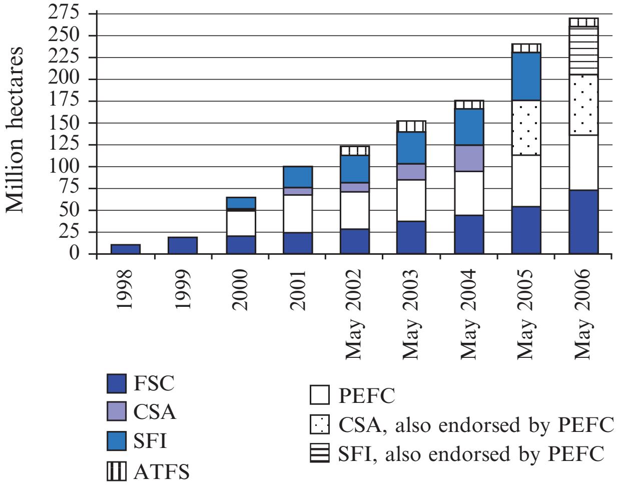

Fig. 10.1 The development of the certified forestry area worldwide for the period 1998–2006 under five different schemes (UNECE/FAO 2006)

must conclude that the main aim of sustainability certification, saving tropical forests, is still in its infancy. The reasons for this will be discussed in Section 10.8. As yet, forestry certification has lead mainly to qualitative improvements of forestry management in the North.

In what follows, we will focus further on certification under the authority of the FSC, because it is the best-known scheme in the developing world, and has recently established a program specifically aimed at smallholders in developing countries (see Section 10.9).

10.6 General FSC Requirements

To certify a forest area under the FSC certification scheme, a number of requirements must be met. In principle these relate to the three dimensions of sustainability, people, planet and profit, but in practice they focus on environmental and social conditions. The requirements are laid down in four different levels: principles, criteria, indicators and verifiers.

Principles are qualitative requirements at a policy level. This means that principles are issues that can be debated in a policy discourse. The international FSC principles apply to the following issues (in part as principles, in part just as issues) (www.fsc.org):

1. Compliance with laws (certification must not be illegal according to the national laws in question)
2. Tenure and usage rights
3. Indigenous peoples' rights
4. Community regulations and workers' rights
5. Benefits from the forest
6. Environmental impact
7. Management plan
8. Monitoring and assessment
9. Maintenance of high conservation value forests
10. Plantations

These principles are specified in the criteria, which all have to be met for certification. The FSC has 44 criteria in total for sustainable forestry management, with eight additional criteria for plantations.

Table 10.1 Total forest area, certified forest area, and forest area in developing countries (in million hectares) (Data from 2000: FAO 2001; data from 2006: Kollert and Lagan 2007)

Total forest area in 2000 (including plantations)	3,869	Plantations in 2000	187
Certified total forest area in 2000	210	Certified plantations in 2000	23
– of which in developing countries	1.8		
– idem, in 2006	3.6		

An example may clarify how the four levels relate to each other. Under the sixth principle, “environmental impact”, the second criterion requires safeguards to protect rare, threatened and endangered species and their habitats, and to that end, conservation zones and protection areas shall be established. Indicators are defined at a national level. For instance, for FSC in the Brazilian Amazon, indicators relate to a 100 percent invetory of all threatened and endangered species, the steps taken for protection, the conservation of dead trees, the avoidance of fragmentation of habitats, agreements about scientific studies and the knowledge of the workers about species and habitats. At the lowest level, verifiers relate for instance, to areas demarcated on maps, management prescriptions and management records.

10.7 Requirements Associated with FSC for Plantations

In this section we will discuss the requirements specified for plantations, i.e., a core topic of this chapter. In 2000 there was a total of 187 million hectares of plantations worldwide, which is five percent of the total forest area of 3,869 million hectares (FAO 2001). Of this area a total 23 million has been certified under the FSC (see Table 10.1). As an example, in South Africa, 80 percent of the plantation sector supports FSC (Cashore et al. 2006). Certification of plantations is a contentious issue. On the one hand they are a large source of timber; with five percent of forest area they produce about 35 percent (expected to rise to 44 percent by 2020 [FSC 2005]) of all timber harvested. According to the FSC, this intensive form of forestry can alleviate the pressure on natural forests. Plantations also contribute significantly to carbon sequestration and can replace fossil fuels and increase biodiversity when established on degraded land (e.g., Lamb 1998; Montagnini and Porras 1998; Roshetko et al. 2002; Lal and Singh 2003; Redondo-Brenes 2007). The local employment they create is important socially (FSC 2005). The FSC’s mission to certify forest plantations is based on positive assumptions regarding its effects, and is well expressed in the following adage: “While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world’s needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests” (FSC 2005). This role of supporting the conservation of natural forests is clearly expressed in the FSC criteria and was finalized two years after completion of the criteria for the first nine principles set out in Section 10.6. They must be seen as additional and plantations must therefore meet the criteria for all ten principles.

However, compared to natural forests, these positives are counterbalanced by a number of negatives. Plantations often are the result of intensive exploitation of natural forests and are allied to biodiversity loss and disruption of soil hydrology and nutrient regimes (e.g., Schroth et al. 2002; Díaz et al. 2007; Pandey et al. 2007).

Much controversy also stems from conflicts over land use (e.g., Van den Top 2003), particularly between the owners of a plantation and the traditional use of the land by local people. In absence of land tenure, local people may be displaced, leading to increased deforestation elsewhere (Barney 2004; Nasreen 2007). Because of the differences in character between natural forests and plantations and the rather specific requirements for plantations, FSC in Brazil has developed an independent standard for plantations.

The criteria set out in principle 10 of the international FSC Principles and Criteria, can be summarized as follows:

1. The objectives of the plantation should be laid down in a management plan.
2. The plantation should help to conserve or restore the natural forest.
3. The plantation should be diverse regarding tree species, and the age and size of the trees.
4. There should be a preference for native species; monitoring of exotic species and their impacts.
5. Part of the plantation should be managed to restore the natural forest.
6. The management of the plantation should aim for soil conservation and good water quality.
7. The management should aim for integrated pest management.
8. The ecological and social impacts of the plantations should be monitored.
9. The plantation should not have been established in areas converted from natural forests after November 1994.

Criterion 9 may need some explanation. The date refers to the establishment of the standard and was included to discourage conversion of natural forests into plantations: such plantations cannot be readily certified.

Next, these criteria are expressed in a number of more specific indicators, which translate into requirements for practical management. These have not yet been developed for all regions. For instance, the Malaysian Timber Certification Council (MTCC) has not included criteria for plantations in its standard, and is now developing a special standard to this end. In Table 10.2, for each criterion for plantations of the international FSC Principles and Criteria, the indicators are presented with the Dutch national FSC standard as example (FSC/NL 2004).

In 2005, the total certified forest area increased to about 200 million hectares, worldwide. Of this total about 6 million hectares pertains to plantations, and a further 17 million hectares to mixed plantation-and-natural-forest, certified under FSC (FSC 2005). Of the plantations, on average 12 percent is covered by natural forest, clearly scoring beyond compliance with regard to indicator number five. However, due to the contentious nature of the plantations under FSC, and the need for further research in this area, a global process has recently been started under the authority of FSC-International, aiming at a review of the implementation of the environmental, social and economic criteria for plantations. The final technical phase of this review is about to begin (cf. www.fsc.org/plantations).

Table 10.2 Indicators for plantations for each of the criteria of the International FSC Standard, according to the National Dutch FSC Standard (FSC/NL 2004; see also www.fscnl.org)

International criterion	Dutch indicators (summarized)
1	The objectives of the plantation shall be explicitly stated in the management plan and demonstrated in its implementation
2	Plantations not established on land with high natural values
	No negative effect on adjacent forests
	Areas with high natural values are identified and recorded on maps
	Mosaics of stands must be identified in the management plan
3	Plantations smaller than 25 hectares consist at least of two tree species; larger plantations are drivers in species composition and age
	Individual forest stands should not exceed two hectares
4	No species planted on a large scale, unless proven well-adapted, non-invasive and without negative ecological impacts
	For exotic species proof of monitoring must be available
5	At least 10 percent of plantation is planted with native species
	At least five percent of the plantation will not be harvested
6	Management plan shall describe measures taken for soil and water conservation
7	Proof of monitoring available of pests, diseases, fire and invasive plants; evidence of measures taken against these
	Aim to control pests without chemical pesticides and fertilizers
	Chemical pesticides and fertilizers only permitted if no biological alternatives available or effective; manager must prove the need
8	Monitoring of negative effects on plantation and its surroundings
	Management plan shall include impacts of plantation on local welfare and social wellbeing
9	Only recent forests (planted after 1975) can qualify as plantation, older plantations are regarded as multifunctional forests
	Note: This does not replace the requirement that plantations should not be converted from natural forest after 1994

10.8 Barriers Towards Forestry Certification in Developing Countries

As already indicated in Section 10.5, the development of forest certification in developing countries lags behind the industrialized countries. The FSC systems and the connected MTCC system are the only ones to have third party verification to deal with certification in developing countries.

In developing countries barriers do exist for forestry certification and a lack of demand for certified timber products is a major constraint. An overview, based mainly on Molnar (2003) is given below of the main barriers, focusing on the role of smallholder tree growers in particular. First, there are policy and regulatory barriers to the extraction and processing of forest products. In this context it is important to point to the first principle of FSC, which requires compliance with existing laws. In particular, problems can lie in the prohibition of all logging in protected areas. Of course, a well functioning prohibition of these areas should be the ultimate aim, but many protected forests suffer from serious problems with illegal logging. In such circumstances, sustainable forestry may create an effective counter force. An example is the Sierra Madre Natural Park on Luzon, the northern island of the Philippines. This park, a former site of the Conservation of Priority Protected Areas Project (CPPAP), is presently protected throughout by the National Integrated Protected Areas System (NIPAS) Law passed in June 1992. It has nevertheless been logged all over its western areas. In that section of the park sustainable forestry management may well be a real improvement on the present illegal situation. Yet, such a development is hampered by the existence of a law that is not adhered to (Snelder et al. 2005).

Secondly, there are a number of economic barriers, including the high costs associated with the first evaluation for qualification of the forest unit, the required yearly assessment procedures and the implementation of recommended actions with the aim of repairing shortcomings in the management. Price premiums should compensate for this but as seen in Section 10.4, such premiums do not generally exist. Moreover, it can be difficult to meet the high quality and quantity requirements associated with the given price premiums. Higher market prices may also not be realized in practice because of the lack of markets dealing specifically with certified timber, or with products made from it. This may particularly hold true in remote areas. For the initial costs such economic difficulties can in principle be overcome by support from donor organizations, but it is not always easy to find such an organization in practice. This is a particular problem for producers in remote areas who do not have easy access to such bodies.

Thirdly, there can be cultural and organizational barriers. The world of certifiers, who in line with the criteria ask for explicit formal plans and strict yearly auditing measures, is a very different place to that of smallholders or communities managing a plantation in developing countries. There will often be internal constraints in these communities against making the necessary organizational changes towards a more profitable business model. Higman and Nussbaum (2002) argue that the length and complexity of the standard constitutes a barrier in itself and in their opinion at least 27 of the 52 FSC criteria are inappropriate for small private forestry enterprises.

It is also believed that the sustainable use of natural forests faces competition from the cheaper plantations. Although this may be positive for the plantations, they themselves face competition from the even cheaper, unsustainable logging in natural forests. In addition, Cashore et al. (2006) have also stressed that a significant part of the forestry is managed by communities in developing countries. Community forestry is in general more complex than that conducted by individuals or companies. Although the FSC has special criteria for group certification, this creates another barrier to forestry certification in these countries.

10.9 The FSC SLIMFs Initiative

To address these barriers, the FSC has recently introduced the Small and Low Intensity Managed Forests (SLIMFs) Initiative (FSC 2003, 2004a, b, c) This program aims to allow certification bodies to use streamlined certification procedures for small forest management units, low intensity management units and groups of these units. Small units are all forest areas under 100 ha or, depending on regional conditions, up to 1,000 ha. These units will often be part of smallholder farms. Low intensity units refer to units with operations such as non-timber forest product harvesting. Groups of management units enable certification by communities, while each of the members has his own private unit.

The new program involves a streamlining of the certification process for the target groups. On the basis of field trials, the international list of criteria has been adapted for small and low intensity units. In addition, the program allows for the development of national or sub-national criteria, which is well under way, together with the development of national indicators and verifiers.

The changes involve a reduction of the field audits, a simplification of the methodology used and of the way of reporting. In the main FSC program, a yearly site audit is required. In SLIMF this annual surveillance can be based on documentation audits and a minimum of one site visit must take place during the period of the certificate. These site visits may be undertaken in only one day, which is possible because of a focus on high-risk areas instead of a percentage-based areas audit. The reporting of the surveillance is also simplified, as it can be written in any language in a short report. For small management units, no peer review of the report is required.

Further streamlining lies in cost reduction by group certification. This enables many of the costs and work to be borne by a group of private companies, thus spreading them throughout the community.

Finally, certification has become a step-by-step process. Thus, over a five year period, timber from forestry-in-transition will get preferential treatment on the market. In 2002, the SLIMF's Initiative came into force. An overview in December 2006 (www.fsc.org/slimf) revealed that 39 forest areas, with a total of 110,000 ha (half of which was group certification, distributed over 15 countries) had qualified according to this scheme. Half of this area involves plantations in developing countries, including Namibia and Papua New Guinea.

10.10 Prospects for Certification of Plantations in the Philippines

In a developing country like the Philippines, it is questionable whether certification of plantations should be the first priority for protection of the forests. Given the rampant illegal logging, protection measures may well be directed first to the banning of illegal logging in high conservation value forests (see also Jurgens 2006). In the shadow of illegal logging, certification will not easily get off the ground, given the competition with the very low prices of illegal timber. For the country's government, the first priority may therefore lie there. In Indonesia encouraging developments take place in this respect at present (G. Persoon, personal communication 2007). Conversely, a check into the legality of imported timber may also be priority for the industrialized countries. Once the government has set its priorities and been able to get grip on illegal logging, the scene is ripe for private initiatives for certification. In this section the viability of such a step for the Philippines is explored.

Plantations have had a varied history in the Philippines. In recent decades many policies have been launched to stimulate them, on the whole with a remarkably low rate of success. Between 1988 and 1992 alone, a total of $621 million was loaned to the Philippine government for the purpose of reforestation from, amongst others, the Asian Development Bank, who also lent another $200 million between 1993 and 1995. This huge budget was invested in various reforestation schemes, under full governmental authority and by stimulating private initiative, but results lagged severely behind expectations. A study conducted by Pasicolan (1996) revealed that only 10 to 15 percent of the planted trees survived and the reasons for these disappointing results were analyzed, by comparing successful and unsuccessful plantations run by communities. Important factors for achieving successful results included in particular, the need for intercropping so that the land continued to be productive for the community's direct needs, a direct interest by the community in the produce of the plantations, clearly established property rights over the plantations, a good organization of community co-operation, healthy finances of the project participants and the prospect of a good timber market.

In contrast to subsidized tree growing, spontaneous tree growing also appears to take place without any clear help from the government (Garrity and Mercado 1994), that is, the growth of small plantations for fuel wood and timber by individual smallholder farmers on their private farms. In general this relates to plantations of one to two hectares, as part of farms of about 10 hectares. The main drivers are an enterprising attitude of the farmers and good market conditions, including easy access to roads (Pasicolan 1996). Since the mid-nineties, this development has extended; at present this spontaneous development seems to offer the best prospects for increasing plantations, albeit with some governmental support, such as the provision of free seedlings.

The question is, as to what the prospects are for the application of sustainability certification for smallholders' plantations in the Philippines. This must clearly be a well-planned process as starting too quickly at farm level, without the involvement of the whole chain, could well result in failure.

It must be acknowledged that certification will, in general, only pay back on an international – mainly European – market because the organization of a niche market of buyers who are willing to pay a price premium can probably only be found there, aside from a small market formed by foreign and Philippine elite groups in Metro Manila. Indeed, examples elsewhere point to successes at a local market level. Ota (2006) described an example in Japan, where an ecological housing movement successfully realized FSC certification for over 11,000 ha with local supply. But on a country level, the factor that best explains the development of sustainable forestry management is the proportion of exported forest products (Van Kooten et al. 2005).

A crucial requirement is the constant high quality and sufficient quantities of the timber products (see also Kollert and Lagan 2007). This limits the use of a species like gmelina (*Gmelina arborea*), which is mostly grown in the spontaneous tree plantations of individual farms. Wood from this species requires a thorough drying process, preferably by use of a timber drying machine or kiln, to achieve high quality. In contrast, the national and the international market in particular, demands species such as narra (*Pterocarpus indicus*) or tindalo (*Paludia rhomboidea*). The main reason for the smallholders' choice of gmelina is the high growing speed, allowing harvesting after seven to 10 years (between seven and 10 years, the production per tree doubles). High value hardwood species such as narra can only be harvested after 40 to 50 years, rendering their use in private smallholder plantations nearly impossible. A solution could possibly be found in the improvement of the quality of gmelina wood by the use of good quality seeds (Roshetko et al. 2004) and drying the timber in kilns instead of in the sun. Further ahead is quality improvement, for instance through treatment with so-called platonization, a process that consists of heating timber under pressure, of drying and then reheating (www.platowood.nl). This is a crucial first point for further investigation, the focus being on the required product quality.

A related point concerns the economics: the market prices along the value chain for different kinds of timber quality, and the potential price premiums that can be achieved due to certification. Plain gmelina wood is too cheap for transportation on an international market but high quality timber may well provide that opportunity. Some data, based on an exploratory field study by the authors, that compares wood and a wooden product from narra and gmelina along the value chain, is presented in Box 10.1. It can be concluded that there is a much smaller price difference between high quality gmelina and hardwood furniture than is the case for gmelina and narra wood at the level of producer to middleman. The tentative conclusion is that because of the high added value in the chain, the choice of the fast growing species is not prohibitive for a certification endeavor, provided that good wood quality is ensured.

There are a number of organizational questions, including the establishment of local or regional smallholder organizations, the link to a Philippine or regional umbrella organization, and finding a donor organization to facilitate the transition process. The most direct first step should involve a closer investigation of case studies about the use of certification in comparable situations in the Philippines or nearby countries.

In conclusion, there is a potential role for sustainability certification by smallholders for gmelina and the conservation of forests in the Philippines. The FSC SLIMF program offers the best prospects for that. A central point relates to the production of high quality lumber, enabling trade to take place on an international market. The main driver should be a desire for sustainable forestry, with its various qualitative benefits. From an economic standpoint, breaking even is the initial aim, but successful implementation would create opportunities for additional wood-based processing activities that are adjusted to international consumer needs and standards, and add value to the final product. After completion of an exploration of comparable case studies, the next step should be to organize the market and to find a donor organization to support the transition process.

Box 10.1 Price indications for narra and gmelina wood (in \$ per m^3) and products (in \$) along the value chain (Field data collected in 2005, from Isabela and Cagayan provinces in North Luzon, the Philippines)

Material/product	Narra	Gmelina
	(*Pterocarpus indicus*)	(*Gmelina arborea*)
Round log (diameter; cm)	(20–30)	(25–65)
– From farmer to middleman (\$/m^3)	135–170	20–30
– From middleman to manufacturer (\$/m^3)	215–230	60–75
Square log (thickness; cm)	(20–35)	(30–45)
From middleman to manufacturer (\$/m^3)	215–245	105–130
Sawn wood (thickness, width, length; cm)	(5 × 30 × ≥ 365)	(5 × 30 × 245–305)
– From farmer to middleman (\$/m^3)	245–290	75–105
– From middleman to manufacturer (\$/m^3)	265–420	90–120
Unfinished rocking chair (\$)		
– Pick up (= local market)	24	18
– Manilla	45	27
Finished rocking chair with carvings (\$)		
– Pick-up (= local market)	27	20–22
– Manilla	54	36

The image of the hardwood narra is, like that of other hardwoods, very high. In contrast, the image of a softwood species, such as gmelina, is low. This is highlighted by the tendency of furniture shops to paint light colored gmelina furniture in the red narra color and is also clear from the price, which is much higher for narra wood and furniture. The question is, whether the low price of gmelina is in fact prohibitive for certification. If we compare the price that farmers or loggers receive from middlemen, there is about a factor 6 difference (about \$135–170/m^3 for narra and \$20–30/m^3 for gmelina, respectively). But if we go along the value chain, we observe that for the leading product in Luzon, a carved and varnished rocking chair, the price difference decreases to about a factor 1.5, both locally and in Manilla. Due to the larger added value along the chain, gmelina therefore seems to be a competitive product open for certification.

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Chapter 11

Exploring the Agroforestry Adoption Gap: Financial and Socioeconomics of Litchi-Based Agroforestry by Smallholders in Rajshahi (Bangladesh)

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Abstract This paper takes a multistrata agroforestry system, based on *Litchi chinensis* and widely practised in North Bangladesh, as a case study to address the common problem of lack of adoption in agroforestry. Although the financial cost-benefit analysis of agroforestry systems may show clear-cut profitability, these systems are often hardly adopted by farmers. Our data clearly show this pattern. Net present values and returns to labor of agroforestry were five times higher than those of alternative (annual) crops, and yet the adoption rate remained very low, even though an agroforestry project had been carried out in the study area and agroforestry had positive cultural value. Common economic reasoning is that in such cases, adoption is hampered by capacity constraints of the farmers. Our data allow to argue, however, that not the capacities but rather the *motivations* of the farmers are key, in spite of the financial characteristics of the system. This is caused by the underlying institutional structures, that are highly unconducive to agroforestry. We conclude that action for agroforestry should focus first of all to get supportive institutions (rules and organisations) in place before focusing on trees and projects, if needed at all.

Keywords Tree-based system, cost-benefit analysis, institutional economics, smallholder farmers

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11.1 Introduction

In Bangladesh, 41.3 percent of the population lives under the poverty line, compared to 5.6 percent, 17 percent, and 34.3 percent in Sri Lanka, Pakistan, and India respectively (UNDP 2007). Moreover, with an annual growth rate of 1.7 percent, its total population may increase from 158.66 million in 2007 to 206 million in 2025 (ESCAP 2007). The grave poverty situation and steady population growth have mounted pressure on the country’s natural resources. Forests are depleted by commercial timber exploitation and gradually converted into pastures, plantations, and cultivated fields. By the year 2005, only 6.7 percent of the country’s surface area was left under forest, with a net forest loss estimated at 2,000 ha per year for the period 2000–2005 (FAO 2006). Forest fallows have been eliminated completely, with the cycle period of slash-and-burn cultivation declining from about 20 years in 1900 to about 3 years today. Due to the depletion of firewood resources, rural communities turn to alternative fuels such as cow dung and crop residues that previously served as organic manure on agricultural fields. The shorter fallow periods, reduced organic inputs and repeated removal of nutrients with harvested crops have contributed to soil degradation and, consequently, lowered crop yields and farmers’ returns leading to more poverty.

Agroforestry is often seen as one of the very few options that might lift farmers out of the poverty trap. In developing countries, approximately 1.2 billion poor people depend directly on a variety of agroforestry products and services (IPCC 2000). In the five sub-Saharan African case studies described in Franzel and Scherr (2002), agroforestry is shown to have the potential to increase farm incomes and resolve difficult environmental problems. It is financially more profitable to local farmers than the traditional cultivation is, besides providing other economic and social benefits. Thus, agroforestry can help reduce poverty and support the transition to permanent cultivation (Mai 1999). Agroforestry is not only economically but also envrionmentally promising, supporting as it does the agroclimate and biodiversity (Huxley 1993), shelter and soil organic matter, water and nutrients (Sae-Lee et al. 1992; Wu 1996; Elevitch and Wilkinson 1998). Another study (Ahmed and Rahman 2000) suggests that establishment of multi-layered cropping systems is inevitable for Bangladesh to supply enough fruits, fuel wood, timber and various agricultural products for the growing population.

Bangladesh lies in the ‘homegarden zone’ of the global map in Nair and Kumar (2006) and indeed in Bangladesh, practices of agroforestry are well-known to most farming families in rural areas. Before the widespread introduction of rice, wheat and other seasonal cash crops in the 1970s, traditional mixed cropping systems based on perennial tuber, root, and fruit tree crops grown in association with vegetables were practiced throughout Bangladesh (Alim 1993). Moreover, with the decreasing yields of crops planted in seasonal crops, farmers have recognized the need for modifying their farming practices and conserving soil resources. Some alternative farming technologies including multistrata agroforestry systems (e.g., fruit gardening, multipurpose homegardens) have been introduced especially after 1980 in the north as well as in other parts of Bangladesh under various development projects of both government and other organizations such as the Asian Development Bank and the European Union.

Many economic studies have underscored the financial viability of agroforestry. In a study of strip plantation on logged-over forest plots in the Dinajpur district, for instance, Rahman and Islam (1997) calculated a benefit-cost ratio (B/C) of 1.95 and an internal rate of return (IRR) of 42 percent. This is comparable to the financial results of cashew plantations established at central Tamil Nadu, India under an agroforestry system (B/C ratio of 1.65 and IRR of 41 percent; Sekar and Karunacharan 1994). Elevitch and Wilkinson (2000) reported that agroforestry in Hawaii is financially viable and less risky than seasonal crops or forestry. At the same time, however, it has been questioned whether these systems are indeed as economically viable as they are claimed to be, e.g. by Siddiqui and Khan (1999) who studied the socio-economics of rural homestead forestry in the Chittagong district. Moreover as a general observation, one might wonder why, if indeed its economic viability would be as pervasive as the financial analyses suggest, the world is not full of agroforestry yet. There appears to be a gap between the financial analyses and what farmers are actually doing.

Taking as a case study a common multistrata agroforestry system in Northern Bangladesh, in comparison with the seasonal cultures of rice and wheat grown in that region, the present paper is designed to address this ‘agroforestry adoption gap’. Special attention will therefore be paid to the difference between what we have called the ‘financial’ and ‘social’ economic perspectives. The financial-economic approach is defined here as focusing on the formal cost-benefit analysis of the agroforestry system, abstracting away to a large degree from the complexities of the farmers’ daily life; it coincides to a large degree with ‘financial accounting’ or ‘cash flow analysis’ in mainstream cost-benefit analysis (Irvin 1978). The social-economic approach as exemplified here is not a variation on financial accounting in order to express rationality at the collective level, as in mainstream cost-benefit analysis. We remain on the household level but take a broader look, aiming to come to grips with relevant aspects of the full set of factors, e.g. including the psychological, institutional, and moral, taken into account by farmers in their land use considerations. For a broad example of this type of approach, see Platteau (2000).

11.2 The Study Area and Agroforestry System

The research has been conducted in the Shibpur village of Puthia Upazila in Rajshahi District in Northern Bangladesh. The study village contains some 500 households and is located 22 km east of Rajshahi city centre, between the 24°25′ to 24°20′ northern latitudes and between the 88°40′ to 88°45′; eastern longitudes. It experiences a tropical monsoon climate, with a rainy season extending from May to November and a dry season from December to April. A mean maximum daily temperature of 32°C to 36°C has been recorded during the months of April, May, June and July; and a mean minimum daily temperature of 7°C to 16°C in January.

The annual average rainfall is 1,448 mm, with highest intensity in July, followed by August and September. The average humidity ranges from March lows of 45 percent to 71 percent to July highs of 84 percent to 92 percent. The topography is a floodplain with loamy soils and an average elevation of 20 m above sea level.

The agroforestry system practiced in the village is one of the most common in the district, and is a multi-strata cropping system based on litchi (*Litchi chinensis*), a multipurpose tree species, interplanted with vegetable, condiment, or fruit crop species such as ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), eggplant (*Solanum melongena*), lemon (*Citrus limonum*), papaya (*Carica papaya*), and banana (*Musa* spp.). Generally, this system is practiced on land where the farmers previously planted seasonal cash crops. In spite of the very small size of the management units (0.25 ha on average), the multistrata system is characterized by high species diversity (five to seven species per plot, see Table 11.1) and usually three to four vertical canopy strata, which results in intimate plant associations. The lower strata can usually be partitioned into two layers, with the lowest one (less than 1.0 m height) dominated by eggplant, ginger, and turmeric and the higher one (1.0 to 3.0 m) by banana, papaya, and lemon. The upper stratum is dominated by the litchi trees. Eggplant, papaya, banana, and lemon serve as intercrops during the first four years after the litchi is planted. Then, the shade-tolerant species ginger and turmeric are commonly planted under the litchi trees, in order to maximize the utilization of sunlight and improve soil protection.

The agroforestry system has been introduced and promoted in the village by a project implemented by the District Forestry Office of the Government of Bangladesh, called “Development of Social Forestry” that provided training, seeds, and seedlings. The first phase was carried out between 1981 and 1987, and the second phase, then called ‘Extended Social Forestry Project” (Muhammed et al. 2005) was executed from 1995 to 1997. The agroforestry adoption rate in the village was 14 percent in the year 2001. A re-visit of the village early 2007 showed that the adoption rate is still at the same level.

The seasonal crop system is a double-cropping of either rice followed by wheat or rice twice a year. We use the rice/wheat system here as basis for comparison because it is the most widely practiced in the region and the village.

Table 11.1 Components of the litchi-based multistrata agroforestry system in Rajshahi district, Bangladesh. (Litchi being the main crop, it dominates the overall grid and receives priority at intersections.) (Field observations for this study)

Species name	Spacing (m)	Number of rows per ha	Number of plants per ha
Litchi (Litchi chinensis)	8 × 8	12	144
Lemon (Citrus limonum),	3 × 3	24	792
Papaya (Carica papaya)	2.5 × 2.5	12	480
Banana (Musa species).	2.5 × 2.5	12	480
Eggplant (Solanum melongena)	0.75 × 0.75	50	2,000
Ginger (Zingiber officinale)	0.50 × 0.20	200	100,000
Turmeric (Curcuma domestica)	0.50 × 0.20	200	100,000

11.3 Material and Methods

Research data were collected during the period from August 2005 to January 2006 among a total of 100 households, including 60 farmers that have an agroforestry plot and 40 farmers that only practice the seasonal crops of rice and wheat. Structured interviews were used to gather data on species combinations, actual input and output prices for both the agroforestry and the seasonal systems and the adoption factors of agroforestry. Five in-depth household studies were carried out in order to determine envisaged costs and benefits of both types of land use. Field observations were aimed at identifying the actual species combinations of agroforestry. Other data was gathered by way of open interviews with key informants (government, non-government and public organizations) and by market prospecting. Secondary data were collected from statistical yearbooks, local administration, and various other sources.

Quantitative analyses were carried out using descriptive statistics and economic models, especially cost-benefit analysis at the household level. The net present value (NPV), internal rate of return (IRR), benefit-cost ratio (B/C), return-to-land and return-to-labor were calculated and compared for both types of land use.

The NPV determines the present value of net benefits by discounting the streams of benefits and costs back to the beginning of the base year. The NPV is calculated by the following formula:

$$NPV = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t}$$

where

B_t – the benefits of production by a cultivation practice
C_t – the costs of production by a cultivation practice
t – the year time
r – the discount rate

The IRR is equal to the discount rate (r) that brings the NPV down to zero. An investment is considered financially attractive if the IRR is higher than the opportunity cost of project financing (i.e. what one would pay to the bank for borrowing the investment capital). Following the definition, IRR is obtained by solving the equation:

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} = 0$$

The B/C compares the discounted benefits to discounted costs. A B/C of greater than 1 means the project is profitable, whilst a B/C of less than 1 means the project generates losses. The B/C is calculated as follows:

$$\frac{B}{C} = \frac{\sum_{t=0}^{n} \frac{B}{(1+r)}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}}$$

The return-to-land for a certain year is calculated as B–C for that year per ha; this measure is especially relevant for households with high man-to-land ratios and desiring to maximize yields even at low labor efficiencies (return-to-labor). Return-to-labor for a certain year is how much farmers make per day of farm work on average during that year. It was calculated as (B–C) divided by the number of family labor days, with family labor cost excluded from C. This figure may be compared with the local off-farm wage; if farmers make less than that, farmers run at a loss compared to hiring themselves out (though they may still prefer to work on their own farm).

A sensitivity analysis has been carried out to study the effects of change in mutable factors such as input and output prices, yields of products and discount rate on farmers' benefit.

11.4 Basic Data and Assumptions

11.4.1 Land

The land market is underdeveloped in the study area, especially for land under traditional cultivation. However, as mentioned by MacDicken and Vergara (1990), there is no need to know land values if only changes of land use are considered, such as in our case.

11.4.2 Establishment Cost

Establishment cost involves for example land preparation, seedlings, and planting materials. Costs for preparation vary greatly depending on the condition of the site. The farmers in the study area purchased seeds and seedlings from private or state sources, and the average establishment cost is US$1,520 for multistrata agroforestry and US$1,140 for seasonal cultures per hectare (Table 11.2).

11.4.3 Labor Cost

The work at the farm lots is mainly carried out with household labor though use of hired labor is also practiced in the area. Family labor is not a cash expenditure from the farmer's perspective. Therefore, all calculations will be carried out for two variants: with and without inclusion of family labor in the production costs. The scenarios with the exclusion of family labor costs seem more meaningful for poor farmers. The labor cost is shadow-priced at US$1/workday, which is the common wage of casual labor in this region.

Table 11.2 Yearly costs per hectare of the litchi-based multistrata agroforestry system and rice/wheat double cropping system in Rajshahi district, Bangladesh

Type of operation	Year	Operation costs (US$/ha)		
		Multistrata agroforestry	Seasonal culture	
Establishment cost	1	1,520	1,140	
Labor cost	1–10 11–30	152 190	57 57	Average yearly labor costs for weeding, thinning, pruning, harvesting, protection, etc. For agroforestry during years 11 to 30, litchi gives high yields requiring high protection and harvesting cost.
Pesticide cost	1–30	10	11	
Fertilizer (NPK) cost	1–6 7–10 11–30	228 190 114	114 114 114	
Irrigation (excl. labor)	1–30	570	133	

11.4.4 Pesticide and Fertilizer Cost

Chemical fertilizers are often used for enhancing farm production. The average cost for pesticides and fertilizers do not change through the years except that in the agroforestry system, the quantities of chemical fertilizers gradually decrease over the years, because the trees increasingly provide nutrients for the understory crops. Pesticides are not generally used in both systems.

11.4.5 Irrigation Cost

Irrigation is essential during the dry season. In the study area, the average yearly irrigation cost is US$570 for agroforestry and US$133 for the seasonal cultures.

11.4.6 Discount Rate

The analysis is carried out from the farmer’s perspective, hence using the individual rather than a social discount rate. A common way to estimate this rate is by taking the opportunity cost of capital for farmers. This rate is estimated at 10% by deducting the inflation rate of 4% from the average nominal interest rate of the loans for agricultural production (14%) in the banking system. The effect of other discount rates is assessed in the sensitivity analysis.

11.4.7 Yields

The common and popular cash crops of rice and wheat are considered for seasonal culture. For agroforestry, the multi-strata system of litchi, ginger, turmeric, eggplant, lemon, papaya, and banana is considered. Eggplant, papaya and banana are intercropped with litchi only for the first 4 years, and lemon is for first 6 years. After that time shade tolerant ginger and turmeric are intercropped. Yields of litchi are calculated under three categories, (1) low yields during the fourth to sixth year, (2) medium yields during the seventh to tenth year, (3) high yields from the eleventh year onwards. Table 11.3 gives the overview of the yield in both systems.

11.4.8 Time Horizon

A period of 30 years has been taken as the time horizon for present analysis.

Table 11.3 Yearly average yields of the litchi-based multistrata agroforestry system and the rice/wheat seasonal cropping system in Rajshahi district, Bangladesh. For both the agroforestry and the seasonal culture columns, yearly totals are the full column for the given years (second column)

Name of variety (species)	Year	Average yields ($ha^{-1}year^{-1}$)		Selling price (US$ $year^{-1}$)
		Multistrata agroforestry	Seasonal culture	
Rice	1–30	–	6,600 kg	1,064
Wheat	1–30	–	2,400 kg	646
Eggplant	1–4	8,000 kg	–	304
Papaya	1–4	49,419 kg	–	1,901
Banana	1–4	92,640 piece	–	1,140
Lemon	1st	37,064 piece	–	570
	2nd	111,193 piece	–	1,711
	3–6	247,096 piece	–	3,801
Ginger and turmeric	7–30	5,400 kg	–	2281
Litchi	4–6	74,100 piece	–	1,140
	7–10	123,741 piece	–	1,904
	11–30	617,741 piece	–	9,504

11.5 Results of the Financial Analysis

Figure 11.1 indicates that multistrata agroforestry is much more profitable than seasonal culture, even in the year of establishment.[1] Including family labor cost shadow-priced at \$1 day^{-1} (see previous section), the minimum income per hectare per year of multistrata agroforestry is US\$2,375 and the maximum is US\$10,818. On the other hand, the minimum income of seasonal culture is US\$565 and the maximum is US\$1,319 per hectare per year.[2]

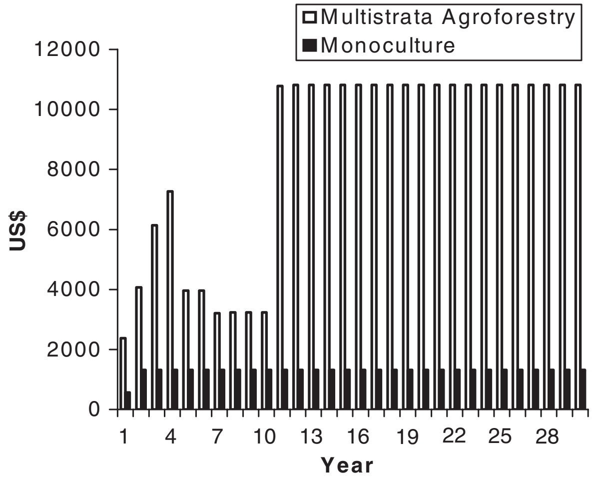

Fig. 11.1 Net returns (in US\$ ha^{-1}) of multistrata agroforestry and seasonal monoculture in Rajshahi district of northern Bangladesh (Field data)

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[1] Some risk factors such as floods, droughts, and insects are excluded.

[2] These incomes may be compared with those of (social forestry) plantations producing forestry products such as timber, firewood, and poles. Muhammed et al. (2005) supply nation-wide figures from Bangladesh. Felling of 6,676 ha of such plantations in 2002/2003 brought a revenue of US\$8,363,000, i.e. 1,250 \$ ha^{-1}. Since these plantations require a growth period of 7 years (minimum), the annual benefit is 180 \$ ha^{-1} year. This is gross benefit, excluding all inputs. Returns-to-labor cannot be calculated from the data because the time input of the social forestry participants is unknown. The returns-to-land of the forestry-based plantations, compared with the (net) 1,300 \$ ha^{-1} year for the seasonal crop system and (net) 10,800 \$ ha^{-1} year for the litchi-based multistrata system clarifies why for a land-scarce country such as Bangladesh, forestry-based plantations are a good idea only on non-arable lands such as roadsides, tank bunds, derelict slopes, watershed forest etc. And if villages would have enough social capital to be able to plant fruit trees rather than timber trees on places such as tank bunds or school yards, they should. See for instance the cost-benefit analysis and social capital analysis in Tadepally (1999) and De Groot and Tadepally (2007).

The calculations of net present value (NPV), internal rate of return (IRR), benefit cost ratio (B/C), return to land and return to labor (both averaged over the 30 years) of seasonal culture and the multistrata agroforestry systems are presented in Table 11.4. The discount rate used for the NPV is 10 percent. Calculations were made with and without inclusion of the cost of family labor (shadow-priced at \$1 day^{-1}). In both cases, the agroforestry system gives much higher NPVs than seasonal culture. The IRR and B/C of agroforestry is more than twice that of seasonal culture. At US\$24 day^{-1}, the returns to labor of agroforestry are six times higher than the of seasonal cropping that stands at less than \$4 day^{-1}.

The sensitivity analysis focused on the discount rate and a reduction of yields or prices. Higher discount rates should express the well-known argument that poverty causes 'survival behaviour' with a strong focus on the very near future. Higher discount rates should normally make agroforestry less attractive compared to annual cropping, due to the time lag between investment and first fruits. For the agroforestry system discussed here, however, this effect is only very slight. At a discount rate of 40 percent, the NPVs of agroforestry and seasonal cropping still compare as US\$10,893 versus US\$2,759, i.e. four to one, while comparing as five to one at a 10 percent discount rate (see Table 11.4). The reason is that the understory crops are very fast yielders (see Fig. 11.1); even the citrus already fruits in the first year of planting.

Lower yields or prices reflect an obvious insecurity of farmers. Also in this respect, however, the results of the financial analysis are robust when testing for what could normally be expected in terms of yield or price changes. On the input side (Table 11.2), the two systems are not greatly different in the sense that one would depend on a special risk factor. On the output side, the prices of the agroforestry products (turmeric, litchi, etc.) would have to drop enormously compared to wheat and rice for the agroforestry system to end up below the seasonal cropping option (see Fig. 11.1).

Overall, the financial analysis shows that agroforestry is by far and robustly the superior land use option, financially. The logical prediction would then be that agroforestry would be prevalent in this region, or at least spreading. That, however, is not the case at all. As stated, only some 14 percent of the households practice the litchi-based or any other agroforestry system, and neither the adoption rate nor the

Table 11.4 Financial results of litchi-based multistrata agroforestry and rice/wheat monoculture in Rajshahi district, Bangladesh (per ha)

	Costs including family labor		Costs excluding family labor	
	Multistrata agroforestry	Seasonal monoculture	Multistrata agroforestry	Seasonal monoculture
NPV (at 10%) (US\$)	61,074	11,750	62,039	12,506
IRR	208%	86%	289%	131%
B/C	7.70	3.77	9.51	4.59
Return to land (US\$ ha^{-1} year^{-1})	8,567	1,294	8,712	1,358
Return to labor (US\$ day^{-1})	–	–	23.87	3.72

total area under agroforestry shows any tendency to increase. The obvious question is why? This is the subject of the next section.

11.6 A Broader Look: The Socioeconomics of the Agroforestry System

In the study area, most of the agroforestry has been established with support of an agroforestry project. The project did well, apparently, in sowing the agroforestry seeds but the system did not blossom at all, neither in terms of new adoptions nor in terms of area increase of households who adopted agroforestry initially.

The interviews with the 40 farmers that plant only rice and/or wheat reveal some of the factors that underlie the failure of agroforestry to spread in spite of the financial benefits as analyzed in the previous section. Table 11.5 gives the overview.

The first thing to note from the table is that it contradicts the mainstream economics idea that if something is profitable in the financial calculus and yet not practiced, the reason must lie in 'constraints', i.e. lack of capacity (capital, land, know-how, etc.). This type of reasons (*i*, *iii* and *v*) was mentioned indeed 60 times by the farmers, but another 59 times farmers mentioned reasons in the motivational realm (*ii*, *iv* and *vi*), i.e. referring to what they want to do rather than what they can do (Elster 1989:13; Overmars et al. 2007). Underneath, we will take a deeper look, starting out from the candidate constraint factors and then moving to the motivational factors.

Lack of suitable land or tenure issues were never mentioned by the non-agroforestry farmers and indeed we may assume that virtually all farmers would have some area, if only close to the homestead, where agroforestry would be feasible. Table 11.6 shows the overall land situation of the two types of farmers. The Table also shows that the two types of farmers have the same land area on average. The distribution of these areas among the farmers is quite even. The medians are very close to the means, for instance, and the standard deviations are less than 40 percent of the means. It can therefore be excluded that many farmers would have so little land that they have no space for agroforestry. Moreover, land that could be unsuitable for

Table 11.5 Constraints of agroforestry, as mentioned by 40 non-agroforestry farmers. Motivational factors are marked with M and factors of capacity (capital, skills, etc.) are marked with C

Reasons	Number of farmers	Percent
(*i*) No knowledge (C)	7	17.5
(*ii*) No interest (M)	5	12.5
(*iii*) Lack of capital (C)	32	80.0
(*iv*) Delay in profit earning (M)	22	55.0
(*v*) Lack of technical assistance (C)	21	52.5
(*vi*) Unstable market price (M)	32	80.0

Table 11.6 Mean land areas cultivated by the two types of farmers

	Seasonal croppers (ha)	Agroforesters (ha)
Total land area	0.53	0.57
Agricultural land	0.45	0.27
Agroforestry land	0	0.21
Other land (e.g. pond)	0.08	0.09

Table 11.7 Educational levels of the farmers (%)

	Seasonal croppers	Agroforesters
Never attended	20.0	15.0
Not completed primary school	22.5	15.0
Primary school	10.0	11.7
Secondary school	30.0	40.0
Higher schooling	17.5	18.3
Total	100	100

agroforestry due to hydraulic conditions amounted to only 27 percent of the total area. In sum, the low adoption rate of agroforestry cannot have been caused by lack of suitable land to any significant degree in this area.[3]

Agroforestry and non-agroforestry farmers do not differ greatly in terms of general educational level either, as shown in Table 11.7. The table also shows that almost half of both groups have secondary education or higher. Lack of general education cannot explain the very low adoption rates of agroforestry, therefore.

Closer to the factors mentioned by the farmers themselves, we might wonder if a lack of specific agroforestry skills would be a constraint to agroforestry expansion. This could be a candidate factor for non-agroforestry farmers indeed (see Table 11.5), but much less so for the non-expansion of agroforestry by the farmers who are agroforesters already. They already possess the necessary skills and, as shown in Table 11.6, they still have some 60 percent of their land left for such expansion. Moreover, agroforestry in home garden form had already been practiced in the village and the region on a wide scale before the entry of the agroforestry project that focused on the conversion of cropland into agroforestry; in general terms, agroforestry is nothing new to the farmers.

The same would appear to hold for the constraint mentioned as ‘lack of capital’ for the initial investment in agroforestry. For the non-agroforestry farmers this may be true indeed. The agroforestry system has higher establishment cost financially (see Table 11.2) and psychologically, since it is a break with established routines. (The difference of financial cost is in fact higher than Table 11.2 suggests because already established seasonal crop farmers use seeds from the previous year.) Again,

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[3] The situation appears to be the reverse here compared to other regions such as the drylands of Africa where farmers may work much larger areas but agroforestry may be feasible only on the very few spots with favorable water and soil conditions (Timmermans and De Groot, 2002).

however, this does not hold for the group of agroforestry farmers. If they would be motivated, they could easily circumvent the capital constraint by piecemeal expansion of their agroforestry area, adding a few seeds and seedlings from their own stock each year, just like, for instance, farmers in the Philippines do with investment in terracing (Romero 2006). And, coming to that, what would really be the capital constraint also for a non-agroforestry farmer to plant a few trees with some help from his agroforestry neighbors?

"Delay in profit earning", mentioned by half of the non-agroforestry farmers (Table 11.5), may be seen as a capacity constraint factor as well, referring to the lack of capital to bridge the gap before the agroforestry species bear fruit. The argument contradicts our financial analysis based on field data from the same village (see Fig. 11.1). Either farmers do not know the performance of the multi-strata system or they do not believe it will also be possible in their farm, or they may refer to a time span of less than 1 year, since even the fast agroforestry species are not as fast as the rice or wheat that mature within a few months. The income of the agroforestry planter will therefore be lower than of the seasonal cropper for, say, half a year before compensated by the agroforestry crops. We may doubt if this argument really cuts ice, however, e.g. since farmers may again spread the investment over the years. If a farmer would plant the agroforestry system on, say, five percent of his land each year, his income flow would be delayed only once by only that percentage.

By way of interim conclusion, we hypothesize that if farmers would be motivated for the agroforestry system, they would easily find ways to circumvent their capacity constraints. In other words, *motivational* factors rather than capacity constraints appear to underlie the lack of spreading of agroforestry in the village, in spite of the results of the financial analysis. We now take a look at these motivational factors.

First of all, it might be proposed that a negative cultural value of agroforestry could somehow block a positive economic motivation of farmers, e.g. if agroforestry would be associated with poverty or low prestige. This is the case in our study area, however. Agroforestry has a positive prestige value and gifts of fruits such as litchi or mango play an important role in the maintenance of social networks. Moreover, banana is positively regarded in Hindu religion, e.g. its leaves are used in ceremonies.

"Unstable market prices" are the major motivational issue mentioned by the farmers themselves (Table 11.5). In view of our financial analysis, they must be referring here to something more structural than just a simple drop of prices as has been taken up in the sensitivity analysis of the previous section. We surmise that farmers here refer to a deeper feeling of insecurity than only regular price fluctuations. Investing in agroforestry amounts to locking oneself practically irreversibly into the markets of vegetables, spices and fruits – markets that to the farmers may feel more like niche markets for luxury goods, which are inherently less stable than those of rice and wheat. Rice and wheat are basic food grains; the agroforestry products are frivolous fruits with a volatile economic future.

Moreover, wheat and rice are basic subsistence crops for the farmers themselves, too. Whatever may happen, a good area under rice or wheat secures the family food supply. The area needed for subsistence on a rice-based diet may be estimated from the daily rice intake of such diets, being 252 kg per capita per year (Hobbes 2005). A family of 6 then would need 1,512 kg year^{-1}, and with the local productivity of 6,600 kg ha^{-1} (Table 11.3), this would amount to 0.23 ha. Note that this is almost exactly the area that the agroforestry farmers keep under rice or wheat (Table 11.6). For the agroforestry farmers, the *income* security argument against agroforestry in general is fortified into a *subsistence* security argument against expansion of their agroforestry acreage.

The general atmosphere of insecurity surrounding the agroforestry option in this region is augmented by a lack of government backing. The agroforestry plots were established under the auspices of a project that brought farmers the superficially needed elements of skills, seedlings and attention, but failed to lay a structural basis under the agroforestry. When the project was closed down the farmers were again on their own, left to the whims of private middlemen and far-away consumer markets. No back-up is provided to agroforestry in any suitable form. There is no agroforestry extension, no market information, no price guarantees, no on-farm research and development, no specific credit for agroforestry, no quality seedlings supply, no support to start cooperatives or added-value activities or any suchlike actions. Meanwhile rice and wheat are backed up by the government providing subsidies, support prices, soft loans and income tax concessions and recently a comprehensive crop insurance scheme for the farmers.[4] These services are not only important for the farmers as such; they also emanate the general message that these crops are important for the government and therewith the safest bet for any farmer.

11.7 Discussion and Conclusion

Starting out on a brief methodological note, it may be remarked that what we think have been our key insights have grown neither from a purely outsider perspective (the financial analysis), nor from a purely insiders' view (the farmers' opinions in Table 11.5), but from a critical juxtaposition of the two. It has been the financial analysis *versus* the farmers' behaviour of non-adoption and non-expansion, and also the farmers' opinions *versus* our own analysis of motivational factors. A critical attitude towards farmer's voiced reasons for non-adoption is justified, *inter alia*, by the general phenomenon that if an actor (farmer, government agent, country) fails to do the good thing, it is always better for the actor to blame this on lack of capacity than on lack of motivation. Lacking capacity, one gets rewards (credit, capacity building, etc.), but lack of motivation elicits penalties.

The financial analysis of litchi-based agroforestry system has shown that in this region, agroforestry is solidly more profitable than are the seasonal crops of rice

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[4] A similar pattern has been observed in the Philippines where government support is lacking for both the agroforestry and monocrop (corn), but farmers can use corn and not agroforestry as a collateral for loans from private traders (Snelder et al., 2007).

and wheat. The net present values are more than five times higher, the internal rates of return benefit/cost ratios are almost twice as high, and the return-to-labour, at almost US\$24 day^{-1} for agroforestry, is almost six times higher than for the seasonal crop system. The sensitivity analysis showed that this finding stands up well against what could normally be expected in terms of discount rate and price fluctuations. Other sensitivity might have been overlooked in our analysis. It could be, for instance, that some parts of the farmers' land lies so far from the homestead that the cost of guarding the agroforestry crops would become prohibitive. If this would be the case indeed, farmers would still have a 'home plot' for agroforestry, however.

Mainstream economic reasoning assumes, however tacitly, that people are basically and solely financially motivated. Logically then, if something is financially attractive but not practiced in reality (as in our case with a very low and static adoption rate of agroforestry), this can only be caused by capacity constraints; people want it but they cannot do it due to lack of capital, knowledge, land, seedlings, and so on. Farmers did mention some of such factors in our interviews but these statements do not live up to more analytical scrutiny. One major reason is that no constraint prevents farmers in this region – those who have agroforestry already but even those who have not yet – to expand agroforestry little by little over the years. If people would really be motivated for agroforestry, they would get it. We conclude that in spite of the impression given by the financial analysis, farmers are not really *motivated* for agroforestry.

Unstable market prices were mentioned by the great majority of farmers as a disincentive against agroforestry. The financial analysis has indicated that farmers must refer here to something deeper than bounded price fluctuations. Rather, they appear to express a fundamental aversion of locking oneself into a land use system that produces foodstuffs that are much less basic than rice or wheat. Rice and wheat are fundamental to the farmers and to the country. Agroforestry farmers express this by maintaining an area for family subsistence besides the agroforestry plot. The country expresses this by government back-up of rice and wheat through support prices, soft loans, tax concessions, crop insurance, research, extension and so on – institutions (laws, regulations, policies, organizations) that fail in the case of agroforestry. This government support works at two levels. The first is the level of the measures themselves, if farmers make use of these loans, insurance etc. The second, deeper level is that through the institutional support, the government emanates that rice and wheat are basic indeed and with that, safe for farmers to do. Likewise, the lack of institutions for agroforestry is not only a concrete disincentive, but also reinforces the feeling that agroforestry is a fundamentally unsafe bet.

The agroforestry in this region has been greatly stimulated by a field project. Generally, the tragedy of field projects is that they cannot change laws, factor markets, banking regulations, tenure rules or other, foundational institutional structures and therefore tend to supply their target groups with only superficial capacity and motivation. Like the seeds sown on rocks in the biblical parable, the trees resulting from superficial incentives are easy to plant but do not multiply, lacking the deep soil of supportive institutional structures.

Very favorable results of financial analysis of agroforestry as in our case may lead governments to think that the diffusion of agroforestry can be ‘left to the market’. Although market parties naturally have a great role to play, our case study shows that they cannot work alone, even if agroforestry has already been introduced by a project. If agroforestry is to become a real option for poor farmers, institutional structures need crucial attention.

The necessary quantum leaps of agroforestry may be blocked in a myriad of institutional ways. For instance, tenure rules may be such that landlords tend to prohibit perennial crops; government credit may be lacking and middlemen credit available only for specific seasonal crops as collateral; agroforestry extension may be left to special projects instead of being taken up in the regular package of government attention and extension; agroforestry may be propagated with watershed or biodiversity arguments to such extent that farmers distrust the financial messages, and so on. These institutional issues need to be analyzed and rectified before field projects are even considered. Field projects might, after all, not even be necessary if the institutional structures are put right.

In summary, our case strengthens a central theme in Kumar’s (2006) review study of Asian agroforestry. Agroforestry, if financially viable and culturally embedded as it is in our case and will be in many others, should be propagated not by temporary projects and neither by leaving it all to the market but by supportive, permanent and government-backed institutions. Agroforestry action should then aim first to get these institutions in place, not the trees.

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Chapter 12
Growing 'The Wood of The Gods': Agarwood Production in Southeast Asia

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Abstract Agarwood, also known as eaglewood or *gaharu*, is a valuable non-timber forest product which sometimes grows in *Aquilaria* species. The genus species occur mainly in South and Southeast Asia. As a result of a defense mechanism to fend off pathogenes, *Aquilaria* species develop agarwood which can be used for incense, perfume, and traditional medicines. The main markets for these products are in South and East Asia and the Middle East.

The high prices demanded for agarwood has led to the rapid depletion of *Aquilaria* trees in natural forests. The search for agarwood has spread from one country to another. At present Indonesia and Papua New Guinea are the main supplies. Because of the rapid depletion of the agarwood in the wild, the species was put on the CITES Appendix II as endangered.

Efforts have been undertaken to increase the production of the infected wood by deliberately wounding the trees. A variety of methods is used towards this end. Some recently developed techniques have proven to be most effective. This resulted in planting of *Aquilaria* trees by small holders as well as large industrial size plantations.

In this chapter we shall discuss a particular agarwood project in Vietnam and some other locations elsewhere promoting growing of *Aquilaria* trees among small holders. The general approach of the project to stimulate the growing of the trees among local communities will be discussed against the background of the international demand for this highly valuable non-timber forest product. Finally some potential developments of the future will be described.

Keywords Domestication, future developments, plantations, Vietnam, wild harvesting

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12.1 Introduction

In the intellectual discourse about deforestation, there is, since about two decades, a strong plea for attention to the economic and social relevance of non-timber forests products. It is argued that the sustainable exploitation of products like rattan, bush meat, honey, medicinal plants and numerous other products, provides a viable alternative to the rapid and large scale commercial logging. This discussion was largely stimulated by two provocative publications both published the same year (Peters et al. 1989; De Beer and McDermott 1989). It is also argued that forests might include a large number of potentially relevant plants and animals which are undiscovered for their use in pharmaceutical and other products. Even though their economic value might be difficult to calculate at this moment, numerous scientists remind us that the economic potential of these resources should not be overlooked. Even more difficult to value is the wealth of in-tact forest areas in terms of non-utilitarian biological diversity and environmental services (Kusters and Belcher 2004).

Local populations depend to a large extent on non-timber forest products for their food, medicine as well as cash income. For that reason socio-economic as well as the cultural value of forest areas and biodiversity should not be neglected in the economic appraisal of forest resources (Posey 1999).

Though this debate has generated a large body of interesting and sophisticated science, it has contributed relatively little knowledge that persuaded decision makers to slow down the process of forest degradation in many tropical rainforest areas (Dove 1993; Ros-Tonen 1999). In addition there is another interesting aspect to be considered in relation to the economic value of non-timber forest products which is related to the process of domestication of these products by small holders, and which has implicitly undermined the potential value of forest areas. Through manipulation, or domestication of the reproductive process of certain plants and animals, the harvest of such products can be increased and can generate additional income for the local communities (Wiersum 1999). Many development projects are based on this pre-conception. However, in case income is really substantial or market opportunities are really attractive, new groups of people might get involved in the production of such products and transfer the production of such plants and animal or animal products to other locations. In this process the real or potential value of the forest resources are removed from their place of origin and moved to new localities. The forest dwelling communities find themselves in an unequal competition with these external producers. In other words, both economic and social value is being removed from forest areas. This process seems to follow the logic of market forces (supply driven by demand) and little in terms of protection of rights to genetic resources or intellectual property held by the forest dwelling small holders. International conventions like the Convention on Biological Diversity which also aims at the equitable access and benefit sharing of benefits from genetic resources have not been able to provide sufficient guarantees for forest dwelling communities.

In this chapter we want to discuss the economic importance of a particular non-timber forest product, agarwood, that is harvested from the wild in the lowland forests of Southeast Asia but is increasingly being produced in a domesticated way. This domestication denies forest dwelling communities economic opportunities, and real and potential value from the forest.

Agarwood is without doubt one of the most fascinating non-timber forest products in the world. It is the infected wood of the *Aquilaria* and *Gyrinops* species. Agarwood is often called 'the Wood of the Gods' because of its use as incense for religious ceremonies. Agarwood is in high demand in many countries and cultures. As incense it is a product with an almost universal religious function as incense is used to symbolize purification and to accompany sacrifices and prayers from earth to heaven. Incense has pervaded religious history and agarwood incense is by far the most expensive type of incense. It has been in use since ancient times. Egyptians and Greeks are known to have used it for death rituals. But does this special religious function imply a special treatment of the tree in terms of production or processing? Does it lead to special protective measures? And does the agarwood producing tree enjoy a status as a 'sacred plant' or can it be used as an example of a religiously inspired example of environmental care?

12.2 The World of Agarwood

Buddhist monks, Arabic perfumers, Japanese incense producers, Thai farmers and Papuan collectors were just some of the cast at the 2nd International Agarwood Conference (March 2007, Bangkok). Participants came from more than thirty countries. The 'world of science' was represented by wood pathologists, anthropologists, foresters, economists and laboratory analysts each with their specific research interests. Alongside the scientists were entrepreneurs from Australia, potential investors in the opportunities that *Aquilaria* plantations might offer. Finally there were nature conservationists concerned with the survival of the tree species as agarwood features on the CITES appendix II list. In total more than 120 people – covering the full agarwood spectrum from production to consumption – came together to discuss the future life of the infected wood of a wounded tree.

Over a period of one week they were all discussing the results of their research and experiences. Visits to plantations, distillation factories and agarwood trading companies completed the programme. Throughout the week there were fascinating comparisons between the results of the laboratory experiments and the judgments of traders who still rely heavily on the 'naked eye and nose' for determining the grading the quality of agarwood. This stood in sharp contrast with the state of the art scientific discovery in the fields of microbiology, bioreactor analysis and DNA fingerprinting. Besides the plenary sessions, there were also discussions in small circles about business secrets with respect to the best sources of agarwood, the art of perfume design and incense making and the continuing illegal trade.

12.3 Agarwood: Its History and Its Uses

Agarwood is resin impregnated wood produced by a number of *Aquilaria* and *Gyrinops* species (Thymelaeaceae). There are 25 different species found in Southeast Asia. Not all species are found in all Southeast Asian countries. The most important species are *Aquilaria malaccensis*, *Aquilaria crassna*, *Aquilaria sinensis*, *Aquilaria rugosa* (Santisuk 2007). The trees occur from near sea level altitude up to about 1,500 m above sea level (depending on species). It is a large evergreen tree that can reach a height of over 30 m and a maximum diameter of over 1 m. Indonesia, Malaysia, Cambodia, Lao DPR and Papua New Guinea are the main present day producing countries. Recent research is adding new species to the list of agarwood producing trees, like *Gyrinops ledermannii* in Papua New Guinea (Compton and Zich 2002), and *Aquilaria rugosa* (Kiet et al. 2005). The resin-impregnated wood is fragrant and, highly valuable as it is rare and in short supply. This resin is formed as a result of pathological processes. It is also thought that resin production is a response to fungal infection. Interestingly however, not all *Aquilaria* trees produce resin and it is difficult for the inexperienced to judge if a tree holds agarwood. Cutting the tree down is the only way for many to find out whether the tree contains agarwood.

Use of agarwood has been reported in many ancient cultures, even though the history of agarwood use has still to be written. The Egyptians are believed to have used agarwood incense as part of their death rituals more than 3,000 years ago. It is also suggested that incense trade was in fact the first international trade route that existed in history. In Japan, agarwood is said to have arrived with Buddhism. In Vietnam ancient texts also refer to the use of agarwood in relation to traveling Buddhist monks. In the colonial literature in Southeast Asia (Indonesia and Malaysia, agarwood is often mentioned as a very important non-timber forest product (see for instance: Schuitemaker 1933; Dunn 1982).

Today the range of agarwood products and their uses is seemingly endless. Solid pieces of agarwood are highly appreciated as ‘natural art’ in Japan, Korea and Taiwan. Craftsmen carve raw pieces of agarwood into beautiful wooden sculptures. Agarwood is also turned into beads and bracelets. Most of the wood, however, is processed and either turned into oil which is used in perfumes and other cosmetic products, or the agarwood chips are ground into powder which is used as the raw material for incense making. Thin sticks are used to insert into cigarettes in for example Taiwan. Powder is also used in the production of traditional Chinese and Korean medicine, and for the preparation of (medicinal) wine and various other products.

The oil is mainly used in the Arab world where it is in high demand. It is by far the most precious of essential oils with prices reaching as much as ten times that of sandalwood oil (obtained from *Santalum album* and *Santalum spicatum*). The largest market for top class incense is Japan with its long tradition in incense making. Both the Arab countries and Japan are interested in high quality agarwood and manufacturers in these countries prefer to process the raw material themselves. This also avoids the mixing of high grade agarwood with wood of lower quality.

The oil is extracted from the agarwood through distillation. This delicate process determines both the amount and quality of oil produced. The wood is ground into very small pieces and/or powder, which are immersed in water and left to soak. Then the material is transferred to kettles and distilled. After heating, the condensed water and oil are captured in a container where the oil is separated and floats on top of the water. The water is removed and the oil is thus recovered. The price of high quality oil can be as much as US$30,000–US$50,000 per litre. This process can be repeated once or twice depending on the quality of the water and the costs of the distillation process. The powder which remains after distillation can be used for low grade incense making. It is estimated that for the production of one liter of oil up to 150 kg of agarwood is needed.

The most important use of agarwood is without doubt incense for religious purposes. Incense is used in a wide variety of religions. In fact incense plays an important role in almost all religions, because of its pleasant smell, its smoke rising to heaven, its purifying nature because of its relation fire and various other reasons. Some of the symbolic functions of incense that are mentioned in the literature about its religious use are the following:

1. Homage to God, the Gods or the ancestors and other spirits
2. Zeal of faithful to be animated
3. To accompany the prayers rising to heaven
4. To accompany the sacrifices made to heaven
5. In relation to death rituals, the safe passage of a deceased person to the after life
6. Cleaning/preparation of religious icons, altars and the religious officials (Groom 1981; Hoskin 1994; Catholic Encyclopedia 1998; Sinha 2005)

In comparison with the attention paid to the use and importance of incense in religious symbolism, it is surprising to notice how little attention is actually paid to the incense producing plants, including the *Aquilaria* trees. Other plants producing incense ingredients are frankincense (*Boswellia Thurifera*), sandalwood (*Santalum album* and *Santalum spicatum*), benzoin (*Styrax benzoin*), camphor (*Cinnamomum camphora*), and patchouli (*Pogostemon heyanus*). Little if anything is written in these publications on the production itself, the people involved in its harvesting or the status of the trees. Incense materials are in most cases obtained through complex trading networks involving collecting traders operating in the frontier of harvesting areas, wholesale dealers and distributors. Quality and price are the dominating factors involved, but giving the nature of the product it is evident that trust between sellers and buyers is of utmost importance. Only a small proportion of the agarwood users do harvest or grow agarwood themselves. Some Buddhist monasteries in Vietnam, Lao DPR and Thailand have agarwood trees planted in their gardens to supply their limited needs. In other cases supply is obtained through trade networks based on economic principles.

All actors involved in the agarwood business acknowledge that a large part of the trade takes place illegally. The CITES requirements are often not fulfilled. Sustainability of agarwood production does not seem to be a major concern for most traders and end users. As yet there is no certification system for agarwood comparable for instance with a Forest Stewardship Council (FSC) certificate for sustainably produced timber.

12.4 Wild and Cultivated Agarwood

For centuries agarwood has been harvested from natural forests. Usually *Aquilaria* or *Gyrinops* trees were cut and people looked for infected wood inside the stem of the tree. Highest quality agarwood can fetch as much as US$1,000 per kilograms. The agarwood trade has been connected to an ever moving frontier across the forest of Southeast Asia. Traders were continuously searching for untouched forests with stands of *Aquilaria* trees. The trees were fetching high prices and as a result, the news about agarwood harvesting spread like 'gold fever' among forest dwelling communities. Large sums of money and all kinds of luxury items were offered to the forest inhabitants in exchange for agarwood. In recent times this kind of 'agarwood fever' has spread in a similar fashion into the forests of East Kalimantan, Papua New Guinea, and Lao DPR. Interesting case studies have been written on this moving frontier of agarwood harvesting and their effects on the economy of the local, forest dwelling communities (see for instance Momberg et al. 2000; Wollenberg 2001, 2003; Zich and Compton 2001; NTFP Programme 2006). Usually this 'fever' was

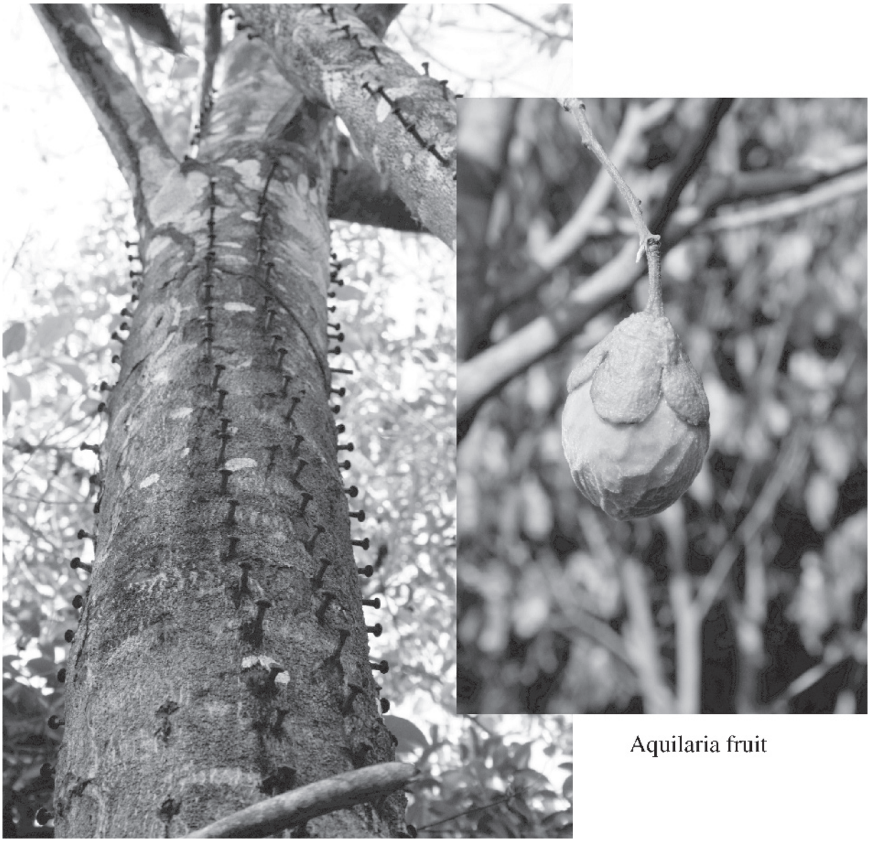

Photo 12.1 The application of nails to Aquilaria trees to agarwood growth (©GA Persoon)

only temporary. Once the largest trees were cut, new harvesting expeditions became less successful and just as in the case of gold, the collecting of small quantities of agarwood became a less rewarding activity. This method of harvesting however has lead to overexploitation of the resource, far beyond the reproductive ecology of the *Aquilaria* trees (Soehartono and Newton 2001).

The high prices for agarwood and the local depletion of resources in the wild have led to a variety of efforts to stimulate the growth of agarwood. Farmers started to integrate *Aquilaria* trees into their home gardens as these trees can easily be intercropped with other home garden tree species. Moreover the agarwood trees need little care during the first few years. The trees have to grow first before the agarwood formation can actually be started. These small holders use a variety of simple wounding techniques to start this process. Farmers in countries such as Vietnam, Lao DPR, Indonesia and India have gained some experience in the production of low grade agarwood. Axe wounds, severe bark removal, nailing and other types of wounding are being applied. These methods only yield small amounts of low quality resin for a limited period and due to their low yield, these methods may also lead to the destruction of trees. The most common method is the deliberate wounding of trees with large knives or the hammering of nails into tree trunks. The agarwood produced in this way is of inferior quality and can only used for home consumption, and low quality agarwood. Moreover high quality agarwood takes many years to develop and not many small holders are willing to wait that long.

12.5 Planting *Aquilaria* Trees for Agarwood Production

It is only during the last few decades that a more scientific approach has been developed to stimulate the cultivation of agarwood through artificial wounding of the trees. Planting *Aquilaria* trees has become a common practice now at numerous localities. In particular people who used to be gatherers of wild agarwood have started to grow *Aquilaria* trees in their home gardens or in their forest fields experimenting with all kinds of wounding techniques. More scientific experiments were set up by forest research institutions in several countries including China, India, Thailand, Vietnam, Bhutan, and Indonesia. In Indonesia for instance plantations are established in East Kalimantan, Lombok, Sumba and Papua. In some of these areas relatively large scale plantations are established with thousands of *Aquilaria* trees and substantial investments in processing units. In some cases these plantations developed out of small holder initiatives while in others enterprising individuals with business interests were attracted to the potentially high profits that can be made in agarwood production.

12.5.1 Agarwood Cultivation in Vietnam

One of the most successful efforts to date has been a project initiated in Vietnam. Several independent research initiatives were started in the middle and late nineties in Vietnam. One of these initiatives was The Rainforest Project Foundation's (TRP)

Agarwood Project which was partially funded by the European Commission. TRP started in 1993 in An Giang and Phu Quoc Island, two of the three last remaining areas with highly endangered and isolated *Aquilaria crassna* populations in the Mekong Delta. The third *Aquilaria* growing area in the Mekong delta is situated around Ha Tien City on the border of Cambodia and the gulf of Thailand, in Kien Giang province.

In An Giang *Aquilaria crassna* was still growing in the early 1990's as the result of natural propagation around a dwindling number of large mother trees. In 1993 only 13 larger, over 20 year old seed producing trees remained, with several hundreds of smaller trees providing regeneration. One plantation of around 50 trees had been established several years earlier. Phu Quoc still contained about 30,000 ha of disturbed, but viable lowland tropical forest at the time with some *Aquilaria* trees remaining. The Forestry Service of Kien Giang had planted about half a hectare in the early 1990s. All in all the entire *Aquilaria crassna* population in the early 1990s in the Mekong delta consisted of just a few thousand genetically closely related *Aquilaria crassna* trees. Today, at least half a million trees are growing in the delta in home gardens and plantations.

Photo 12.2 Preparation of Agarwood (Aquilaria crassna) seedlings in An Giang, Vietnam (©GA Persoon)

In addition to laboratory analysis, field experiments were developed. Local inhabitants in the An Giang Seven Mountain Area, including the Buddhist monks, had used various simple wounding techniques for generations. They had used the agarwood for personal and religious reasons for a very long period already. In the Central Highlands of the country nails were applied to *Aquilaria* trees to induce agarwood growth.

The experiments were undertaken with local farmers and provincial authorities. Building on their knowledge, experimental plots were developed to stimulate the production of agarwood. The new technology to cultivate agarwood in plantations was developed by a team of scientists at the University of Minnesota in the United States (UMN) led by Professor Robert Blanchette and Henry Heuveling van Beek of The Rainforest Project.

The Seven Mountain Area was a logical start for the project because of the familiarity of the farmers with small scale agarwood production. Some farmers had already started their small scale plantation even before the project had entered the area. This area had suffered heavily from the invasion of the Khmer Rouges guerilla before 1978. During that period thousands of *Aquilaria* trees were chopped down. The political unrest and the resettlement of the inhabitants in the decades that followed also negatively influenced the number of *Aquilaira* trees in this mountainous borderland with Cambodia. Once the situation slowly returned back to normal again, the monks and local people were faced with a shortage of agarwood for their ritual and traditional purposes. That is why the initial response to the idea to promote the growth of *Aquilaria* trees was very positive. At the start of the project, when it was proposed to initiate agarwood production on a larger scale, farmers pointed to the lack of income during an estimated five to seven year inception period. After that period farmers could start selling the first agarwood while replanting would also take place at the same time. In order to stimulate the planting of *Aquilaria* seedlings these were provided to farmers at no costs. During the first few years of the project the farmers would receive a payment for their investments on condition that they share the profit after harvesting. Four years after the start of the project, and that was still before the first harvesting took place, about 25,000 *Aquilaria* seedlings were planted in the Seven Mountain Area (TRP 1999).

In the years that followed numerous technical experiments were done in order to determine the optimal formation of agarwood. The experiments included the drilling of holes in the trees and the insertion of different combinations of chemicals and many different naturally occurring fungi into trees of varying age or size, density and degree of intercropping. A chemical treatment was added to the wound to encourage the trees defense mechanism which stimulates the production of the resin. After years of experimenting, the first trees were recently harvested and the production of incense made from the cultivated agarwood has begun. The success of the experiment means it will not be long before the technology spreads to other areas where *Aquilaria* trees are being grown.

Chemical analyses were conducted of the cultivated agarwood and these were compared with the chemical composition of agarwood harvested from forests. In the initial phase relatively good agarwood was produced after two years of wounding and treatment but based on continuous evaluation and improvement of the technology, this time frame has now been shortened to 15 to 18 months. The agarwood produced in this way turns out to be suitable for the production of incense sticks and medium grade oil (Eurlings and Gravendeel 2005, 2007).

In the past 10 years agarwood tree plantations really began to take off with an enormous boost in planting in the last few years. This was driven by the higher pricing caused by lack of supplies of forest based agarwood, and the successful inducement technology, fueled by hope and rumors as well as by serious concerted research efforts.

As stated above agarwood is the woody part of *Aquilaria* and *Gyrinops* trees containing resin. Agarwood only rarely and infrequently occurs in those tree species naturally. Wounding trees triggers resin formation. This resin in *Aquilaria* or *Gyrinops* trees forms very slowly and fills areas around the wound(s) to fend off pathogens such as bacteria and fungi.

A first generation of domestication processes was developed in 1996–1997, using drill wounds and a variety of biological agents such as fungi. However, while superior to previously known inducement methods, UMN/TRP research and hundreds of field tests showed limited amounts of resin formation and inconsistent results with this early technology.

In contrast, consistent results are obtained when the second generation advanced inducement technology is applied: holes are drilled into the tree in a particular pattern, a special mix of chemicals is inserted, and special PVC tubes are inserted and

Photo 12.3 Demonstration of Agarwood harvesting in An Giang, Vietnam (©GA Persoon)

remain in the tree for the rest of its life. Complete installation takes about 20–30 minutes per tree. TRP has designed agarwood inducement kits, which are now available in Thailand, Lao PDR Vietnam, and by 2008 in Malaysia and Bangladesh. The application varies according to tree size and the diameter at breast height (DBH). Kits will be provided in standard packages to treat different sizes of trees.

A third generation is now developed with a special re-treatment, which can be applied after 12 months to maximize resin formation. Harvesting can be initiated six to 12 months after the second treatment. Trees, which are allowed to grow longer, will produce higher quality agarwood.

TRP technology uses the entire tree to form agarwood; it is the least labor intensive and the highest yielding method for producing agarwood. Comparing TRP Cultivated Agarwood technologies:

Simple inducement (wounding)	First generation CA technology	2nd and 3rd generation CA technology
Only low yields	Low-medium yields	Highest possible yields
Commercially not viable	Commercially hardly viable	Commercially viable
Low cost/low return	Medium cost/low return	Medium cost/high return
I.P.R. acquired or pending	I.P.R. acquired or pending	I.P.R. acquired or pending
Low labor intensity	Medium labor intensive	Low labor intensive
Simple application	Complicated technology	Uncomplicated technology
Technology free	High costs to manufacture	Medium cost manufacture
Training simple	Training easy	Training easy
Slow	Duration 12–36 months	Duration 12–36 months
Not certified	Will be certified	Certified
Now applied	Applied small scale	Applied in trials
Scientifically tested	Scientifically tested	Scientifically tested

In the Seven Mountain Area hundreds of farmers have established their plantations in combination with the cultivation of other tree or food crops. Production of commercial agarwood has started. Incense is produced in the area and sold under the name of Scented Mountain *Cultivated Agarwood*. The quality is relatively good and is rapidly increasing.

12.5.2 Agarwood Production in Thailand

Thailand has been a traditional producer and consumer of relatively large amounts of agarwood. Over the years trade in the wide variety of agarwood products has developed in Bangkok. Large amounts of agarwood products not only from the country itself but also from neighbouring Cambodia and Lao DPR is channeled through the city to markets in East Asia as well as in the Arab world.

The declining supply has lead Thai scientists in combination with the private sector to set up some relatively large scale plantations. One of these plantations is run by a company called Krissana Panasin in Chantaburi in Southeast Thailand. Over the years it has established a substantial plantation of several hundred hectares, including nurseries and processing and distillation units. The research department of the company has been experimenting with all kinds of techniques to obtain the optimal quality of agarwood. There is a close cooperation with a number of scientists in the country. Moreover it provides seedlings to interested farmers who can produce agarwood trees on their own farm lots. The company has also been instrumental is the establishment of an organization called the Thailand Agarwood Grower Society to assist and train farmers, as small holder tree growers, in the cultivation of agarwood. It is a non-profit organization aimed to transfer knowledge on the whole process of producing agarwood in an effort to reach the quality standards of the Middle East.

The technology to wound the trees in order to start agarwood production is also provided to the small holder farmers by the company. In due time the trees are being sold for processing to the company as the farmers usually lack the connections and skills to organize the transport or processing to other buyers outside the area.

The company is not only involved it the cultivation of agarwood it also has started the production of a range of end products for which an extensive public relation department was established in order to reach whole sale traders in consumer countries directly. In this way it tries to by-pass the intermediate traders at least within Thailand but also in places like Singapore or Hong Kong which mainly serve as import and re-export sites.

12.5.3 Agarwood Production in Indonesia

All over Indonesia, in areas that used to produce agarwood harvested from the wild, local people have started experimenting in cultivating agarwood using a wide variety of techniques. In some cases forestry research departments of local universities are involved in the experiments as agarwood is considered one of the most valuable non-timber forest products with a good potential for forestry-based incomes. In East Kalimantan for instance forest scientists of Mulawarman University in Samarinda in cooperation with the research institute of the Forestry Department are involved in research on agarwood producing techniques to assist local farmers in finding new livelihood alternatives now the harvesting of wild agarwood is rapidly decreasing. Large scale logging sometimes followed by complete conversion into other form of land use like oil palm plantations or transmigration sites have led to an enormous reduction of ‘wild forest’ from which agarwood could still be harvested. In the efforts to promote agroforestry and in particular the production of NTFP’s agarwood is one of the main products. In addition research activities are undertaken for the production of other NTFP’s like rattan, *gemor* (tree bark used for the production of mosquito repellant), honey and birds’ nets (certain species of swallows) (Yusliansyah and Kholik 2003; Siran 2006).

Another area within Indonesia where agarwood plantations are being established at the moment is in the districts of Assue and Mappi in Southeast Papua. It is an area in which harvesting from the wild is largely a thing of the past. The agarwood ‘fever’ developed in this district since around 1995 but, just like in so many other areas, within a relatively short time the harvest was over and took place without any form of control. It did not only involve the local population but it attracted also large numbers of migrants invading indigenous territories. All major stands of agarwood trees have been exploited. In a kind of second or even third harvest people even dig up roots of trees in the swamps which might still contain some agarwood.

At the same time however a church based organization (Roman Catholic) has initiated a project to start the cultivation of agarwood. The project consists of three elements: the cultivation of *Aquilaria* trees, the technique of inoculation and the practice of harvesting. The main purpose of the project is to help the people in gaining a more sustainable form of livelihood. Nurseries are set up using seeds from a number of mature *Aquilaria* trees. The seedlings are being planted in combination with other annual or perennial crops. The cultivation fits nicely with other agroforestry practices promoting the planting of crops like rubber, dammar, sago, cashew and a wide range of other trees.

The process of inoculation can only be done when the trees have reached a minimal diameter. It is assumed that trees should be at least 10 cm in diameter and at least five or six years old before they can be treated. Holes are drilled and a fungus is placed in them. It is assumed that harvesting should not take place before one year after the inoculation of the tree, but the longer the harvest is postponed the more agarwood the tree will contain. Harvesting in itself is probably the most difficult aspect of the cultivation process, determining very much the quality of the agarwood chips and thereby the price of the product. One needs to carve out the infected wood carefully. The project is assisted by a scientist from the Mataram University on the island of Lombok who has gained some training and experience abroad. As yet there are no processing or distillation units available in the area. The chips are being sold to intermediate traders who eventually will trade the agarwood to Singapore.

At present some 400 farmers are involved in this project, each having planted twenty or more seedlings in their home gardens and agroforestry plots. It is hoped that the investment in agarwood seedlings, land preparation, tree care, inoculation and final harvesting will bear fruit in the near future. Whether this will in the long run also lead to some activities in the field of agarwood processing is not yet clear. It will require additional expertise and investments while in the end it is still the agarwood trader who determines the price of the product in whatever form it is offered to him (Ogi 2007).

12.6 Protection

As a result of serious overexploitation of agarwood from the wild, a number of measures to protect the *Aquilaria* trees, and thus ensure the survival of the trees in the lowland forest of Southeast Asia, have been taken. Production of cultivated agarwood seems to be a logical way out of this problem. Cultivated agarwood could simply replace the 'wild' agarwood. However, some representatives of conservation organizations point to an apparent lexical confusion as one of the main obstacles in this thorny trade domain. For some years the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has listed all *Aquilaria* species in its Appendix II. This implies the need to monitor the trade (both import and export) (Newton and Soehartono 2001). However, because agarwood is known across the world by many different names (such as eaglewood, aloeswood, *jinko*, *gaharu*, and *oudh*), and because it is used or even disguised in so many different products (such as oil, perfumes, incense, wine, wood dust and chips), tracking agarwood products requires highly sophisticated detection procedures which are not yet in place in most countries. This is one of the reasons why the illegal trade in agarwood cannot easily be stopped. One of the challenges ahead will be the differentiation between wild and cultivated agarwood. Without doubt some of these issues will be discussed during the next agarwood conference which will take place in a few years time. During the recently held Conference of Parties to the CITES convention (The Hague, 2–15 June, 2007) proposals were submitted through the plants commission to differentiate between the wild and cultivated agarwood products, in a way similar to many other products (like for instance crocodile skins). In this way export and import of cultivated agarwood products would become less troublesome. However these proposals were not adopted by the parties because of the lack of effective implementation methods.

12.7 Conclusion

It may come as a surprise to some that the chain of production to consumption of agarwood, does not enjoy any special position along the way until its final destination. It seems that it is only once agarwood has been turned into incense that it obtains a special status as a product to be used in rituals with a symbolic meaning. Until that moment it is devoid of any special relevance. It is just another object of trade and profit making even though the trade itself is highly specialized and requires substantial skills in terms of smelling, grading the quality and processing. The history of exploitation of agarwood producing trees does not seem to be any different from any other equally high valued but non-religious product. Resource extraction through an ever moving frontier leading to over-exploitation dominates its history. It is highly unlikely that this will change in the future in spite of some prevailing ideas to look for religiously inspired caring for the environment (Palmer and Finlay 2003).

The rapidly diminishing agarwood harvests from the wild have stimulated the production of agarwood through active tree planting and treatment by small holders throughout South and Southeast Asia. Initially the people involved in this domestication process were the same as those involved in the harvesting from the wild. But as domesticated agarwood is likely to become more important and more productive it also attracts the attention of potential investors from a number of countries. Plantations are already established in Thailand, India, Indonesia, Vietnam, Bangladesh, Lao PDR, Cambodia, Malaysia and others (small scale but also in Bhutan, China, Burma, etc.) Absolutely new on the scene are the business people from Australia and the United States. Having gained substantial experience in the production of sandalwood in Western Australia, some companies are now ready to turn their efforts to *Aquilaria* plantations which potentially could yield even higher prices per production or investment unit (Coakley 2007). These companies also have the possibility to plan for a more distant future than many small holder tree growers who, because of a shortage of resources to invest, require quicker returns for their investments. Harvesting at an earlier stage and thereby of lower quality will therefore be the result (see Fig. 12.1).

In the meantime, and as is the case with many other expensive products, there is an influx of fake agarwood products into the market. Some of these products go by the name of Black Magic Wood (BMW), and in fact are made from *Aquilaria* wood which has been impregnated with cheap artificial oil. It requires a trained eye and nose to differentiate real agarwood from these fake products however there is a ready market for this product, which however is often sold as genuine agarwood (in Malaysia, Thailand and middle eastern countries).

There are of course a number of questions to be asked in relation to the large scale domesticated production of agarwood: Can the high prices currently paid for agarwood be sustained if production is substantially increased? What will the quality of the cultivated product be? There are also concerns about the consequences of large-scale cultivation for the traditional producers of agarwood, the collectors inside the forested areas. It is generally assumed that the natural top quality agarwood will become rare but remain in demand, particularly in Japan. This ‘top end’ of the market cannot easily be replaced by cultivated agarwood. At the mid and lower level of the agarwood supply, it is predicted that there will be an increase in supply from the new areas. In the foreseeable future prices will remain high. However, a slow and gradual reduction in price is expected when large supplies enter the market in about 10 years as a result of this increased cultivation. Finally it is assumed that the production, and therefore the value, will gradually move from the original rainforest areas to plantations located in other areas. There are also other cases of non-timber forest products in the tropics of which the centres of production have been transferred to other areas. Rattan, orchids and various types of bush meat or animal skins

Type of activity	Producers
Harvesting from wild *Aquilaria* stands	Traditional forest dwellers
Harvesting from wild stands and deliberate wounding of trees	Forest dwellers and commercial collectors
Cultivating of wild trees and deliberate wounding	Forest dwellers and commercial collectors
Production of domestication trees, small plantations and new wounding techniques	Forest-based farmers, and neighbouring communities
Larger plantations and research based wounding and inoculation techniques	Local and national forest-based industries
Large industrial plantations at new (and distant) locations	Foreign forest-based enterprises

Fig 12.1 Stages in agarwood production

were originally products harvested from the wild by the forest dwelling communities earning a substantial part of their income by the hunting and gathering activities. However in all these cases new actors entered the scene, once domestication of the plant and animal species turned out to be a profitable business. In many cases and depending on the amount of technology and specialized labour involved, the productive units were transferred to other and often distant locations. People originally involved in the domestication process were not recruited anymore once sufficient seedlings or breeding animals were collected. Rattan and orchid gardens, crocodile and deer farms are just some of these examples. It is likely that a similar development might also take place in the future with respect to the production of agarwood. Most likely the forest based people will continue to harvest until collecting agarwood will no longer be rewarding. The technology involved in the artificial production of high grade agarwood and the need for technically high level processing units can not easily be organized by local producers. The more sophisticated producers, with more financial and technological means at their disposal can simply out-compete the local ones. In this process market forces and business opportunities are likely to completely dominate this development. Traditional growers of agarwood such as those in Vietnam and Thailand will easily be out-competed and become only the providers of the local demand for agarwood. They can only maintain a special position if a kind of differentiation in the market will actually take place for instance on the basis of the production methods or the area of origin. This may allow for an appreciation of the way agarwood is produced (e.g. by monks), or a positive appreciation for the locality where *Aquilaira* trees are grown. Differentiation based on certification of agarwood referring to its geographical origin, traditional methods of production, aspects of 'fair trade' or 'ethical shopping' in particular for an item that is used for religious purposes, might provide some relative advantage for small holder agarwood farmers. As yet however this differentiation is not yet in place. This fact indicates that the small holder agarwood farmers may be facing severe competition from large scale agarwood producers in other parts of the world. If the consumers of whatever kind of agarwood products are willing to include aspects like 'tradition', 'religiosity', 'original or indigenous producers', or 'fair benefits' in their considerations when buying agarwood products, then small holder agarwood farmers might have a chance to survive as suppliers of the 'wood of the gods'.

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Chapter 13

Local Vulnerability, Project Risk, and Intractable Debt: The Politics of Smallholder Eucalyptus Promotion in Salavane Province, Southern Laos

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Abstract This paper analyses the ideology, implementation and outcomes of a donor-based smallholder tree planting project in Lao PDR. Drawing on project documents and local level fieldwork in southern Laos, an analysis of the failure of this project to promote viable smallholder eucalyptus plantations is forwarded. The donor vision of producing new rural subjectivities, transforming subsistence oriented peasants into smallholder arboreal entrepreneurs was spectacularly unsuccessful. A series of unintended consequences resulted, which undermined both the livelihoods of enrolled farmers and the financial position of the key institutional partner, the Lao Agricultural Promotion Bank. This paper provides an analysis of this failure, emphasizing differing conceptions of and responses to vulnerability and risk between rural farmers in Salavane province and the project proponents. While maintaining interpretations which centre upon project mismanagement and corruption, this paper also argues for a perspective in which even failed donor tree planting projects are constitutive of broader patterns of political power, through which new ideologies of development are formulated and deployed. Drawing on the work of James Ferguson, David Mosse, and Gillian Hart, this paper argues that the ADB Industrial Tree Plantation Project provides an analytical window into the nature and exercise of state power, donor influence, and the politics of agrarian transformation in globalizing Laos.

Keywords Asian Development Bank, Laos, project failure, rural debt, smallholder eucalyptus

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"*The problem is not one that can be solved by bureaucratic tinkering with the formal design of the institutions and processes involved, since it is a problem not of formal structures but of the actual function and substance of real relationships, which reflect the nature and exercise of power in rural society*" (White 1999: 251).

13.1 Introduction

Is the promotion of commercial smallholder tree plantations an appropriate rural development strategy in contexts of severe rural poverty and livelihood vulnerability? In Southeast Asia, this question is an important one, for guiding more effective state policies and donor projects. Given the questionable track record of success of public sector investments into forestry in Asia (Mir 2003), and often serious problems of mismanagement, corruption, and poor planning which have arisen, there are serious questions concerning the actual utility of smallholder tree planting projects for poverty reduction in the region. Despite numerous documented problems, the popularity of smallholder tree planting programs for bilateral donors and development banks continues, in large part due to the pressing situation with respect to forest degradation and rural poverty in much of Asia. The most immediate goals of smallholder tree planting are often to raise rural income levels by successfully linking farmers to new national or regional markets for forest products (see Scherr 2004). When combined with improvements in rural governance and removal of restrictive policy barriers, smallholder forestry can serve as a basis for additional objectives. Benefits are thought to follow from securing tenure rights, including facilitating access to sources of formal credit, which can promote virtuous cycles of investments in productivity. The requirements of smallholder forestry programs for official tenure security may also form a basis for promoting ecological conservation, and possibly, for developing markets for ecosystem services (e.g. Scherr et al. 2002).

However smallholder tree planting projects are about much more than the technical practices of planting and growing trees on farms. Different groups of people can impute very differing meanings and objectives into tree planting activities, and this in turn can have a major effect on project outcomes and the 'success' of farmer-led forestry (e.g. Schroeder 1999 on tree planting and gender relations in the Gambia). As major donor-based smallholder tree planting projects can involve considerable financing packages, they can also present significant opportunities for elite actors to influence resource allocations in contexts of uneven governance controls. Tree planting projects can thus become arenas for political control and patronage, and there is a constant potential for scarce public funds and donor resources to be misdirected or rendered ineffective as smallholder tree planting projects to fail in field implementation.

In bringing into focus the political relationships and project framings of local poverty and vulnerability which can characterize smallholder tree plantation efforts, this chapter looks at the Asian Development Bank funded Industrial Tree Plantation Project (ITPP), implemented in Laos between 1994 to 2003. The chapter will proceed in three sections. First, I introduce the policy context and ideology of smallholder tree planting programs in Laos, as situated in a broader framework of state-donor forestry and agrarian policy reforms. Next, is a description of the ADB ITPP project and its outcomes, through an analysis of project documents, participant interviews, and ethnographic, local-level field work from an ITPP smallholder tree planting community site in Salavane province, southern Laos.

The chapter then turns to how diverging objectives and ideologies of tree planting held by different project actors combined to contribute to a broad-based failure of the ITPP smallholder tree planting effort. A key point of this chapter is how an analysis of local farmer skills, capabilities, and vulnerabilities was underemphasized through the first ITPP project phase, in the ITPP project evaluations, as well as in the ADB project documentation in support of a proposed second phase (for which eventual agreement between the Government of Laos and the ADB could not be reached). It is argued that the active imputing of significant risks of plantation failure onto impoverished smallholder farmers in Laos leads not only to questions of the structural constraints farmers faced in undertaking tree growing activities, but arguably raises questions concerning irresponsible lending practices by the donor agency.

The fact that the smallholder-entrepreneurial vision of the ADB ITPP project resulted in failed plantations, and increased rural debt and poverty, does not simply mean that this particular project was unduly characterized by ‘poor design and management’ or that it was ‘ridden with corruption.’ While these may be important conclusions to draw, many other donor-financed tree planting projects, in Laos and indeed the region, have met with similarly outcomes.[1] In fact, the regular ‘failure’ of donor-based smallholder tree plantation projects in Southeast Asia does not appear to be significantly hindering their continual reiteration. Vietnam for example, has recently attracted US$60 million in funding through an Asian Development Bank (ADB)-Trust Fund for Forests project (Vietnam News 2007). This comes in addition to a major World Bank project investment into Vietnam’s forest sector, which includes a significant smallholder component, of nearly US$50 million (World Bank 2004).

This paper argues that our understanding of the ‘functional utility’ of donor-based plantation promotion projects can be situated within broader practices of aid policy and development (Ferguson 1994; Mosse 2005). Smallholder tree planting projects can be usefully seen as complex and unstable arenas for the exercise of power, in which the linkages established between enlisted farmers, project trees, state institutions and donor networks, are reflective of broader political configurations.

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[1] See for example, the Japan International Cooperation Agency’s FORCAP smallholder acacia planting project in Vientiane province Laos, or the ADB’s Compensatory Tree Plantation project in peninsular Malaysia.

Through the practices of tree planting, new power relations and ideologies of state development are established and re-worked through different scales and institutions (Hart 1989; White 1999). In the example I present below, the ADB ITPP project can provide an analytical window into the nature and exercise of state power, donor influence, and the politics of agrarian transformation in globalizing Laos.

13.2 Forestry and Agrarian Policy in Post-socialist Laos

Contemporary forestry and agricultural policy in Laos needs to be understood in relation to the historical and political-economic context of post-socialist Lao PDR. From 1975, political power and decision making control in Laos has been centralized into the Politburo of the Lao Communist Party. There is a very low tolerance for political dissent, and no independent domestic media. On the other hand, due to a national infrastructure destroyed by war time bombing, inaccessible terrain, and historically autonomous provincial principalities, until recently central level authorities in Vientiane have held only a tenuous ability to implement state building projects in the countryside (Stuart-Fox 2004). These contradictory aspects of political and institutional culture in Laos continue to frame the ways in which development policy interventions have been implemented in the ‘post-socialist’ era (Evans 1995). Added to this are other features characteristic of political arrangements in Laos, including: low levels of institutional capacity and inter-bureaucratic coordination; inaccurate or missing information on investment flows and budget expenditures; poor skills training and education for lower level state authorities, inadequate salaries for civil servants; and significant governance issues. These problems are not unrelated to a long history of conflict precipitated by more powerful military powers. This mixture of history and politics in Laos, which is to a degree distinctive, lends itself to a proliferation of central target-driven agrarian planning, which then experiences a high rate of implementation failure and rural avoidance (e.g. see Evans 2005 on the experience with socialist-era agricultural collectives in Laos).

The World Bank (2006: 36–39) has identified further problem areas in the Lao agriculture and natural resources sector. Together, they represent a severe structural challenge to the Ministry of Agriculture and Forestry (MAF) in implementing sustainable forest management and rural development policy.[2] These identified issues include: (i) shortfalls in actual central budgets allocations to provincial and district authorities, leading to the adoption of autonomous revenue generation strategies by

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[2] An analysis of these structural political-economic factors assist in moving the debate beyond one of rent seeking in the Lao forestry sector, although there remain significant problems with forest governance in Laos. See Hodgdon (2007) for one account of how provincial level authorities in Sekong province actively undermined a successful donor-funded village participatory sustainable forest management initiative. Other interpretations of forest policy failure focus on personalized and family-based networks of political patronage (e.g. Singh 2007).

provinces, and poor budget expenditure tracking and project monitoring by both the central and local levels; (ii) a donor-driven agricultural development sector in which the majority of rural expenditures are in the form of 'off-budget' projects, which present difficulties for the central government in terms of effective monitoring and co-ordination; and (iii) in part due to the above, provincial levels in Laos have incurred significant debts to private contractors for state work programs, which then tend to be reimbursed through the allocation of logging quotas.

The Government of Laos Forest Sector 2020 Strategy document, the official plan for the sector, includes ambitious targets aimed at reversing a rapid decline in the nation's forest resource base. State planners stipulate that forest cover should increase from 41.5 percent (mapped in 2001), up to 60 percent by 2020. Informed observers however have communicated to the author that the actual figures for forest cover in Laos are moving in the opposite direction, and that forest cover will continue on a sharp decline, likely coming in at less than 30 percent by 2012. Plantation forestry has in turn been identified by the MAF as a key technical approach to boost forest cover. The official policy target in Laos is to establish 500,000 ha of industrial plantations by 2020, largely though foreign direct investments. In addition to leasing large-scale tracts of land to private sector companies, smallholder farmers in Laos represent an alternate, *in situ* approach to promoting reforestation. Smallholder tree plantations might also then aid in reducing poverty in the countryside, and, by transforming the rural peasantry into 'arboreal entrepreneurs', helping to move Laos out of 'Low Income Status' by 2020.

Given the chronic fiscal shortfalls faced by the Lao government, the implementation of this strategy is reliant upon donor funding. Through the 1990s, the ADB's Industrial Tree Plantation Project (ITPP) was the major tree planting donor initiative active in Laos. It focused on establishing eucalyptus plantations through both corporate-concession and smallholder-outgrower approaches, on identified degraded lands.

The next sections focus on the ADB ITPP project, outlining the formal goals and reviewing the outcomes of this effort. Following this, the paper shifts focus, to the perspectives of villagers from an ADB smallholder plantation site in Salavane province, southern Laos. This will help to explore the ways in which the implementation and the evaluations of the ITPP project, as well as the planning documents for a proposed Phase 2 project, tended to frame peasant realities in the Lao countryside in ways which matched the project's plantation promotion mandate.

13.3 The Lao PDR-Asian Development Bank Industrial Tree Plantation Project: Outline of Project Activities

The Asian Development Bank funded Industrial Tree Plantation Project was a significant loan and grant facility aimed at transforming a national forestry sector characterized by unsustainable and illegal logging of natural forests, and deep levels of institutional corruption, into an efficient, competitive wood fibre producer.

The project was designed to operate from 1994–2001, although the field implementation was not established until 1997, due to initial institutional delays. As a result the closing date for the project was extended to 2003, in order to provide continued support to the Lao institutional partners. By its conclusion, the ITPP project involved a total expenditure of US$15.4 million, including US$10 million in ADB financing. The ADB provided a soft loan to the Lao government in support of the project, charging one percent interest per annum, with a 10 year grace period and a 40 year loan maturity (ADB 2005a: ii–iii). The ITP project funding was to generate a 13 percent internal rate of return, via an average production of 128,000 cubic meters of wood per year, which would generate $2 million (in 1993 dollars) in exports per year (ADB 1993).

The primary objective of the project was aimed at establishing 9,000 ha of fast growing tree plantations on unstocked and degraded forest land, and to promote a national policy and institutional framework supportive of industrial plantations and forestry investors. ITP project funding was channeled through the newly established, state-owned Lao Agriculture Promotion Bank (APB). Onward loans in support of tree planting were then extended to secondary borrowers, organized into three borrowing classes: companies, individual-entrepreneurs, and small farmers. The ITPP was not conceived of as 'community forestry' – this was intended as a market-based plantation program aimed at the provision of formal, subsidized credit to the top class of skilled farmers, entrepreneurs, and companies. The loan conditions for second-step borrowers included an interest rate of seven percent per year, with the a maturity date of eight years for farmers and 12 years for companies, including an interest grace period of 6 years. Extension support and training for smallholder tree planting was initially provided through the MAF, and then, in 2000, by the newly established National Agriculture and Forestry Extension Service (NAFES) under the MAF. A total of 19 ADB missions were sent in support of the project between 1992–2005. The project's progress was reviewed by ADB missions four times between 1994 and 2003, receiving a 'satisfactory' rating on each occasion (ADB 2005a: v).

While the original design was weighted towards extending credit to companies and individual entrepreneurs, the project experienced early difficulties in identifying interested firms in Laos that qualified for the loan facility, as well as with other regulatory issues which acted to block the enrollment of larger plantation investors.[3] In an effort to meet loan disbursement and plantation establishment targets, the strategic emphasis of the Agriculture Promotion Bank shifted mid-project towards extending more loans to smallholder peasant farmers. In response to this slow rate of secondary loan disbursements, in 2000 the ITPP Project Coordination Unit (PCU) made a key decision. The PCU decided to expand the geographic scope of the project, from the original design which targeted eight districts in four provinces; up to 32 districts in seven southern Lao provinces (see Fig. 13.1). This geographic expansion of the project range proved successful in increasing the rate of loan disbursements, and

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[3] ADB (2005a: 2) states "… a lack of adequate land classification/allocation systems to identify suitable plantation sites, and cumbersome customs procedures designed to preserve natural forests also hindered the participation of foreign investors."

eventually the project exceeded the planting target of 9,000 ha. By December 2003, approximately Lao Kip 58 billion (US$7.15 million) had been lent to onward clients; with the final borrower profile including 2,496 smallholder families, 166 individual entrepreneurs and 10 plantation enterprises. According to NAFES, by the project closing date of 2003, some 12,940 ha had been planted with fast growing tree species, largely eucalyptus. Despite some delays and challenges, it appeared that the project was broadly on track to establishing a viable plantation sector in Laos and a supporting credit culture for plantation development. In 2003, the ADB provided funds in

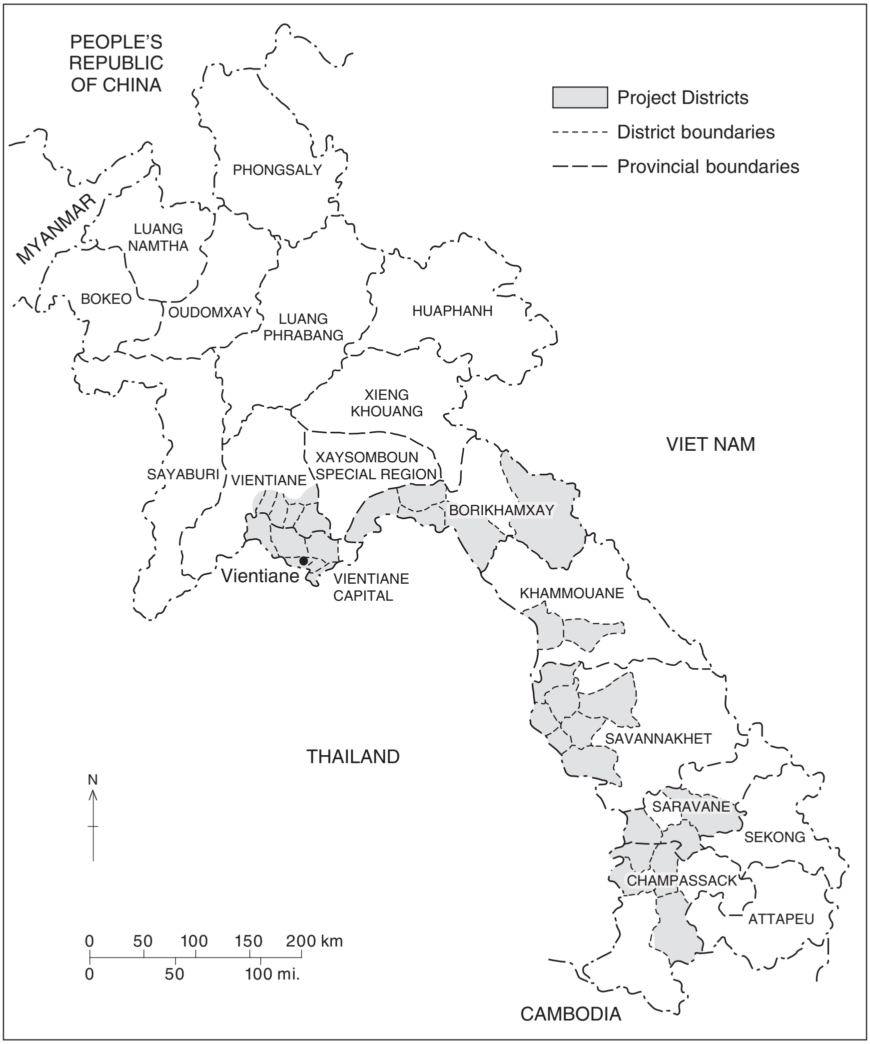

Fig. 13.1 Map of Laos showing locations of the eventual 32 ITPP target districts

Table 13.1 ITPP project credit summary (ADB 2005a: 38)

Administrative Area	No. of Households[a]	Individuals	Enterprises	Total Number of Loans	Total Area Planted	Amount of Loans (KN million)
Vientiane Municipality	17	46	6	69	5,402	39,108
Vientiane Province	208	33	0	241	1,159	2,668
Borikhamxay	729	50	1	780	2,359	5,987
Khammoun	0	1	3	4	245	1,439
Savannakhet	565	24	0	589	1,889	4,855
Saravan	502	2	0	504	939	2,070
Champassak	475	10	0	485	904	2,114
Total	2,496	166	10	2,672	12,897	58,240

[a] Loans to households were mostly done through group loans, so the total number of loans for this borrower class is recorded as less than the beneficiary households.

support of a Preparatory Project Technical Assistance (PPTA) grant, to prepare the framework for a Phase 2 project.

Table 13.1 details the geographic pattern of project disbursements. The data shows a significant portion of the total project loan portfolio was extended to borrowers from Vientiane Municipality – where 46 individual planters and six enterprises accounted for a majority of the total funding extended. Hundreds of smallholder families were also enlisted into the project in locations extending into the deep south of Lao PDR, including as far as Champassak and Salavane provinces.

13.3.3 ADB ITPP Project Evaluations

Throughout its operational period, external observers had been critical of the ITPP project in Laos (see Lang 2001, 2003, 2006). This critique identified the significant subsidies extended to plantation companies, the potential adverse ecological effects of eucalyptus, a lack of public consultation by the ADB, and the potential problems for local livelihoods when swidden agricultural land was zoned for industrial plantations. Even projects critics however presumed that the majority of the eucalyptus trees planted through the ITPP would result in generally productive plantations. Without approvals from higher-level officials, independent researchers and civil society actors can experience difficulties in gaining access to research sites in rural Laos. Thus, there was little independent information available concerning how the project was progressing in specific communities.

Internal ADB sponsored project field surveys conducted in 2003 began to reveal a series of concerning problems with the yields of the smallholder plantations. Lao

APB surveys showed that the area actually planted with tree seedlings represented only 60 per cent of the area for which loans were extended (ADB 2005b: 36). Analysis in the ADB's project completion report (ADB 2005a: 4) showed a similarly worrying discrepancy. The extent of smallholder credit default was also becoming clear, with APB data indicating that up to 87 per cent of the sub loans extended to early borrowers were non-performing by December 2003. At the end of 2003, the ITPP project alone formed approximately 45 per cent of the total loan portfolio of the Lao APB (ADB 2005a), implying that the APB itself was heading towards insolvency. Even without the high levels of default, the inflation rate in Laos through the project period often reached much higher than the seven percent interest rate charged in the ITPP loans, particularly in the years following the 1997 Asian financial crisis. The actual commercial lending rate in Laos was generally between 20 to 30 percent through this period, implying that the ADB and Lao APB were distributing credit at an extreme discount." Overall, in 2003 the Lao APB was holding 108 billion kip in non-performing loans, representing 46 percent of the institution's gross loan portfolio (ADB 2005a). The ADB advised that APB would require significant re-capitalization from the central Bank of Laos to remain financially viable, even as the ADB's own ITP project represented the most direct contributor to this situation.

As mentioned, in 2000, as the project was experiencing difficulties in identifying suitable borrowers under the initial screening format, the Lao Project Coordination Unit extended its geographical scope to include more districts. Many of the eventual 32 districts which were included in the extended target area were likely outside the transportation range of any wood buyers.[4] The closest major pulpwood purchaser for plantations in central and southern Laos, is the Phoenix Pulp and Paper factory at Khon Kaen, northeast Thailand. Thus, even if the subsistence-oriented farmers enrolled into the project were successful in achieving the minimum annual growth rates, for many there would be no existing, viable market for their trees.

Yet, by 2003 the smallholder eucalyptus trees were clearly showing very poor growth rates. For corporate tree plantation projects in the region, a mean annual increment (MAI) of approximately 18 to 20 cubic meter per hectare is generally considered as the minimum rate which will provide an adequate return on investment. But mensurational surveys of smallholder and individual eucalyptus growers enrolled in the ITPP project indicated MAI's as low as one to three cubic meter per hectare per year. Given their scattered locations in smallholder plots, these yields would render it grossly unprofitable to even harvest the trees. Indeed, it appears that the majority of the smallholder plantations under the ITPP were a complete

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[4] Given prevailing prices, the maximum overland hauling distance for pulp logs is usually considered to be in the range of 250 to 300 km. However, from 2000 in Thailand, there has been a cyclical reduction in the supply of pulpwood logs, leading to increased competition between Thai pulp factories for supplies. As a result the Thai source ranges have extended into Laos. This situation is not expected to remain in place permanently (see Barney 2005). Even with these extended supply ranges, sites such as rural Salavane province would have remained outside of the interest of these Thai buyers. There may have been a limited number of smaller wood purchasers, located in southern Laos.

financial loss for enrolled farmers. In some locations the author visited in Salavane province, the smallholder eucalyptus plots had long been abandoned, and were overgrown with dense underbrush.

In an internal evaluation of the ITP project, ADB (2005b: 37) summarized the situation:

> "The ITPP hinged on the prospect of a market rather than on actual markets…The ITPP failed to improve the socioeconomic conditions of intended beneficiaries, as people were driven further into poverty by having to repay loans that financed failed plantations… ITPP adversely affected the financial health of APB and undermined the development of rural finance in the Lao PDR."

What had gone so wrong with this multi-million dollar ADB project investment in tree planting in Laos?

13.4 ADB Interpretations of Project Failure

The ITPP project was subject to a project completion report (PCR), completed in November 2005 (ADB, 2005a), and was included in a broader Sector Assistance Project Evaluation in December 2005 by the ADB's Operations Evaluation Department (ADB, 2005b). These project evaluations identified a host of problem areas with the project, involving both the ADB and its hired consultants, and the key Government of Laos institutions. The key overarching interpretations of project failure in these documents include: (i) inadequate ADB assessment of the capacities of Lao institutions, and inadequate supervision of the project by the ADB (ii) effective tree planting extension services under NAFES were not established, (iii) the poorly planned mid-term geographic expansion into 32 districts undermined the development of plantations within core areas, and further stretched the capacity of project extension and marketing services (iv) the entire project was based upon an assumption that markets for pulpwood in Laos would appear spontaneously once the project was underway, it was not based upon existing market opportunities, (v) the provision of loans to foreign, private firms raised questions about the overall justification of using public sector financing for this purpose (vi) the Lao Project Coordination Unit was focused on meeting physical planting targets, and not enough upon acceptable plantation management and promoting market access. The ADB's rating of the project was abruptly changed to 'unsatisfactory'.

The ADB's (2005a:22) assessment of the more immediate technical failings, in terms of low smallholder yields, identified the following issues: (i) "questionable farmer motivation" to grow trees, which led many farmers to skip fertilizer applications, (ii) poor quality growing stock, (iii) weakness in extension services, a lack of effective training for farmers leading to inappropriate site selection, and problems with plantation management, especially with fire and termites, (iv) poor adoption of intercropping options by farmers, (v) a lack of APB experience in provision of credit, leading to problems with timely provision of inputs, and (vi) marketing challenges.

The ADB's 2005 evaluation reports were more directly critical of the bank's own performance, identifying problems with short-duration missions, high staff turnover, a lack of forestry specialists in review missions, insufficient assistance from project consultants, questionable interim assessments which continued to provide 'satisfactory' ratings, and a period of 20 months from 2000–2001 where no ADB review missions were sent at all. Notably, the ADB asserts that this 20 month period when all decisions were made by the Lao Project Coordination Unit coincided with the timing of the decision by the PCU to expand the project from eight districts in four provinces, to 32 districts in seven provinces.[5]

Included in the ADB internal evaluation document was the following stark assessment:

> "Thousands of inexperienced farmers and individuals were misled by prospects of unattainable gains, leaving the majority of farmers with onerous debts, with no prospect of repaying their loans, and with failing plantations." (ADB 2005b: 37)

Echoing Ferguson's (1994) analysis of development projects in Lesotho the very failure of the first ITPP project seemed to form a justification for a second project phase. In a report to the ADB Board of Governors (ADB 2005c: i) in preparation for the proposed Phase 2 of ADB-Laos plantation project, entitled the Lao Forest Plantation Development Project (FPDP), the following surprising lessons were drawn from the ADB's ITPP experience:

> "…ITPP has established that: (i) efficient forest plantations of all sizes are financially viable, and (ii) existing Government institutions have inadequate capacity to provide effective support to this important and emerging sub sector."

The Phase 2 ADB-FPD project was in turn designed as a US$15.35 million dollar project, including a $7 million loan and a $3 million grant facilities to the Lao government from the ADB. The new project would correct the major institutional problems encountered in the ITPP through the creation of an autonomous, para-statal Lao Plantation Authority (LPA) (ADB 2005c). Run at arms length from government, the LPA would be a 'one stop window' for private sector investment into the Lao plantation sector. It would be free of the suggested incompetence and rent-seeking predilections of Lao organizations, and headed by an internationally-recruited Chief Executive Officer. The LPA would operate according to strict principles of revenue generation, competitiveness, and transparency. The main revenue source for the LPA was to be derived from the annual land rents charged to multinational plantation companies, who would be enticed into investing in Laos by LPA's investment promotion activities. LPA would also hold an important regulatory function. It would coordinate land use and concession agreements for major corporate investors, as well as conduct environmental and social impact analyses of the plantation investments, in-line with international standards. A goal of the FPDP was to attract at least one major international wood pulp manufacturing complex into Laos.

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[5] It is worth mentioning that an ADB-approved feasibility study, completed in 1992, originally targeted these seven Lao provinces along the Mekong River as "…*prima facie* suitable for industrial tree plantations" (ADB 1993: 1).

Continuing with the experience gained in smallholder plantations, a new Phase 2 program of 'livelihood plantations' would be established, which would enlist up to 2,000 additional smallholder farming families into growing pulpwood plantations. Based on the lessons of ITPP, under FPDP, farmers would only be included into the project if they were located in three geographically restricted 'clusters', within a 25 to 30 km radius. It was suggested that this would allow for three critical masses of smallholder plots, of between 3,000 to 3,500 ha. The clusters would each produce sufficient wood fibre to attract a value-added processor, for example, a modern, medium-density fibreboard (MDF) factory. Similar to ITPP, it was concluded by ADB analysts that wood markets would spontaneously develop after a valuable plantation resource was established (ADB 2005c: 9).

The primary objective of the FPDP project was aimed at aggressively expanding corporate investments into concession-style pulpwood plantations. Critics, including this writer, pointed out that rural Laos represents an agrarian context where tenure rights between the state and communities are still unclear; where state policy emphasizes rapid modernization in the context of significant local reliance upon subsistence and common property resources, and where a vulnerable rural population is effectively excluded from participation in the policy process by central authorities. FPDP documents did little to assuage concerns that customary local access to important common property resources and upland swidden fields would be zoned for corporate-industrial tree plantations, by a para-statal corporation with a direct financial interest in doing so. There was also no effective institutional mechanism proposed which would independently represent the best interests of rural communities, introducing a classic conflict of interest into the LPA's mandate. The ADB's own project documents continued to refer to degraded swidden lands in Laos as having "little or no alternative economic value" (ADB 2005c: 8), even though years of applied research in Laos had provided clear evidence for the importance of such forest-land resources for rural livelihoods (e.g. Foppes and Ketphanh 2000).

From one perspective, few real lessons seemed to have been learned from the failure of the ITPP in the preparations for the Phase 2 FPDP. The new project proposed to work around the capacity constraints of Lao forestry institutions by establishing a parallel, semi-privatized organization. The LPA would recruit its employees from the top ranks of public sector institutions, undermining the capacity of these agencies. Secondly, vulnerable smallholders in Laos would again be enlisted into a relatively high risk tree planting project. Although a new equity sharing and profit sharing framework was established, small farmers would again be enlisted to produce plantation timbers without a proven market. The inclusion of the smallholder component into the FPDP appeared to many to be an attempt to incorporate a 'poverty alleviation' mandate into the project. Arguably, the overall project design was focused upon a set of neoliberal-inspired policy reforms favouring the entrance of major plantation firms, and rezoning access to common property land and degraded forest resources in Laos in pursuit of more efficient (corporate) market production.

With respect to the financial after-effects of Phase 1, ADB project officers recommended – despite the acknowledged institutional shortcomings of the Lao project partners with the implementation of the credit disbursements – that the non-performing loans arising from the ITPP should be addressed through a redoubling of the enforcement of loan covenants by the APB. In an astounding move, which (perhaps willfully) glossed over the reality of their project's activities in southern Laos, the ADB project officers forwarded:

> "Loan applicants were screened closely by both NAFES and APB, and most farmers and individuals who qualified for the loans were *not particularly poor*. The farmers owned farmland, livestock and various other assets." (ADB 2005a: 81, *italics added*)

For critical observers, the ADB approach in the Lao plantation sector raised a series of red flags. Negotiations for Phase 2 proceeded through 2005 and 2006, however the ADB and Lao government failed to reach an agreement. A main issue was the line of authority within the proposed, semi-privatized LPA. Perhaps unsurprisingly, actors within the Lao Communist Party and the Lao government were uncomfortable with the notion of creating a new institution which would be responsible for a key resource sector, but which would be managed outside of direct state control. As of January 2007, the validity period for the Government of Laos to approve the new loan and grant facility for the FPDP had expired, and the project had lapsed into inactive status. Soon afterwards, the interim-LPA chief technical advisor, an ADB consultant, left Vientiane.

While stating that most enrolled farmers were 'not particularly poor', ADB documents provided little insight into how local farmers interpreted their involvement in ITPP, or how they viewed the issues and constraints which may have affected their performance as smallholder tree farm entrepreneurs. What assumptions, for instance, were packed into the ADB statement concerning a 'questionable motivation to grow trees' on the part of ITPP smallholder farmers? In the next section, a closer analysis will inform an understanding of how this forestry promotion program functioned in actual communities, and in the political-institutional context of rural Laos.

13.5 Perspectives on ITPP Smallholder Tree Planting from Ban Naa Pang Yai, Salavane Province

In this section, I explore the ways in which villager perspectives differed from formal policy and project assumptions and objectives in the ITPP project. I also interrogate how the ADB evaluations and technical assistance documents – considered here as a set of "second order rationalizations" to a complex set of ongoing events transpiring in the field sites (Mosse 2005: 132–133) – only selectively incorporated local perspectives and outcomes into the design for a second project phase. This section reverses the approach of the paper as presented thus far, and travels *from* the field-operational world *back to* the conceptual, central planning world; or *from* messy and contingent local practices and outcomes, *to* donor-project rationalizing (Mosse, 2005).

Field research in Ban Naa Pang Yai was carried out in relation to a broader dissertation project on resource tenure, rural livelihoods and commercial forestry programs in Laos. In Naa Pang Yai village, this involved four extended stays of four to five days each, between July 2005 and August 2006. In depth, qualitative interviews were conducted with a random selection of 18 households who had received ITPP loans, out of a total number of 92 village households, and out of 32 total ITPP participating families in Naa Pang Yai. Provincial level officials accompanied the researcher and field assistant on initial trips, but after confidence has been established, the researcher and assistant would go to visit the village without official escort.

Naa Pang Yai is a predominately ethnic Lao, wet rice farming village, located about 15 km from the provincial centre at Salavane town. The village is located along a rural cobble stone road; a sure indication in southern Laos that the route was constructed as a section of the ‘Ho Chi Minh Trail’ during the Vietnam-American War. The forest cover, outside of villager paddy fields in the area is a patchy, dry dipterocarp forest, which becomes extremely dry in the hot season and susceptible to fire. From villager interviews there was never any shifting cultivation practiced in this lowland site, which would appear to make Naa Pang Yai a poor match with the ADB/Government of Laos forest strategy goals of “…reforestation of denuded and degraded areas and stabilization of slash-and-burn farming” (ADB 1993: 3).

The primary source of livelihood in Naa Pang Yai is single crop, non-irrigated wet rice farming. Secondary activities include raising livestock and trading animals for sale in the district centre, local wage labour (largely involving sawing construction timbers by hand, which can provide an income of about \$1.50 day^{-1}), and collection of a range of household food resources from the surrounding environment (Photo 13.1). Depending on the season, these include fish, frogs, insects, and edible mushrooms. *Kiisi* resin[6] is one locally important non-timber forest product (NTFP) which is often sold to passing Vietnamese traders, the collection of which can generate US\$20–30 in wet season income per household. The physical environment in the dry season in Salavane district however is harsh, and the village forests in Naa Pang Yai are dry and relatively unproductive compared with nearby districts in southern Laos. Other minor commercial products sold from the village are charcoal and rice whisky. One villager, the assistant headman, owns an electric rice milling machine, which along with a small tuck shop and petrol kiosk, provides this wealthiest of families with regular cash income. Approximately 50 percent of the 92 village households in Naa Pang Yai do not produce sufficient rice for their annual requirements. The poorest five households, including a number of female headed households, have no farmland, and no tractor or buffalo to prepare rice fields for planting. Both land and draught buffalo must be rented annually by the most disadvantaged households, at high rates of interest.

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[6] A damar resin from *Shorea spp*., particularly from mai si (*Vatica cinerea*), a common dry evergreen forest tree species in Laos.

Photo 13.1 Smallholders digging for insects in their rubber plantation, Salavane, Laos PDR (© K. Barney)

According to the headman, there are a number of primary reasons why villagers would be considered as 'poor' in Naa Pang Yai. These factors include: (i) a young, recently married family (ii) inherited little land from their parents, (iii) loss of a spouse, and (iv) requirement to rent land and/or buffalos for agricultural production. As in many areas of rural Laos, migration is also having a deep effect on village social structures. In 2005, four or five villagers were working in Salavane capital in the state bureaucracy, another four or five villagers worked in Vientiane capital, and 15 to 20 teenagers had migrated across the Mekong for risky and illegal labour market opportunities in Thailand.

In terms of core knowledge capabilities, interviewed villagers consistently rated highly their abilities to farm wet-rice successfully, even under prevailing conditions of poor soils and an unpredictable climate. Paddy yields however are generally low if compared to other lowland districts in Laos, at about two tonnes per hectare with fertilizer. Rice yields drop by half without fertilizer applications. Villagers rated their knowledge of markets, and abilities in negotiating commercial transactions, as one of the areas they have the least amount of knowledge. As the soils in the village are drier and less productive than, for instance, in nearby Lao Ngam district, farmers in Naa Pang Yai do not plant teak, coconuts, rubber, or coffee, crops which are widely planted on the slopes of the Bolavens plateau. Previous to the arrival of the ADB ITPP project, Naa Pang Yai farmers had no experience with commercially-oriented tree planting.

Core vulnerabilities in Naa Pang Yai village are closely related to differential access to productive land, and the requirement to sell their rice crop in advance of the harvest, at near-crippling rates of interest, for access to land, draught buffalos, or to purchase agricultural fertilizers.[7] Health care represents a second area of vulnerability: a child's encounter with malaria could mean expensive stays in the district hospital, incurring costs in the range of $50 USD for a four-day stay.

The ADB Industrial Tree Plantation Project arrived in the village through visits by Provincial Agriculture and Forestry Office and Lao Agricultural Promotion Bank staff. The first year, only three Naa Pang Yai villagers agreed to enroll into the project. Others were reticent to enter into such a significant debt relationship. The loans on offer by the project to participating farmers were without precedent. Participating farmers received loans of more than 3.5 million kip per hectare in 1999 and 2000 (approximately US$350 at current exchange rates), including direct cash inputs of approximately 1.3 million kip per hectare (US$130) to compensate for the required wage labour and other inputs. For farmers proposing to plant three hectares of eucalyptus, this could involve loans of greater than 10 million kip (US$1,000).

By the second year, 2001, the promotional campaign by the provincial officials from the APB and NAFES had improved. Naa Pang Yai villagers reported that officials promised significantly increased incomes for participating farmers. A Naa Pang Yai villager recalled the promotional tactics of the project staff: "if you now have a bicycle, after planting eucalyptus you can have a motorbike!" Enrolment rates into the ITPP project in the district soon picked up. An additional 29 families from Naa Pang Yai made the decision to take out APB loans and plant eucalyptus in 2001, as did many other farmers from nearby villages. For a peasant whose wage labour rate from sawing wood in 2005 was US$1.50 day^{-1}, or from working in a nearby brick factory was $0.80 day^{-1}, the APB loans involved significant sums of cash income.

In 2000 and 2001 therefore, the village was flush with cash. With no previous experience with formal credit, and with a project that was heavily promoted if not pushed upon them by local officials seeking to meet the central targets, some farmers in the village made 'off-project' spending decisions. Metal roofing for leaky houses, household implements, and bicycles for transportation were common purchases – all functional additions to their livelihoods. In interviews, farmers reported using these cash inputs to address other core vulnerabilities, including health costs for children with malaria; paying down personal debts; or purchase of draught livestock, or even additional land.

Fertilizer and fencing material inputs were provided by the ITPP in kind. Almost all interviewed farmers in Naa Pang Yai reported applying their ITPP fertilizer inputs upon *both* their rice fields *and* the new eucalypt plantations. It is worth noting

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[7] Villagers report that renting a buffalo from a non-relative or close acquaintance could cost up to 60 *taeng* of rice from the harvest. This is equivalent to approximately 600 kg of rice, up to 1/3rd of the eventual yield from 1 ha for some farmers. Interest rates on advance fertilizer purchases are reported as between 25 to 40 percent.

that these could all be considered as rational farmer choices, aimed at addressing very immediate livelihood concerns, and in some cases alleviating direct household food insecurity. These villager poverty-reduction decisions and investments were not however in line with ITPP project directives for livelihood improvement.

As documented in the ADB's own macro-project reviews, there also were many problems with plantation establishment in the case of Naa Pang Yai. The key project inputs, healthy eucalypt seedlings, were in many cases not delivered until July or later, which is the very peak period for labour intensity in the Lao agriculture calendar. As a result, sometimes there was no time to actually plant the seedlings until September or even October, which marks the beginning of a six-month dry season. The quality of the seedlings provided by the company[8] contracted by the provincial forestry office was also reported to decline in the second year by villagers. Fencing materials could arrive even later than the seedlings, which meant that some smallholder trees were trampled by grazing livestock after planting.

Not all of the implementation problems can be traced back to problems with project disbursements. Many farmers in Naa Pang Yai actually suggested that one of the reasons they felt that their eucalypt trees were performing poorly was that village children tended to burn the scrub forest in the hot season, to flush out rodents and other animals for food. Often, these fires would enter into a farmer's eucalypt garden, causing damage to the trees. Such unruly livelihood practices are only incorporated into the analytics of large, modernizing, donor funded projects with great difficulty.

From interviews, and from fieldwork observations of how provincial project officials interacted with villagers during my visits, the provincial extension service was seriously inadequate to their task of facilitating farmer knowledge of tree growing. Many Naa Pang Yai farmers reported that I and my field assistant were the first people to come to look at their plots. Villagers reported that PAFES extension advice and management instructions were delivered through verbal seminars at meetings, not through actual site visits and demonstrations.

Today, the results of the ITPP project in Naa Pang Yai village are clear to anyone with even a passing knowledge of eucalyptus forestry. Despite the genuine efforts of the villagers, all of the smallholder plots in Naa Pang Yai are complete financial losses. After five or six years their trees have diameters of two to three centimeters, with spindly, one to two meter trunks, diseased leaves and patchy crowns. In extended interviews, not a single Naa Pang Yai farmer held accurate information concerning what the market price of a ton of eucalyptus was, or what their options were for selling any marketable trees. It was commonly thought that the Salavane provincial forestry office, the APB or even the ADB might come to purchase their eucalypt trees when they matured, which is most certainly not the case. Many villagers interviewed during the course of research were not yet aware, or perhaps did

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[8] Reported as DAFI, *Department of Agriculture and Forestry Industries*, a state-owned forest and logging company based in Pakse.

not wish to admit to being aware, that their plantations were in fact complete failures, and that the ITPP project had landed them directly into very serious financial difficulties.

By 2005–2006, staff from the provincial APB branch were making visits each month to the district collect interest payments on the ITPP loans.[9] Villagers in Naa Pang Yai would pay small sums of 10–20,000 kip (US$1–2) during these encounters, if anything. One woman voiced the following, widely held perspective of her encounter with the project:

> "*The Agriculture Bank invested in me to plant the trees, and then they calculated the interest and capital. I would sell the eucalyptus to the APB and profits would go to me. But now they come each month to ask for payments on interest, and I have no money to pay. I don't pay the interest so far. I said to them, 'you provoked me to plant, and you said you would come to buy the eucalyptus*!' "

Another man forwarded:

> "*The project was supposed to be for the poor. But we do not agree with this project. Maybe the answer is that the people did not understand so well…The project was not such a good idea, and I worry about paying the money back with my family budget. But no way, I would not plant eucalyptus again.*"

It bears noting that the provincial staff directed the author and research assistant to this village. Naa Pang Yai was considered as among the 'top 3' ITPP villages in the district. In other villages, in Salavane's Lao Ngam district which the author visited briefly, many of the farmer ITPP eucalyptus plantations could not even be located through the dense forest regrowth.

There are additional issues which act to counter the stated goals of the project. Under the Lao Forestry Law, farmers who plant seedlings above a density of 1,200 per hectare are to be exempt from paying land taxes on those parcels. In Naa Pang Yai, farmers continue to pay land taxes to district officials, even on their failed eucalypt plantations which should have qualified for this tax break.

The failure of the ADB ITPP project in Naa Pang Yai is already having ripple effects onto other livelihood activities in the village. Because they cannot repay their loans to APB, the entire village of Naa Pang Yai is now no longer eligible for subsidized credit for fertilizer purchases, a program the APB usually extends to rural communities in Laos. As a result, villagers now have to borrow in advance for purchasing fertilizers from district traders. As noted, this involves repayment terms of up to 40 percent interest (which is in addition to the terms of credit for anyone requiring draught buffalo and/or land). These onward livelihood effects could be made much worse if villagers are forced into a full repayment of the ADB loans. In Naa Pang Yai, this would seriously impoverish many participants, and for most there would be little way of meeting the full repayment terms without selling off core assets. Usually, this would mean livestock. For some, they would have no other asset as a basis for repayment, besides their land and homes.

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[9] How the current APB loan collection program relates to the original project design, which was to grant a six-year interest grace period, is unclear.

13.6 Peasant Subsistence Risks, Market Risks, and Investment Risks

> "The biggest risk is not taking one." – ADB (2005d: 18)
> *Model for the Proposed Lao Plantation Authority*

The primary activities of the Asian Development Bank in Laos are organized around delivering and managing loan and grant programs for rural poverty reduction, through environmental management and private sector development. Another crucial function of the development banks is the management of external perceptions of Laos as a high sovereign investment risk country. For example the Phase 2 FPDP plantation promotion project was to include a *US$200 million* political risk guarantee for facilitating foreign direct investments (ADB 2005c). And based on the field experiences with the ITPP Phase 1 project, it was concluded by the ADB project managers that a smallholder pulpwood plantation sub-sector in Laos could only develop in relation to assistance and expertise from private plantation actors.

As indicated in Table 13.1, a majority of the ITPP smallholder loan recipients were from peri-urban areas around the cities of Vientiane and Savannakhet. However there were also many smallholder loan recipients from more marginal provinces such as Salavane. The poor performance and outcome of the first ITPP project, especially in these peripheral areas raises significant questions concerning the weighting of market and livelihood risks by the project. In Ban Naa Pang Yai, it is clear that the extent of the project risks borne by peasant farmers was unacceptably high. Arguably, insufficient analysis and conceptualizing of smallholder risks in Laos characterized both ITPP and the design proposals for a Phase 2 project.

For peasant farmers in Naa Pang Yai, the 'biggest risk' was indeed to agree to accept a loan for an unproven forestry technology from the ADB, with no market, no extension advice, and delayed or inadequate provision of technical inputs. Many farmers in Naa Pang Yai are barely able to produce a sufficient surplus of calories and cash income to feed their families. Under these conditions, the decision to use the cash and fertilizer input facilities of the smallholder loan program to spread their livelihood risks, and to address immediate household vulnerabilities, was a rational approach based on a rural-peasant's perspective of risk reduction. Yet, such understandings of peasant vulnerabilities and responses to risk were never featured in any ADB project planning documents. The messy contingencies which characterized villager's actual interactions with the ADB's ITPP eucalyptus program did easily not fit with the project's view of marginalized Lao farmers as incipient 'arboreal entrepreneurs', who would, with the proper incentives, organize their conduct only around silvicultural imperatives and the seven year planning horizons required for growing eucalypt trees. Another reason for this lacuna concerning peasant livelihood and risk on the part of the ADB may have been that smallholders were always conceived of as subsidiary tree planting actors. The primary goal of the ADB project designers, particularly evident in the Phase 2 proposal documents, involved career-building loan tranches, concession-based plantation production involving large companies, and the creation of a modernized, globally competitive pulp and paper sector in Laos. The tension between these two forms of plantation promotion, concession versus smallholder, was arguably never resolved.

13.7 Smallholder Forestry, Development Failures, and State Power in Laos

This chapter makes a case that smallholder forestry programs need to be considered in terms of how the development objectives become transformed through state practices and village realities during implementation. In the case of the Industrial Tree Plantation project in Laos, a full understanding of the rationales of the Lao institutional actors involved is difficult to gain. As a project which was evaluated as a failure (even though a series of mid term reports deemed it 'satisfactory', see Mosse 2005, for a discussion of the social production of 'success' and 'failure' in contemporary development), some of the associated actors were not interested in discussing its progress and outcomes. Indications of additional objectives which became attached to the project by state actors in Laos can however be gleaned from project documents. Drawing from Ferguson (1994), next I consider less whether the project was a success or failure, but what nevertheless were its 'functional effects' in terms of state power. That is, what do such development programs accomplish, even through their ostensible failure.

From the financial perspective of the ADB, the success or failure of their projects does not affect the fact that the terms of the agreement are being upheld and they receive monthly payments from client governments on their loans. The continued failure of their projects could eventually make state governments more reticent to accept the loans, and indeed this may have been part of the reason why agreement for the Phase 2 project was not reached. The ADB consultants, similarly, have received their salaries, although for them also, continued involvement in failed projects may eventually undermine their legitimacy as technical development experts. The Agriculture Promotion Bank is now in serious financial constraints as a result of the project, although officials with the bank who directed loans through personal networks or to ghost borrowers would have captured their share of the project largesse. For APB and NAFES, the project certainly helped to extend their presence into many new districts in Laos. As Ferguson (ibid.) suggests, it is this element of extending and intensifying state power through even failed donor projects, which may represent an ultimate 'rationale' for development.

The process whereby the project expanded from eight into 32 districts between 2000–2001 is also highly suggestive concerning the interests of central level state actors in Laos. It is notable that this was also the 20 month period when there were no ADB missions were sent to monitor the project's progress, and the Lao Project Coordination Unit (PCU), comprised of high ranking officials from the relevant Lao ministries, was making all key decisions (ADB 2005a). In the 2003, Preparatory Project Technical Assistance documents, which led up to the formal Phase 2 proposal, interviewed officials from various departments, including from the APB and the MAF, were in near unanimity that the Phase 2 proposals should further extend the scope of the project into the northern mountainous provinces of Laos. This recommendation was forwarded despite the fact that the move to expand the ITPP project in 2000 resulted in isolated and uneconomic smallholder plantations (even if they had produced adequate yields), because of the distances to potential markets. What made the PCU and other Government of Laos officials interested in pushing for an expansion of the project's geographical scope into further mountainous and remote areas?

A complete response to this question will remain partial, however smallholder tree planting activities can usefully be contextualized into a broader ideology of forest and development policy in Laos. Linking farmers to new forest and agricultural markets and new tree crops, including pulpwood, but also teak, rubber, or agar wood, is such an alluring prospect for government officials and planners because it simultaneously addresses so many key Government of Laos directives. Tree planting is viewed as a means of halting shifting cultivation; of rehabilitating degraded forest; of restricting farmers to sustainable land uses within smaller, officially zoned and titled plots of land; of encouraging (or coercing, if need be) the transition of rural people more fully into market relationships which will solve rural poverty; and of increasing forest cover (directly through tree planting, and indirectly, through stopping swidden). Aided in part through such donor-based tree planting programs, the delineation of state land and community land in Laos's forest-lands can then be established, and organized for improved biodiversity conservation, logging, or agricultural concession schemes.

All of these new spatializations of livelihood and development, linking farmers, land, trees, and markets, tends to increase the resources and patronage opportunities which flow through the central government and the Lao Communist Party, and acts to facilitate the extension of central state power in Laos. In a country which, until recently, powerful provincial governors acted if not independently, then in flexible arrangements with the central administration (Stuart-Fox 2004), direct incentives exist in Vientiane to expand centrally-administered projects into additional areas. Given that each ministry and department in the Lao state apparatus can act in competitive arrangements with each other, donor projects represent a crucial source of resources which can be distributed through these organizations. It is likely true that development projects which result in local impoverishment as opposed to poverty alleviation can undermine the state's legitimacy in the countryside. In general however, rural peasants in Laos are almost completely excluded from the political process, by both the potential force of the state, and by their own immediate livelihood vulnerabilities. In Laos therefore, 'development' involves numerous political balancing acts, between the increasing trend towards resource capture and rent seeking by state and party-linked elites, competition between state departments, and central-provincial-district actors, and to an extent, demands for genuine and beneficial livelihood options by peasants in the countryside.

13.8 Conclusion: Placing Donor-Led Smallholder Forestry in Political Context

This chapter has analyzed the outcomes of a multi-million dollar ADB smallholder pulpwood plantation project in Laos. The above sections have made three key points in relation to smallholder forestry programs: how the ITPP project fit into the broader ideology of forestry and agrarian development policies in Laos; how farmers' conceptions of risk were not incorporated into the ITPP project and the proposals for a Phase 2 project; and how the implementation and effects of the ITPP project was transformed through Lao institutions and village realities. It is also argued that it can be useful to move beyond narrows interpretations of the 'failure' of the ADB's efforts around smallholder tree plantations in Laos, especially given that project implementation failures are rather common in Laos. It may be more useful, following Hart (1989) and White (1999) to place rural development with state patronage and the structural power relations which characterize rural society in Asia. From Ferguson (1994), we can ask what this project worked to *accomplish* even though the fact that most of the trees planted were complete silvicultural and financial losses. Building on Mosse (2005), we can also question how 'success' and 'failure' are interpreted and socially produced through project evaluation, analysis and documentation, and with what implications for new reiterations of development.

I will make a couple of remarks for what this analysis implies for understanding smallholders and tree planting adoption in Asia more broadly. First, in locations of severe livelihood vulnerability and at times food insecurity which are targeted for smallholder agro-forestry, local issues and conceptions of livelihood risks could benefit from further understanding and elaboration. This will be particularly important as state and donor policies in Laos moves vulnerable rural communities towards a fuller integration with global market forces, in significant part through tree planting development and land rezoning.

Secondly, the ITPP project's broad failure to produce an economically viable production base of smallholder livelihood plantations, speaks perhaps less to an incipient process of the 'proletarianisation' of Lao peasant farmers through outgrower or contract plantation schemes (e.g. Little and Watts 1994), as much to the politics of aid program (dis)implementation in authoritarian, post-socialist Laos. In Ban Naa Pang Yai, farmers have few options to directly contest the problems they have encountered with the ADB program, although they do attempt to avoid the APB's demands for interest repayments. Up to 2006, APB had not applied more forceful pressure upon non-performing loan households in Salavane province, although the ADB has recommended such an approach. It remains unclear for how long peasant farmers in Laos will remain patient in their responses to state-donor development interventions which directly undermine their livelihoods.

Third, this study implicitly suggests that analysis of smallholder tree planting programs in Southeast Asia can to be understood through more than technically-oriented regression modeling of farmer decision-making patterns, or through analysis of the local factors influencing agro-forestry innovation and diffusion (cf. Mahapatra and Mitchell 2001; Mercer 2004). Overly abstracted or formalized understandings of market opportunities and the competitive advantage of smallholders in national or regional forest product industries should also be treated with caution (cf. Scherr 2004). While such approaches contain their insights, one cannot separate smallholder forestry from a broader political-economy of aid and development. As White (1999: 251) indicated in the introductory quote to this chapter, it is also important to locate smallholder agro-forestry within the "… actual function and substance of real relationships, which reflect the nature and exercise of power in rural society." Lastly, and at minimum, a 'do-no-harm' principle could be adopted for smallholder agro-forestry programs. Indeed, publicly funded donor agencies such as the Asian Development Bank should be held to much greater account for documented instances of funded projects which leads not to livelihood improvement and poverty alleviation, but directly to intractable debt and impoverishment.

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Part IV
Smallholder Tree Growing for Environmental Services: Practices and Potentials

Chapter 14
Improving Productivity, Profitability and Sustainability of Degraded Grasslands Through Tree-Based Land Use Systems in the Philippines

C.D. Predo[1]* and H.A. Francisco[2]

Abstract This study aimed to quantify and analyze the productivity, profitability and sustainability of alternative land uses in the degraded grasslands using a bioeconomic modeling approach. It was conducted in Claveria, Misamis Oriental in Mindanao, the Philippines. Results of bioeconomic analysis showed that tree-based land use systems have significantly higher financial profitability and environmental benefits. The latter were measured in terms of higher carbon sequestration, least soil erosion, and sustained soil nutrients relative to current farmers' practice of maize cropping. Despite these, survey results showed the extent of tree farming remains low (<10 percent of land area). The risk analysis indicated that while timber-based systems earned the highest net present value (NPV), they seemed to be the most risky options as reflected by the high coefficient of variations of the NPV ranging from 164 percent to 205 percent. The study recommended measures to reduce price risk and the need to improve risk management capability of farmers to promote expansion of smallholder tree farming. Provision of relevant and timely price information and price risk insurance are such possibilities. It is also suggested that payments to farmers for environmental services like carbon sequestration be explored to encourage expansion of tree-based land use systems.

Keywords Bioeconomic analysis, carbon sequestration, *Imperata* grasslands, land use, risk analysis, tree growing

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14.1 Introduction

Uplands are important geographical components of Philippine agriculture. Vast areas of the uplands in the Philippines are covered with grassland vegetation mostly dominated by *Imperata cylindrica* or cogon indicating low soil fertility and productivity level. Historically, these vast degraded uplands are the results of a land use transformation from natural forest to grassland areas through shifting cultivation and consequently into permanent agriculture due to increasing population pressures in the uplands (Bandy et al. 1993; Garrity and Agustin 1995).

Traditionally, shifting cultivation is sustainable with interspaced long fallow periods. When the fallow period shortens, soil fertility declines significantly. Grasses invade areas with soils low in organic matter and prone to soil erosion. In the Philippines, the environmental consequences of shifting cultivation in upland areas are severe and widespread with soil erosion as the worst outcome (World Bank 1989). Estimated total annual soil loss from the Philippines varied from 74.5 million tons (DENR 1992) to 80.6 million tons (Francisco 1994). Soil erosion is a natural process, however, it is greatly accelerated by human activities.

The intensive cultivation of upland areas without adopting appropriate soil conservation practices produces high rates of soil loss and threatens the long-term sustainable productivity of the upland resource base (Francisco 1998; Nelson and Cramb 1998). This has serious implications for the economic welfare of a growing upland population with few feasible livelihood alternatives. There is evidence to claim that the future of low input shifting cultivation in the uplands is grim (Menz and Grist 1998). Where smallholder farmers continue intensive cultivation without applying new technologies or inputs, returns to labor will fall and most of these upland farms will no longer be viable (Menz and Grist 1998; Nelson et al. 1998; Magcale-Macandog et al. 1998a). The challenge therefore is to improve the productivity and profitability of degraded uplands by enhancing (and subsequently maintaining) the environmental quality of this resource in order to achieve sustainable livelihood among upland smallholders.

Tree-based farming systems are potential profitable alternatives for improving the productivity and sustainability of marginal upland areas. Tree growing is recognized to be effective in the control of *Imperata* and other grasses through shading (Menz and Grist 1996; Gouyon 1992). It also provides additional public benefits in the form of carbon fixation by sequestering atmospheric carbon through their growth process (Nowak 1993). Tree growing is the only known practical way to remove large volumes of greenhouse gases (GHGs), especially carbon dioxide (CO_2), from the atmosphere (Trexler and Haugen 1995). CO_2 is the most abundant and important GHG under human control (Moura-Costa 1996; Houghton 1996) and it is expected to account for more than 50 percent of the radiative forcing of GHGs released from human activity over the next century (Houghton 1996; Houghton et al. 1990).

In this study we aimed to quantify the economic and environmental impacts of grassland conversion to tree-based land use systems. Specifically, we here (i) estimate and analyze the private profitability, social and environmental benefits of smallholder tree-based land use systems at the farm level in terms of carbon sequestration, soil fertility and erosion, and long-term productivity; (ii) assess the degree of economic risk associated with each alternative land use system of degraded uplands; and (iii) draw policy implications related to productivity improvement and sustainable land use in degraded uplands in order to achieve sustained livelihood and, at the same time, protect the environment. To answer these objectives, the rest of the paper is organized as follows. Section 14.2 presents the methodology, particularly the bioeconomic modeling procedures employed in this study. It is followed by the results and discussion of findings in Section 14.3 and by the conclusions, policy implications and recommendations in the last section.

14.2 Methodology

A bioeconomic analysis (Fig. 14.1) was carried out to determine the economic and environmental impacts, including carbon sequestration benefits of tree-based farming systems vis-à-vis current cropping or land use system. The biophysical component was modeled and simulated using Soil Changes Under Agroforestry (SCUAF) version 4.0 (Young et al. 1998). SCUAF is a simple, deterministic model that can be used to predict crop yield as a function of changes in soil carbon, nitrogen and

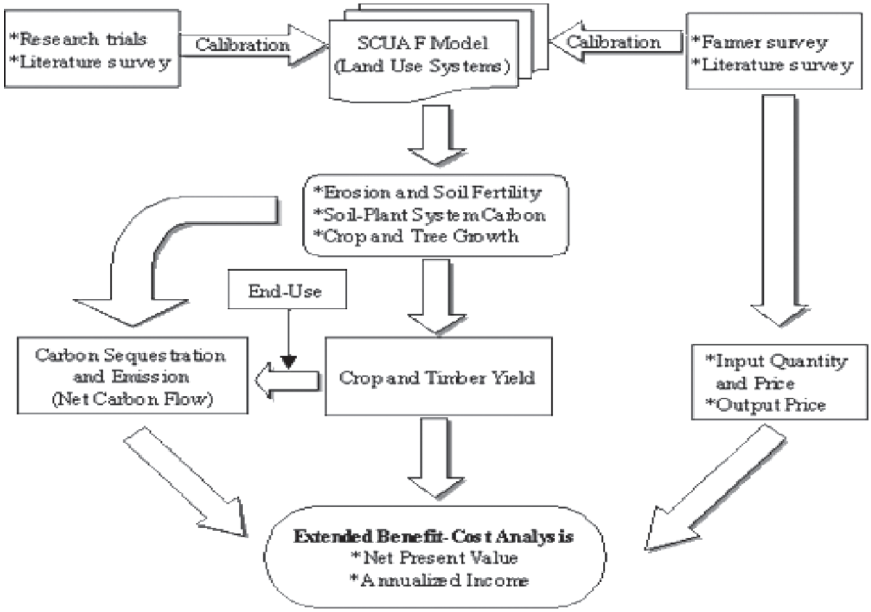

Fig. 14.1 Economic valuation framework used to quantify the impacts of alternative land use systems

phosphorus content. These changes depend on various plant and soil processes taking place for each land use system.

Data from research trials and literature surveys were used in calibrating SCUAF. The major inputs or parameters in the model include soil profile/characteristics, soil erosion, plant growth, plant composition, removals (harvests), and transfer (pruning). SCUAF determines plant growth and soil changes on a per hectare basis. Hence, the systems under study are modeled on a hectare of landholding. Land use systems were specified in the SCUAF model and the simulation outputs[1] served as the basis for the analysis of economic and environmental outcomes. The associated economic model was implemented through the extended benefit-cost analysis (BCA) framework.

14.2.1 Sampling and Data Collection

The study was conducted in four villages in Claveria, Misamis Oriental, the Philippines. The criteria for village selection included the presence of mixed land use systems and accessibility. In each village, respondents of households with farms contiguous to each other were selected for the household survey. A total of 192 farmers were interviewed, among who tree-based farming systems adopters and non-adopters were identified. The identification was based on their current land use and particularly on whether or not they had planted trees on their farms. This method of classifying respondents served as the basis in the data analysis.

This study utilized both primary and secondary data. Primary data such as socio-economic and farm characteristics were collected through a survey using a pre-tested structured interview schedule and a key-informant interview. Other primary data collected include landholding, land use patterns, and other relevant information.

14.2.2 The Study Site

Claveria, Misamis Oriental was chosen to be the study site to calibrate the model for the following reasons: (i) it is considered as a representative *Imperata*-dominated grassland area in the Philippines, which meets the centre of interest of this study; (ii) the area has been subjected to long-term government and non-government interventions relating to soil conservation practices; (iii) there is significant adoption of soil conservation practices and transformation of *Imperata* grassland into tree-based land use systems; and (iv) availability of biophysical and economic data for model parameterization.

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[1] Changes in soil carbon, nitrogen and phosphorus contents resulting from soil erosion, recycling of plant materials and mineral uptake in a specified land use system within a given environment.

Claveria is located 40 km northeast of Cagayan de Oro. It lies on an undulating plateau between a coastal escarpment and mountainous interior, ranging in elevation from 200 to 500 m above mean sea level. The soil in the site is well-drained oxisol, acidic (pH between 4.5 and 5.0), and has a soil profile depth of more than 1 m (Garrity and Agustin 1995). The study site has an average annual rainfall of 2,000 mm for a 5-year period (Limbaga 1993). The wet season is from May to October while the dry season occurs for the rest of the year. The majority of the crops planted include root crops, tomato, and maize, with maize being the dominant crop and is used as staple food and animal feed. Tree farming of fast-growing tree species (e.g., *Gmelina arborea*, *Acacia mangium*, and *Eucalyptus deglupta*), is emerging in the area.

14.2.3 Estimation of Carbon Sequestration

Carbon flow (in the form of CO_2) in crop or forest production depends on two processes: fixation (assimilation) and emission processes. The former represents the biomass growth in living crop/trees (in CO_2 equivalents) due to photosynthesis, while the latter represents the biomass decay of the wood (in CO_2 equivalents), resulting from natural mortality or human related removals and end-uses. For this study, the carbon flow for each land use system was estimated using SCUAF by simulating the net carbon gains/losses from plant-soil system carbon and annual emissions from decaying biomass.

The SCUAF model simulated the changes in plant-soil system carbon annually as the difference between total carbon gains and losses for each system. Gains for plant-soil system carbon are from the atmosphere like photosynthesis or net primary production, and from additions of organic material from outside the system. Soil carbon arising from organic matter or leaf litter decomposition is accounted for in the gains from photosynthesis. Carbon losses, on the other hand, are those from harvest, burning, erosion and oxidation. The mathematical derivation for the calculation of net carbon flow is given in Appendix 1.

14.2.4 Land Use Systems Modeled in the Study

The study modeled six land use systems based on the existing and potential land use transformation pathways for *Imperata* grassland (Table 14.1). Farmers at the study site practiced these systems singly or in a portfolio of farming systems as a household livelihood strategy of reducing income risks.

IMPLUS refers to *Imperata*-dominated grasslands that have not undergone any burning or cultivation. In the modeling exercise, 100 percent of the area of the one-hectare farms was devoted to *Imperata* and 95 percent of above-ground biomass was consumed by grazing animals (cattle) during the year while the remaining parts

Table 14.1 Description of land use systems considered in the study

Land use system	Description
IMPLUS	*Imperata* land use for animal pasture or grazing system
FPLUS	Farmer's current practice of annual maize cropping system (100 percent of the area devoted to maize)
TIMPLUS	Timber species with *Imperata* for animal pasture or silvopastoral system (85 percent is allocated to *Imperata* and 15 percent is planted to trees)
TCLUS	Timber species planted in hedgerows with annual maize cropping system at the alley areas (85 percent is devoted to maize and 15 percent to timber)
TCSFLUS	Timber-maize system where bigger area is planted to timber species in hedgerows with annual maize cropping at the alley areas (40 percent devoted to timber and 60 percent devoted to maize)
TPLUS	Timber plantation land use system (100 percent of the area devoted to timber)

were allowed to regrow in the subsequent year. FPLUS refers to a continuous open-field maize cropping system where soil is cultivated prior to planting maize seeds. In the model, inorganic fertilizers were applied during the growing season at 60 kg ha^{-1}/cropping for nitrogen and 24 kg ha^{-1}/cropping for phosphorus. The FPLUS was modeled with 100 percent of the area devoted to maize production.

In the case of TIMPLUS, 85 percent is allocated to *Imperata* (treated as crops) and timber trees occupy only 15 percent of the total area. Modeling scenario for TCLUS was based on current land use practice in the area where 85 percent is allocated to maize cropping at the alley areas and the remaining 15 percent is planted to timber species in hedgerows. TCSFLUS, a variant of TCLUS system, is an adaptation of the social forestry agroforestry model where 40 percent is planted to timber trees in hedgerows while the 40 percent alley areas is devoted to annual cropping of maize. Two tree-species were modeled in the timber-based systems: (i) *Gmelina arborea* (non N-fixing tree) and *Acacia mangium* (N-fixing tree). Except for TCSFLUS system, all tree-based systems allocated 60 percent of the tree component to *Gmelina arborea* and 40 percent to *Acacia mangium.* In TCSFLUS system, the tree component was planted equally (50 percent of 0.4 ha) to both timber tree species. Timber seedlings were planted with 3 × 4 m spacing, yielding a density of 834 trees per hectare. A block planting method was used for timber plantation system (TPLUS). Pruning of branches and twigs of trees were done in all tree-based systems during the first 2 years of the rotation interval to induce straight growth of *Gmelina* and *Acacia*.

Farmers preferred to cut *Gmelina* trees at seven years (Magcale-Macandog et al. 1999), however, majority of tree growers in the survey reported the best age to harvest

Gmelina and other fast-growing timber tree species was between eight to 10 years. Thus, an optimal rotation interval of 10 years was specified in the model for timber trees. Simulations were run for two cycles of tree growth or 20 years in all land use systems. The analysis was based on a 1-ha system since SCUAF determines plant growth and soil changes on a per hectare basis.

14.2.5 Model Parameterization, Economic Data and Assumptions

The default values of biophysical parameters used in SCUAF model are based on the characteristics of the physical environment inputted in the model such as climate, slope class, soil drainage, parent material, soil texture, soil reaction and organic matter status. The physical environment used in SCUAF model for Claveria has the following characteristics: lowland humid class of Koppen climate classification, moderate slope class, free soil drainage, intermediate parent material, clayey soil texture, strongly acid soil reaction, and intermediate organic matter status. The plant growth, nutrient composition, soil properties and erosion parameters were specified in the model for each land use system. A detailed discussion of these parameters can be found in Predo (2002).

Data and assumptions used in the economic analysis were derived from SCUAF simulations, primary data (survey and key informant interviews), and secondary sources. The base parameter values used in calculating the net present value of each system are presented in Appendix 2. These parameters include the following economic data and assumptions: labor requirements, wage or labor costs, material input requirements, input and output prices, cost of capital and other data (Predo 2002).

14.2.6 Economic Analysis

The economic component of the model was linked to SCUAF with specification of production and conservation inputs and outputs for harvest, including other biophysical impacts of modeled land use systems. These outputs from SCUAF were subjected to economic analysis through the BCA framework. Two decision criteria were used in evaluating each land use system: (i) net present value (NPV) and (ii) annualized net benefits (ANB). The discount rates used in the analysis were based on existing cost of capital to upland farmers (25 percent) and the social cost of capital of 10 percent (Medalla et al. 1990).

The NPV of the land use systems over a period of time was computed as:

$$\mathrm{NPV} = \sum_{t=0}^{T} \frac{\left(B_{\mathrm{t}} - C_{t}\right)}{\left(1+r\right)^{t}}$$

where: B_t = benefit at time t, C_t = cost at time t, r = discount rate, t = time (years) where observation is noted, and T = life span of investment (years).

In order for the land use system to be acceptable, the NPV must be greater than zero (i.e., positive). With mutually exclusive land use systems, the one with the highest NPV should be preferred.

In private/financial terms, *B* and *C* were calculated from all quantifiable on-site outputs and inputs valued at market prices. Private benefits were estimated by multiplying the farm gate price with marketable outputs of the system resulting from SCUAF simulation. This measure of financial profitability ignores risks and other market imperfections such as externalities and public goods, including carbon sequestration and emission.

The BCA was extended to incorporate the social benefits from carbon sequestration. Carbon sequestration benefits were derived by quantifying the value of carbon sequestration from soil and biomass accumulation over a given rotation interval. Thus, social NPV of the tree-based systems was calculated by adjusting the private NPV as follows:

$$NPV_{social} = \sum_{t=0}^{n} \frac{\left(B_t - C_t + G_t\right)}{\left(1+r\right)^t}$$

where G_t is the imputed value of carbon sequestration function of each land use system at time *t*. All other variables are defined as above.

Ideally, social NPV should reflect the economic value of alternative systems to society. For this study however, the social profitability of each system incorporated only the imputed value of carbon sequestration, while the other benefits and costs were still evaluated at market prices.

The net carbon sequestration potential for each land use system was quantified following the modeling procedure outlined above. Nordhaus (1993) as cited by Tomich et al. (1997) estimated the marginal cost of carbon emissions to be between US\$5 and US\$20 per ton of carbon (tC). The monetary value of carbon sequestered for each system was calculated using the intermediate price[2] level of US\$10 tC^{-1} or PhP 510 tC^{-1}.

The annualized net benefit (ANB) indicates how much the NPV translates into yearly income over the lifespan of the investment (T). The annualized net benefit was computed as:

$$ANB = \frac{\text{r (NPV) } (1+r)^T}{(1+r)^T - 1}$$

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[2] Exchange rate: US\$1 = PhP 51, June 2001.

14.2.7 Risk Analysis

To quantify the impacts of price risks (variability) on the estimates of the net benefits of the tree-based options considered in the study, risk analysis was undertaken. While SCUAF model is a deterministic model, a stochastic component can be built into the economic decision variables of the model. The stochastic version of the model was solved through Monte Carlo Analysis based on deterministic results. This analysis was implemented using the @RISK software package trial version (Palisade 2000).

Following Purnamasari et al. (1999), the uncertainty specified in the output prices (i.e., historical price series from 1985–2001) of timber and crop was used as a base to produce numerical results as probability distribution of NPV. One thousand iterations were used for each stochastic run. A 10 percent discount rate was used, thus the results from the risk analysis are comparable to the point estimates obtained with a 10 percent discount.

14.3 Results and Discussion

14.3.1 Socio-economic Characteristics

The mean age of the farmer-respondents was about 45 years. The mean age of tree-based system adopters was 46 years while the mean age of non-adopters was about 39 years. This indicates that upland farmers who invested in tree-based farming systems were significantly older than non-adopters. In a similar pattern, the average years of farming experience of adopters (20 years) was significantly longer than non-adopters (13 years).

On average, upland farmers reached at least the primary level of education, which implies spending at least six years in school. The mean educational attainment of adopters (6.2 to 6.3 years) was not significantly different compared with the non-adopters (5.8 years). A majority (92 percent) of the upland farmers who make decisions concerning their upland farming activities were male. Both tree-based system adopters (90 percent to 94 percent) and non-adopters (93 percent) were predominantly male. The household size of all upland farmers surveyed ranged from two to 11 people with an average of about six members. The average household size of adopters and non-adopters were not significantly different, which means that adopters and non-adopters have similar family labor resources.

The annual cash income of upland farmers came from farm, off-farm, and non-farm sources. Among these, the farm income provided the highest cash income for both adopters and non-adopters, while the off-farm source provided the least income for adopters and also for the non-farm source for non-adopters. Farm income came from the following sources: (i) annual crops such as corn, lowland and upland rice; (ii) perennial crops such as mango, coffee, coconut, and banana;

and (iii) animal and livestock production. The average farm income over the last 12 months for tree-based system adopters ranged from PhP 32,263 to PhP 51,691 with an average of PhP 37,861. This was significantly higher than the average farm income of non-adopters (PhP 15,379). This suggests that the higher farm income of adopters may be due to increased farm fertility and productivity which, in turn, are the result from the integration of trees into the farming system.

14.3.2 Farm Characteristics

A majority (92 percent) of the upland farmers had one to two farm parcels. On average, tree-based system adopters had a slightly higher number of farm parcels (1.5) than the non-adopters (1.1). Total farm area ranged from 0.25 to 18 ha, with an average of 2.08 ha for all respondents. Adopters of tree-based farming systems have a significantly higher average farm size (2.2 ha) than the non-adopters (1.19 ha).

The respondents owned the majority (59 percent) of the total farm parcels they were cultivating. The tree-based system adopters owned about 52 to 75 percent of their farms but only about 26 percent were owned by the non-adopters. The rest of their farms were tenanted and rented/leased. The majority of non-tree growing farmers (42 percent) were tenants of the farm parcels they tilled while only about 13 to 29 percent of the tree-based system adopters were tenants. This could be a reason for not growing trees because they are only tenants. For farm parcels owned by farmers, a majority of both adopters and non-adopters have titled to the land they cultivated (39 percent). The second highest proportion of land ownership was the certificate of land transfer or CLT (25 percent), followed by ownership with no formal document, tax declaration, certificate of stewardship contract (CSC), and mortgage.

14.3.3 Extent of Adoption of Tree-Based Land Use Systems

Survey results revealed a significant adoption of tree-based land use systems by smallholder farmers. Of the total 192 farmers interviewed, about 86 percent have planted trees on their farms (Table 14.2). A majority of the adopters (49 percent) started to invest in tree growing not later than five years ago, while about 29 percent and 22 percent planted trees in the farm between respectively six to 10 years ago and 11 years-above (Table 14.3). On average, tree-based adopters began planting trees on their farms about seven years ago. The high adoption rate at a later period possibly indicates that the farmers' adoption of new technologies or land use systems was not an automatic response to the introduction of the new systems. This happens even for land use systems or technologies with high financial returns and more environmental benefits. The most probable reason is that the adoption of tree-based systems may also be driven by factors other than financial considerations such as risks (particularly income risks, and, consequently, consumption risks).

Table 14.2 Frequency distribution of smallholder farmer-respondents, Claveria, Misamis Oriental, The Philippines

Category	Number	Percent
Adopter	165	86
Non-adopter	27	14
Total	192	100

Table 14.3 Distribution of tree-based systems adopters by length of adoption, Claveria, Misamis Oriental, The Philippines

Length of adoption (Years)	Number	Percent
Not later than 5 years ago	81	49
6–10 years	48	29
11 years and above	36	22
Total	165	100
Mean (Std. Dev.)	6.64 (5.11)	

While the proportion of tree-based system adoption was high, the extent of adoption was considerably low. Tree-based system adopters only allocated a relatively smaller share of their farms to timber and fruit trees rather than to maize and other annual crops combined (Table 14.4). For instance, *Gmelina arborea* was planted by about 58 percent of the adopters but the average current land use share was only 4.8 percent, which is equivalent to 0.11 ha. The average land use share for other tree species was also minimal (0.07 to 3.7 percent). Nonetheless, the average land use share reported for *Gmelina* could be considered as an underestimate of actual land use share since it includes all tree-based adopters in the calculation, even those without *Gmelina* in their tree-crop portfolio. When only those adopters with *Gmelina* are considered, the average land use share ranged from 10 to 15 percent. This corroborates with the findings of Nelson et al. (1996) and Shively (1996) stating that an optimal share of the tree – or hedgerow component in a tree-crop portfolio ranges from 10 to 20 percent.

In terms of annual crop production, tree-based adopters allocated on average a relatively smaller land use share (in percentage) for maize production (58 percent) compared to their non-adopter counterparts (68 percent). This is primarily because adopters devoted certain parcels to fast-growing timber species (e.g., *Gmelina arborea*, *Eucalyptus deglupta* and *Acacia mangium*), fruit trees and other cash crops in combination with maize crop or upland rice. Since tree-based system adopters have relatively bigger farm size than non-adopters, the smaller percentage has translated to a larger area devoted to maize production for adopters compared to non-adopters.

Besides trees and annual crop production, banana production constituted the next highest average land use share in the whole farm portfolio for both adopters (4 percent) and non-adopters (10 percent). This was followed by the fallow system (10 percent for adopters and eight percent for non-adopters), which is aimed at restoring soil fertility.

Table 14.4 Mean current land use allocation (% and ha) of adopters and non-adopters of tree-based land use systems, Claveria, Misamis Oriental, The Philippines

Land use[a]	Adopter		Non-adopter		All	
	% Land share	Area (ha)	% Land share	Area (ha)	% Land share	Area (ha)
Maize	58.12	1.302	67.94	0.734	59.12	1.230
Lowland rice	4.65	0.104	5.28	0.057	4.21	0.088
Upland rice	1.80	0.040	0.28	0.003	2.18	0.045
Cassava	2.32	0.052	1.94	0.021	2.48	0.052
Gmelina arborea	4.80	0.108	0.00	0.000	4.11	0.085
Eucalyptus deglupta	0.95	0.021	0.00	0.000	0.81	0.017
Acacia mangium	0.07	0.002	0.00	0.000	0.06	0.001
Swietenia macrophylla	0.28	0.006	0.00	0.000	0.24	0.005
Fruit trees and other trees	3.66	0.082	0.00	0.000	3.82	0.079
Coconut	2.47	0.055	0.00	0.000	2.12	0.044
Coffee	0.56	0.013	0.00	0.000	0.48	0.010
Vegetables	3.96	0.089	5.96	0.064	4.54	0.094
Fallow (natural/improved)	9.73	0.218	7.59	0.082	8.32	0.173
Pasture/grazing	1.45	0.032	1.11	0.012	1.40	0.029
Banana	4.16	0.093	9.95	0.107	5.78	0.120
Peanut	0.18	0.004	0.00	0.000	0.16	0.003
Watermelon	1.15	0.026	0.00	0.000	0.89	0.019

[a] Multiple response

14.3.4 Economic Impacts

14.3.4.1 Predicted Yields of *Imperata*, Maize and Timber

The productivity of various land use systems was not directly comparable in terms of yield since each system has different outputs and/or harvested products. However, the pattern of herbage, maize and timber yields was explained by the rates of soil loss predicte d and consequently the predicted soil quality in terms of carbon, nitrogen and phosphorus associated to each land use system. For instance, maize yield declined more rapidly under current practice of maize cropping without tree component (FPLUS) than the system with trees (TCLUS and TCSFLUS) throughout the simulation period (Fig. 14.2). Relative to initial maize yield, the rate of maize reduction was about 28 percent under FPLUS systems while maize yield under TCLUS and TCSFLUS declined only by 10 percent and eight percent respectively, after 20 years.

Predicted herbage yield of *Imperata* declined at a much lower rate in the *Imperata*-animal grazing system (IMPLUS) than under silvopastoral (TIMPLUS) system. This is most probably caused by the competition effect of trees and grass in terms of light capture and nutrients uptake (Fig. 14.2). Meanwhile, all the tree-based systems exhibited a slower yield reduction over the two rotation intervals

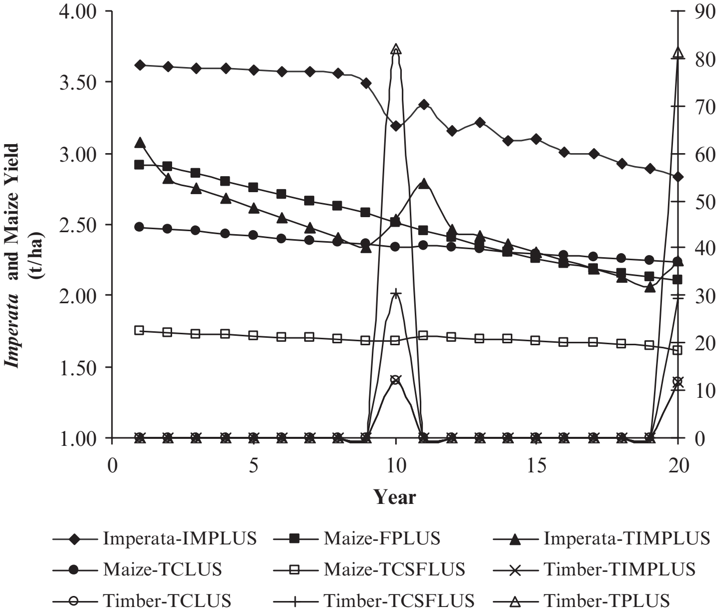

Fig. 14.2 Predicted yields of the alternative land use systems, Claveria, Misamis Oriental, The Philippines

than in other land use systems. Yet, the least reduction in timber yield of one percent was observed under TPLUS system. This result could be explained by the lower rate of soil loss under this system.[3]

14.3.4.2 Financial Profitability of Alternative Land Use Systems

The results of the benefit-cost analysis are presented in Table 14.5. With a discount rate of 25 percent, all land use systems have positive NPV, which implies that they were all profitable at this level of the cost of capital. The timber plantation system (TPLUS) obtained the highest NPV (PhP 241,170 ha^{-1}) followed by TCSFPLUS (PhP 98,121 ha^{-1}) and the lowest NPV (PhP 271 ha^{-1}) was obtained by the *Imperata*-grazing (IMPLUS) system. The current farmers' practice of annual maize cropping (FPLUS system) predicted a relatively higher NPV (PhP 21,161 ha^{-1}) than IMPLUS system, but lower than the TIMPLUS system (PhP 35,031 ha^{-1}), TCLUS system (PhP 56,074 ha^{-1}), and the TCSFLUS system (PhP 98,121 ha^{-1}). Consequently, the TPLUS system predicted the highest annualized net benefits (PhP 60,996 ha^{-1} year^{-1}) to farmers and the lowest ANB (PhP 69 ha^{-1} year^{-1}) was from IMPLUS

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[3] Soil erosion results are discussed in detail in the succeeding environmental impacts section.

Table 14.5 Private net present values (PhP ha^{-1}) and annualized incomes (PhP ha^{-1}) of alternative land use systems over 20 years at 25 percent and 10 percent discount rates, Claveria, Misamis Oriental, The Philippines

Land use system	NPV (PhP ha^{-1})		ANB (PhP ha^{-1} year^{-1})	
	25%	10%	25%	10%
IMPLUS	271	498	69	58
FPLUS	21,161	30,913	5,352	3,631
TIMPLUS	35,031	149,459	8,860	17,555
TCLUS	56,074	185,762	14,182	21,819
TCSFLUS	98,121	381,466	24,816	44,807
TPLUS	241,170	1,019,206	60,996	119,716

Note: ANB = annualized net benefits; US$1 = P51, June 2001

system. These results indicate that it was financially profitable to retain *Imperata* grassland for animal grazing purposes. However, it was not the most efficient type of land use. Conversion of *Imperata* grassland into tree-based systems appeared to be a more efficient land use than other land use systems. Among the timber-based systems, the most efficient land use was observed on the TPLUS system because of the high value of harvested timber, in addition to having lower predicted soil loss due to the erosion and high level of soil nutrients sustained (see the discussion of environmental impacts in the following section).

At a 10 percent discount rate, the relative ranking of the alternative land use systems in terms of net present value and annualized income remained unchanged. However, the financial profitability of the tree-based systems increased further since a lower discount rate over longer periods increased the present value of sustained future yields for both crops and timber trees. The NPV of tree-based land use systems increased to a range between PhP 149,459 ha^{-1} and PhP 1,019,206 ha^{-1}. Over 20 years, the highest benefit was realized by the TPLUS system and then followed by the TCSFLUS system. The NPV for annual maize cropping system (FPLUS) increased only at minimal level (PhP 30,913 ha^{-1}) due to the increasing value of productivity losses of future yields, which results from high soil erosion.

It is interesting to note that while the FPLUS system was not the most financially profitable option for *Imperata* grassland at current prices and technology, survey results have shown that farmers still continue to practice this system. In contrast, tree-based systems were found to be the most profitable option, but the extent of adoption was low in relation to the annual crop production. As observed, if ever adoption takes place, then tree-growing investments are usually done in combination with annual crops and other cash crops. Now, the question is "why are smallholders hesitant to increase investment in tree-based farming systems"? One possible reason is that smallholder farmers with limited resources and opportunities may need to have a minimum cash flow each year to sustain their families. Since tree-based land use systems have higher NPVs but with lower cash flows each year, they might be considered by farmers as inferior options to invest in compared to an annual crop which has a lower NPV over the same number of years, just like the tree-growing, yet with a higher annual cash flow. This minimum cash flow is a rational consideration for farmers because of the risk associated with the value of one's investment tied up in a long-cycle crop such as a tree crop where future prices may be uncertain.

Another reason is that farmers may be reluctant to trade the production risk associated with subsistence crops for three other types of risks: yield risk for timber, price risk for the timber, and price risk for the staple food purchased. As a risk-coping mechanism, farmers may want to diversify their investments, and hence income. Diversification is simply captured in the principle of not putting "all the eggs in one basket" (Pandey 2000). The risk of income shortfall is reduced by growing several crops that have negatively or weakly correlated returns. The effect of price risk on the profitability of alternative land use systems is examined in the risk analysis section.

14.3.4.3 Social Profitability and the Value of Carbon Sequestration

The social profitability of each system was assessed using a social discount rate of 10 percent plus the imputed value of carbon sequestration but the other benefits and costs were still evaluated at market prices. When the value of carbon sequestration was accounted for, the NPVs for tree-based land use systems increased but the relative ranking of alternative land use systems remained unchanged with the TPLUS system realizing the highest benefit from biomass carbon payments of about PhP 42,321 ha^{-1} for a period of 20 years (Table 14.6).

Table 14.6 Net present values (PhP ha^{-1}) with imputed value of carbon sequestration of alternative land use systems over 20 years at 10 percent discount rate, Claveria, Misamis Oriental, The Philippines

Land use system	NPV without C (a)	ANB without C (b)	NPV of biomass C (c)	NPV of soil C (d)	NPV with biomass C (e = a + c)	ANB with biomass C (f)	NPV with biomass and soil C (g = a + c + d)	ANB with biomass and soil C
IMPLUS	498	58	0	264,782	498	58	265,280	31,160
FPLUS	30,913	3,631	0	243,113	30,913	3,631	274,026	32,187
TIMPLUS	149,459	17,555	10,866	261,138	160,325	17,007	421,464	44,709
TCLUS	185,762	21,819	14,282	259,660	200,043	21,220	459,703	48,765
TCSFLUS	381,466	44,807	21,472	259,291	402,938	42,743	662,230	70,249
TPLUS	1,019,206	119,716	42,321	265,643	1,061,527	112,606	1,327,170	140,785
Marginal benefit:								
FPLUS-IMPLUS	30,415	3,573	0	−21,669	30,415	3,573	8,747	1,027
TIMPLUS-IMPLUS	148,961	17,497	10,866	−3,643	159,827	16,949	156,184	13,549
TCLUS-IMPLUS	185,264	21,761	14,282	−5,121	199,545	21,162	194,424	17,605
TCSFLUS-IMPLUS	380,968	44,748	21,472	−5,490	402,440	42,685	396,950	39,089
TPLUS-IMPLUS	1,018,708	119,657	42,321	861	1,061,029	112,547	1,061,890	109,626

US$1 = P51, June 2001

The inclusion of soil carbon payments increased NPVs significantly in relation to the biomass carbon payments only. The lowest value of biomass carbon was predicted under TIMPLUS system while zero payment was received for both IMPLUS and FPLUS systems since they do not accumulate standing biomass over time. For soil carbon payments, the TPLUS system obtained the highest NPV and the lowest was from the FPLUS system. This occurred because of high carbon losses through erosion and lower decomposing organic matter from leaf litters under the FPLUS system.

The net present value increased further when all carbon pools were valued and accounted for in the analysis. Like in the previous scenario, TPLUS system earned the highest NPV (PhP 1,327,170 ha^{-1} over 20 years) and the highest annual income (PhP 140,785 $\text{ha}^{-1}\text{year}^{-1}$). For this system, carbon sequestration benefits helped reduce the period with negative net returns. However, the amounts were still insufficient to cover the deficit resulting from the establishment costs and maintenance costs before the harvest. In the case of the TIMPLUS and TCSFLUS systems, the value of sequestered carbon reduced the deficit period to only one year. The results clearly illustrate the importance of carbon payments in reducing the income risk involved in tree growing to enhance investment in timber-based systems, and consequently influence the climate mitigation policy that would support smallholder farmers' provision for environmental services such as carbon sequestration.

The marginal benefits from switching land use would be more meaningful since the opportunity costs of existing land use are taken into account. This is particularly relevant in the imputed value of carbon sequestration since the net effect on carbon storage of implementing a tree-based system depends on the carbon content of the land use practices that are replaced. On the basis of this perspective, a switch in land use from the IMPLUS system to TPLUS resulted in the highest marginal benefits of PhP 42,321 ha^{-1} from biomass carbon and PhP 861 ha^{-1} year^{-1} from soil carbon. Thus, the highest marginal NPV with biomass and soil carbon payments occurred under the TPLUS system (PhP 1,061,890 ha^{-1}), which is equivalent to about PhP 109,626 ha^{-1} of annual income.

14.3.5 Environmental Impacts

14.3.5.1 Soil Erosion

The annual and cumulative soil erosion of the six land use systems, predicted over 20 years, is represented graphically in Fig. 14.3. It was observed that the soil erosion predicted has increased over time in all of the land use systems. This occurred most rapidly under the FPLUS system with the highest average soil erosion of 48 t ha^{-1} year^{-1} over 20 years (Appendix 3). Predicted soil erosion under the timber-based systems averaged one to 10 t ha^{-1} year^{-1}; the lowest has been observed under the TPLUS system and it was significantly lower than the

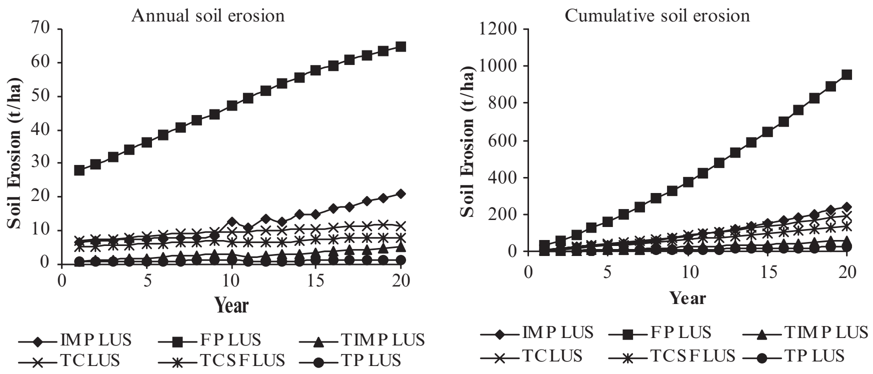

Fig. 14.3 Predicted annual and cumulative soil erosion (t/ha) over time of alternative land use systems, Claveria, Misamis Oriental, The Philippines

average soil loss observed from the IMPLUS and FPLUS systems. However, land use systems with *Imperata* have relatively lower soil erosion than with the FPLUS system. This may be due to some protection from topsoil loss afforded in these systems because of the surface cover provided by the *Imperata* grass throughout the period, since not all biomass in the model was consumed by the grazing animals.

The cumulative soil loss under the FPLUS system in the 20th year of the simulation period was about 953 t ha^{-1} compared to 241 t ha^{-1} under IMPLUS, 58 t ha^{-1} under TIMPLUS, 192 t ha^{-1} under TCLUS, 134 t ha^{-1} under TCSFLUS, and 21 t ha^{-1} under the TPLUS systems (Appendix 3). The conversion of *Imperata* grassland to tree-based land use systems reduced the rate of soil erosion by between 20 percent and 91 percent. In contrast, the rate of soil loss increased by 75 percent for land use change, from *Imperata* grassland to current farmers practice of continuous maize cropping. The results strongly indicate that tree-based land use systems were effective in minimizing soil erosion. Incorporating timber species in any land use would help reduce soil erosion even in the most erosive farming practice.

14.3.5.2 Changes in Biomass and Soil Carbon

The time-trajectory of above-ground biomass carbon and soil carbon are presented in Fig. 14.4. The predicted above-ground biomass carbon under tree-based land use systems (TIMPLUS, TCLUS, TCSFLUS and TPLUS) increased and accumulated during the growth period of timber trees (i.e., for the first nine years) and then dropped to zero in the 10th year, which was a cut year or harvest time of each rotation. Among the tree-based land use systems, the TPLUS system

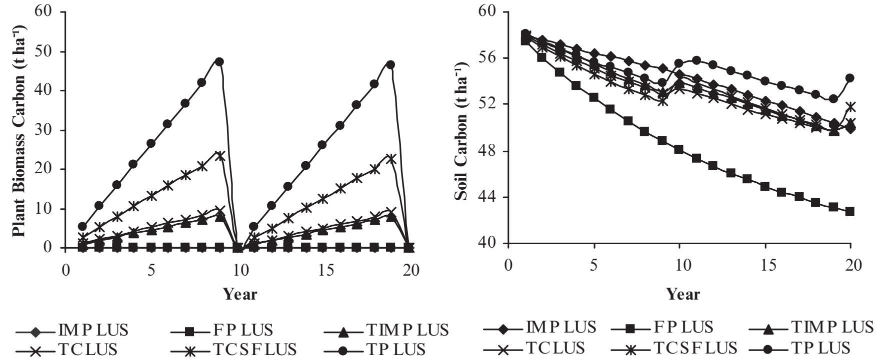

Fig. 14.4 Predicted carbon stocks in above-ground biomass and soil (t ha^{-1}) over time of alternative land use systems, Claveria, Misamis Oriental, The Philippines

produced the highest accumulated biomass carbon because of the fast growth of timber species being planted and the entire system area was devoted to timber species whereas only 40 percent in TCSFLUS and 15 percent for both TIMPLUS and TCLUS systems were planted to timber species (Appendix 3). On the other hand, the predicted annual biomass carbon under IMPLUS and FPLUS systems was zero throughout the simulation period, since the annual harvesting of above-ground biomass has been specified on these systems and hence, plant carbon was reduced to zero at the end of each year.

Simulation results of the changes in soil carbon showed that predicted total soil carbon decreased throughout the simulation period for all land use systems (Fig. 14.4). The slowest rate of reduction in total soil carbon was in the timber plantation system (TPLUS), with only a seven percent reduction over 20 years. Current farmers' practice of maize cropping (FPLUS) had the highest rate of soil carbon reduction, amounting to a 26 percent reduction of the initial total soil carbon content. The predicted decline in total soil carbon under tree-based land use systems was influenced by the interaction of soil erosion and organic matter recycling. The level of soil carbon was sustained under TPLUS systems because soil loss was low while the amount of organic matter recycled was high.

The severe soil loss under FPLUS system could have resulted in a sharp decline in soil carbon over time. It is also interesting to note that the level of total soil carbon under TPLUS system was lower than those under IMPLUS system during the first nine years of the simulation period. This is because systems with steadily growing trees may have had a greater loss of carbon from the soil to support the increasing standing biomass (Young et al. 1998). As a result, the average total soil carbon under tree-based land use systems (53.4–54.9 t ha^{-1}) was almost similar to those under IMPLUS system (54.2 t ha^{-1}) (Appendix 3).

14.3.5.3 Changes in Soil Organic Nitrogen and Phosphorus

Predicted total soil organic nitrogen declined more slowly under the tree-based land use systems (TIMPLUS, TCLUS, and TPLUS) than under the current practice of the annual maize cropping (TCLUS) system (Fig. 14.5). The predicted soil organic nitrogen was highest under the TPLUS system because of the nitrogen and organic matter cycled through leaf litter and also because of the pruning during the first year's rotation. Although there was a decline in soil organic nitrogen during tree growth, it increased at a higher level after timber harvest, though not at the same level as the initial soil nitrogen content. The soil total organic nitrogen slowly built up after harvest due to the addition of organic matter from plant residues. Similar pattern was observed under the IMPLUS system but soil nitrogen slowly declined in a continuous and linear manner throughout the simulation period and at a much slower rate compared to those under the FPLUS system. The average total soil nitrogen under FPLUS system was 5.4 t ha^{-1} compared to 6.0 t ha^{-1} under IMPLUS; 5.9 t ha^{-1} under TIMPLUS, TCLUS and TCSFLUS systems; and 6.1 t ha^{-1} under the TPLUS system (Appendix 3).

As in total soil nitrogen, the predicted total soil organic phosphorus showed a downward trend over the simulation period (Fig. 14.5). The lowest decline of soil phosphorus occurred under the TPLUS system while the greatest was under the FPLUS system. The IMPLUS system sustained the soil phosphorus at a level similar to the systems with the trees component. The average total soil phosphorus over 20

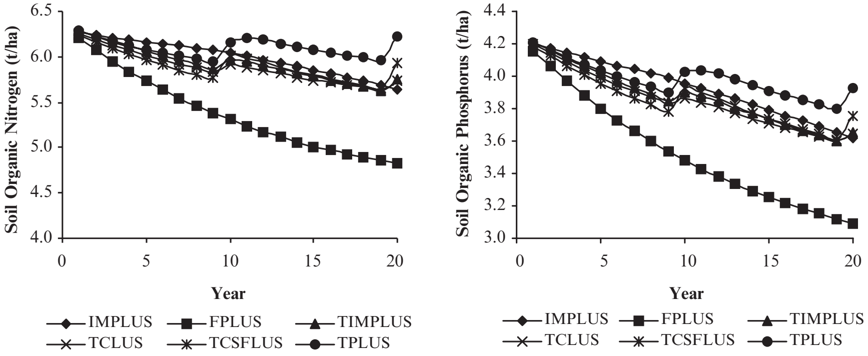

Fig. 14.5 Predicted soil organic nitrogen and phosphorus (t/ha) over time of alternative land use systems, Claveria, Misamis Oriental, The Philippines[4]

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[4] The trends or the shapes of the curves for soil carbon, soil organic nitrogen and phosphorus were similar probably because the quantities of these nutrients were calculated from the same initial amount of soil. Another reason may be due to the model's limitation to capture actual soil nutrient loss rather than relative to its original conditions before the simulation period.

years under TPLUS (3.98 t ha^{-1}) was almost similar to those under IMPLUS (3.93 t ha^{-1}), TIMPLUS (3.87 t ha^{-1}), TCLUS (3.85 t ha^{-1}), and TCSFLUS (3.86 t ha^{-1}) systems but relatively higher than under the FPLUS system (3.52 t ha^{-1}) (Appendix 3). The results indicate that tree-based systems would be able to sustain soil nutrients at higher levels over time than current farmers' practice of annual maize cropping.

14.3.5.4 Net Carbon Flow[5]

The pattern of predicted net carbon flow (NCF) was similar to that of aboveground biomass carbon for all land use alternatives (Fig. 14.6) since NCF is the incremental value of carbon accumulation in standing biomass with adjustment from erosion and oxidation losses, and emission. The average net carbon flow for 30 years under the TPLUS system was about 5.95 t C ha^{-1} year^{-1} compared to 2.98 t C ha^{-1} year^{-1} for TCSFLUS, 1.96 t C ha^{-1} year^{-1} for TCLUS, 1.47 t C ha^{-1} year^{-1} for TIMPLUS,

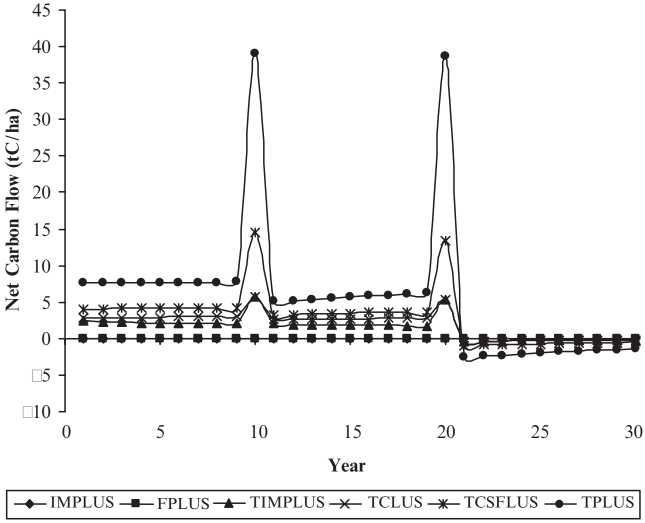

Fig. 14.6 Net carbon flows (tC/ha) over time of alternative land use systems, Claveria, Misamis Oriental, The Philippines

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[5] The annual net carbon flow (NCF) is the summation of the annual carbon flow in the plant-soil system and the amount of carbon locked up in the timber products used in durable products such as furniture less the amount of carbon emission from the gradual decay of woods in the durable products. Alternatively, NCF is the net incremental amount of carbon sequestered over time used in the analysis to impute the value of carbon sequestration for each land use alternative.

and 0 tC ha^{-1} year^{-1} for both IMPLUS and FPLUS systems (Appendix 3). The timber plantation system (TPLUS) had the highest net carbon sequestration and fixation because of huge biomass production and higher timber yield. The *Imperata*-grazing system (IMPLUS) and current farmers' practice of annual maize cropping (FPLUS) have zero carbon sequestration because there is no accumulated standing biomass over time on these systems, which is due to the annual and seasonal harvests of grasses and maize crops respectively.

14.3.6 Risk Analysis Results

Incorporating risk into the analysis allows us to consider how variations in the output price may affect the point estimates of NPV obtained above. The expected mean NPVs estimated with the output price risks taken into account were slightly higher than the point estimates obtained from deterministic results, except those from the IMPLUS system (Table 14.7). The expected mean NPV estimates under tree-based systems ranged from PhP 152,352 ha^{-1} in TIMPLUS system to PhP 1.39 M ha^{-1} in TPLUS system. For FPLUS system, the expected mean NPV was about PhP 31,007 ha^{-1} and PhP 488 ha^{-1} for IMPLUS system. The relative ranking of alternative land use systems did not change under the stochastic results. The TPLUS system gave the highest expected NPV and the lowest was under the IMPLUS system.

The risk analysis not only provided mean estimates, but also the entire distribution of the NPV estimates. The NPV of various land use alternatives can lie within a wide range of values. For example, the expected NPV of TPLUS ranged from a low value of PhP-29,577 ha^{-1} to a maximum of PhP 31.4 M ha^{-1}. There were about four percent and three percent probability of obtaining negative NPV for IMPLUS and TPLUS systems respectively. The IMPLUS system has only one

Table 14.7 Expected and probability distributions of net present value of alternative land use systems at 10 percent discount rate, Claveria, Misamis Oriental, The Philippines

Land use system	Expected NPV (P ha^{-1})			Probability (%)		CV (%)
	Mean	Min	Max	NPV ≤ 0	NPV ≥ point estimate	
IMPLUS	488	−133	1,224	1.09	51.53	46
FPLUS	31,007	22,313	40,163	0.00	48.33	10
TIMPLUS	152,352	−4,959	3,724,745	3.97	76.33	205
TCLUS	188,727	28,088	3,734,460	0.00	76.24	164
TCSFLUS	388,403	12,978	8,856,102	0.00	76.26	191
TPLUS	1,038,894	−29,577	25,288,820	3.37	76.32	204

percent probability of incurring a negative NPV while other land use systems have zero probability of incurring a loss.

For all tree-based systems, there was a probability greater than 70 percent for the NPV to be higher than their deterministic results, while the probability was more than 40 percent for FPLUS and IMPLUS systems. There was also a high variation for the expected value of NPV across land use system alternatives based on the coefficient of variation (CV) results. It is interesting to note that while timber-based systems obtained the highest NPV, they seemed to be the most risky options, as reflected by the high CVs ranging from 164 percent to 205 percent. A high CV on the profitability of tree-based systems suggests that income from these systems is highly variable and uncertain.

14.4 Conclusions, Policy Implications and Recommendations

The conversion of degraded forest margins dominated by *Imperata* grassland into tree-based land use systems can provide significant improvements to a range of on-site and off-site benefits. Tree-based land use systems (especially timber plantation systems) appear to be superior compared with the current farmers' practice of farming because they had the least cumulative soil loss, highest biomass and soil organic carbon retained in the plant-soil system, and also greater amounts of nutrients conserved in the soil.

Smallholder farmers are however driven by economic imperatives. For smallholders to consider changing to a significantly different land use system, the new system must be more profitable than the existing system. Benefit-cost analysis has shown that at current prices, the tree-based systems are substantially more profitable than the *Imperata* system and farmers' current farming system. In addition, there are substantially high social benefits from carbon sequestration for tree-based systems. While there is an economic incentive for smallholders to transform degraded forest margins to tree-based systems, the time horizon of smallholders is important. Investments in tree-based systems will expose smallholder farmers to some minimum income constraints and risks (and consequently consumption risk) as they will incur a loss before timber harvesting. While payments to farmers for environmental services related to carbon sequestration would help reduce the risks of negative returns, smallholders are less likely to adopt tree-based land use systems unless they are capable of accepting negative profitability in the first 9 years of tree growing.

Finally, it is important to emphasize that conversion of *Imperata* grassland to tree-based systems is environmentally sustainable and economically efficient (though not a fully risk-efficient) option to undertake either for smallholder investment or for a government poverty reduction program. This clearly illustrates the case of a win-win strategy for improving the productivity of degraded forest margins and agricultural sustainability. This lends strong support to the hypothesis that there is no trade-off between economic growth and poverty reduction objectives in pursuing smallholder-based strategies. A caveat for the findings of the study is that the analysis was based on the assumptions of tenure security and effective fire control.

The following policy implications and recommendations were drawn based on the findings of the study:

- Tree-based land use systems provide greater environmental and economic benefits to smallholders and the society than current farming practice. This implies that wide promotion and adoption of these technologies in a large number of areas in the Philippines with similar settings as the study site will help reduce poverty among smallholders and sustainable resource management in the uplands.
- Since tree-based systems are associated with high-income risk, there is a need to assist farmers in price risk management. One way of doing this is to provide farmers access to timely and accurate price information of relevant products. The possibility of providing smallholder tree growers with price risk insurance is also warranted.
- To encourage smallholders to improve their present farm management practices, particularly those that provide environmental services like carbon sequestration, a policy that will provide payments for said environmental services is warranted. The implementation of the “Clean Development Mechanism” identified in the Kyoto protocol for carbon offset is one such mechanism for effecting environmental services payment.

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Appendix 1: Derivation for Calculating Net Carbon Flow

From SCUAF simulation, the predicted changes in plant-soil system carbon at time t can be expressed as:

$$Cf_t = (Cp_t + Ca_t)\text{-}(Ch_t + b_t + Ce_t + Co_t) \tag{14.1}$$

where: Cf_t= annual carbon flow; Cp_t = carbon from biomass growth, calculated as the annual net biomass accumulation multiplied by 0.50 – the proportion of carbon in the biomass (Young et al. 1998); Ca_t = carbon from organic material additions; Ch_t= carbon losses from harvest; Cb_t = carbon losses from burning; Ce_t = carbon losses due to erosion; and Co_t = carbon losses from oxidation. If harvesting follows a clear cutting regime, C_p at time t can be calculated also as the carbon difference between the biomass of the stand at the end of period t (i.e., at the start of period t+1), C_{t+1}, less the biomass of trees at the start of period t, $C_{t,}$ that is, $Cp_t = 0.50 * (C_{t+1}–C_t)$.

When biomass is harvested, most of the sequestered carbon will ultimately be emitted back to the atmosphere either through decay or burning. Carbon emission was specified as a function of the decay rate of harvested biomass and the end-use of its products and residues. Thus, the fate of carbon for the harvested biomass was traced through a simple products' end-use equation. Let Cw_t be the net carbon storage from all harvested products at time t. By definition

$$Cw_t = \sum_{i=1}^{n} \rho_i Ch_i - \sum_{i=1}^{n} We_{it}; \quad i = 1,2,\ldots,n \text{ (outputs)} \tag{14.2}$$

where: Ch_i= carbon from i harvested output; ρ = proportion of harvested biomass used in the final product; We_{it}= carbon emission from product i at time t.

An exponential decay function was applied to estimate the CO_2 emissions from harvested biomass. Following Barson and Gifford (1990), a lumped parameter exponential decay function has been specified, which varies according to the half-life (after harvest) of product's end-use:

$$W_{r_t} = W_0 e^{-\lambda} \tag{14.3}$$

where: W_{rt} is the weight of carbon remaining after decay for time t; Wo is the weight of carbon sequestered by the forest (timber) at time of felling or harvest; λ is the decay constant. Using this approach, biomass was depreciated with a constant proportion of the remaining biomass. The decay constant for timber products was derived according to their half-life period using the relationship:

$$t_{1/2} = \frac{\ln 2}{\lambda} \Rightarrow \lambda = \frac{\ln 2}{t_{1/2}} \tag{14.4}$$

From Eq. (14.5), the emission at time t from product i, We_{it}, was computed as the difference between the weight of carbon remaining after decay for time $t\text{-}1$ ($Wr_{i(t-1)}$) and at the current time t (Wr_{it}):

$$We_{it} = Wr_{i(t-1)} - Wr_{it} \tag{14.5}$$

Using the above relationships, the net carbon fixation at time t (NCF_t) from plant-soil system and product's end-use was calculated as:

$$NCF_t = Cf_t + Cw_t \tag{14.6}$$

By substituting Eq. (14.2) into (14.6), NCF_t becomes:

$$NCF_t = Cf_t + \sum_{i=1}^{n} \rho_i Ch_i - \sum_{i=1}^{n} We_{it}$$

Appendix 2: Base Parameter Values Used in Cost-Benefit Analysis of Alternative Land Use Systems, Claveria, Misamis Oriental, The Philippines

Parameter	Value	Units	Description	Source
Labor requirements				
L_{MD}	103	MD/ha/year	Man-day labor requirements for maize production	c
L_{MAD}	32	MAD/ha/year	Man-animal labor requirements for maize production	c
L_{AP}	22.8	MD/au/year	Labor required for tethering and caring animal	a
L_{TP}	9.6	MD/ha	Labor for tree planting	d, e
L_{PW}	90.4	MD/ha	Labor for pruning and ringweeding trees, twice per year for first two years	d, e
L_{H}	67.8	MD/ha	Labor for harvesting timber and post harvest processing	d, e
L_{HL}	13	MD/ha	Man-day to layout hedgerow for timber trees component	c

(continued)

Appendix 2 (continued)

Parameter	Value	Units	Description	Source
L_{HA}	2	MAD/ha	Man-animal day to layout hedgerow for timber trees component	c
Wage price				
W_{MD}	70	P/MD	Labor wage for man-day	a
W_{MAD}	140	P/MAD	Labor wage for man-animal-day	a
W_{AD}	70	P/AD	Labor wage for animal-day	a
Material inputs				
S_M	32	kg/ha/year	Maize seeds for planting	c
S_T	834	seedlings/ha	Planting density (500 Gmelina; 334 Acacia mangium)	i
F_N	120	kg/ha/year	Nitrogen fertilizer application rate (approximately 261 kg/ha/year urea)	c
F_P	48	kg/ha/year	Phosphorus fertilizer application rate (approximately 264 kg/ha/year solophos)	c
C_{AI}	1,765	P/au/year	Cost of inputs (feed supplements, veterinary drugs, ropes, etc.) for animal maintenance	o
Input prices				
P_{SG}	15	P/seedling	Price of Gmelina seedling	a
P_{SA}	10	P/seedling	Price of Acacia mangium seedling	a
P_{SM}	10.50	P/kg	Price of maize seeds	a, c
P_{FU}	8.30	P/kg	Price of urea fertilizer	a
P_{FS}	10.40	P/kg	Price of solophos fertilizer	a
Output prices/value				
P_M	6.3	P/kg	Price of maize (grain)	a
P_C	510	P/tC	Price of carbon	b
P_T	10	P/bdft	Price of lumber	a
B_{AS}	10,710	P/au/year	Animal services benefit at current wage rate	a, o
A_V	3,434	P/au/year	Value of change in animal inventory per year	
Cost of capital				
r_p	25	%	Private discount rate (opportunity cost of capital)	c
r_s	10	%	Social discount rate	f, g
Other data				
CPI	1.62	–	Consumer price index for 2001	h
Ψ_m	18	%	Selling moisture content of maize	c
ψ_t	54	%	Selling moisture content of lumber	e

(continued)

Appendix 2 (continued)

Parameter	Value	Units	Description	Source
δ	0.5	–	Carbon content of biomass and wood	j, k
λ	0.07	–	Decay constant of timber products based on half-life of 10 years	l, m
ω_G	0.35	t/m^3	Wood density of Gmelina	e
ω_A	0.60	t/m^3	Wood density of Acacia mangium	n

Sources: a = survey and key informant interview, b = Nordhaus (1993) cited by Tomich et al. (1997), c =Nelson et al. (1996), d = Magcale-Macandog and Rocamora (1997/4), e = Mamicpic (1997), f = Medalla et al. (1990) as cited by Grist et al. (1997/2), g = Menz et al. (eds) (1998), h = NEDA (2002), i = Magcale-Macandog, Predo et al. (1997), j = Lasco (1997), k = Young et al. (1998) and Schroeder (1994), l = Bechmann (1990), m = Grist et al. (1997/10), n = MacDicken and Brewbaker (1984), o = Magcale-Macandog et al. (1998b)

Appendix 3: Summary of Biophysical Results from SCUAF Simulation of Alternative Land Use Systems, Claveria, Misamis Oriental, The Philippines

Land use system	Soil erosion (t ha^{-1})		Carbon (t ha^{-1})		Soil nutrients (t ha^{-1})		NCF (t Cha^{-1})
	Annual	CSE	Biomass	Soil	ON	OP	
IMPLUS	12.06	241.25	0.00	54.19	5.99	3.93	0.00
FPLUS	47.67	953.35	0.00	48.55	5.36	3.52	0.00
TIMPLUS	2.88	57.69	4.01	53.41	5.92	3.87	1.47
TCLUS	9.60	192.00	4.59	53.11	5.89	3.85	1.96
TCSFLUS	6.70	133.97	11.58	53.23	5.90	3.86	2.98
TPLUS	1.06	21.20	23.46	54.94	6.10	3.98	5.95

CSE = cumulative soil erosion, ON = organic nitrogen, OP = organic phosphorus, NCF = net carbon flow

Chapter 15
Restoration of Philippine Native Forest by Smallholder Tree Farmers

E.L. Tolentino, Jr.

Abstract This chapter examines how indigenous tree species domesticated by smallholder tree farmers can contribute to the restoration of the Philippine native forests vis-à-vis the popular use of exotic species in many forest plantations. The dominance of exotic tree species in the Philippines is attributed to the following reasons: (a) wide adaptability and tolerance to stress particularly in marginal sites; (b) fast growth and high yield; (c) available research and technological information and; (d) abundance of and access to quality germplasm.

There are mounting interests and experiences in growing indigenous tree species (ITS) as indicated by the planting initiatives documented in various parts of the country. With community-based forest management as a national policy, the role of smallholder tree farmers particularly in forest restoration has become more important than ever. These two developments require important strategies to be put in place to surmount the constraints of, and facilitate the domestication of, ITS namely: (a) prioritizing the ITS by region; (b) increasing the availability of, and improving access to, good quality germplasm which includes seeds, vegetatively-propagated stocks and wildlings; (c) generating farmer-friendly technologies that spans from production to processing; the strategy also includes the appropriate dissemination and adoption of these technologies to the end users; (d) strengthening the use of ITS in biodiversity conservation programs; (e) improving access to market information by tree farmers and establishing close links to the wood market and; (f) reviewing and reforming policies and providing adequate incentives to promote plantation development.

Keywords Forest restoration, indigenous tree species, smallholder tree farms, tree domestication

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15.1 Introduction

The composition of the Philippine flora is estimated to be at least 14,000 species (DENR-PAWB, CI & UP-CIDS 2002). An estimated 3,500 are classified as trees indigenous to the country (Salvosa 1963). Of this number, only 10 percent (≈350) is considered economically important (Meniado et al. 1974) with the family Dipterocarpaceae as the prime source of premium hardwood timber for many decades. Lush tropical forests occupy approximately 90 percent or 27 M ha of the country's total land area back in the 1500s, prior to the colonization by the Spaniards (Garrity et al. 1993). As of 2000, pristine forest has decreased to 0.8 M ha (Acosta 2004) or a lost of almost 97% of the original forest cover. Deforestation peaked at 170,000 ha annually in the 1970s while reforestation averaged only at 52,150 ha per year (Forest Management Bureau Statistics 2003).

With a staggering loss of forest cover, forest rehabilitation became critically important. The start of reforestation was traced to the pioneering School of Forestry at the University of the Philippines Los Baños (UPLB) in 1910. The Silviculture class made experiments on various methods of replanting areas covered with *Imperata cylindrica* (cogon grass). The pioneering effort of the first forestry school in the country paved the way for the formal government reforestation efforts which started in 1916 in Cebu then quickly spread in other parts of the country. Reforestation saw its full-scale implementation from 1937–1941 with regular government appropriations. World War II wreaked havoc to the nearly 28,000 ha plantations (Agpaoa et al. 1976). A revitalized effort was initiated in 1960 with the creation of the Reforestation Administration. Later, private sectors took active part in the reforestation efforts particularly the big logging concessionaires, e.g. Paper Industries Corporation of the Philippines (PICOP) and the Provident Tree Farm Inc. (PTFI) (JOFCA 1996). Recently, a shift from the corporate-based type of forest management to community-based forest management by virtue of Executive Order No. 263 was instituted. Consequently, smallholder tree farmers and people's organization in the uplands became major actors in forest restoration particularly in plantation development.

Plantation forests in the Philippines occupy approximately 7.53 M ha (FAO 2005). Plantations are vital to meet the country's wood demand as stipulated in the Revised Forestry Master Plan for the Philippines (2003) where a target of 460,000 ha of commercial plantations is envisioned within 12 years. This chapter examined the trends and patterns in species selection for plantation forestry in the country. It also provided perspectives in the use of indigenous tree species (ITS) particularly by smallholder tree farmers. Lastly, discussions were made on the constraints and limitations besetting the use of ITS and how smallholder tree farmers will be capacitated to contribute to forest restoration using ITS.

15.2 Species Selection in Plantations in the Philippines

Species commonly used in reforestation is surprisingly few considering the abundance of commercially valuable species used by the wood industry. The popularity of exotic trees in the Philippines as a reforestation species dates back when reforestation started early in the 20th century. Data from the Reforestation Division of the Forest Management Bureau (2000) immediately confirms this assertion. Of the top ten species planted in reforestation projects around the country, eight are exotics and only two are ITS (Fig. 15.1). Mahogany (*Swietenia macrophylla*) and gmelina (*Gmelina arborea*) are among the dominant exotic trees planted. Narra (*Pterocarpus indicus*), a common ITS, comes as a close second. Another ITS, agoho (*Casuarina equisetifolia*) ranked seventh among the commonly planted species.

Reports on the plantations of private concessionaires showed a similar pattern: Paper Industries Corporation of the Philippines (PICOP) Resources Inc. (Surigao del Sur Mindanao) have plantations of more than 40,000 ha planted mainly to

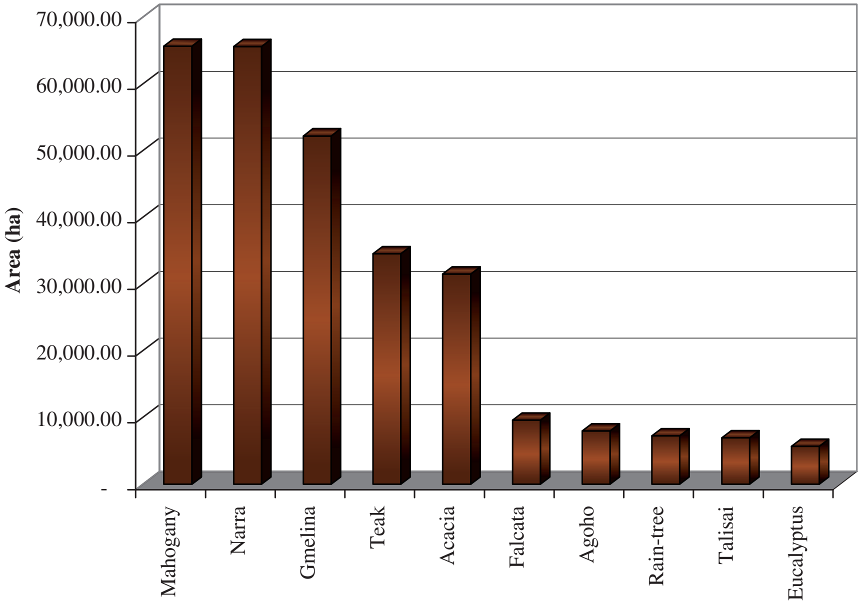

Fig. 15.1 Top ten species planted in reforestation projects in the Philippines, including (from left to right) *Swietenia macrophylla*, *Pterocarpus indicus*, *Gmelina arborea*, *Tectona grandis*, *Acacia* spp., *Paraserianthes falcataria*, *Casuarina equisetifolia*, *Samanea saman*, *Terminalia catappa*, and *Eucalyptus* spp. (Forest Management Bureau 2000)

Paraserianthes falcataria, Eucalyptus deglupta and *Acacia mangium*. Nasipit Lumber Company (NALCO) (Agusan del Norte) has more than 4,000 ha of exotic plantation. The main species planted are: *P. falcataria, G. arborea, Acacia auriculiformis, A. mangium, Pinus caribaea, Swietenia macrophylla* and *Tectona grandis*. Provident Tree Farm Inc (PTFI) (Agusan del Sur) has established another 6,000 ha of plantation dominated by exotics like *A. mangium* and *G. arborea* (Ecosystems Research and Development Bureau 1998). The Bukidnon Forest Inc. an industrial tree plantation in Malaybalay (Mindanao) has successfully established 6,367.52 ha of assorted exotic trees. The major species planted are: *A. mangium, Eucalyptus urophylla, E. deglupta* and *P. caribaea*. Some native species have been tried which includes: *Pinus kesiya, Casuarina equisetifolia, Lagerstroemia speciosa, Pterocarpus indicus* var. *echinatus* and *Shorea contorta*. However, very small areas were allocated for planting these native species. It was claimed that most of the native species are slow growing with high mortalities which increased plantation costs and therefore undesirable to management (Cuevas 1999).

Private tree farms have followed suit and planted mainly exotics. Gmelina and large leaf mahogany are the top choices among private tree farmers. In fact, in Region 2 (northeastern Philippines) all tree farms registered with the Department of Environment and Natural Resources (DENR) were planted to either of the two species. Nationally, the two species are found in all regions. In a study of six regions, it was found out that Gmelina (75 percent or 47 respondents) and mahogany (40 percent or 25 respondents) are indeed the two most popularly planted species. Mangium (*A. mangium*; 38 percent), eucalyptus (37 percent), falcata (*P. falcataria*; 24 percent) and narra (*Pterocarpus indicus*, six percent) are the other commonly planted species in these private tree farms (Carandang 2000).

Another study conducted among 50 smallholder tree nursery operators in Cebu, Bukidnon and Misamis Oriental reinforced the predominant practice of raising exotic trees. Seedlings in the forest nurseries studied were composed of 59 percent timber species, 36 percent fruit trees, and five percent species. Of the timber species being raised, 35 percent are indigenous and 65 percent are exotic. Bagras (*Eucalyptus deglupta*) ranks as the most popular species being raised in 48 percent of the nurseries studied. Other popular species include large leaf mahogany (*Swietenia macrophylla*, 35 percent), *A. mangium* (21 percent), Black wattle (*Albizzia lebekkoides*, 19 percent), *Eucalyptus robusta* (19 percent), *E. torreliana* (17 percent), narra (*P. indicus*, 17 percent), and yemane or gmelina (*G. arborea*, 15 percent). All, with the exception of narra, are exotics (Tolentino et al. 2001). *Eucalyptus deglupta* is an indigenous species but the local provenances were not used and instead exotic provenances (Papua New Guinea) were planted.

The use of exotic species is not an exclusive silvicultural preference in the Philippines. In Southeast Asia, countries like Indonesia, Thailand and Vietnam have developed extensive plantations of exotic trees like *S. macrophylla*, *P. falcataria, A. mangium, P. caribaea, Eucalyptus* spp, and *Casuarina* spp (FAO Forestry Database). Even in Brazil, another country with active plantation activity, data as early as 1900s revealed an inclination towards the exotic eucalypts over Brazilian timber species (Navarro de Andrade 1941). In fact, as of

2005, Brazil has an estimated 3.2 M ha of eucalyptus plantations (Neto 2005), the exotic species most abundant in that country's plantation program (McNabb 2005).

Exotic trees dominate the country's tree planting program for the following reasons: (1) wide adaptability and tolerance to stress; (2) fast growth and high yield; (3) available researches and technologies and; (4) availability of abundant and superior germplasm.

15.2.1 Wide Adaptability and Tolerance to Stress

An obvious advantage recognized by most foresters and tree farmers planting exotic trees is their versatility especially to unfavorable conditions which are characteristic of many target areas for restoration. The adaptability of exotics to degraded sites (e.g. acidic, low soil fertility, fire-prone areas) and their ability to colonize even marginal grasslands is an attractive feature of these trees that makes them widely planted. As an example, the exotic legumes (e.g. *Acacias, Paraserianthes*) are nitrogen-fixing trees that permit optimum growth and development even in nitrogen-depleted soils. Additionally, the wide adaptability of exotic trees enables them to grow in a new environment free from the usual pests and diseases common in its natural habitat (Pryor 1978; Evans 1992) making them almost pest and disease-free at least for the first rotation. Gmelina and *A. auriculiformis* are fire resistant and will coppice after a fire. Likewise, their fast growth enables them to compete even with the obnoxious *Imperata cylindrica* (ERDB 1998).

15.2.2 Fast Growth and High Yield

Concomitant with the ability to survive and grow under a wide range of environmental conditions, exotics exhibit exceptionally fast growth and high wood yield. These characteristics make them very attractive for smallholder tree farmers desiring quick income and immediate returns to their investments. Some estimates revealed that the yield of exotics trees ranges from a low of 5 m^3 ha^{-1} year^{-1} in poor sites to as much as 40 m^3 ha^{-1}year^{-1} in good sites (ERDB 1998; Table 15.1). However, most of these species exhibit impressive growth yields averaging from 30 to 35 m^3 ha^{--1} year^{-1}. This is almost similar to the average growth performance of *Eucalyptus* species in Brazil which is 20 to 40 m^3 ha^{-1} year^{-1}. Additionally, a phenomenal growth of 75 m^3 ha^{-1} year^{-1} was accordingly observed (Kageyama 1980 cited by McNabb 2005). In comparison, many indigenous trees are notoriously slow growing making them less attractive to many smallholder tree farmers. In the case of dipterocarps, an important ITS in the Philippines, growth rates vary from different diameter classes ranging from a low 0.44 cm year^{-1} (10 cm dbh class) and peaking at 0.86 cm year^{-1} (70 cm dbh class) (Weidelt and Banaag 1982). In

Table 15.1 Summary of the average growth, yield and economic rotation of selected exotic trees (Ecosystems Research and Development Bureau 1998)

Species	Growth		Yield (m^3 ha^{-1} year^{-1})	Economic rotation (year)
	Height (m)	Diameter (m)		
Acacia mangium	15–30	0.5–0.9	Dry site: 20–25 Good site: 40	Pulp: 6–8 Solidwood: 14–16 Pole: 15
Acacia auriculiformis	8–15	0.4–0.6	10–25	Fuelwood: 3–5 Pulp and paper: 8–10
Swietenia macrophylla	30–40	1.0–1.5	10–20	Solidwood: 17–50
Paraserianthes falcataria	24–30	0.5–1.0	25–35	Pulp: 7–9 Solidwood: 10–15
Eucalyptus camaldulensis	30–40	1.0–1.5	Dry site: 5–10	Dry site: 20–25 Good site: 5–10
Gmelina arborea	20–30	10–15 cm (3 year) 0.6–1.0	Average site: 20–25 Good site: ≥30	Pulp: 6–8 Solidwood: 15–30

Malaysia, dipterocarp plantations registered a maximum diameter increase of 1.22 cm year^{-1} (Primack et al. 1989). Obviously, these growth rates pale much too far than the popular exotic trees.

15.2.3 Available Researches and Technologies

Most research works have often focused only on a few economically important tree species, thus making available technologies for the plantation development of these species (Hooper et al. 2005) easily accessible to tree growers. Many of these plantation species are exotics grown outside its native range (Zobel et al. 1987). In the case of exotics planted world-wide, e.g. *Pinus caribaea, Eucalyptus grandis,* and *Tectona grandis* available research, technology packages and experiences allows many users to plant them with acceptable degree of certainty (Evans 1992). From seed production, planting stock production to appropriate silvicultural treatments as well as successes and failures, information about exotics abound and are accessible to many tree farmers (e.g. Lamb 1973; Chapman 1973; Chapman and Allan 1978; Pryor 1978; International Labour Organization 1979; National Academy of Sciences (NAS) 1980; Boland and Turnbull 1981; Greaves 1981; Jacobs 1981; National Research Council (NRC) 1983; Schonau 1985; Willan 1985; Glover 1987; Midgley 1988; Withington et al. 1988; Boland 1989; Brewbaker 1989; Pryor 1989; Evans 1992; Wadsworth 1997; Schmidt 2000). Information on growth and yield of exotics (e.g. Revilla 1974; Ugalde and Perez 2001) and economics (Sedjo 1984) which are major concerns among tree growers are very much available. Plantation problems like pests and diseases have been examined and published for many exotic trees (e.g. Quiniones 1983; Lapis 1995). In contrast, information for ITS is scanty, fragmented and oftentimes completely lacking.

An average Filipino forester (or even student) will be more familiar with the exotic tree species than of the ITS. Lamentably, even academic programs for many forestry schools and colleges have strong emphasis on exotics. Foresters in the field usually encounter the native species in the scaling station or as cut or processed material but less likely as seedling produced in large quantities in the nursery and much more as plantation crop.

15.2.4 Availability of Abundant and Superior Germplasm

Another obvious advantage of the exotics is the availability of abundant germplasm particularly improved seeds. ICRAF published a tree seed suppliers' directory where several hundred species were included. It is striking that the popular exotics here in the Philippines were among those with the most number of seed suppliers around the world, e.g. *Tectona grandis,* (32) Acacia *auriculiformis* (34) Gmelina (31), *A. mangium* (29) and *Swietenia macrophylla* (17) (Kindt et al. 2002). The database lists only formal seed suppliers but informal seed suppliers (local seed collectors and small tree nursery operators) that abound in the country produces or sells mostly exotic species. In one study by the author (Tolentino et al. 2005), informal seed producers in the three major islands commonly sell seeds or seedlings of mahogany, *Acacia*, *Gmelina* or eucalypts. In two studies to be described later (Tolentino 2000a; Tolentino et al. 2001), germplasm availability was clearly identified as the limiting factor for the planting of ITS. The presence of seed periodicity aggravated by few and sparsely scattered mother trees which are mostly located in remote and inaccessible sites would explain this acute shortage of germplasm of ITS. Tree improvement and domestication programs for many of the popular exotics have advanced in many developed countries who have found marketing of improved seeds as a lucrative business. For example, the Australian Tree Seed Center has listed in its website (http://www.ensisjv.com/atsc) the availability of improved seeds for 14 different tree species at this time and a few dozen more species in the coming years.

15.3 Initiatives to Promote Indigenous Tree Species

Despite the prevalence of exotic trees in many tree farms and plantations around the country, the planting of ITS is gaining support and popularity. The subsequent sections will describe small and budding efforts to plant ITS in farms or plantations. From these planting programs important lessons on how ITS are propagated and grown in different parts of the country are drawn. Solutions and recommendations that enabled these tree growers to shift to ITS are also explained. Although there are still many obstacles to the growing of ITS, the planting initiatives described below would debunk the criticism that ITS is not grown by tree farmers particularly by smallholder tree farmers.

15.3.1 The UP Land Grant Experience

The University of the Philippines (UP) has two land grants (LGs) in the Sierra Madre Mountain Ranges (Laguna and Quezon provinces) covering an area of 10,000 ha. Timber harvesting started in the 1960s and was repeated in the 1980s. It was only in 1989 that legitimate logging was ordered to a halt. Unfortunately, local residents continue to illegally extract timber, make charcoal and gather other forest products (poles, rattan, wildlife). The threat to the remaining forests is exacerbated by the practice of shifting cultivation including the entry of land speculators.

A forest rehabilitation program using indigenous tree species was initiated in 1997. The initial step was the species selection which considered understanding of user needs and preferences, technological opportunities and systematic methods for ranking species (Jaenicke et al. 1995). A modification of species priority setting scheme by Franzel et al. 1996 was used. A series of consultative meetings, mostly informal discussions, were held with approximately 30 upland farmers practicing *kaingin-making* (shifting cultivation) inside the LGs and actual interviews with illegal loggers mostly during the moment when they are apprehended. A total of 61 tree species were identified and initially listed (Tolentino 2000b). Tree species preference based on uses (e.g. lumber, furniture, handicrafts, medicine and food) and market value were ranked (see Appendix). The final list contained tree species mostly used for general construction – a need very common to the local upland communities. The study learned that the preferred species are also those which command good market prices. In addition to the user preference and their marketability, the Land Grant Management included germplasm availability as another criterion. In the end, there were about 20 species included in the trials. All of the species were identified by the participants using the local name. The project management sought the assistance of tree taxonomist to identify the species but a few remained unidentified. The taxonomic identification of many ITS is one of the identified limitations in the use of this class of species.

For the selected species simple experiments accompanied by trial and error procedures were employed to grow them in the nursery and plantation site. A complete description of the results of the nursery and preliminary plantation performance was described in Tolentino (2000 a and b). Below is a summary of these findings for the top eight species planted in a trial of about 20 species.

Most of the fruits and seeds were collected from the ground due to their large size. Seed dormancy expressed as delayed and staggered germination was observed only in Batikuling (*Litsea leytensis*) and talakatak (*Castapnosis philippensis*; Philippine chestnut or wild castanias). All the rest of the species have insignificant dormancy. The findings clarify the belief that not all seeds of ITS are dormant which will be advantageous in the large-scale propagation of these species from seeds in the nursery. On the other hand, dormancy in batikuling and talakatak seeds causes delays and disruptions in nursery production schedules, thus the need to neutralize it. This character, however, becomes advantageous if their seeds are bound for storage. Longer longevity can be maintained even under ambient conditions which will simplify the storage of these species.

Practically no propagation problem was encountered in the nursery except for very slow growth. This was observed in batikuling (*Litsea leytensis*), kuling baboi (*Dysoxylum altissimum*), malaruhat bundok (*Syzygium urophyllum.*), and babaysakan (ulayan; *Lithocarpus buddii*). These same species were consistently slow in growth even when outplanted. Unlike fast-growing exotic trees like gmelina, acacia and eucalyptus this growth habit makes many ITS less desirable for many tree farmers desiring quick returns. Mix planting ITS with the fast growing exotic species would provide a spectrum of tree age classes. Consequently harvesting regimes will range from short-term to medium to long-term. Developing planting schemes to mix ITS and exotics is an important knowledge gap that researchers need to address. An ecological advantage of the mixed planting scheme is that it can simulate an uneven aged stand which has stratified canopy structure characteristic of tropical rain forests. This canopy architecture optimizes the light intercepted at the various levels and enhances soil erosion protection due to the combined efficiency of the different canopy layers. Economically speaking, the scheme also insulates the tree farmer from the rapidly changing and dynamic wood market and affords him with flexibility in responding to fluctuating product demand and price variations.

Light requirements of the tested species vary both in the nursery and after outplanting. Many require full shade to partial shade in the nursery except for malaruhat. Batikuling and kuling manok (*Aglaia luzoniensis*) can tolerate open conditions when in the sapling stage. This is indicative that these species are mostly shade tolerant which is common to many species in the advance stages of succession. Silvical information like these are vital when designing the planting mix for the slow-growing ITS and fast growing exotics.

The two-year species survival performance is considered good if provided with adequate maintenance, particularly weeding. Survival ranges from 60 to 90 percent especially for potted seedlings. However, one farmer group used bareroot stocks consequently decreasing survival rates to 40 to 50 percent. Rough handling particularly in the difficult terrain of the land grants contributed to seedling shock that decreased outplanting survival. No significant pests or disease problems were encountered either in the nursery or field. A few leaf-eating insects were observed but no serious threats exist. However, since the environment in which these ITS were planted is a mixed secondary forest, it is possible that the presence of a good balance between prey and predator has minimized the occurrence of epidemic-level pest and disease problems. This has strengthened the niche importance for ITS in enrichment plantings for rehabilitating degraded secondary forests. However, Nair (2001) asserts that there is no existing data to support that ITS is not totally resistant to pest outbreak, and an economic damage to ITS plantations is potentially possible. These vital information issues have to be considered when embarking in ITS plantations that make the smallholder tree farm models attractive, avoiding the extensive monoculture plantations common to many exotics.

The program was seriously limited by the availability of germplasm, particularly from superior mother trees. The successive logging operations and the unabated illegal logging activities have significantly decimated the number and distribution of good mother trees. This dysgenic practice has critically depleted the genetic pools leaving mostly poor quality mother trees or juvenile trees unable to bear abundant fruits and seeds. Additionally, these trees are located in remote and often inaccessible sites making collection extremely difficult. The prevalence of this situation in many parts of the country has significantly decreased the availability of good quality germplasm and is a major debacle in the wide-scale planting of ITS.

15.3.2 The Mindanao and Cebu Smallholder Nursery Operators Perspective

The familiarity with ITS was assessed among 50 smallholder nursery operators from Mindanao (Bukidnon and Misamis Oriental) and Cebu (Tolentino et al. 2001). Indigenous tree species (ITS) appeared to be a vague concept or classification of species to most nursery operators. The term "indigenous or native" might be unfamiliar being an English word. However, when some examples were cited, the respondents readily enumerated what they thought were indigenous trees. It was noted that commonly and widely planted species like eucalyptus, *Swietenia* sp. and gmelina were frequently mistaken as indigenous due to their abundance and prolonged period of plantings. Ninety-one species were identified by the nursery operators. Familiarity was simply gauged by the number of times an ITS was mentioned. Molave (*Vitex parviflora*) was the most popular among the respondents followed by Lauan (which is the generic name for dipterocarps by local people) followed by narra (*Pterocarpus indicus*) and bagalunga (*Melia dubia*) and a species locally known as katii and ulayan (Philippine oak, possibly *Lithocarpus* spp.). This result including that of the UNDP project to be described later clearly show that ITS are not foreign or unknown to many local upland communities. Thus, promotion in the various planting activities using ITS will be facilitated due to the current awareness or knowledge of the local people.

Lumber and furniture species top the list of uses identified for ITS, again confirming the preference of local people for wood construction and highly marketable species. Most respondents cited several uses of the species. The findings indicate that ITS have tremendous potentials recognized by the communities. They have also expressed willingness to plant the ITS in their agroforestry farms. The same study found out that upland farmers have interests and are willing to raise ITS in their nurseries. However, the interest and willingness hinge on several factors with the availability of good germplasm being the most important (51 percent). Obviously, any planting program will require the supply of good germplasm. As earlier described, this has been an important advantage that exotic species possess over the ITS. Additionally, local people have difficulties in identifying ITS wildlings (13 percent) if this germplasm source will be used (Table 15.2). There were a few who still prefer exotics or fruit trees due to slow growth of ITS (eight percent), better markets for exotic trees (eight percent) and restrictive policies on harvesting and transporting of ITS (five percent).

Table 15.2 Explanatory factors for raising indigenous tree species in forest nurseries in Cebu, Lantapan (Bukidnon) and Claveria (Misamis Oriental)

Responses	Total
Limited supply of seeds and planting materials	38
Difficulty with ITS identification	10
Fast growth rate for exotics; slow growth rate for ITS	6
Complicated permit and transport system for ITS	4
Financial difficulties in raising ITS	4
Farmers' preference for fruit trees	3
Interest in planting ITS if there are buyers	2
Perception of ITS as a common plant on the farm	1
Preference for mix planting of exotics and ITS	1
Pejorative mentality of raisers	1
Production of ITS for "testing" only	1
ITS as food for wildlife	1
Knowledge of other ITS yet these are absent	1
Lack of technical know-how in raising ITS	1
Total responses	74

n = 50

Note: Some respondents gave more than one response

15.3.3 Community-Based Production System for Selected Trees and Vines in Support of the Furniture and Handicraft Industries

Currently, the author is conducting a research, "Community-based Production System for selected Trees and Vines in support of the Furniture and Handicraft Industries" in Quezon and Diffun provinces. The Gabriela MultiPurpose Cooperative Inc (GMPCI), a community-based forest management agreement (CBFMA) holder with the Department of Environment and Natural Resources was chosen as the project partner. The People's Organization (PO) is currently testing the following ITS: bagalunga (*Melia dubia*), mamalis (*Pittosporum pentandrum*) and malapapaya (*Polycias nodosa*). Though the species were not familiar to the PO, the researchers observed that the farmers were willing to learn and test new tree species that they thought will contribute to their income. Based on their prior knowledge and experience in raising *Gmelina arborea*, also popular as exotic tree in that region, the farmers quickly tested a variety of methods in breaking seed dormancy of the three new species. The project also documented that these farmers are comparing the new ITS with the exotic gmelina thus, in the site selection for the ITS, similar sites where gmelina was grown were used. Likewise, growth and performance were gauged with gmelina as standard and they have observed that the exotic and ITS were comparatively similar. Tree management like site preparation, maintenance and protection works were patterned to their previous tree farming practices for gmelina.

One year seedlings range in height from 40 to 150 cm, while their diameters vary from 9 to 66 mm. Two fires broke out in the area due to escaped fires from adjacent cornfields and burned several seedlings. However, the ensuing rainy season revealed that both *Polycias nodosa* and *Pittosporum pentandrum* have the ability to re-sprout after the fire. This impressive growth performance and fire resistance of the ITS have impressed even the farmers who are very much convinced of the superiority of gmelina. The general criticism that ITS are slow growing and unable to colonize marginal sites is now a highly debatable statement. These initial results clearly manifest that useful information about ITS should be discovered by researches in order to provide a basis for future wide-scale plantings. On the other hand, the absence of packaged technologies for particular species will not necessarily hinder the planting of previously unknown ITS. However, like many new and introduced tree species, the processing, utilization and markets aspects are major concerns for these farmers.

15.3.4 Facilitating Community-Based Conservation and Planting of Indigenous Trees in Misamis Oriental and Bukidnon

The UNDP Small Grants Programme for Operations to Promote Tropical Forest (UNDP SGP PTF) funded a project entitled "Facilitating Community-based Conservation and Planting of Indigenous Trees" in Misamis Oriental and Bukidnon. The project was implemented by the Landcare Foundation of the Philippines with the Landcare Associations in the two provinces. The participants were mainly composed of indigenous people (Higa-onons and Tala-andigs). The Project reported that for the four barangays (villages) where the project was implemented, the community members were able to list several dozen ITS in their area including their uses, location of mother trees where seeds and wildlings were collected, specific niches of mother trees in the landscape, and flowering and fruiting periods (UNDP SGP PTF 2006). Community members were clearly familiar with the ITS in their locality. The project illustrated the rich information lodged among local indigenous people and the need to externally pump-prime similar projects that will stimulate the use of indigenous knowledge systems in plantation development. The use of seeds and wildlings as sources of germplasm demonstrated the ability of these people to cope with the issue of limited planting materials.

15.4 Capacitating Smallholder Tree Farmers to Domesticate Indigenous Tree Species

The potential of domesticating a variety of ITS by smallholder tree farmers in the Philippines is undeniably tremendous. With the shift in forest management from purely corporate-based to community-based forest management, as mandated by Executive Order No. 263, restoration of native forests by smallholder tree farmers is a viable alternative. There are 4.9 million hectares under CBFMA (Community-based Forest

Management Agreement), 20,000 ha tree farms and 94,000 ha under agroforestry leases (Forest Management Bureau Statistics 2003). Assuming that even 10 percent of these areas will be devoted to the planting of ITS, it still represents an enormous **500,000 ha**! This is even more than the targeted plantation area identified in the Revised Forestry Master Plan. Devoting portions of this area for timber production is important in order to contribute in lessening the current wood product importation amounting to US$162.9 million (Forest Management Bureau Statistics 2003). With appropriate investment climate and incentives, stable market, appropriate technologies, supported by policies friendly to smallholder tree farmers, domesticating ITS has bright prospects in restoring the Philippine native forests. The discussion below includes both a number of constraints that affect the planting of ITS and a number of recommendations that will capacitate smallholder tree farmers to plant ITS in their farm lots.

15.4.1 Prioritization of Potential ITS

The ITS for potential use in upland farms are so diverse and numerous that developing technologies for each species is virtually impossible. It is imperative that technical experts, local communities, indigenous people, wood industry officials, concerned government officials and other key stakeholders in the uplands meet and discuss together to identify the ITS that will be most useful and promising in their respective regions. The prioritization procedure is founded on the basic principles of tree domestication that is farmer-led and market-driven process. A more detailed procedure for setting priorities for multipurpose tree improvement was described by Franzel et al. (1996). The scheme provides science-based practice for species priority setting. This exercise will significantly cut down the long list of ITS and must be done for each of the biogeographic regions. Unfortunately, even for the national tree planting program, the priority listing of species seemed nebulous. Consequently, the vague direction weakens the various initiatives and efforts in plantation development.

Some regions in the Philippines have initiated studies and prioritization, e.g. Region 10 (Northeastern Mindanao) has published a list of Indigenous Tree Species in the region which includes 195 tree species (Anonymous 2002). In an unpublished material from DENR Region 8, (Eastern Visayas), the Ecosystem Research and Conservation Division has actively investigated potentially valuable ITS in the region. From the aforementioned lists, stakeholders can develop a consensus on the priority ITS that tree plantation developers can select from.

15.4.2 Increase Availability of and Improve Access to Quality Germplasm

Subsequently to species prioritization, the supply of quality germplasm is the next step in the production system of ITS. Support for planting ITS can be increased if the government and the private sectors or upland organizations will spearhead the production and distribution of quality ITS germplasm. Genetically diverse and superior sources of the selected species must be identified and conserved. It is not enough that seeds or seedlings are supplied to the farmers. The germplasm must be of superior quality. Many farmers' hopes have been crushed when the promise of millions in income did not materialize because the germplasm used was inferior and the resulting trees grew considerably less or were below market standards. Initiatives to address this critical need are not totally lacking.

In Lantapan, the Agroforestry Tree Seed Association of Lantapan (ATSAL), through the assistance of ICRAF (World Agroforestry Centre), found the seed and seedling business a market niche among the upland farmers. After developing the required appreciation for quality germplasm, the organization, which grew in membership and scope, has reportedly earned PhP 2 million (US$44,444) since its start in 1998. The organization has gained popularity in the Visayas and Mindanao region as a major source of agroforestry germplasm which includes both indigenous and exotic species.

The Mt. Apo Farmers Cooperative (MAFAMCO) is another people's organization that markets agroforestry seeds in Mindanao (Bansalan) through the Mindanao Baptist Rural Life Center (MBRLC). Originally, a seed business organization, it has now expanded into credit and merchandizing (Palmer 1999). However, it is not clear whether the organization is making rigid and strict selection of seed sources like ATSAL.

In another study (Tolentino et al. 2005), a village along the highway of Diadi, Nueva Vizcaya has engaged in the seedling production business mainly for exotic trees like gmelina, mahogany and acacia. However, a few of them were found to be producing ITS like dipterocarps, *Vitex parviflora, Dracontomelon dao,* and *Agathis philippinensis*. Accordingly, there are some demands for this species from customers coming from different parts of the Luzon Island. Interestingly, the exotics are priced much lower than the ITS. Seedlings of exotic species are sold at PhP 2 to PhP 5 (US$0.05 to US$0.10) a piece while the ITS ranged from PhP 20 to PhP 50 (US$0.40 to US$1.0) per seedling. Difficulties in the collection and limited sources of the ITS are the reasons for the price difference.

The Haribon Foundation, an NGO dedicated to the conservation of biodiversity in the Philippines, has also listed 10 nurseries around the country producing indigenous tree seedlings (www.haribon.org.ph/?q=node/view/367).

The existence of informal seed and seedling producers of ITS is a clear indication that with the demand for quality germplasm, upland organizations can respond to the needs. However, with vast hectares to be planted in the uplands, this may not be sufficient. Other sectors have to come in and beef-up the efforts of providing quality germplasm. Additionally, information about the existence of seed and seedling producers, and how to contact them, is not widely publicized. A national directory of small and informal seed and seedling producers will be an important piece of information for many tree growers searching for ITS germplasm. A simple seed and seedling directory is currently being prepared from the study by Tolentino et al. (2005).

Other sources of planting stocks are needed to complement the shortage of seeds of many ITS. This will include vegetatively reproduced stocks and wildlings.

Asexual propagation, particularly of recalcitrant species and those with seed periodicity (e.g. dipterocarps) is a good alternative source of germplasm materials. For example, Pollisco (2006) described propagating dipterocarps vegetatively employing IBA as rooting hormone in a non-mist sand propagating system. In another study, cuttings of 15 dipterocarp and premium hardwood species were propagated in a mist and non-mist system with varying degrees of success (Dimayuga and Pader 2006). Regional offices of the Ecosystems Research and Development Service (ERDS) have established hedge gardens of many dipterocarps and some premium hardwoods. The main ERDB office at UPLB has a significant collection of these species (Pollisco 2007). An emerging propagation technology for the mass propagation of cuttings of dipterocarp is the KOFFCO system (Komatsu-FORDA Fog Cooling system) tested for cuttings of 36 indigenous dipterocarps species in West Java, West Kalimantan and East Kalimantan (Subiakto et al. 2005). Its possible application for the Philippine dipterocarps may be explored.

Protocols for tissue culture of ITS are having some headway with the development of protocol for micro-propagation of bagras (*Eucalyptus deglupta*) plantlets using explants from selected mature genotypes (Capuli and Calinawan 1999). Another researcher has also successfully developed the mass propagation of *Endospermum peltatum* Merr through tissue culture (Quimado and Umali-Garcia 1997). In Malaysia, they have successfully micropropagated *Shorea leprusola* using a temporary-immersion technique, the RITA system (Kandasamy et al. 2005) which may find possible application for the Philippine dipterocarp species.

Wildlings are another potential source of quality germplasm, but with limited natural forests, they may be hard to find. Additionally, the possible sources of these wildlings are located in protection forests where gathering of wildlings is strictly regulated. For remote sources, transporting shock is a serious threat that results in high mortality. A solution to this was developed by Pollisco (2006). Wildlings are protected from desiccation during collection by placing them in large polyethylene plastic bags (62 × 25 in.) with small amounts of water. Upon reaching the nursery, the wildlings are immediately potted and placed for about two months in an airtight wildling recovery chamber.

The policies on silvicultural treatments to existing trees in protected areas where wildlings are collected are nebulous except for a blanket policy that no cutting or logging is permitted. There is a necessity to revise policies to designate germplasm production areas in protected areas where silvicultural treatments such as thinning of competing trees, girdling and fertilization of potential mother trees are allowed, including regulated collection of wildlings, to increase fruit and seed production.

15.4.3 Generation of Farmer-Friendly Technologies

Information and technologies about ITS are either limited, fragmented or non-existent. This was confirmed through an analysis of available information about ITS (Tolentino 2000b; Tolentino 2003). The comprehensive tree species selection and reference guide Agroforestree Database (Salim et al. 2002) listed 43 tree species native to the Philippines. Of these 43 species, 28 species have good and sufficient information about propagation methods (65.1 percent). This is adequately complemented by equally good information about tree management (60.5 percent or 26 spp). On the other hand, only ten species are provided with good information about germplasm management whereas for 30 species this information is limited. Natural habitat is next with limited information for most species (27 species; 62.8 percent). A close third is pests and diseases (limited information for 26 species; 60.5 percent) followed by reproductive biology and history of cultivation (limited information for 21 species; 48.8 percent). Finally, various species lack any information in one or more of the following themes: history of cultivation, pest and diseases, germplasm management, tree management, natural habitat, biophysical limits, reproductive biology and propagation methods. Based on functional use, the native species are obviously multi-use or multi-service tree species. The matrix analysis also provided some interesting observations regarding the way other countries plant these native species. *Barringtonia racemosa* (apalang) is solely found in the Philippines, but 32 other places plant it as an exotic species. Another species, *Artocarpus altilis* though native to three other places is planted in another 51 countries or major islands. Several of these native tree species have wide exotic distributions (>20 countries/places), namely: *Albizia procera, Aleurites moluccana, Flemingia macrophylla, Lawsonia inermis, Sennasiamea, Sesbania grandiflora,* and *Syzygium cuminii*. This proves that it is not only the Philippines that have a proclivity for exotics.

In tree domestication researches on appropriate seed, nursery and plantation technologies for the prioritized species are conducted on-station and on-farm levels to insure that the production technologies will be acceptable and affordable to the upland farmers. Tree domestication is farmer-led thus the old paradigm of purely researcher-generated technologies for the uplands must be complemented by this new paradigm. Farmers can play an active role in the planning, implementation, management, monitoring and evaluation of the smallholder tree farm programs. Incorporation of indigenous knowledge, when available, is another viable step. The UNDP Project cited earlier reinforces this recommendation. CBFM sites with strong community participation are ideal areas for researches of this nature. Various community-based researches are in existence and the author is currently involved in one of those (Quirino study cited earlier).

Another problem that needs to be addressed by researchers will be improved planting stock production. In one study, quality of the many nursery stocks in smallholder nurseries was found to be generally low (Tolentino et al. 2001). Root-shoot ratios were low, many roots were defective and quite a number were overgrown. Recommendations were made to improve the production of plantings stocks namely: availability of improved or quality sources of germplasm, applications of root pruning, use of alternative containers (e.g. root trainers), development of appropriate nursery stock quality assessment, and promotion of the use of composts. Since operators of these smallholder tree nurseries are resource-limited, assistance on training and logistical support is necessary. Other technological aspects needing specific information for ITS are on proper site selection, appropriate tree management and sustainable harvesting system.

Active participation of the smallholder tree farmers is critical in the development of appropriate production model. Considering the diverse conditions, options, limitations and stakeholders present in various regions of the country, a generalized pattern for species planting, species mix or combination is difficult to make for all the smallholder tree farmers in the Philippines. The challenge to evolve site and locality-specific domestication strategies for ITS is clear and imperative. However, the scale of production from a particular species in a locality must be economically feasible to support the wood processing requirements in that area. Wood industries normally require large-scale plantations as reliable sources of raw materials for their processing plants. The shift to the community-based forest management, demands models of smallholder tree farms aggregated together as a confederation large enough to sustainably supply the needs of wood processing plants using ITS. Additionally, upland farmers rarely plant trees in blocks (boundary or contour planting), thus models or schemes which integrates the ITS in the agroforestry farm that respond to market requirements and demands while at the same time addressing the farmers limitations and their livelihood options are critical research questions.

Enrichment planting technologies are already available but prioritizing ITS in enrichment plantings particularly in CBFM projects is an important move. Accomplishments of the community-based projects with Assisted Natural Regeneration (ANR) and Timber Stand Improvement (TSI) components with funding from Asian Development Bank (ADB) and Japan Bank for International Cooperation (JBIC) revealed that most of the species planted are the fast growing exotic species, e.g. *Gmelina arborea*, *Swietenia macrophylla* and *Gliricidia sepium*. *Pterocarpus indicus* is the only indigenous tree species commonly used by the POs (NFDO 2003). This ground reality is quite off tangent to existing policies of DENR, e.g. DENR Memorandum Circular No. 20 Series of 1990 (Guidelines on the Restoration of Open and Denuded Areas within National Parks and Other Protected Areas for the Enhancement of Biological Diversity) and DENR Administrative Order No. 32 Series of 2004 (Revised Guidelines on the Establishment and Management of Community-based Programs in Protected Areas) which prescribes the planting of indigenous and endemic species for these particular areas.

Dipterocarp pilot plantations have been established by DENR Regional Offices all over the country by virtue of DENR Administrative Order No. 21 Series of 1996. Pollisco (2007) provided information regarding the distribution and accomplishments of this particular directive. On average, most regions established and maintained around 100 ha of dipterocarp plantations with Region 7 (Central Visayas) topping the list with more than 600 ha. Key lessons from these plantations have not been widely disseminated to allow wide replication of this notable endeavor. Despite, these seemingly impressive accomplishments, these pilot plantations are still significantly less than the existing exotic plantations.

Another innovative approach employing indigenous tree species that could be emulated is the Rainforestation Farming pioneered at the Leyte State University (now Visayas State University) in Eastern Visayas. The Project combines the elements of sustainable rural development, conservation of remaining primary forests and natural resources and biodiversity rehabilitation (Göltenboth 2005) and specifically employs indigenous tree species in its planting programs. The details of planting and maintenance scheme which includes indigenous pioneer trees (e.g. *Samanea saman, Artocarpus blancoi, Melia dubia, Casuarina nodosa*), indigenous shade loving trees (e.g. *Dipterocarpus validus, Shorea contorta* and *Litsea leytensis*) and fruit trees (e.g. *Artocarpus heterophylla, Nephelium lappaceum, Garcinia mangosteen, Durio zibethinus* and *Sandoricum koetjape*) were described by Göltenboth (2005). The project reported about 1,500 ha under long-term trials using this mode of farming in the islands of Leyte, Bohol, Palawan and Mindanao involving subsistence farmers and farmer cooperatives (EURONATUR 2002).

Technologies for wood processing and post-harvest practices suitable for the production models of the smallholder tree farmers are required to assist farmers to efficiently process their trees. There is a need for small sawmills for the processing of small diameters and volumes of wood that are grown in most smallholder tree farms. Farmers need post-harvest technologies to minimize losses due to poor handling and storage. This will include wood drying and, if necessary, wood preservation technologies.

The experience of Landcare in the Philippines highlights how farmer participation was promoted to adopt soil conservation measures. Although in another realm, these principles appear to be a good model to follow when generating technologies for the domestication of ITS by the smallholder tree farmers (ACIAR 2004; ACIAR 2003).

Appropriate and aggressive dissemination of technologies is part of the technology generation program. Data banking of relevant information for ITS is vital to widespread dissemination. The Agroforestree Database was developed by ICRAF and is already on its second version. The database contains both exotic and indigenous tree species. The Department of Forestry, Leyte State University (now Visayas State University) is using software called ALICE which accordingly stores information for ITS (Mangaoang, E.O., 1999). Both of these databases are undergoing regular improvements and updates. It is also recognized that many information and data have not been integrated into these existing databases and are just in some libraries, research offices or in the communities. Thus, there is an obvious need to gather, collate, analyze and validate the information before their inclusion in the data banks. Knowledge management of these sources of information is critical to facilitate adoption of the technologies by the smallholder farmers. More importantly, this information should be easily accessible to the end users.

15.4.4 Strengthening the Use of ITS in Biodiversity Conservation Programs

Indigenous tree species will find a good niche in the proposed biodiversity corridors as advanced in the National Biodiversity Strategy and Action Plan (Department of Environment and Natural Resources-Protected Area and Wildlife Bureau) (DENR-PAWB), Conservation International (CI), & University of the Philippines-Center for Integrative and Development Studies (UP-CIDS), 2002. In these corridors, planting of so-called keystone species will make good use of ITS. Keystone species are those indispensable species which control the structure of the community and help determine which other species are present. While we still lack information on what are those keystone species, it is undeniable that these are ITS which provides the food for and habitat requirements of wildlife or are the associated species of other trees in the forest. The aforementioned Rainforestation Farming utilizes pioneer species which are potentially keystone species.

The Framework Species Method pioneered in Chiang Mai, Thailand utilizes the so-called framework species in forest restoration of degraded sites. These species are defined as *indigenous, non-domesticated forest tree species, which, when planted on deforested land, help to re-establish the natural mechanisms of forest regeneration and accelerate biodiversity conservation*. The method "re-captures" the site by shading out the herbaceous weeds, establishes a stratified crown system, restores ecosystem processes and improves microclimatic conditions for the establishment of new regenerations. The framework species provide bird perches, habitat and food for seed dispersing animals that will enhance natural regeneration in the area (FORRU 2005). This approach can likewise be modified for application in the Philippines particularly in designated protected areas.

ITS in protection forests may have enormous potential for carbon sequestration as revealed by the fast growth performance of several ITS. Since many of these ITS are long-lived unlike their exotic counterparts, their ability to store carbon for longer periods presents another important role of ITS in mitigating climate change.

15.4.5 Market Information and Links

Farmers have always complained of poor markets for the crops (either agricultural or trees) raised in their upland farms. Correct market information particularly the seasonal demands, price fluctuations, product specifications or standards, existing or potential competitors (both direct or substitute), attendant risks, are vital information the farmers needs to know. It might even be worthwhile that the people's organizations have an honest-to-goodness discussion with potential buyers who will directly provide information about their wood requirements and the prices they are willing to pay. Assistance in linking them to the potential buyers or market will be crucial in the farmers' decision to raise ITS species. This should be linked with the earlier discussion on species prioritization.

ITS absorption by the wood processing industry or the wood market is critical in the production chain. Undeniably, the ITS were the species that the wood industry was processing during the start of the logging era except that the trees were naturally-grown and of bigger diameters. Improved technologies for processing of plantation-grown smaller diameter trees are important imperatives to allow the market for ITS to expand and develop.

The case of malapapaya (*Polycias nodosa*) in Gumaca, Quezon is an example on how ITS was promoted due to market forces. A processing plant which manufactures chopsticks, popsicle sticks, veneer and bento box (Japanese lunch box, a good substitute for styrofoam boxes) buys naturally-grown malapapaya trees from the area. The presence of this market has encouraged the planting of the species in the area. However, while planting has increased, production technology particularly of planting stocks is not fully perfected. The Ecosystems Research and Development Bureau and the company (MP Woods Inc.) have partnered together to conduct production technology research for the species, but the technology has not reached the smallholder tree farmers.

15.4.6 Policy Review and Reforms Coupled by Incentives for Plantation Development

The Director of the Forest Management Bureau himself admitted that *the development of private industrial forest plantations has not progressed well despite the incentives provided and the prescriptions of the Philippines Forestry Master Plan* (Acosta 2004). He enumerated the factors that hinder forest plantation in the Philippines namely: (a) financial viability of plantation development; (b) security of land tenure; (c) unstable forest policies (changing personnel who do not honor previous commitments between government and investors).

Resource-limited farmers are always plagued by the lack of capital to finance even the most essential components of their agroforestry farm. Financial assistance at reasonable interest rates would augment the farmers' meager resources. However, most upland farmers are non-bankable, i.e. practically no bank is willing to extend credit to the tree farming business of this sector of the society. High risks associated with environmental problems and low repayments are the major reasons. It would be better if the farmers' organization itself will be the one to apply for credit.

The short land tenure scheme currently offered by the government (25 years renewable for another 25 years) does not encourage plantation investors to put in their money to tree farming. The private sector is suggesting a tenure security close to private ownership or if possible complete privatization of state forest lands (Acosta 2004).

The same paper on plantation incentives (Acosta 2004) suggested the following actions to tap into the potential of CBFMs for plantation development: (a) *full rationalization of forestry rules and complete devolution of forest management functions to communities and people's organizations;* (b) *Research and development and extension support to CBFM and;* (c) *strengthening the financing and market links between corporate forestry entities and CBFM organizations*. Furthermore, he proposed the re-evaluation of the present ban on export of logs and rough lumber from the natural forests and deregulation of harvesting, transport and trade of plantation timber.

Another paper on financial and other incentives for plantation establishment contends that financial incentives are effective but needs supporting policies and conditions to be successful (Williams 2001). He suggested indirect incentives like research, training, extension and market information instead of the usual direct government subsidies.

On the regulatory side, special permits are required to harvest and transport certain indigenous tree species particularly premium hardwood species. DENR Administrative Order No. 78 regulates the cutting of several premium hardwood species to specific areas and amounts only. In private lands, a special private land timber permit (SPLTP) has to be secured for the purpose of harvesting and transporting the planted trees. Almaciga (*Agathis philippinensis)*, on the other hand, is totally banned from cutting in any part of the country as per DAO No. 74 series of 1987. No regulative problems will be encountered in the planting operations except some registration procedure, but the difficulties will arise when these trees reach harvesting age. For the ITS, volumes less than $10\,m^3$ are approved for cutting and transporting by the Regional Executive Director of the Department of Environment and Natural Resources (DENR; not CENRO or PENRO at, respectively, the municipal and provincial administrative levels). Volumes in excess of this amount will have to be approved by the DENR Secretary. A smallholder tree farmer or owner of a private land may not have the patience, time and resources to secure the necessary special permit from the DENR Regional or Central Office. Exotic trees when harvested are not subject to similar stringent regulations. Instead of going hard on illegal loggers of premium hardwoods from the natural forests, these policies have created an environment that tend to discourage the massive planting of these ITS and have spawned conditions that favor the planting of exotic trees. The deregulation of plantation timber described above is supported by this analysis. Obviously, a revision of these "anti-ITS" policies have to be instituted to encourage the planting of ITS.

Simplification of policies governing the establishment, harvesting and transport of ITS from CBFM and private tree farms will facilitate the procedures that these farmers have to go through during the harvesting and transport of their produce. The current cumbersome and bureaucratic process discourages many farmers from engaging in ITS planting. The Forestry Development Center of the CFNR-UPLB has recently completed a study towards the simplification of rules, regulations and procedures of DENR.

15.5 Conclusions

Philippine reforestation efforts dating back in the early 1900s are characterized by the dominant planting of exotic tree species. Reasons for their widespread use include: (1) wide adaptability and tolerance to stress; (2) fast growth and high yield; (3) accessible information and technologies and; (4) availability of abundant germplasm, particularly improved seeds. Despite this apparent edge over the indigenous tree species, ITS still has a niche to occupy in Philippine forestry particularly for forest restoration by smallholder tree farmers. Experiences and interests on ITS are emerging as manifested in the planting initiatives described in the UP Land Grants, Quirino, Mindanao and other parts of the country. There are fast growing and stress-tolerant ITS that have comparable performance in marginal sites like the exotic trees. Limited germplasm, particularly seeds, is complemented by the collection of wildlings from adjacent natural forests, a coping mechanism by resource-limited farmers. Propagation and tree management of these ITS are not very complicated and difficult despite the absence of intensive researches like their counterpart exotics. In some sites, indigenous knowledge has played a major role in addressing the lack of formal research studies needed as basis for technological practices.

The current national thrust on community-based forest management highlights the potential contribution of smallholder tree farmers in forest restoration. Familiarity with the ITS among upland dwellers is high which can facilitate widespread domestication. However, there are important strategies that needs to be put in place to facilitate the domestication of ITS. These are: (a) the need to prioritize the ITS by region to limit the list to the potentially useful and marketable species; (b) increase the availability of and improve access to good quality germplasm; this involves the use of the traditional seeds complemented by vegetatively-propagated stocks (macro and micro) as well as wildlings; (c) generation of farmer-friendly technologies that spans from production to processing; indigenous knowledge is useful when available; the strategy also includes the appropriate dissemination and adoption of these technologies to the end users; (d) strengthening the use of ITS in biodiversity conservation programs; (e) improving access to market information by tree farmers and establishing close links to the wood market and; (e) policy review and reforms coupled by adequate incentives to promote plantation development.

There are existing policies and programs that clearly support the planting of ITS in the various forest restoration programs of the country. However, there are certainly big hurdles that need to be surpassed but with a resolute stand to bring back the Philippine native forests, foresters, smallholder tree farmers and private land owners can unite to restore the lush tropical forests. A last note, this paper does not advocate a complete shift from exotics to purely indigenous trees but offers a pragmatic approach to species selection which aims to provide the best options for the benefit of the people and the society who depend on the Philippine forests. Similar to exotic species, indigenous tree species offer immense potentials that remain to be tapped by many tree growers both for production and environmental services.

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Appendix: Indigenous Tree Species with Potentials for Plantation Forestry Identified and Classified by Local Residents in Areas Covered by the University of the Philippines Land Grants

Priority level	Scientific name	Use
1	*Pterocarpus indicus*	Furniture
1	*Aglaia luzoniensis*	General construction, furniture
1	*Diospyros philippensis*	General construction, furniture
1	*Litsea leytensis*	Handicraft
2	*Shorea negrosesnsis*	General construction
2	*Callophyllum* spp.	General construction, furniture
2	*Shorea squamata*	General construction, handicraft
2	*Shorea contorta*	General construction, handicraft
2	*Shorea polysperma*	General construction, handicraft
2	*Dehaasia triandra*	General construction
2	*Parashorea malaanonan*	General construction, handicraft
2	*Dracontomelon dao*	General construction, furniture
2	*Litsea* spp.	General construction, handicraft
3	*Dysoxylum octandrum*	General construction
3	*Hopea foxworthyi*	General construction
3	*Dillenia philippinensis*	General construction, furniture
3	*Alstonia macrophylla*	General construction, furniture, medicine
3	*Syzygium* spp.	General construction, furniture
3	*Palaquium merrillii*	General construction
3	*Dipterocarpus grandiflorus*	General construction
3	*Anisoptera thurifera*	General construction
4	*Alstonia scholaris*	General construction
4	*Endospermum peltatum*	Handicraft, frame
4	*Agathis philippinensis*	Furniture
4	*Sandoricum vidalii*	General construction, furniture, handicraft
4	*Syzygium* spp.	General construction, furniture, food
5	*Glochidion triandrum*	General construction
5	*Artocarpus blancoi*	General construction
5	*Cinnamomum mercadoi*	General construction, furniture, medicine
5	*Dysoxylum altissimum*	General construction, furniture
6	*Buchanania arborescens*	General construction
6	*Cratoxylum blancoi*	General construction
6	*Melicope triphylla*	General construction
6	*Canarium asperum*	General construction
6	*Diplodiscus paniculatus*	General construction
6	*Mussaenda philippica*	Fuel/charcoal, construction
6	*Polycias* spp.	General construction
6	*Myristica philippensis*	General construction
6	*Artocarpus ovata*	General construction
7	*Teijsmanniodendron ahernianum*	Fuel/charcoal, handles
7	*Kibatalia gitingensis*	Furniture, handicraft
7	*Diospyros pilosanthera*	General construction, furniture
7	*Symplocos villarii*	General construction
7	*Ormosia grandifolia*	General construction

(continued)

(continued)

Priority level	Scientific name	Use
8	*Endospermum peltatum*	White lumber
8	*Ficus balete*	White lumber
8	*Ficus variegate*	White lumber
8	*Macaranga tanarius*	Fuel/charcoal
8	*Pterocymbium tinctorium*	Wooden footwear
9	*Lithocarpus buddii*	Fuel/charcoal
10	*Castapnosis philippensis*	Fuel/charcoal, food

Chapter 16
Human-Altered Tree-Based Habitats and Their Value in Conserving Bird and Bat Diversity in Northeast Luzon, The Philippines

M. Van Weerd* and D.J. Snelder

Abstract This chapter discusses the conservation value of smallholder tree-based systems for bird and bat species in the human-altered landscape of the Cagayan Valley, Northeast Luzon. Birds and bats in village homegardens, small *Gmelina arborea* plantations and uncultivated shrub-land were surveyed in 11 localities, using 118 point counts for birds and 34 mist-net-lines for bats. A total of 1,093 individual birds were observed representing 58 resident bird species, including 11 species endemic to the Philippines, 15 forest bird species and one globally threatened species. A total of 409 bats were captured belonging to 16 species, including five endemics, five forest bat species and also one globally threatened species. Gmelina forest plantations held slightly more forest bird species than homegardens and surrounding shrub-land. However, the human-altered landscape fails to serve as an alternative for closed-canopy forest habitat containing only 13 percent of lowland forest birds, 15 percent of endemic lowland birds and eight percent of threatened lowland birds known to occur in the region. For bats, human-altered habitats offer slightly better conditions, containing 44 percent of all lowland bats, 42 percent of endemic bats and 29 percent of forest bats in the region. Most forest birds and bats were restricted to a narrow zone bordering contiguous forest. Reforestation through mono-culture *Gmelina arborea* plantations is of little direct value to bird and bat conservation but it could act as a catalyst for forest recovery. Better structured, diverse and interconnected homegardens and forest plantations potentially have higher conservation values for birds and bats.

Keywords Biodiversity conservation, ecosystem services, endemic species, exotic tree plantation, homegardens, off-park conservation

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16.1 Introduction

Traditionally, ecologists and conservationists have focused their attention on wilderness areas, such as large undisturbed protected forest areas, in their attempt to conserve tropical biodiversity (Bruner et al. 2001). However, while deforestation continues, there is concern that the remaining forest areas will not be large enough to conserve the original tropical forest species diversity (O'Riordan and Stoll-Kleeman 2002).

Consequently, more attention has been given in recent years to the role of human-altered landscapes and off-park conservation in sustaining tropical biodiversity (Hughes et al. 2002; Petit and Petit 2003; McNeely 2004; Atta-Krah et al. 2004; McNeely and Schroth 2006). Agroforestry and other tree-based land use systems are considered highly relevant within this context as they may offer a suitable habitat for a range of forest species (McNeely and Schroth 2006). Moreover, these systems also provide economic benefits in terms of local livelihoods and farmers' income, and environmental services such as watershed protection and carbon sequestration. The integrated ecosystem approach advocated by the Convention on Biological Diversity seeks such combinations of rural development and the conservation of ecosystem services and biodiversity (Garrity 2004; McNeely 2004; McNeely and Schroth 2006).

Within a Southeast Asian context, relatively few studies have been published on biodiversity in human-altered landscapes (Peh et al. 2006) though recently a number of studies compare forest bird species richness between various agro-ecosystems and natural forest (Thiollay 1995; Waltert et al. 2004; Peh et al. 2005, 2006; Sodhi et al. 2005; Marsden et al. 2006; Round et al. 2006). To our knowledge no study has yet been published on birds and bats in agro-ecosystems in the Philippines.

16.1.1 Deforestation and Threatened Biodiversity in the Philippines

The Philippines has lost most of its original forest since 1900 (Kummer 1992). The current forest cover (FAO 2007) is 71,620 km^2 (24 percent of land area) with an annual deforestation rate of 2.1 percent in the period 2000–2005 (see also Chapter 1, this volume). Geographic isolation and specific local circumstances drove a process of local evolution which resulted in large numbers of endemic species restricted to islands and island groups in the Philippines (Heaney 1986). Of the world's plant and vertebrate species, 1.9 percent is endemic to (one of) the 7,100 islands of the Philippines (Myers et al. 2000). Endemism levels within the Philippines vary from 31 percent of all bird species (Kennedy et al. 2000) to 78 percent of currently known amphibian species (IUCN and Conservation International and NatureServe 2006). As Philippine endemic species primarily evolved in forest they are considered to be forest specialists and as such vulnerable to deforestation. The loss of original habitat, in combination with the high proportion of global biodiversity restricted to the Philippines, led to the identification of the entire Philippines as a biodiversity conservation hotspot in a global comparison of conservation priorities (Myers et al. 2000).

Since the early 1970s, the Philippine government has been promoting reforestation through a variety of forestry support programs. Most of the current programs provide tenure rights of government-owned land earmarked for reforestation to smallholders and communities. Assistance in reforestation is often provided by local government, NGOs and international donors (Harrison et al. 2004). Officially, 25,000 km^2 is covered by such forest management programs but not all lands have been reforested (Harrison et al. 2004). The FAO (2007) reports a total area of 6,200 km^2 forest plantations in the Philippines. A number of social, economic and physical factors have hampered successful reforestation on a larger scale (Pasicolan et al. 1997). Reforestation efforts in the Philippines usually concentrate on a few tree species, sometimes planted in mixtures of two up to five species but mainly established in the form of mono-cultures of fast-growing exotic species, such as *Gmelina arborea* (Lasco and Pulhin 2000). *Gmelina arborea* is a fast-growing deciduous tree native to tropical moist forests of mainland Asia. This species is widely introduced in South America, Africa and Asia. It can tolerate a 6–7-month dry season and occurs up to 1,500 m a.s.l. The timber is reasonably strong for its weight and in the Philippines particularly used for construction and furniture (Center for New Crops & Plant Protection 2007). A possible synergy between reforestation, carbon emission offsets and biodiversity conservation has been identified as an opportunity resulting from global climate change mitigation strategies. There is concern however that exotic tree plantations contribute little to biodiversity conservation as opposed to reforestation efforts using mixed native species (Stier and Siebert 2002).

16.1.2 Extinction or Persistence of Forest Species in Human-Altered Landscapes in the Philippines?

Brooks et al. (2002) warn that 58% of Philippine endemic forest species might go extinct as a result of deforestation. This extinction prediction is based on species-area relations and assumes that endemic forest species will not be able to adapt to or persist in any landscape other than undisturbed old growth forest. However, not a single endemic mammal or bird species has been reported truly extinct in the wild in the Philippines. Three different explanations can be put forward: (1) species have gone extinct unnoticed, (2) there is a time gap between habitat loss and species extinction (Brooks et al. 1999) or (3) endemic forest species are less vulnerable to deforestation and forest disturbance than assumed.

It is unlikely that large-scale extinctions of better studied taxa such as birds have occurred unnoticed in the Philippines, as birds have been described relatively well and monitored since the start of the 20th century, i.e., the onset of large-scale deforestation (e.g. Dickinson et al. 1991 for an overview of literature on Philippine birds).

It is well established that biodiversity in the Philippines is under severe threat, and several well-monitored species have reached dangerously low population levels and continue to decline (e.g. WCSP 1997; Heaney and Regalado 1998; Collar et al. 1999; IUCN 2006) supporting the time gap hypothesis.

Perhaps surprisingly, very little information is available to assess hypothesis three. Nearly all biological attention in the Philippines is still devoted to taxonomy, biogeography and basic biodiversity surveys in forested areas. However, Posa and Sodhi (2006) report that in the Subic Bay area of Luzon a number of forest birds and butterflies, including endemic species, were found in disturbed open canopy forest and non-forest habitats although forest species richness declined with urbanisation.

16.1.3 Research Objective

The objective of this study is to determine the conservation value of smallholder tree-based systems for birds and bats in the human-altered landscape of the Cagayan Valley.

16.2 Methods

16.2.1 Study Area

Fieldwork was conducted in Isabela and Cagayan Provinces of Region II. This region is reported to have a forest cover of 11,498 km^2 (43 percent of the region's area and 16 percent of the country's total remaining forest cover), including ca. 336 km^2 of forest plantations (Forestry Management Bureau 2004). Forest plantations in Region II are mainly composed of monoculture *Gmelina arborea* (M. van Weerd and D. Snelder, personal observation 2005).

Survey localities were situated in the human-altered landscape extending from the intensively cultivated lowland areas along the Cagayan River in the West to the contiguous closed-canopy *Dipterocarp* forest in the Sierra Madre Mountain Range in the East. The lowland areas are mainly used for monocultures of rice, corn and tobacco. Towards the hilly uplands land use gradually changes into grassland and corn fields, with banana and forest patches on steeper slopes. The mountains run parallel to the eastern coast of northern Luzon and reach elevations of just under 1,900 m. They are still largely covered with tropical forest, yet mostly selectively logged in areas up to 1,000 m. In 1997, an area of 3,607 km^2 in the Sierra Madre in Isabela Province was declared a protected area: the Northern Sierra Madre Natural Park (NSMNP). An additional area of ca. 2,500 km^2 north of the NSMNP in Cagayan Province is also protected as the Penablanca Protected Land and Seascape.

The climate of the area is tropical and is dominated by the northeast (November–April) and southwest (May–October) monsoons with a dry period between February–May. Tuguegarao in the Cagayan Valley lowlands has an average annual rainfall of 1,649 mm (range 967 to 2,596 mm in the period 1975–2004; PAGASA 2005). Rainfall is estimated to be considerably higher in the hilly uplands and adjacent mountains up to 4,000 mm annually but reliable meteorological data is lacking.

16.2.2 Survey Localities

Eleven localities were surveyed within an area of 90 × 20 km (N-S × W-E) in the human-altered landscape between the Cagayan River and the Sierra Madre forest fringe (Fig. 16.1). All localities included a village with populations ranging from six to 282 households. The localities varied from 0.1 to 18 km in distance to contiguous forest and from 1.3 to 18 km in distance to bat-hosting caves (Table 16.1). With elevation above sea level ranging from 30 to 250 m, all localities belong to the

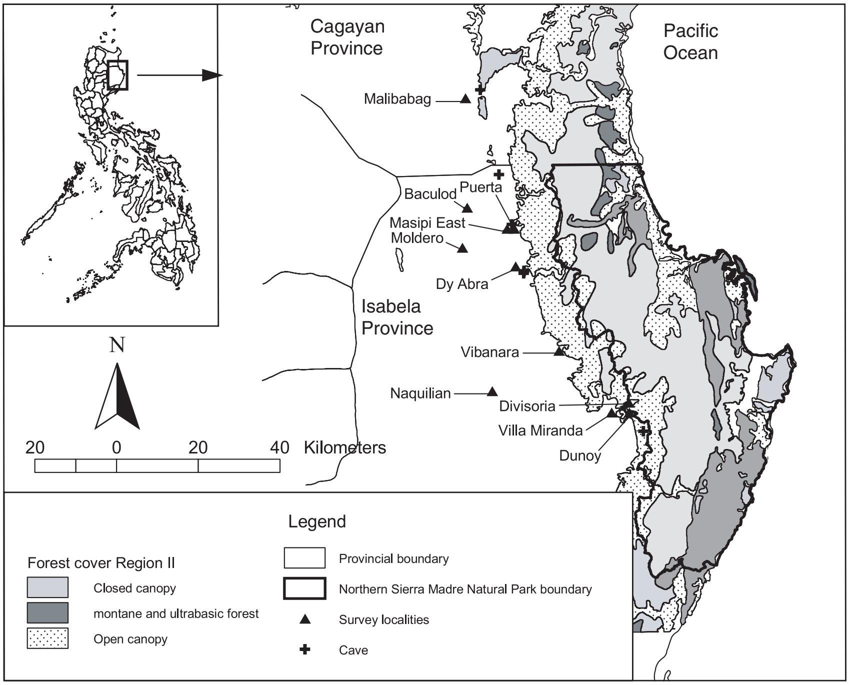

Fig. 16.1 Survey localities within the human-altered landscape situated west of the contiguous forest of the Northern Sierra Madre in Isabela and Cagayan Provinces, northeast Luzon. The inset shows the location of the study area within the Philippines

Table 16.1 Survey localities, number of households in the nearest settlement, distances to contiguous forest and caves and the habitat types surveyed per locality (Field observations, NSO 2000 and Van der Lans 2005)

Locality (municipality)[a]	Households	Distance to forest (km)[b]	Distance to cave (km)[b]	Habitat types surveyed
Dunoy (SM)	6	0.1	5.7	Shrub-land
Divisoria (SM)	10	0.4	7.7	Gmelina forest Homegarden shrub-land
Vibanara (IL)	187	0.9	7.5	Gmelina forest shrub-land
Villa Miranda (SM)	100	1.3	8.8	Gmelina forest Homegarden shrub-land
Puerta (C)	100	1.6	1.3	Gmelina forest shrub-land
Dy Abra (T)	115	1.8	2.2	Gmelina forest Homegarden shrub-land
Masipi East (C)	260	2.5	1.6	Gmelina forest Homegarden
Malibabag (P)	282	3.7	4.0	Homegarden shrub-land
Baculod (SP)	115	12.7	10.3	Gmelina forest Homegarden shrub-land
Moldero (T)	274	13.9	12.8	Gmelina forest Homegarden shrub-land
Naquilian (N)	50	18.1	18.0	Gmelina forest

[a] Municipality codes: SM = San Mariano, IL = Ilagan, C = Cabagan, T = Tumauini, P = Penablanca, SP = San Pablo, N = Naquilian. All survey sites in Isabela Province, except for Malibabag in Cagayan Province

[b] Euclidian distances calculated in ArcView using GPS positions of survey localities (centre) to contiguous forest and nearest caves using the most recent available forest cover map (NAMRIA 1995)

same elevational floristic ecotone (Ashton 2003). Not all 11 localities included all three human-altered habitat types investigated in this study: homegardens were surveyed in seven localities, *Gmelina arborea* plantations (henceforth named Gmelina forest; Photo 16.1) in eight localities and shrub-land in nine localities (Table 16.1).

The three human-altered habitat types differed in various aspects. Homegardens, with an average area of 1,031 m^2 per household (see Snelder, Chapter 2, this volume), were privately owned, situated next to houses and consisted of a variety of vegetables, tuber crops and fruit and timber trees. The surveyed Gmelina forests ranged in size from 0.16 to 25 ha and consisted of mature trees which were not (yet) being harvested. Gmelina forests were owned by private individuals, community organizations or government with use rights granted to local communities. Like the homegardens, we regard the studied Gmelina forests therefore as smallholder tree-based systems. The shrub-land concerned a broad mixed habitat category including deforested land with small trees or solitary large trees, fallow land covered with grass, herbs and shrubs, mainly used for livestock grazing and firewood collection, and some cropped fields. The uncultivated areas could regenerate into secondary forest but frequent fires and grazing pressure generally prevent this (Masipiqueña et al. 2000; Lasco et al. 2001). The shrub-land was assumed less suitable for forest species than homegardens and Gmelina forests. Only shrub-land

Photo 16.1 A *Gmelina arborea* forest plantation surrounded by shrub-land in the foothills of the Sierra Madre, the Philippines (©Van Weerd)

adjacent to village homegardens and Gmelina forest plantations were selected for surveys to make a direct comparison of species richness between habitat types possible. Pure cultivated areas were not included in this study as they represent very specific and changeable habitats, i.e., cornfields are expected to vary greatly in their suitability as a habitat for birds depending on growing season.

16.2.3 Survey Methods

The exact area of surveyed Gmelina forests could be determined as these were confined, unconnected habitat islands within a landscape of different habitat types. However, the area of surveyed homegardens and shrub-land could not be meaningfully determined as these habitats consisted of contiguous and interconnected land use types in and around villages and along roads. Both birds and bats were therefore surveyed using methods that enabled the calculation of relative measures of species richness and densities which could be used further in statistical procedures.

16.2.3.1 Birds

Within the three habitat types combined, a total of 118 point counts were conducted between 4 May and 25 July 2005 at well-spaced locations always more than 200 m apart (Table 16.2). Point counts lasted 10 minutes each, started after a several

Table 16.2 Survey effort and the number of observed bird and bat species and individuals for three habitat types in the Cagayan Valley, northeast Luzon (Values in parentheses show the proportion of total observed numbers of species or individuals)

	Gmelina forest	Homegardens	Shrub-land	Total
Birds				
No. of point counts	46	36	36	118
Resident bird species	38	27	47	58
Endemic species	7 (18%)	3 (11%)	6 (13%)	11 (19%)
Threatened species	0	0	1	1
Forest bird species	10 (26%)	5 (18%)	6 (13%)	15 (26%)
Total individuals	439	352	302	1,093
Forest bird individuals	63	12	16	91
Bats				
No. of mist-net-lines	13	9	12	34
No. of mist-nets	53	25	49	127
No. of mist-net-nights	154	75	147	376
Bat species	9	9	12	16
Endemic species	3 (33%)	3 (33%)	4 (33%)	5 (31%)
Threatened species	1	0	0	1
Fruit bat species	6 (67%)	6 (67%)	5 (42%)	7 (44%)
Forest bat species	1 (11%)	2 (22%)	3 (25%)	5 (31%)
Cave roosting species	3 (33%)	4 (44%)	8 (67%)	9 (56%)
Total individuals	131	128	150	409
Fruit bat individuals	128 (98%)	124 (97%)	130 (87%)	382 (93%)

minute rest period after arrival, and were performed early morning and late afternoon. Point counts were conducted by the first author and one experienced field assistant following Kennedy et al. (2000) for taxonomy. Vocal and visual records were noted with the number of individuals for each species per observation event. Birds flying over the point count locality were not included unless they clearly made use of the habitat, e.g., hunting swiftlets. Only resident species (Kennedy et al. 2000) were included in analyses to avoid bias as a result of differences in migration periods between migratory species. No fixed belt was used for the point counts but distances from observer were estimated. Although the detectability of bird species decreases with distance from observer, limiting a point count radius too much possibly excludes species that are hesitant to move within close distance to an observer and geometrically limits the survey area (Shankar Raman 2003). Unlimited distance point counts need compensation of observer bias due to specific differences in detectability. We followed other researchers in only using observations within a radius of 50 m (91 percent of observation events) within which, in our study, all species could still be vocally identified and assume our point count results approximate total counts (Shankar Raman 2003). To assess the importance of the three habitat types for birds belonging to different habitat preference guilds we categorized bird species into three groups: species primarily found in various types of forest (forest species), species primarily found in open areas (open area species) and species found in both open and forest like habitats (varied habitat species) based on Kennedy et al. (2000). We further distinguished Philippine endemic species (Kennedy et al. 2000) and globally threatened species (IUCN 2006).

Photo 16.2 Short-nosed Fruit Bat *Cynopterus brachyotis*. The most common bat in tree-based human-altered habitat types in this study (©Van Weerd)

16.2.3.2 Bats

Bat surveys were conducted using mist-nets of equal size (10 m long, 3.2 m wide, five shelves, 30 mm mesh size, manufactured by ECOTONE Poland) and good quality. They were placed at strategic locations within a distinct habitat type along creeks and paths or were, in open habitat types, randomly distributed. A total of 34 lines of several nets (2 to 5) were placed a little above the ground in Z-formations (see Table 16.2 for an overview of mist-net efforts). Nets were left open all night long for three consecutive nights and regularly checked. Bats were identified by the first author and several experienced field assistants based on measurements (forearm, hind-foot, ear, tail, total length, body mass) using Ingle and Heaney (1992). A unique identification code was written on the wing of each individual with a large-tip waterproof marker in order to identify re-catches of the same individual (five occasions, all *Cynopterus brachyotis*; Photo 16.2). Re-catches were excluded from data analyses. All species could be identified. No voucher specimens were taken. Although Megachiroptera (fruit bats) and Microchiroptera were caught, several species in the latter category are notoriously difficult to survey using mist-nets as they are able to detect nets using echolocation (Francis 1989). We therefore analyzed results for all bats and for a subset of fruit bats. To further deduct patterns in the distribution of functional groups of bat species in relation to landscape and habitat characteristics we used subsets of bat species that primarily depend on forest habitat (forest bats), and bat species that roost in caves (cave bats) (Heaney et al. 1998). Similar to birds, Philippine endemic bats (Heaney et al. 1998) and globally threatened bats (IUCN 2006) were distinguished.

16.2.3.3 Landscape and Habitat Characterization Variables

In order to correlate observed bird and bat species richness and abundance with landscape and structural habitat characteristics we determined two sets of variables. Landscape variables were determined for the survey locality at large, including the number of households in the nearest settlement, Euclidian (straight) distance from the centre of the locality to contiguous forest of the Sierra Madre, Euclidian distance from the centre of the locality to the nearest cave known to have roosting bats (Van der Lans 2005) and the size of Gmelina forests. Euclidian distances were calculated using a GIS program and GPS-derived locality data. Gmelina forest size was determined in the field using GPS.

Habitat characterization variables were determined using variable-sized plots surrounding point count and mist-net locations. Plot sizes varied from 10 × 10 m to 100 × 100 m. with most plots measuring 20 × 20 m. Different plot sizes were used to enable visual estimations of habitat characterizations from the centre of the plot. Plots in forest were smaller than plots in open areas. Plot size was used to standardize several variables to figures per ha. The study included a total of 64 habitat characterization plots for which the following variables were determined.

Canopy cover was estimated as total percentage cover from the observer's height upwards. No layers were distinguished. Ground cover was estimated as the percentage grass and herb cover. The height of the tallest tree within a characterization plot was determined using an inclinometer. The number of trees with a diameter at breast height (dbh) of more than 1 cm was counted. As a subset, the number of trees with a dbh over 20 cm ("large trees") was counted as well. These two variables were standardized to number of trees/ha. The number of houses within a radius of 100 m surrounding the point count or centre of the mist-net locality was counted.

16.2.4 Statistical Analysis

Heterogeneity in species detectability (Boulinier et al. 1998) and the practical impossibility of infinite biodiversity surveys (Gotelli and Colwell 2001) lead to incompleteness and variability of species richness assessments. We used the computer package EstimateS (version 7.5, Colwell 2005) to calculate smoothed sample-based species accumulation curves (Mao Tao, 100 randomized runs) from point count results (birds: each point count is one sample) and mist-net results (bats: all captures per mist-net-line is one sample) for each habitat type. To compensate for systematic differences in the mean number of individuals observed or captured per sample, we rescaled sample-based species accumulation curves by individuals (Gotelli and Colwell 2001). Species accumulation curves are asymptotic: with infinite sampling effort, species richness eventually no longer increases (Diaz-Frances and Soberon 2005). The slope of smoothed species accumulation curves thus provides information about the reliability of species richness assessments, with flattening curves indicating most species are detected and unsaturated curves indicating sampling effort is insufficient for a reliable species richness appropriation. For birds, we calculated species accumulation curves for all resident species and a subset of forest species. To compare bird densities between habitat types we plotted smoothed individual accumulation curves versus sample size (point counts), for all resident and forest species. For bats, we calculated species accumulation curves for all species and a subset of fruit bats. We also calculated individual accumulation curves here, plotted versus the number of mist-net lines.

In addition we calculated nine non-parametric species richness estimators (EstimateS 7.5, Colwell 2005). These estimators are based on species-abundance relationships (ACE, Chao1), species-incidence relationships (ICE, Chao2, Jackknife1, Jackknife2, Bootstrap) or extrapolation of asymptotic species accumulation curves (MMMeans, MMRuns). Non-parametric species richness estimators are useful for comparative purposes when sample sizes or sampling strategies differ, and are especially precise at small sampling unit size (Hortal et al. 2006). Because the performances of different species richness estimators vary between data and cases (Walter and Moore 2005), we calculated the average of the nine estimators (following, e.g. Sodhi et al. 2005; Posa and Sodhi 2006) to assess the completeness of our surveys and provide a comparison of patterns in species richness differentiation between habitat types. For birds, we calculated the average of the nine estimators for all resident species and for a subset of forest birds; for bats, we calculated the average for all species and a subset of fruit bats.

We calculated Sørensen similarity indices between pairs of habitat types to assess the proportion of shared species. The Sørensen similarity index is calculated by first determining the number of shared species in two habitat types. This figure is then multiplied by two and divided by the sum of all species in habitat type one and all species in habitat type two.

Point counts, mist-net lines and habitat characterisation plots within one locality are spatial pseudo-replicates, meaning these samples are not statistically independent with common locality factors affecting all variables measured in the locality. The smallest independent experimental unit to which statistical analyses are to be applied (Hurlbert 1984) is, in our study, the locality. Hence the averages for all measured variables (point count results birds, mist-net results bats, habitat characterisation variables) were calculated for each habitat type per locality. Tests for homogeneity of variances (Levene test) and normal distributions (Shapiro-Wilk) showed that not all data sets were normally distributed and had equal variances. Hence, non-parametric two-related-samples (Wilcoxon signed rank) tests were used to compare the locality averages of variable scores between habitat types.

Non-parametric Spearman correlation tests were used to determine relationships between bird and bat species richness and abundance, habitat characteristics and landscape variables. The dependant variables for birds consisted of the average number of species and individuals (resident species and forest species) observed per point count in each habitat type per locality. For bats, dependant variables were the number of species and individuals (all bats, fruit bats, forest bats, cave bats) per mist-net-line. We corrected for effort by dividing the number of species and individuals by the number of net-nights. The latter was calculated by multiplying the number of nets in a mist-net-line by the number of nights these nets were open. As all nets were equal in size, no correction of net length or area was needed. For comparisons with other studies: one net-night in our study is equivalent to 10 net-meter-nights, or 120 net-meter-hours (10 m * 12 hours of nocturnal netting time) or 32 net-square-meter-nights (3.2 m * 10 m). All statistical analyses were performed using SPSS version 13 for Windows (SPSS Inc. 2004).

16.3 Results

In 118 point counts we recorded a total of 1,093 individual birds belonging to 58 resident bird species (Table 16.2). Eleven of these were endemic to the Philippines (19 percent) and 15 (26 percent) were forest species. One species, *Anas luzonica,* was listed as threatened (vulnerable) on the IUCN red list (IUCN 2006). A total of 409 individual bats belonging to 16 species were captured in 34 mist-net-lines with a total effort of 376 net-nights. Five bat species were endemic to the Philippines (31 percent) and one species was listed as vulnerable (IUCN 2006): *Haplonycteris fischeri*. Seven species belonged to the Pteropodidae, the fruit bats.

We observed 38 resident bird species in Gmelina forest of which ten were forest birds (26 percent) and seven were endemic species (18 percent). In homegardens we observed 27 resident bird species including five forest birds (18 percent) and three endemics (11 percent). The highest bird species richness was recorded for shrub-land where we observed 47 resident bird species of which six were forest species (13 percent) and six endemic species (13 percent). Gmelina forest and homegardens shared 71 percent of resident bird species (Sørensen similarity index), Gmelina forest and shrub-land 68 percent and homegardens and shrub-land 62 percent.

The most common species in Gmelina forest was *Pycnonotus goiavier* (mean 0.978 per point count). In homegardens, the most common species was *Passer montanus* (mean 5.694 per point count), a species introduced to the Philippines more than 100 years ago and nowadays well established on all inhabited Philippine islands (Dickinson et al. 1991). *Passer montanus* was also the most common species in shrub-land albeit with a lower density than in homegardens (mean 1.417 per point count). All species and their relative abundance are presented in Table 16.3.

In Gmelina forest, seven forest bird species occurred that were absent in the other two habitat types. Among these were four species endemic to the Philippines: *Cuculus pectoralis, Ixos philippinus* (Photo16.3), *Rhipidura cyani-*

Table 16.3 Relative abundances of bird and bat species for Gmelina forest, homegardens and shrub-land in the Cagayan Valley, northeast Luzon

English name	Scientific name	Habitat preference	Gmelina forest	Home gardens	Shrub-land	Total
Birds						
Little Heron	*Butorides striatus*	O			0.028	1
Cinnamon Bittern	*Ixobrychus cinnamomeus*	O			0.056	2
Philippine Duck[a]	*Anas luzonica*	O			0.028	1
Brahminy Kite	*Haliastur indus*	O			0.028	1
Pied Harrier	*Circus melanoleucos*	O			0.028	1
Barred Rail	*Gallirallus torquatus*	V	0.217		0.111	14
White-browed Crake	*Porzana cinerea*	O			0.028	1
Plain Bush-hen	*Amaurornis olivacea*	O	0.065		0.056	5
White-breasted Waterhen	*Amaurornis phoenicurus*	O			0.056	2
Little Ringed Plover	*Charadrius dubius*	O			0.139	5
Island Collared-Dove	*Streptopelia bitorquata*	O	0.043		0.028	3
Red Turtle Dove	*Streptopelia tranquebarica*	O	0.630	0.083	0.111	36
Spotted Dove	*Streptopelia chinensis*	O	0.196		0.194	16
Zebra Dove	*Geopelia striata*	O	0.587	0.500	0.194	52
Common Emerald Dove	*Chalcophaps indica*	F	0.109	0.028	0.028	7
Guaiabero	*Bolbopsittacus lunulatus*	F			0.139	5
Colasisi	*Loriculus philippensis*	F		0.056		2
Philippine Hawk-cuckoo	*Cuculus pectoralis*	F	0.022			1
Brush Cuckoo	*Cacomantis variolosus*	F		0.028		1
Lesser Coucal	*Centropus bengalensis*	O	0.022		0.056	3
Philippine Coucal	*Centropus viridis*	V	0.457	0.056	0.222	31
Great Eared Nightjar	*Eurostopodus macrotis*	V			0.028	1
Island Swiflet	*Aerodramus vanikorensis*	V	0.152	0.111	0.056	13
Whiskered Treeswift	*Hemiprocne comata*	F	0.022			1
White-throated Kingfisher	*Halcyon smyrnensis*	V	0.087	0.111	0.083	11
Blue-tailed Bee-eater	*Merops philippinus*	O	0.174	0.028	0.056	11
Pacific Swallow	*Hirundo tahitica*	O			0.028	1
Striated Swallow	*Cecropis striolata*	O			0.611	22
Australasian Lark	*Mirafra javanica*	O			0.028	1
Pied Triller	*Lalage nigra*	V	0.239	0.028	0.028	13
Yellow-vented Bulbul	*Pycnonotus goiavier*	V	0.978	0.972	0.583	101
Philippine Bulbul	*Ixos philippinus*	F	0.565			26
Black-naped Oriole	*Oriolus chinensis*	V	0.478	0.139	0.139	32
Large-billed Crow	*Corvus macrorhynchos*	F		0.111	0.167	10
Oriental Magpie Robin	*Copsychus saularis*	F	0.087			4
Pied Bushchat	*Saxicola caprata*	O	0.087		0.389	18
Golden-bellied Flyeater	*Gerygone sulphurea*	V	0.217	0.028	0.056	13
Tawny Grassbird	*Megalurus timoriensis*	O	0.261	0.028	0.056	15
Striated Grassbird	*Megalurus palustris*	O	0.304	0.194	1.056	59
Philippine Tailorbird	*Orthotomus castaneiceps*	F	0.261	0.111	0.028	17
Bright-capped Cisticola	*Cisticola exilis*	O			0.083	3

(continued)

Table 16.3 (continued)

English name	Scientific name	Habitat preference	Gmelina forest	Home gardens	Shrub-land	Total
Zitting Cisticola	*Cisticola juncidis*	O		0.028	0.083	4
Mangrove Blue Flycatcher	*Cyornis rufigastra*	F	0.022			1
Pied Fantail	*Rhipidura javanica*	V	0.196	0.389	0.111	27
Blue-headed Fantail	*Rhipidura cyaniceps*	F	0.065			3
Black-naped Monarch	*Hypothymis azurea*	F	0.087		0.056	6
Yellow-bellied Whistler	*Pachycephala philippinensis*	F			0.028	1
Richard's Pipit	*Anthus richardi*	O			0.083	3
White-breasted Woodswallow	*Artamus leucorynchus*	O	0.239	0.028		12
Long-tailed Shrike	*Lanius schach*	O	0.261	0.056	0.389	28
Crested Myna	*Acridotheres cristatellus*	O	0.043	0.111	0.111	10
Plain-throated Sunbird	*Anthreptes malacensis*	V	0.087	0.333	0.056	18
Olive-backed Sunbird	*Cinnyris jugularis*	V	0.717	0.111	0.083	40
Purple-throated Sunbird	*Leptocoma sperata*	V	0.022	0.028		2
Red-keeled Flowerpecker	*Dicaeum australe*	F	0.130			6
Eurasian Tree Sparrow	*Passer montanus*	O	0.565	5.694	1.417	282
Scaly-breasted Munia	*Lonchura punctulata*	O	0.326		0.056	17
Chestnut Munia	*Lonchura malacca*	O	0.522	0.389	0.917	71
Bats						
Fruit Bats						
Common Short-nosed Fruit Bat	*Cynopterus brachyotis*	V	0.513	0.937	0.231	186
Philippine Nectar Bat[b]	*Eonycteris robusta*	F		0.080	0.034	13
Common Nectar Bat[b]	*Eonycteris spelaea*	O	0.013	0.027	0.014	6
Philippine Pygmy Fruit Bat[a]	*Haplonycteris fischeri*	F	0.006			1
Dagger-toothed Flower Bat	*Macroglossus minimus*	V	0.019	0.067		8
Musky Fruit Bat	*Ptenochirus jagori*	V	0.182	0.173	0.088	54
Common Rousette[b]	*Rousettus amplexicaudatus*	O	0.097	0.333	0.517	116
Microchiroptera						
Pouched Bat[b]	*Saccolaimus saccolaimus*	O		0.013		1
Diadem Roundleaf Bat[b]	*Hipposideros diadema*	V	0.006		0.014	3
Yellow-faced Horseshoe Bat[b]	*Rhinolophus virgo*	F			0.007	1
Enormous-eared Horseshoe Bat[b]	*Rhinolophus philippinensis*	F			0.007	1
Arcuate Horseshoe Bat[b]	*Rhinolophus arcuatus*	V			0.007	1
Little Bent-winged Bat[b]	*Miniopterus australis*	V			0.014	2
Whiskered Myotis	*Myotis muricola*	F		0.013		1

(continued)

Table 16.3 (continued)

English name	Scientific name	Habitat preference	Gmelina forest	Home gardens	Shrub-land	Total
Orange-fingered Myotis	*Myotis rufopictus*	V	0.006	0.027	0.014	5
Lesser Asian House Bat	*Scotophilus kuhlii*	O	0.006		0.075	12

Relative abundances of birds (individuals observed per point count) and bats (individuals caught per net-night) per habitat and the total number of observed birds and captured bats per species. Habitat preference: O = Open areas, F = Forest, V = Various. Philippine endemic species in bold. Cave roosting species indicated with [b] (bats only)

[a] *Anas luzonica* and *Haplonycteris fischeri* both classified as Vulnerable on the IUCN red list of threatened species (2006)

Photo 16.3 Philippine Bulbul *Ixos philippinus*. An endemic forest bird fairly common in Gmelina forest (©Van Weerd)

ceps and *Dicaeum australe*. One endemic forest bird was only recorded for home-gardens, *Loriculus philippensis,* a flower and nectar eating parrot. Another small endemic forest parrot, the fruit-eating *Bolbopsittacus lunulatus* and *Pachycephala philippinensis* were only found in shrub-land. The endemic forest bird *Orthotomus* *castaneiceps* occurred in all three habitat types, with the highest density in Gmelina forest. Two endemic open area species were recorded: threatened *Anas luzonica* in shrub-land (one record only) and *Amaurornis olivaceus* in shrub-land and Gmelina forest.

Shrub-land had the highest bat species richness (12 species). Gmelina forest and homegardens had nine bat species each. Although only 44 percent of all bat species mist-netted were fruit bats, in terms of individuals the vast majority (93 percent) belonged to this family. Shrub-land had the highest number of Microchiroptera species (seven) and of forest bat species (three). Homegardens and Gmelina forest had respectively two and one forest bat species. Three (33 percent) cave roosting bat species were recorded for Gmelina forest and four (44 percent) and eight (67 percent) species for homegardens and shrub-land respectively. Gmelina forest and homegardens shared 67 percent of all bat species and 83 percent of fruit bats (Sørensen similarity indices), whereas Gmelina forest and shrub-land shared 67 percent of all bats and 73 percent of fruit bats. Homegardens and shrub-land only shared 57 percent of all bat species but were very similar in fruit bat species composition (91 percent species shared).

The most common bat species in both Gmelina forest and homegardens was *Cynopterus brachyotis* with 0.513 and 0.937 captures per net-night respectively. This species was less common in shrub-land (0.231 captures per net-night); *Rousettus amplexicaudatus* was most common here with 0.517 captures per net-night (Table 16.3). The endemic *Eonycteris robusta* was observed in homegardens and shrub-land. One individual of the threatened endemic *Haplonycteris fischeri* was mist-netted in Gmelina forest. The endemic *Ptenochirus jagori* was common in all three habitat types. Several endemic Rhinolophidae species were only caught once in shrub-land. The little known endemic *Myotis rufopictus* (Heaney et al. 1998) was caught five times in total in all three habitat types (Table 16.3).

16.3.1 Species Accumulation Curves

The resident bird species accumulation curve nearly reached saturation for Gmelina forest and homegardens but did still rise for shrub-land (Fig. 16.2A). For the subset of forest species (Fig. 16.2B) the species accumulation curves were not completely saturated for any of the three habitat types. Very few forest bird individuals were observed in homegardens and shrub-land. Overall resident bird densities were remarkable comparable between the three habitat types (Fig. 16.2C) with shrub-land having slightly lower numbers of individual birds observed per point count. Densities of forest birds however were much higher in Gmelina forest compared to homegardens and shrub-land (Fig. 16.2D).

The bat species accumulation curves (Fig. 16.3A) did not reach complete saturation for all three habitat types. For the subset of fruit bats, the species accumulation curve reached saturation for homegardens and shrub-land but was still slightly rising for Gmelina forest (Fig. 16.3B). Bat densities were highest in homegardens, fol-

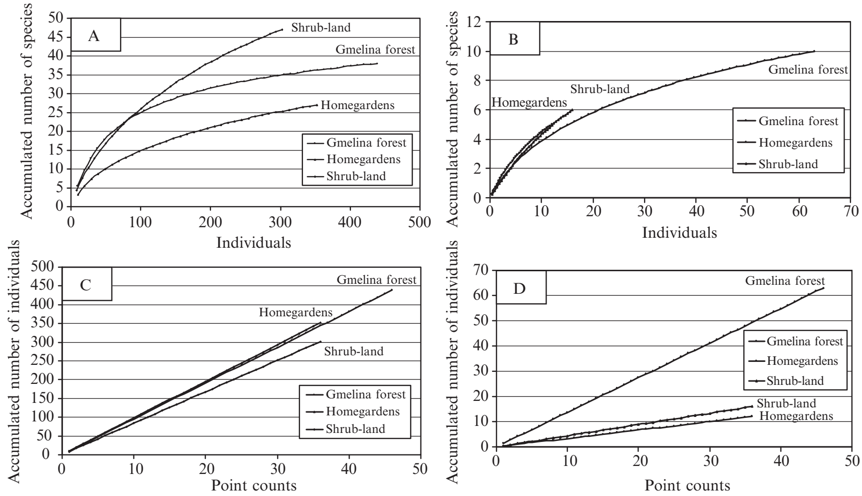

Fig. 16.2 Smoothed bird species accumulation curves rescaled to the number of individuals for all resident species (A) and for forest species (B) and smoothed bird population density graphs for all resident species (C) and forest birds (D)

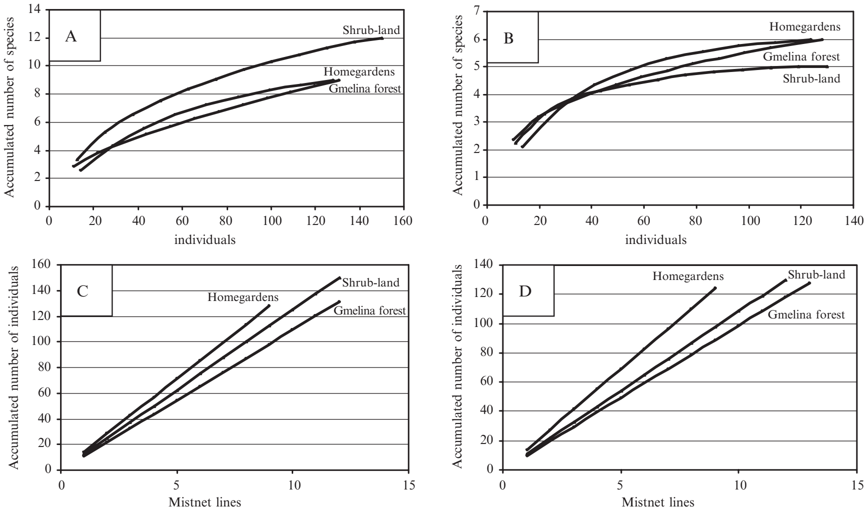

Fig. 16.3 Smoothed bat species accumulation curves rescaled to the number of individuals for all bats (A) and for fruit bats (B) and smoothed bat population density graphs for all bats (C) and fruit bats (D)

lowed by shrub-land and Gmelina forest (Fig. 16.3C). This pattern was similar for the subset of fruit bats, with higher fruit bat densities in homegardens compared to the other two habitat types (Fig. 16.3D).

16.3.2 Observed and Estimated Species Richness

The mean estimated species richness for resident birds in the three habitats was 12 to 30 percent higher than observed species richness (Table 16.4). The pattern in observed species richness was however maintained: shrub-land was most species rich in resident birds followed by Gmelina forest and homegardens. The mean estimated forest species richness was considerably higher for shrub-land (49 percent), homegardens (39 percent) and Gmelina forest (28 percent) than the observed richness. Gmelina forest had the most observed and estimated forest bird species followed by shrub-land. Homegardens had the least number of forest bird species.

For bats, 65 to 78 percent of the estimated species richness was detected. Gmelina forest was least well sampled in this respect, with 65 percent detection. Shrub-land emerged as the species richest habitat type, with 12 observed and 15 to 16 estimated bat species. Gmelina forest followed with nine observed and 13 to 15 estimated species, whereas homegardens were least rich with nine observed and 11 to 13 estimated species. Fruit bats attained much higher detection proportions. Both Gmelina forest and homegardens had six fruit bat species, i.e., 84 percent and 88 percent of the estimated fruit bat species richness. Shrub-land had five fruit bat species, a figure not likely to increase with continued sampling effort (99 percent of estimated species richness).

Table 16.4 Non-parametric species richness estimators and observed species richness

Species richness estimators	Gmelina forest	Homegardens	Shrub-land
Birds			
Mean estimated species richness[a]	43.35 ± 0.84	36.21 ± 1.19	66.30 ± 3.50
Observed species richness	38	27	47
Proportion of estimated species richness detected	88%	75%	71%
Mean estimated forest species richness[a]	13.98 ± 0.75	8.20 ± 0.71	11.83 ± 1.49
Observed forest species richness	10	5	6
Proportion of estimated forest species richness detected	72%	61%	51%
Bats			
Mean estimated species richness[a]	13.95 ± 1.22	11.87 ± 0.88	15.41 ± 0.88
Observed species richness	9	9	12
Proportion of estimated species richness detected	65%	76%	78%
Mean estimated fruit bat species richness[a]	7.12 ± 0.34	6.83 ± 0.32	5.05 ± 0.24
Observed fruit bat species richness	6	6	5
Proportion of estimated fruit bat species richness detected	84%	88%	99%

[a] The mean of nine non-parametric species richness estimators: ACE, ICE, Chao1, Chao2, Jackknife1, Jackknife2, Bootstrap, MMMeans and MMRuns and the standard error of this mean. Percentages show the proportion observed species of estimated species richness

16.3.3 Habitat Characteristics

Gmelina forest had the highest average canopy cover (46.0 percent ± 6.1 S.E.) followed by homegardens (27.6 percent ± 4.8) and shrub-land (9.0 percent ± 3.2) (Table 16.5). The highest tree was also recorded for Gmelina forest (19.9 m ± 1.8), followed by homegardens (16.5 m ± 1.9) and shrub-land (15.5 ± 1.2). The average tree density per hectare for Gmelina forest (1,478.5 ± 278.2) was much higher than those recorded for homegardens (575.5 ± 110.9) and shrub-land (466.7 ± 146.3) whereas the average density of large trees (>20 cm dbh) did not differ much among the three habitat types (345.0 ± 114.5 for Gmelina forest, 302.6 ± 80.1 for homegardens and 323.4 ± 108.1 for shrub-land). Ground cover was highest for Gmelina forest (68.5 percent ± 5.7) followed by shrub-land (64.7 percent ± 5.4) and homegardens (54.3 percent ± 5). The largest number of houses within 100 m of a point count or mist-net line centre was recorded for shrub-land (6.2 ± 1.7) followed by homegardens (3.8 ± 0.9). Gmelina forest localities had on average the lowest number of houses (1.5 ± 0.5). However, none of the differences in habitat characteristics between pairs of habitat types within a locality was significant (non-parametric Wilcoxon signed rank test for related samples).

16.3.4 Average Bird and Bat Species Richness and Abundance per Locality Per Habitat Type

The highest average numbers of resident bird species and forest bird species per point count (Table 16.6) were recorded for Gmelina forest (5.43 ± 0.28 S.E. and 0.78 ± 0.19 respectively). Shrub-land had more resident bird species per point count (4.25 ± 0.31) than homegardens (3.28 ± 0.27) but the average number of forest bird species per point count was similar (0.25 ± 0.08 and 0.25 ± 0.09 for shrub-land and homegardens respectively). The average number of resident bird individuals was comparable for the three habitat types (9.54 ± 0.64 for Gmelina forest, 9.78 ± 1.10 for homegardens and 8.39 ± 0.79 for shrub-land). For forest birds, abundance was higher in Gmelina forest (1.37 ± 0.32 individuals per point count) compared to shrub-land (0.44 ± 0.18) and homegardens (0.33 ± 0.13).

The average number of bat species caught per mist-net-night was comparable for the three habitat types (0.33 ± 0.07 for homegardens, 0.29 ± 0.05 for shrub-land and 0.24 ± 0.03 for Gmelina forest). The abundance of bats (average number of individuals caught per mist-net-night), however, was highest for homegardens (1.54 ± 0.49; for shrub-land: 0.93 ± 0.38; for Gmelina forest: 0.80 ± 0.11). Very few forest bat species were caught, with the highest average species richness and abundance per mist-net night recorded for homegardens (0.05 ± 0.04; 0.10 ± 0.07) followed by shrub-land (0.03 ± 0.01; 0.04 ± 0.02) and Gmelina forest (0.01 ± 0.01; 0.01 ± 0.01). The highest average numbers of cave bat species richness and abundance were recorded for shrub-land (0.11 ± 0.03; 0.52 ± 0.39) and homegardens (0.10 ± 0.04; 0.44 ± 0.29). Gmelina forest had very few cave bats (0.04 ± 0.01; 0.10 ± 0.03).

Table 16.5 Habitat characteristics of survey localities

Habitat[a]	Locality	N	Canopy cover (%)	Highest tree (m)	Tree density (/ha)	Large tree density (/ha)	Ground cover (%)	Houses within 100 m	Gmelina forest size (ha)
GM	Baculod	–							15.0
	Divisoria	1	3.0	15.0	650.0	400.0	20.0	5.0	12.0
	Dy Abra	3	35.0 ± 7.6	19.3 ± 3.5	2,557.7 ± 2,223.3	77.7 ± 32.8	76.7 ± 3.3	4.3 ± 1.8	0.5
	Masipi East	4	88.5 ± 5.4	35.0 ± 0.0	1,800.0 ± 374.6	1,446.8 ± 310.3	85.0 ± 5.0	0.5 ± 0.3	1.3
	Moldero	1	35.0	25.0	1,412.0	181.0	60.0	10.0	0.2
	Naquilian	8	34.6 ± 10.3	11.3 ± 1.2	1,060.4 ± 236.9	51.4 ± 25.5	72.5 ± 12.7	0.6 ± 0.5	25.0
	Puerta	7	47.1 ± 8.6	21.3 ± 0.7	1,438.1 ± 229.8	181.3 ± 37.8	59.3 ± 9.5	0.3 ± 0.2	7.7
	Vibanara	–							7.0
	Villa Miranda	–							–
	Total	24	46.0 ± 6.1	19.9 ± 1.8	1,478.5 ± 278.2	345.0 ± 114.5	68.5 ± 5.7	1.5 ± 0.5	8.6
HG	Baculod	1	30.0	30.0	1,583.0	1,000.0	80.0	15.0	
	Divisoria	4	8.3 ± 3.9	13.8 ± 1.3	744.8 ± 218.0	548.0 ± 148.4	37.5 ± 4.3	4.0 ± 1.0	
	Dy Abra	6	30.8 ± 9.2	11.3 ± 2.8	200.5 ± 61.3	25.5 ± 14.8	78.3 ± 4.8	2.8 ± 0.7	
	Malibabag	3	33.3 ± 19.2	13.3 ± 4.7	359.0 ± 26.3	132.7 ± 23.4	41.7 ± 10.1	4.0 ± 2.1	
	Masipi East	2	32.5 ± 27.5	27.5 ± 7.5	1500.0 ± 525.0	1,012.5 ± 312.5	55.0 ± 5.0	2.0 ± 0.0	
	Moldero	4	38.8 ± 9.7	22.5 ± 1.4	516.0 ± 142.6	138.0 ± 26.5	48.8 ± 16.1	4.3 ± 3.3	
	Puerta	1	0.0	0.0	0.0	0.0	35.0	1.0	
	Villa Miranda	1	40.0	25.0	756.0	338.0	30.0	1.0	
	Total	22	27.6 ± 4.8	16.5 ±1.9	575.5 ± 110.9	302.6 ± 80.1	54.3 ± 5.0	3.8 ± 0.9	
Shrub	Baculod	2	5.0 ± 0.0	17.5 ± 2.5	950.0 ± 150.0	775.0 ± 75.0	80.0 ± 0.0	10.5 ± 10.5	
	Divisoria	1	5.0	20.0	350.0	275.0	60.0	1.0	
	Dunoy	2	5.0 ± 0.0	12.5 ± 2.5	248.0 ± 177.0	98.0 ± 77.0	80.0 ± 10.0	0.5 ± 0.5	
	Dy Abra	4	5.3 ± 1.8	13.3 ± 2.3	10.3 ± 2.5	1.3 ± 0.5	83.8 ± 3.8	10.5 ± 3.9	
	Malibabag	2	7.5 ± 7.5	11.0 ± 9.0	116.0 ± 116.0	24.0 ± 24.0	35.0 ± 5.0	0.0 ± 0.0	
	Puerta	2	6.0 ± 4.0	17.0 ± 1.0	100.0 ± 75.0	75.0 ± 50.0	42.5 ± 17.5	1.0 ± 1.0	
	Vibanara	4	21.3 ± 13.1	16.3 ± 1.3	1,281.0 ± 371.6	887.5 ± 284.0	56.3 ± 14.0	10.8 ± 0.3	
	Villa Miranda	1	4.0	25.0	57.0	47.0	70.0	1.0	
	Total	18	9.0 ± 3.2	15.5 ± 1.2	466.7 ± 146.3	323.4 ± 108.1	64.7 ± 5.4	6.2 ± 1.7	

[a] Habitat: GM = Gmelina forest, HG = Homegarden and Shrub = Shrub-land. N is the number of habitat characterisation plots. Values are means per locality ± standard error

Table 16.6 Bird and bat survey results per habitat type and locality

Habitat[a]	*Locality*	Birds					Bats						
		N	*All species*	*Forest species*	*Abund. all species*	*Abund. forest species*	*N*	*All species*	*Forest species*	*Cave species*	*Abund. all species*	*Abund. forest species*	*Abund. cave species*
GM	Baculod	8	5.38 ± 0.32	0	9.00 ± 0.94	0	1	0.13	0	0.07	1.07	0	0.20
	Divisoria	3	4.33 ± 0.33	0.33 ± 0.33	6.00 ± 0.58	0.33 ± 0.33	1	0.20	0	0.07	0.73	0	0.07
	Dy Abra	3	3.33 ± 1.33	0	5.67 ± 1.67	0	2	0.28 ± 0.06	0	0.06 ± 0.06	0.50 ± 0.28	0	0.06 ± 0.06
	Masipi East	4	5.75 ± 0.48	0.50 ± 0.29	8.25 ± 0.48	0.75 ± 0.48	2	0.20 ± 0.07	0	0.07 ± 0.07	0.80 ± 0.27	0	0.10 ± 0.10
	Moldero	2	4.50 ± 0.50	0	16.00 ± 8.00	0							
	Naquilian	11	5.91 ± 0.67	0.36 ± 0.15	10.36 ± 1.39	0.73 ± 0.33	4	0.23 ± 0.10	0	0.03 ± 0.02	0.79 ± 0.31	0	0.15 ± 0.10
	Puerta	11	6.55 ± 0.68	2.64 ± 0.41	11.82 ± 1.05	4.64 ± 0.59	2	0.30 ± 0.03	0	0.03 ± 0.03	1.12 ± 0.05	0	0.03 ± 0.03
	Vibanara	3	3.67 ± 0.33	0	5.67 ± 1.20	0	1	0.27	0.07	0.00	0.60	0.07	0.00
	Villa Miranda	1	4.00	0	6.00	0							
	Total	46	5.43 ± 0.28	0.78 ± 0.19	9.54 ± 0.64	1.37 ± 0.32	13	0.24 ± 0.03	0.01 ± 0.01	0.04 ± 0.01	0.80 ± 0.11	0.01 ± 0.01	0.10 ± 0.03
HG	Baculod	1	3.00	0.00	7.00	0.00							
	Divisoria	4	4.50 ± 0.29	1.50 ± 0.29	7.75 ± 1.93	2.00 ± 0.58							
	Dy Abra	9	1.44 ± 0.29	0.00 ± 0.00	3.44 ± 0.93	0	2	0.14 ± 0.03	0	0	0.25 ± 0.08	0	0
	Malibabag	9	3.67 ± 0.50	0.11 ± 0.11	11.67 ± 1.27	0.11 ± 0.11	2	0.64 ± 0.19	0.22 ± 0.11	0.28 ± 0.06	3.61 ± 0.39	0.47 ± 0.03	1.75 ± 0.92
	Masipi East	2	6.50 ± 0.50	0.50 ± 0.50	10.50 ± 0.50	1.00 ± 1.00							
	Moldero	8	3.13 ± 0.30	0	17.38 ± 2.64	0	3	0.25 ± 0.04	0	0.10 ± 0.05	1.59 ± 0.77	0	0.14 ± 0.08
	Puerta						1	0.33	0	0	1.00	0	0
	Villa Miranda	3	4.33 ± 0.33	0.33 ± 0.33	6.00 ± 0.58	0.33 ± 0.33	1	0.33	0	0	0.33	0	0
	Total	36	3.28 ± 0.27	0.25 ± 0.09	9.78 ± 1.10	0.33 ± 0.13	9	0.33 ± 0.07	0.05 ± 0.04	0.10 ± 0.04	1.54 ± 0.49	0.10 ± 0.07	0.44 ± 0.29
Shrub	Baculod	4	5.50 ± 0.50	0.25 ± 0.25	10.50 ± 2.06	0.25 ± 0.25	1	0.33	0.00	0.13	0.80	0.00	0.33
	Divisoria	5	4.60 ± 0.40	0.80 ± 0.37	7.60 ± 1.57	2.00 ± 0.95	2	0.20 ± 0.07	0.07 ± 0.07	0.10 ± 0.10	0.73 ± 0.13	0.07 ± 0.07	0.10 ± 0.10
	Dunoy	4	3.75 ± 0.48	1.00 ± 0.00	4.50 ± 0.65	1.25 ± 0.25	2	0.18 ± 0.02	0.00 ± 0.00	0.03 ± 0.03	0.37 ± 0.03	0.00 ± 0.00	0.03 ± 0.03
	Dy Abra	6	4.50 ± 0.85	0	8.17 ± 2.12	0	2	0.61 ± 0.06	0.06 ± 0.06	0.19 ± 0.03	0.81 ± 0.03	0.06 ± 0.06	0.19 ± 0.03
	Malibabag	3	5.67 ± 0.88	0	12.33 ± 2.03	0	1	0.40	0.07	0.27	5.07	0.27	4.80
	Moldero	3	1.00 ± 0.00	0	11.00 ± 1.00	0	1	0.33	0	0.20	0.80	0	0.33
	Puerta	4	4.75 ± 1.49	0	12.00 ± 4.14	0	1	0.17	0	0	0.17	0	0
	Vibanara	5	3.00 ± 0.00	0	4.00 ± 0.45	0	1	0.07	0	0	0.27	0	0
	Villa Miranda	2	6.00 ± 1.00	0	8.50 ± 0.50	0	1	0.20	0	0.07	0.20	0	0.07
	Total	36	4.25 ± 0.31	0.25 ± 0.08	8.39 ± 0.79	0.44 ± 0.18	12	0.29 ± 0.05	0.03 ± 0.01	0.11 ± 0.03	0.93 ± 0.38	0.04 ± 0.02	0.52 ± 0.39

[a] Habitat: GM = Gmelina forest, HG = Homegarden, and Shrub = Shrub-land. N is the number of point counts (birds) or mist-net-lines (bats). Values are mean numbers of species and individuals observed per point count (birds) and mean numbers of species and individuals caught per mist-net-night (bats) per locality ± standard error

Probably as a result of the small sample size due to averaging scores per locality to avoid pseudo-replication, none of the reported differences in average bird and bat species richness and abundance between habitat types proved significantly different in pair wise comparisons per locality (non-parametric Wilcoxon signed rank test for related samples).

16.3.5 Relations Between Species Richness and Abundance and Habitat and Landscape Variables

We tested for correlations between average bird and bat species richness and abundance (all bird and bat species, forest birds, forest bats, cave roosting bats) and average habitat characteristic and landscape variables per locality. Within Gmelina forest, a negative relationship (Spearman r = −0.899, n = 6, $p < 0.05$) was found between the average number of houses within 100 m of a point count and the average number of forest bird species observed per point count. For the other two habitat types this relationship was less obvious (Fig. 16.4A), and not significant. For

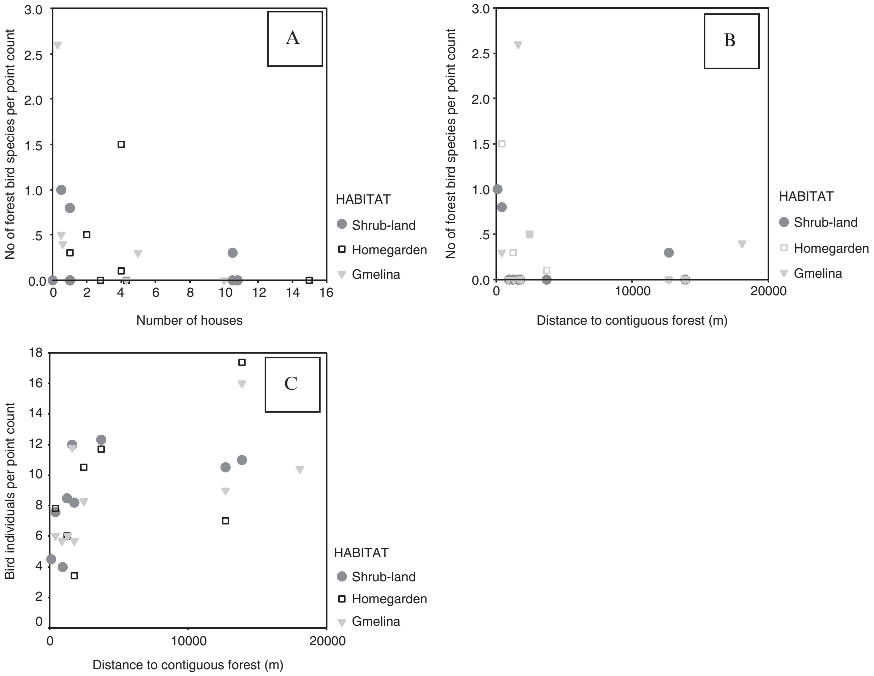

Fig. 16.4 Relationships between the number of houses within 100 m of the centre of a point count and the average number of forest bird species observed per point count (A), the distance to contiguous forest and the average number of forest bird species observed per point count (B) and the distance to contiguous forest and the average number of all resident bird individuals observed per point count (C)

shrub-land, a negative relationship (Spearman r = –0.674, n = 9, $p < 0.05$) was found between the distance to contiguous forest and the average number of forest bird species observed per point count. Whereas similar relationships seemed to exist for the other two habitat types (Fig. 16.4B), these were not significant. A positive relationship (Spearman r = 0.733, n = 9, $p < 0.05$) was found between the distance to contiguous forest and the average number of resident bird individuals observed per point count for shrub-land. This was also found for homegardens and Gmelina forest (Fig. 16.4C) but the correlations were not significant.

The abundance of all bats and a sub-set of fruit-bats was negatively correlated to the number of houses within 100 m of the centre of mist-net lines for Gmelina forest (Spearman r = –0.900, n = 5, $p < 0.05$ for both correlations). For shrub-land, fruitbat species richness was negatively correlated to the density of large trees (Spearman r = –0.830, n = 8, $p < 0.05$) and to the distance to caves (Spearman r = –0.679, n = 9, $p < 0.05$). Cave bat species richness and abundance were both positively related to the distance to contiguous forest (Spearman r = 0.686, n = 9, $p < 0.05$ for cave bat species richness and Spearman r = 0.714, n = 9, $p < 0.05$ for cave bat abundance).

16.4 Conservation Importance of Human-Altered Habitats in Cagayan Valley for Birds and Bats

A comparison of the bird species found in our study habitats with the species known from the Northern Sierra Madre Natural Park (NSMNP) (Danielsen et al. 1993; Poulsen 1995; NORDECO and DENR 1998; M. van Weerd unpublished data 2000–2007) situated at the eastern fringe of the research area, shows that the conservation value of the study habitats for forest, endemic and threatened birds is very low. All bird species observed in our study habitats also occur in the NSMNP. Although the bird species recorded in all three habitats (58 species) represent 32 percent of resident lowland birds identified in the NSMNP (179 species, strictly coastal and montane species excluded), they only represent 13 percent (15 of 115 in total) of lowland forest birds, 15 percent (11 of 72) of endemic lowland birds, and eight percent (1 of 12) of globally threatened lowland bird species in the park. Of all bird species observed in the study habitats only 26 percent are forest birds compared to 64 percent of lowland birds of the NSMNP. The resident bird species found in the human-altered landscape of the Cagayan Valley are mainly open area species and various-habitat generalists.

The representation of forest birds in the human-altered habitats is further very low compared to findings in similar studies elsewhere. Hughes et al. (2002) report that agricultural areas in Costa Rica serve as a habitat for 46 percent of the native bird species found in the region. In Sumatra, 59 percent of bird species found in lowland primary forest are also found in complex agroforestry systems (Thiollay 1995). Mixed-rural habitat in southern Peninsular Malaysia contains an estimated 28 to 32 percent of primary forest bird species of that region, including a number of globally threatened species (Peh et al. 2005). Mixed-rural habitats in central Sulawesi contain 76 percent of total forest bird species richness recorded in a study of a variety of habitats including primary and secondary forest. The majority of these forest bird species is endemic to Sulawesi (Sodhi et al. 2005). The same study shows that within mixed agroforestry plantations 32 percent of all forest bird species is present, a much higher representation of regional forest bird species compared to the proportion of lowland forest birds of northeast Luzon found in our study habitats (13 percent). Why does the human-altered landscape in northeast Luzon have so few forest bird species?

A first explanation may be serious under-sampling of forest birds which are usually harder to detect than open area species. But although forest bird species accumulation curves for all three studied habitats are not fully saturated, they show flattening towards the asymptote (Fig. 16.2B). A further "check" on observed forest bird species richness using the average of nine non-parametric species richness estimators (Table 16.4) indicates that in Gmelina forest, homegardens and shrub-land respectively 72 percent, 61 percent and 51 percent of forest bird species has been detected. When compensating for "missed" species, the estimated forest bird species richness is 13 to 15 species for Gmelina forest, 8 to 9 species for homegardens and 11 to 13 species for shrub-land. Using these estimated forest bird species richness figures, Gmelina forest and homegardens still have very little representation of forest birds occurring in nearby natural forest compared to studies of tree-based human-altered habitats in tropical landscapes elsewhere.

A second explanation may be related to the characteristics of the habitats studied. At local-scale level, the vertical complexity of vegetation, the presence of tall trees and a relatively high canopy cover all enhance the suitability of human-altered habitats for forest birds (Hughes et al. 2002; Sodhi et al. 2005; Peh et al. 2005; Sekercioglu et al. 2007). In our study area, Gmelina forest has the highest canopy cover, the tallest trees and the highest tree densities. The highest forest bird species richness and abundance are also found in these plantations. Correlations are however not significant. Although homegardens have a higher average canopy cover than shrub-land, other habitat characteristics such as the tallest tree and tree densities are comparable. Homegardens do not have more forest bird species than surrounding shrub-land. Both homegardens and Gmelina forest have low mean canopy covers (28 percent and 46 percent respectively) and relatively low means for the tallest tree (16.5 and 19.9 m; Table 16.5) compared to agroforestry habitats in other studies. Thiollay (1995) surveyed birds in agroforestry systems with 35 to 45 m high near-closed canopy, i.e., a height and cover comparable to that of natural forest in Sumatra. In the Subic Bay area in Luzon forest birds hardly occur in human-altered habitats when canopy cover is below 30 percent, with most forest birds requiring at least 60 percent cover (Posa and Sodhi 2006). The Gmelina forest and especially the homegardens in the Cagayan Valley seem to lack the vertical complexity and the minimum canopy cover needed to be important habitats for forest birds.

At landscape level, the proportion and quality of forest or tree-based habitats in a predominantly human-altered landscape influence forest bird persistence (Marsden et al. 2006). Likewise, the quality of the human-altered landscape surrounding tree-based habitats, i.e., the matrix, plays an important role in colonization and dispersal possibilities for forest species (Ricketts 2001). Matrix landscapes show varying degrees of hostility to forest species, which influences species' abilities to survive outside original forest and disperse between patches of forest-like habitats and form meta-populations (Hanski 1999). In our study, forest bird species richness and abundance are negatively correlated to distance to contiguous forest in shrub-land limiting the dispersal of forest birds through matrix landscapes away from forest. In contrast, overall resident bird abundance was positively correlated to distance to forest in shrub-land; non-forest birds reach higher densities in a more open and human-dominated landscape.

Twelve of the 15 forest bird species observed in this study, and 84 percent of forest bird individuals, are observed within 2 km of contiguous forest. Of these, nine forest bird species are limited to this 2 km forest-bordering zone (point count effort was roughly similar within (63) and beyond (55) the 2 km boundary). Hughes et al. (2002) argue that most forest birds will probably not travel more than 2 km from nesting areas to forage areas. Only locally nesting forest birds are then really able to sustain populations outside natural forest in a larger human-altered countryside. *Chalcophaps indica* and the endemics *Ixos philippinus* and *Dicaeum australe* are the only forest species relatively common in Gmelina forest beyond two km of contiguous forest where we suspect they occur as breeding species. The endemic *Loriculus philippensis* has been observed in small feeding groups in homegardens beyond 2 km of contiguous forest. We suspect this species makes longer foraging trips than other forest species to feed on flowers and nectar in gardens. We deter from these findings that contiguous forest of the Sierra Madre functions as a source of forest birds to the nearby non-forest landscape. However, tree-based human-altered habitats in this landscape do not provide suitable conditions for forest birds to establish themselves as breeding species, neither as sink nor as source populations (Pulliam 1988), with the possible exception of Gmelina forest for the three forest bird species mentioned above. As these forest plantations are established on deforested land, the three forest species occurring here are not a relict population of former larger natural forest (Brooks et al. 1999). Even if patches of Gmelina forest are suitable for a larger number of forest bird species, colonization of these patches will have to take place through the surrounding shrub-land matrix but the shrub-land in the Cagayan Valley seems very hostile to forest bird species. Only six forest bird species have been observed in the shrub-land, with only 16 individuals.

The human-altered landscape of the Cagayan Valley does offer suitable habitats for the endemic habitat generalist *Centropus viridis*, observed in Gmelina forest and shrub-land, and the endemic *Amaurornis olivacea*, a relatively common shrub-land species. One more open area endemic has been observed, the threatened *Anas luzonica* (once). This species congregates during the wet season in several lakes in the Cagayan Valley and disperses during the dry season to breed in shrub-land. The largest remaining congregations of this species are found in the Cagayan Valley. The shrub-lands are important as breeding areas to sustain this increasingly rare species, although hunting rather than breeding habitat conversion seems a more serious threat to the conservation of this species (Van Weerd and Van der Ploeg 2004).

A comparison of the results of the bat surveys with the bat species recorded in the NSMNP (Mudar and Allen 1986; Danielsen et al. 1993; Balete et al. 1995; NORDECO and DENR 1998; M. van Weerd unpublished data 2000–2007) shows that the human-altered habitats are more important for the bats than for the birds of northeast Luzon. The NSMNP has 36 recorded bat species (and two strictly montane species which are excluded from this comparison), 44 percent of the bat species of the park also occur in our three study habitats (16 of 36). No new species have been found outside the park. The bat species in our study habitats represent 58 percent of the fruitbats (7 of 12), 29 percent of the forest bats (5 of 17), 38 percent of cave-roosting bats (9 of 24), 25 percent of globally threatened bats (1 of 4; only 1 record) and 42 percent of the endemic bats (5 of 12) known from the NSMNP.

Shrub-land has more bat species than Gmelina forest and homegardens but less fruit bats (Table 16.2, Fig. 16.3A). Fruit bat species richness for Gmelina forest and homegardens are similar (Fig. 16.3B) but homegardens have higher densities of fruit bats (Fig. 16.3D). The higher bat species richness for shrub-land is the result of the larger number of captured Microchiroptera species (all insectivorous). Most of these have been captured only once or twice (Table 16.3). Microchiroptera, which use echolocation to capture insects, are difficult to survey using mist nets (Francis 1989), and the results on these species are therefore difficult to interpret. Shrub-land may offer more insects than the two other habitats, or bats may hunt lower to the ground thus increasing the chance to be captured in a mist net. Estimated detection rates of all bat species range from 65 to 78 percent but for fruit bats these rates are much higher (84 to 99 percent).

No correlations are found between bat species richness and abundance and habitat structure variables. Although fruit bat densities are highest in homegardens, the abundance of all bats and a sub-set of fruit-bats is negatively correlated to the number of houses within 100 m of the centre of mist-net lines in Gmelina forest suggesting human disturbance affects bats.

Forest bat species richness and abundance are negatively correlated to the distance to contiguous forest, yet, the correlations are statistically not significant. Our results indicate that forest bats venture further into human-altered landscapes than forest birds but are still restricted to habitats at a limited distance to contiguous forest. Of the two fruit bats which are classified as forest species, the globally threatened endemic *Haplonycteris fischeri* has been captured only once: in Gmelina forest near contiguous forest. The cave roosting endemic forest bat *Eonycteris robusta* has been captured in homegardens and shrub-land near caves at a maximum of 3.7 km from contiguous forest. The single individuals of three Microchiroptera forest bats have been captured in shrub-land (two species) and in a homegarden (one species), in both cases also near contiguous forest. No forest bats have been captured at locations far from forest (12.7 km and beyond). A caveat in our study is that we did not survey localities at medium distances to closed-canopy forest. It is therefore not possible to determine a reliable maximum distance to contiguous forest at which most forest bats forage. In contrast to forest bats, no relation has been found between the abundance and species richness of cave roosting bats and the distance to caves. The cave roosting fruit bat *Rousettus amplexicaudatus* occurs in all habitat types at all distances from caves (max 18 km). Other studies show that bats are capable to fly considerable distances from roosts to feeding sites, up to 10 km in a study in Mexico in agricultural mosaic habitats for example (Estrada and Coates-Estrada 2002). There is also evidence that there is differentiation between forest bat species that are sensitive to deforestation and species that are more tolerant to forest fragmentation and isolation and readily fly over, and make use of resources in open areas (Law et al. 1999). A recent study in Brazil suggests, for most bat species, no significant difference in abundance between forest, forest fragments and surrounding savanna vegetation although some species are restricted to forest and others to savannas. Furthermore, the open savannas seem not to act as an ecological barrier to bats (Bernard and Fenton 2007). Our study shows that human-altered habitats in Cagayan Valley do offer suitable conditions for a moderate number of bats found in the region including several endemic and forest bat species. Forest bat species are however restricted to a maximum distance to contiguous forest.

Reforestation with mono-culture *Gmelina arborea* is of little direct value in terms of bird and bat conservation in the Cagayan Valley. Yet elsewhere, plantations of exotic tree species do provide conservation benefits, such as the mono-cultures of Chinese ash *Fraxinus chinensis* in the Colombian Andes serving, in addition to watershed reforestation, as a habitat for birds comparable to that of natural regenerating forest (Duran and Kattan 2005). In addition, fast-growing trees like the Chinese ash act as catalysts for recovery of degraded habitats, something that will be hard to attain with slow-growing native tree species. *Gmelina arborea* can play a similar role as a catalyst in reforestation of degraded forest land in the Philippines and elsewhere.

16.5 Conclusions

The human-altered Cagayan Valley in northeast Luzon provides a habitat for a moderate number of resident bird species of the region, including several endemic and one threatened (*Anas luzonica*) open area bird species. For bats, the valley offers slightly better conditions. Forest birds and bats are restricted to a human-altered zone bordering the contiguous forest of the Sierra Madre mountains although forest bats venture further away than birds. For most of the forest, endemic and globally threatened lowland bird and bat species in northeast Luzon, homegardens and *Gmelina arborea* forest plantations, and the surrounding shrub-land, in their present state fail to serve as alternative habitats for closed-canopy forest. Yet, further studies are needed to understand why Gmelina forest plantations have a much lower conservation value for birds compared to exotic tree plantations elsewhere. Likewise, studies on habitat diversification such as enrichment planting in Gmelina forest plantations are needed to determine whether more diverse and complex forest plantations offer a higher conservation value for both forest bird and bat species. The same is true for diversification studies of village homegardens, which could have the additional benefit of creating more varied local food supplies and prospects for livelihood development. Special attention is needed for the connectivity of these forest-like habitats that may enhance dispersal possibilities for forest birds and bats within a larger fringe along contiguous forests. Management options need to be identified to enhance the species conservation value of these habitats and increase and sustain forest-habitat connectivity.

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Chapter 17
From Principles to Numbers: Approaches in Implementing Payments for Environmental Services (PES) in the Philippines

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Abstract This paper proposes a way to classify PES projects based on how environmental service payments are justified and determined. Using the IPCC[1] approach as a model, we recommend the use of the tier system to classify PES projects. The three tiers are summarized below:

- Tier 1: Payments based on established ecological principles and local knowledge
- Tier 2: In addition to the above, payments based on simulation modeling and limited site information
- Tier 3: In addition to above, payments based on site-specific quantitative measurements of environmental services

We illustrate this with case studies from existing PES projects in the Philippines. We then presented a decision tree to determine how the tier system can be used.

Keywords Payments for environmental services (PES), tier approach

17.1 Introduction

There is a lot of interest in PES schemes around the world (Landell-Mills and Porras 2002). An environmental service payment or reward refers to *compensation for service, merit or effort, and/or incentive for maintaining or enhancing*

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environmental service functions, received by the sellers or paid by the buyers of the environmental service(s) (Van Noordwijk 2005). Compensation and incentives can be economic, social and moral. Economic incentives may be made in terms of direct payments, financial incentives, or in kind. Rewards and payments in kind may include the provision of infrastructure, market preference, planting materials, health and educational services, skills training, technical assistance or other material benefits. In addition to indirect and direct monetary payments, rewards can take the form of land tenure security (which may be considered an economic incentive). Social and moral incentives and rewards may address non-material aspects of poverty including recognition and respect in the community, and personal satisfaction for doing something, which is currently considered beneficial to the society now or in the future.

The Philippines has a severely degraded natural resources capital base which has adversely affected the environmental services they provide. In the early 1900s, it was estimated that 70 percent of the country was covered with 21 million hectares of forests (Garrity et al. 1993). However, at present only about six million hectares of forests remain (FMB 2004). Thus, in the last century alone, the Philippines lost almost 15 million hectares of tropical forests.

Since the early 1970s, when extensive reforestation efforts began in the Philippines, various incentives schemes have been devised and implemented to encourage people to plant trees on private and public land. However, after more than three decades of support, reforestation in the Philippines has largely been ineffective and inefficient (Garrity et al. 1993; Chokkalingam et al. 2006), partly because the incentives provided were either inappropriate or did not consider the long-term nature of reforestation. On public forest lands for instance, the 25-year renewable CSC instrument of land tenure is 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. Short-term contracts and direct payments to farmers were not able to draw a genuine interest in tree planting either.

Partly in response to the limited success of government-initiated programs, a number of local governments, research organizations and NGOs in the Philippines are testing various PES schemes as a way of reversing environmental degradation. The environmental services being compensated in existing projects include water resources (i.e., RUPES Bakun), carbon sequestration (Lasco et al. 2005), seascape and landscape beauty, and biodiversity (Padilla et al. 2005). Smallholder tree farmers are the intended beneficiaries of most of these efforts. For example, carbon sequestration projects under development for the Kyoto and voluntary markets in the country are targeted for small holder tree farmers.

However, the sustainability and long-term success of PES mechanisms is limited by various institutional, social, political and operational factors, and several issues remain, such as quantification and attribution of ES, which require rigorous technical work to achieve technical accuracy. In addition, the design of payment schemes is marred by complex social issues – all these affect the speed and timeless of implementation of PES mechanisms. In trying to address these issues, we propose a way to classify PES projects based on how environmental service payments are justified and determined. We propose the use of a tier system of the Intergovernmental Panel on Climate Change (IPCC) to classify PES projects, which will guide even small farmholders. We illustrate this with case studies from existing PES projects in the Philippines.

17.2 Proposed Tier Approach to PES

The use of tiers proved effective in classifying the methods employed in national greenhouse gas inventories as shown by its wide use in the IPCC guidelines including the 2006 Guidelines now under preparation (IPCC 2003, 2006). Its effectiveness arises from its ease of use and as a way of facilitating communication among parties under the UN Framework Convention on Climate Change (UNFCCC). Here we propose adopting a three-tier system for PES projects based on the basis of determining payments. The three tiers are summarized below:

- Tier 1: Payments based on established ecological principles and local knowledge
- Tier 2: In addition to the above, payments based on simulation modeling and limited site information
- Tier 3: In addition to above, payments based on site-specific quantitative measurements on environmental services

Tier 1 can also be called the “default” method which projects can use in the absence of site-specific data.

17.2.1 Tier 1: Use of Ecological Principles, Default Values, and Local Knowledge

Tier 1 is basically a qualitative approach to PES. It is based mainly on established ecological principles. On the basis of these principles, buyers of environmental services may already be willing to compensate providers even without direct attribution. For example, at the coarsest level, it is widely accepted that forest cover is desirable because it provides environmental services such as biodiversity protection, soil conservation, climate regulation, and watershed protection (Angelsen and Wunder 2003). Thus, protection of existing forest cover may be of value and “buyers” of environmental services may be willing to compensate stakeholders who can protect these forests. In addition, certain types of forest cover may be known to be of more value in providing environmental services (e.g., habitat for rare or endangered species, limited area). For instance, the tropical forests in Mt. Apo are home to the highly endangered Philippine Eagle (*Pithecophaga jefferyi*). Protecting these forests may therefore be a service that can be ‘sold’ on the basis of its known importance.

Other established ecological principles that can be used for PES include: planting trees which leads to carbon sequestration and thereby helps mitigate climate change (Watson et al. 2000); planting trees helps stabilize watershed functions (FAO 1989); incorporating forest trees in pastoral land will help increase the biodiversity of the area (Pagiola et al. 2005). It is on the basis of these principles that actual payments for environmental services are currently being made in the Philippines. We illustrate the use of Tier 1 methods with four cases below.

17.2.1.1 Case 1: Baticulan Watershed, Negros Island

The Baticulan watershed is located within the boundary of San Carlos City at the northeastern side of Negros Island. It lies between the towns of Palampas and Rizal, covering a total of 428 ha. Part of the main Mandalagan Watershed, it is one of the six main water sources that supplies for both domestic and agricultural use in and around the city.

Historically, the whole of Negros Island was naturally covered with rainforest, however due to massive logging during the 1950s and 1960s, and continuous shifting cultivation, its original natural vegetation coverage has reached below five percent. Currently, the watershed is mostly farmed using shifting cultivation. Both past and current land use practices have resulted in serious soil erosion, flooding particularly during the rainy seasons and degradation of agricultural land.

The widespread degradation in the uplands has urged the City Government of San Carlos to incorporate in the City Ordinance No. 37 Series of 2004, a special levy for an environmental fee of PhP = 0.75 (US$1 = PhP 52 at the time of writing) to be taken for every cubic meter of water billed. This amount has been included in the restructured water rates imposed on the consumers. The proceeds of the special levy for the environmental fee will accrue to form a special account known as the "Watershed Development and Environmental Protection Fund" under the "Baticulan Watershed Management and Development Project". The concept of this fund is that inherent with the use of water are the negative externalities incurred in the production and consumption of water. The price of water should include the cost of externalities to address the negative impacts on the environment. It is estimated that the budget allocation per year for the project is approximately 1.2 million pesos.

In this case, there is site-specific data on the role of watersheds in the production of water for the city. Payments are made based on the implicit assumption that a forested watershed is desirable.

17.2.1.2 Case 2: Manupali Watershed in Northern Bukidnon

The municipality of Lantapan is located in a river valley that is crossed by Mindanao's major north-south highway some 100 km southeast of Cagayan de Oro City. The left bank of the Manupali River bounds Lantapan on the south, and to the north lies the Mt. Kitanglad Range Natural Park. Several sub-watersheds drain from

Mt. Kitanglad Range across the extensively cultivated lands to the Manupali River, and the river then runs into a network of irrigation canals operated by the Manupali River Irrigation System (MANRIS). Lantapan is wholly contained within the Manupali watershed, which forms part of the upper Pulangi watershed. In 1992, the DENR declared the Manupali watershed "critical" making it subject to restricted development and mobilizing increased conservation efforts.

In 1999, the World Agroforestry Centre (ICRAF) initiated the Landcare program in partnership with the LGU of Lantapan. Landcare is a farmer-centred program involving farmer-to-farmer knowledge sharing, training, and capacity building on conservation farming. As an approach, Landcare focuses on formation of farmers into Landcare groups, to promote rapid adoption of conservation and agroforestry practices and to link these groups into wider social networks and various service providers. As a result, a rapid and widespread adoption of agroforestry and conservation practices took place on more than 1,000 maize and vegetable farms (representing 13 percent of the total agriculture based households, covering 11 percent of the total cropped area, and 18 percent of the critical portion of the watershed). Widespread adoption of conservation practices is found to provide positive impacts on the overall health of the watershed.

The Local Government of Lantapan passed an ordinance to support and encourage the adoption of conservation farming practices. An incentive clause in the policy stipulates that those adopting conservation practices shall be given priority for government support and extension services. Furthermore, as a form of encouragement and reward for environmental services, the Landcare Foundation of the Philippines Inc. (LFPI) provided small grants to qualified Landcare groups, managed through the municipal-wide Landcare association. In addition, the management of MANRIS has allocated a certain amount collected from the irrigators association to support the efforts of Landcare farmers in Lantapan. These schemes are based on a general understanding that collective adoption of conservation technologies produce significant environmental services and therefore the providers (farmers) of services can be immediately recognized and rewarded.

Several advantages emerge from the use of Tier 1 approaches. For organizations and stakeholders in developing countries, Tier 1 approaches provide an entry-level approach that allows them to test the PES concept. In other words, it allows for proof of concept testing and learning by doing, while avoiding (or at least delaying) the costly and lengthy research needed to quantify environmental services provided. It also allows for "confidence" building among stakeholders, which can be expected to produce more tangible actions on the ground. It breaks the barrier to participation in PES where stakeholders are overwhelmed by the need to quantify and attribute the environmental services provided by an ecosystem. The latter requires outside experts to assist them – this is why foreign donors fund most of the existing PES schemes in the Philippines. However, with the Tier 1 approach, the stakeholders involved need to be in a "learning and adaptive" mode, to allow for testing of new and better PES schemes.

Tier 1 approaches also have inherent weaknesses, such as becoming a simplistic approach to more complex issues. For example, simply conserving a forest area may not necessarily lead to biodiversity conservation. In addition, there are pitfalls in using the deductive approach (i.e., applying general principles to species cases). For instance, the indiscriminate planting of trees in watershed areas could actually lead to increased evapo-transpiration, resulting in a reduction in the total water flowing out of the watershed (Farley et al. 2005; Jackson et al. 2005). This has already been observed in some watersheds in the Philippines (Cruz et al. 2005). Finally, another weakness of the Tier 1 approach is that attribution is not clear. In other words, it is not clear whether an environmental service has indeed been delivered based on the actions taken. This returns to the problem of the lack of quantitative measurements currently available for the environmental services being provided.

17.2.2 Tier 2: Use of Simulation Modeling and Limited Site-Specific Data

Under the Tier 2 approach, simulation modeling and limited site-specific data are used to quantify the flow of environmental services expected. This assumes that a minimum data set is available to parameterize models developed in other locations. Below we present two cases to illustrate the use of this approach.

17.2.2.1 Case 1: Bakun Watershed, Benguet

Bakun municipality and its watershed is located in the northwestern part of Benguet province. It is about 86 km north of Baguio City. The centre of the watershed is located on 120°40′48″ E longitude and 14°48′00″N latitude.

The Bakun watershed is the source of domestic water supply for the local community. More importantly, it is the source of irrigation water for the rice fields and expanding vegetable farms in the area and the operation of two hydroelectric power plants.

A Rapid Hydrological Assessment (RHA) was conducted to develop an effective, fair and transparent environmental transfer mechanism as well as to find an acceptable method of determining the extent to which the quantity and quality of water delivered to downstream users can be attributed to the management efforts of the upland communities. The hydrological functions of the watershed were assessed using three knowledge domains as the framework, namely, the scientific ecological knowledge using quantitative hydrologic methods, local ecological knowledge and the public ecological knowledge. Additionally, the GenRiver hydrologic model[2] was used to estimate the streamflows and related hydrologic processes.

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[2] A model developed by the ICRAF for hydrologic assessment.

Based on the assessment, the environmental conditions in Bakun Watershed reveal that land use and ground-cover changes seems to be the most significant change alterations that have taken place in the watershed, and could explain the variations in the streamflow pattern (Cruz et al. 2005). Results of simulation runs using the GenRiver model suggest that less forest cover is more beneficial than greater cover when the ultimate goal is to induce more streamflow during the dry season (Fig. 17.1). This pattern of hydrologic behavior could be related to the tendency of forests to increase the use of water through higher evapotranspiration, resulting in lower net rainwater available for streamflow. Despite the inability to validate the outputs of GenRiver due to the absence of reliable streamflow records, the estimates generated in this study seem reasonable and consistent with current scientific knowledge as well as local and public ecological knowledge.

Presently, the Rewarding Upland People for Environmental Services (RUPES) – Bakun and the Bakun Indigenous Tribes Organization (BITO) are working together to develop effective, fair and transparent environmental transfer mechanisms that will enhance livelihoods and reduce poverty among the Bakun people and to provide a model of intervention that will fully exercise their rights. A comprehensive watershed development and management plan is currently in progress.

17.2.2.2 Case 2: Kalahan Carbon Sequestration Project

ICRAF with support from IFAD is supporting the Kalahan Educational Foundation Inc. (KEF), a group of indigenous people in the Philippines, to market the environmental services they provide.

The carbon sequestration project will be implemented over a 900-ha portion of the Ikalahan Ancestral Domain located in the provinces of Pangasinan, Nueva Ecija and Nueva Vizcaya, Philippines. The Domain covers 58,000 ha of mountainous forest and farmlands from 50 to 1,717 m above sea level. The main strategy of the project will be community-based forest management while the key stakeholders of

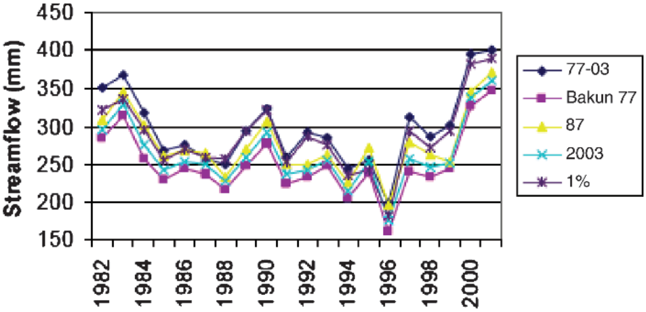

Fig. 17.1 Dry season total flow of Bakun river watershed under five scenarios of various forest cover simulated for 20 years using the GenRiver model (Cruz et al. 2005)

the project will be the Ikalahan-Kalanguya indigenous communities, local NGOs, the DENR, project monitoring team, and the funding organization.

The project has two major components: agroforestry and reforestation. The agroforestry component will involve the introduction of fruit trees to existing upland farms (typically with annual crops such as corn and rice). Aside from the environmental benefits, fruit trees will also be able to provide livelihood for poor upland farmers. Only native species and those that have been introduced in the Philippines in the last 10 years will be used, with priority for those species already growing in and around the project area. For reforestation, the following species have initially been identified: mostly indigenous Dipterocarp species, with *Bischofia javanica,* and *Alnus nepalensis* which are observed to be favorable to wildlife and also intended to rapidly establish vegetative cover in the area. Indigenous species will be planted in more favorable areas and underneath fast growing nurse trees.

The grassland areas to be reforested have been historically covered with grasses since at least 1990 and are likely to remain so without the project activity. Thus the project sites are expected to regenerate as they have for decades, at a level considered insignificant under the CDM.

The environmental service (carbon sequestration) to be provided by the project has been estimated in Fig. 17.2 under three growth rate scenarios. This simulation was done based on information on tree growth rates in the area supplemented with data from other parts of the country. The main purpose of the exercise was to assist the Kalahan indigenous people obtain funding for the carbon sequestration service they could provide. For this purpose the estimated carbon sequestration rates will suffice since the objective is to show potential buyers the expected range of benefits.

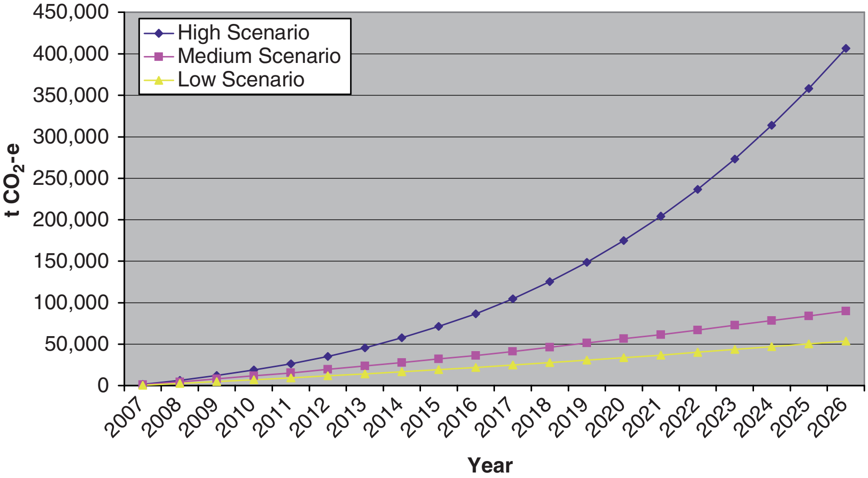

Fig. 17.2 Estimated net cumulative CO_2-e removals by the proposed Kalahan Reforesation Project, The Philippines

The advantages of Tier 2 methods are as follows: quantitative estimates are given; long range projections are possible; some attribution is possible; and costs are lower (compared to Tier 3 methods). In addition, Tier 2 methods can be cost-effective ways of marketing PES projects such as in the case of Kalahan, where for a minimal investment, environmental benefits were quantified. These methods can also be used for preparing feasibility studies where cost and benefits can be estimated. As illustrated in the case of Bakun, the role of the watershed condition in producing water has been shown.

The main disadvantage of Tier 2 methods is that simulation models are only as good as the input data and assumptions. Their output is at best estimate of the environmental services being provided.

17.2.3 Tier 3: Quantitative and Site Specific Approaches

Tier 3 methods involve the most accurate measurement of environmental services. They can be a combination of the above plus actual on-site measurements of the service being provided. For example in the case of water resources, this may involve actual monitoring of streamflow as a result of tree planting activities in the watershed. Or in the case of climate change mitigation, this may involve actual measurements of the carbon sequestered in plants and soil. Tier 3 approaches may be most appropriate when there is a market for an environmental service as in the case of the Kyoto Protocol-driven market for carbon. In such cases, sellers must conform to certain standards of measurements before their "goods" can be sold in the market.

17.2.3.1 Case: The LLDA-Tanay Streambank Rehabilitation Project

This project is being implemented in the Laguna Lake Basin, close to Metro Manila, Philippines. The main proponents/sellers of this project are the Municipality of Tanay and the Laguna Lake Development Authority (LLDA) while the implementers will be farmers in the Tanay watershed. The main objective of the project is to reduce greenhouse gases (i.e., CO_2) in the atmosphere while helping rehabilitate the Tanay watershed and providing socio-economic benefits to the local people. Specifically, the project aims to reforest 70 ha of private lands and establish 25 ha of agroforestry farms. There are three components of the project: streambank rehabilitation, reforestation and agroforestry orchard development.

Streambank rehabilitation aims to increase the riparian forest cover of the Tanay river in order to reduce erosion. Reforestation will be implemented in upland areas near the headwaters of the Tanay river in order to reduce erosion. The planting of agroforestry orchards aims to provide an income for the Katutubo village through fruit production, while reducing erosion in the upland areas. This component will be undertaken on an area of 25 ha of communal land belonging to this IP community.

The expected GHG benefits were calculated using a high and low scenario. For the project period (2004–2014), the project will have total net carbon benefits of 3,204 tC (11,759 tCO_2-e) and 1,424 (5,230 tCO_2-e) under the high and low scenarios, respectively (Santos-Borja et al. 2005). The anticipated Total Emission Reduction Purchase Agreement (ERPA) Value is US$31,380 for the low scenario and US$70,554 for the high scenario. These calculations were essentially made using the Tier 2 approach.

During project implementation, a Tier 3 method will be employed in measuring carbon removals which will be the basis for actual payments. The carbon monitoring method to be used is the one prescribed by the UNFCCC for small scale afforestation and reforestation projects (CDM Executive Board 2006). Annual net GHG removals by sinks during a monitoring period shall be projected using the equation:

$$N^* = N_{(t)} - N_{(t-1)}$$

Where,

N^*: Annual changes in carbon stocks in the carbon pools within the project boundary of the project scenario

$N_{(t)}$: Carbon stocks within the project boundary at time "t" under project scenario (ton C)

The stocks of carbon for the project scenario at the starting date of the project (t = 0) is the same as for the projection of the baseline net greenhouse gas removals by sinks at t = 0. For all other years, the carbon stocks within the project boundary at time "t", $N_{(t)}$ shall be calculated as follows:

$$N_{(t)} = SUM_i((N_{A(t)} + N_{B(t)})_i * A_i)$$

Where,

$N_{A(t)}$: Carbon stocks in above ground biomass of stratum $_i$ at time "t" from project scenario (ton C/ha)

$N_{B(t)}$: Carbon stocks in below ground biomass of stratum $_i$ at time "t" from project scenario (ton C/ha)

A_i: Project area of stratum $_i$ (ha)

The main advantage of the Tier 3 approach is that it is the most accurate, quantitative estimate of the environmental services being "sold". Payments for ES can be done on a per unit basis (e.g., US$5 per metric ton carbon). Its main drawback is the relatively high cost required to implement it. Thus, it will most likely only be feasible in cases where a high price is expected for the environmental service and/or where a market for the service already exists.

17.3 Implementing the Tier System

17.3.1 The Use of Decision Trees

Figure 17.3 illustrates how the tier system can be used depending on which type of information can be collected. This can be used by potential ES project developers in determining the measurements needed to reach a certain tier level. It can also be used by buyers to specify what tier level they require in order to make a purchase.

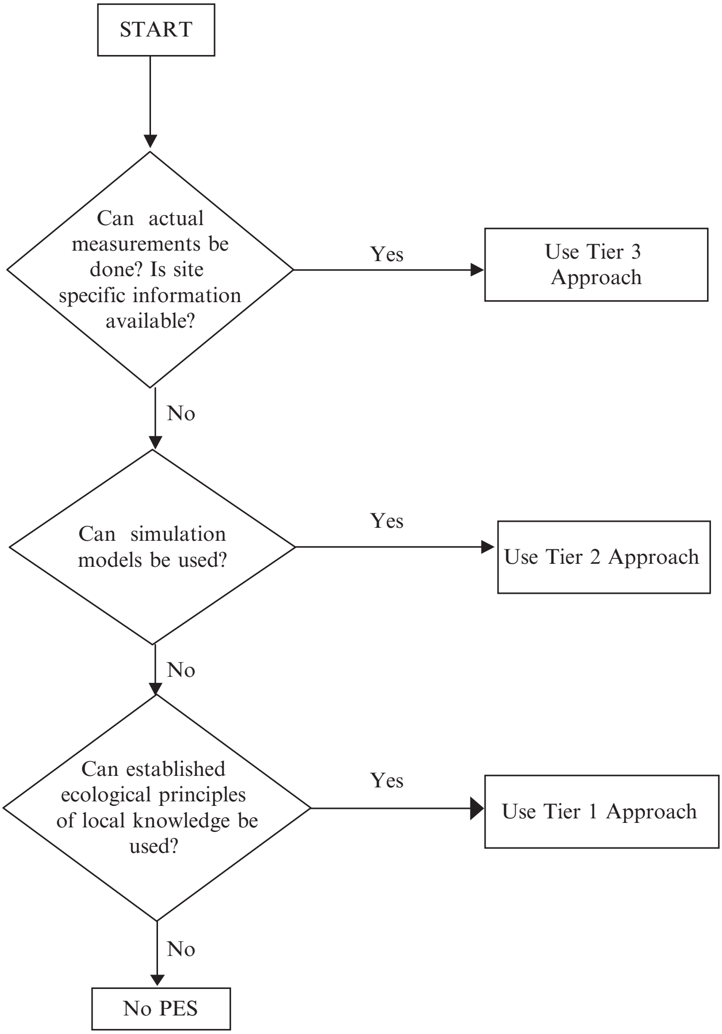

Fig. 17.3 Decision tree for determining which tier to use in a PES project

It is possible for ES projects to advance from a lower tier to a higher tier as confidence increases and funding becomes available. It should also be noted that the tiers are not discrete groups. In other words, some middle-of-the-ground methods are possible. The tier system is simply a way to systematizing the various methods of valuing an environmental service.

17.3.2 Price of ES and the Tier System

The tier used could help set the price of an environmental service. The higher the tier level used the higher the price for the same environmental service. For instance, someone willing to pay for forest protection to conserve carbon will pay a higher price if the carbon stocks conserved are quantified (Tier 3) compared to if they are simply assumed to be some amount based on global default values (Tier 1). Thus, the tier system can also be used as a guide to compare the quality of the ES being offered for "sale".

17.4 Concluding Remarks

Interest in PES is bound to increase as environmental problems escalate in many parts of the world. The tier approach we propose here could provide a way of facilitating the entry of more players in the PES through a graduated and learning-by-doing approach, especially in developing countries like the Philippines.

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Chapter 18

Values and Services of Nitrogen-Fixing Alder Based Cardamom Agroforestry Systems in the Eastern Himalayas

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Abstract Recent challenges for sustainable development are linked to large-scale land use transition and its impact on forest-dependent populations. Alternatively, agroforestry practices offer multiple opportunities to farmers to improve farm production and incomes; they also result in productive and protective forests functions. Large cardamom (*Amomum subulatum*) cultivation with N_2-fixing Himalayan alder (*Alnus nepalensis*) as a shade tree in the Eastern Himalayas is one such alternative agroforestry practice. Performances were analyzed for cardamom agroforestry *with* N_2-fixing alder (alder-cardamom), *without* alder (forest-cardamom), and with an age series of alder-cardamom between 5 to 40 years. Alder tree association accelerates the cycling of both nitrogen and phosphorus, and more than doubles production and yield. While increasing soil fertility, alder-cardamom agroforestry also conserves soil and water, and sequesters atmospheric carbon. This leads to ecological sustainability in mountain watersheds. It also provides a high aesthetic value and draws upon cultural, recreational and educational values that are harnessed by local communities as non-farming employment opportunities in ecotourism. Ecosystem services provided by cardamom agroforestry contribute to the well being of the upland people and at the same time profit the beneficiaries downstream.

Keywords *Alnus nepalensis*, *Amomum subulatum*, biodiversity, nutrient cycling, carbon flux, ecosystem services

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D.J. Snelder and R.D. Lasco (eds.), *Smallholder Tree Growing for Rural Development and Environmental Services.*

18.1 Introduction

The conversion of forests into other forms of land use has been the general trend in mountainous areas. Such changes in land-use have been conspicuous in recent decades in the Himalayan region (Rai et al. 1994). Forest-dominated watersheds have been converted into agrarian watersheds. This type of conversion was induced by an increasing population pressure and the limitations of productive agricultural land (Rai and Sharma 1998). The goal of forested watershed management is the rational utilization of land and water resources, with minimal disturbance to natural resources (Sundriyal et al. 1994). Land management in catchment areas of mountainous regions like the Himalayas essentially relates to the ecosystem services provided by these areas to upland and lowland people. Such ecosystem services specifically involve the conservation of soil and water, the protection of land from soil quality deterioration, and the conservation of water for drinking and other farm uses. Maintenance of these services is of great importance in achieving sustainable and optimum productivity of land use systems (Sharma et al. 1992). Soil on steep slopes with upland farming systems low in tree cover, such as those associated with more intensive agricultural practices is vulnerable to erosion and fertility reduction (Rai and Sharma 1995). The recent challenges in the field of sustainable development are linked to the degradation resulting from large-scale land use, and meeting the growing demand for food. The majority of the population who depend on forest and tree resources for their subsistence have become vulnerable. In such a situation, agroforestry offers multiple opportunities to farmers while also improving farm production and income, and providing productive and protective forest functions.

This chapter discusses a traditional practice of agroforestry with multiple opportunities to farmers in areas subject to land-use change, i.e., large cardamom cultivation with N_2-fixing alder. The practice has been a boon for the mountain populations in the Eastern Himalayas by providing economic benefits, ecological sustainability and ecosystem services (Sharma et al. 2000). Likewise, it has proven to contribute to integrated natural resource management, i.e., a management approach aimed at increasing agricultural production in a sustainable manner (Izac and Sanchez 2001; Lambin and Geist 2003).

18.2 Study Area and Alder-Cardamom Agroforestry

The Eastern Himalayas is spread over a wide spectrum of ecological zones and has a diverse socio-economic potential. It harbours three of the world's 34 biodiversity hotspots, with an array of unique plants and animals. The five major farming systems operative in the region are: (1) pastoralism, (2) agro-pastoralism, (3) mixed farming systems, (4) shifting cultivation and (5) commercial cash crop cultivation (see Photo 18.1; Sharma and Kerkhoff 2004).

Photo 18.1 Mountain mixed farming system in the Eastern Himalayas (©E Sharma)

Most of the case studies presented here were carried out in an agro-climatic range of 800–1,800 m from the north East Indian state of Sikkim. The study area is in the Indian monsoon region with a subtropical-temperate climate and with three main seasons: winter (November–February), spring (March–May) and rainy (June–October). The mean monthly temperature ranges from a maximum of 14°C to 24°C and a minimum of 5°C to 15°C, and rainfall from 2,500 to 3,500 mm. Relative humidity varies between 80 percent and 95 percent during the rainy season, and down to 45 percent in spring.

Large cardamom (*Amomum subulatum* Roxb.) is the most important perennial cash crop in the Eastern Himalayas, covering parts of Eastern Nepal, Sikkim and Darjeeling in India, and Southern Bhutan. Recently, its cultivation has spread to the northeast Indian states of Nagaland (550 ha), Mizoram (35 ha), Meghalaya (35 ha), Manipur (10 ha) and the central Indian Himalayan state of Uttaranchal (41 ha), and covers a total of 34,252 ha in India (Srinivasa 2006). *Amomum subulatum* belongs to the Zingiberaceae family, and the species cultivated in Sikkim has six local varieties that are suitable for cultivation at different elevations and are adaptable to various factors such as water deficit and frost. Cardamom is predominantly farmed between 600–2,000 m elevations. The plant is a shrub and has several tillers consisting of pseudostems with leaves on the upper part. The inflorescence (spike) appears on the rhizome where the pseudostem shoots up. It is mainly a cross-pollinated crop, although it is capable of self-fertilization. The capsule (fruit) is used as spice or condiment and contains about three percent essential oils and rich in cineole (Gupta et al. 1984). The harvested capsules are cured in traditional kilns.

A total of 16,949 cardamom holdings have been recorded in Sikkim State, most of which were smaller than one hectare. About 30 percent of the total area under cultivation was one to three hectares in size (Sharma et al. 2000). The cardamom agroforestry practice relies on a smallholder farmer engagement system.

Photo 18.2 Alder cardamom agroforestry in Sikkim, Eastern Himalayas (©E Sharma)

Cardamom is a shade-loving crop, grown under forest cover. Himalayan alder (*Alnus nepalensis* D. Don) is the most common species used as a shade tree in cardamom farming (Photo 18.2). Himalayan alder, henceforth called alder, regenerates naturally on landslide affected, freshly exposed and degraded sites. It is grown in forestry, agroforestry like cardamom, shifting cultivation in northeast India, and as a nurse tree in *Cinchona* (medicinal plant) plantations. Alder is a useful associate tree capable of fixing nitrogen efficiently with *Frankia* symbiosis (Sharma and Ambasht 1984). The altitudinal range of the Himalayan alder is sympatric with the agro-climatic range of large cardamom farming. It provides fuel-wood for both cardamom-curing and domestic use. Trees attaining more than 25 to 30 years of age provide timber for either domestic or commercial purposes. The majority of the 30,039 ha area under cardamom cultivation in Sikkim and Darjeeling have alder as the shade tree.

In this chapter, cardamom-based agroforestry systems in an age series of 5, 10, 15, 20, 30 and 40 year old stands will be discussed. In addition, both systems with N_2-fixing alder (alder-cardamom) and systems without alder (forest-cardamom) will be looked at and described.

18.3 Ecosystem Services

The cultivation of agricultural crops with trees in the form of an agroforestry system results in a variety of food and tree-based products (Sharma and Sharma 1997). In addition, when practised in mountainous areas, it provides communities in both upstream and downstream areas with various vital ecosystem services. Based on the Millennium Ecosystem Assessment (MA 2005), the ecosystem services arising from alder-cardamom agroforestry system can be classified into four categories:

(a) Supporting services which are evident from the system's positive impact on productivity, nutrient cycling, nitrogen fixation, energy fixation and nutrient use efficiency
(b) Provisioning services which are evident from the system's yields of cardamom, firewood, fodder and other products
(c) Regulating services which are evident from the system's contribution to soil and water conservation, soil fertility, carbon storage and flows, and a favourable microclimate
(d) Cultural services which are evident from the system's aesthetic, educational and recreational benefits

In the sections below, the various ecosystem services associated with alder-cardamom cultivation in the Eastern Himalayas will be discussed based on the authors' extensive research experience in the region. Furthermore, the efficiency in delivering these services will be described and compared for agroforestry systems with and without N_2-fixing alder, and also for systems with stands of different age.

18.3.1 Productivity, Yield and Energy Efficiencies

The performance of alder-cardamom systems was much higher in terms of productivity and agronomic yield, compared to the forest-cardamom systems (Table 18.1). Alder actually influenced the system by its fast growth which contributes to higher total biomass, and also by enhancing cardamom performance as illustrated by greater tiller numbers, basal area and biomass (Sharma et al. 1994). The agronomic yield of cardamom increased 2.2 times under the alder canopy. Similarly, the comparative study on the impact of standing age (5, 10, 15, 20, 30 and 40 years) on the cardamom crop and the alder trees associated revealed that net primary productivity was the highest (22 t ha^{-1} $year^{-1}$) in the 15-year-old stand and the lowest (7 t ha^{-1} $year^{-1}$) in the 40-year-old stand (Sharma et al. 2002a). Agronomic yield of cardamom peaked between 15 and 20 years of age. Cardamom productivity doubled between the 5 to 15-year-old stand and then decreased with plantation age. It reached a minimum in the 40-year-old stand. The performance of cardamom in association with alder remained ecologically and economically beneficial until the plantation was 20 years old. This suggests that the re-plantation cycle should begin around this age for sustainable management practice. Cardamom being a shade-tolerant plant does not perform well when the canopy opens, as observed after 30 years of age. Ageing could also play a role in the decreasing performance of both the crop and the associated alder.

Studies of energy distribution and flow rates determined for various components of the alder-cardamom and forest-cardamom agroforestry systems highlighted that

Table 18.1 Productivity, yield and nutrient dynamics of large cardamom agroforestry under alder and mixed tree species (After Sharma et al. 1994)

Parameters	Alder-cardamom	Forest-cardamom
Biomass (kg ha^{-1})	28,422	22,237
Net primary production (kg ha^{-1} year^{-1})	10,843	7,501
Agronomic yield (kg ha^{-1} year^{-1})	454	205
Nitrogen		
Standing state in biomass (kg ha^{-1})	395.15	205.26
N_2-fixation (kg ha^{-1} year^{-1})	65.34	–
Uptake from soil (kg ha^{-1} year^{-1})	78.49	80.56
Retention (kg ha^{-1} year^{-1})	56.12	49.55
Return to soil (kg ha^{-1} year^{-1})	83.67	29.23
Exit through agronomic yield (kg ha^{-1} year^{-1})	4.04	1.78
Use efficiency*	73	93
Back-translocation from senescent tree leaf (%)	3.85	17.49
Phosphorus		
Standing state in biomass (kg ha^{-1})	32.357	17.900
Uptake from soil (kg ha^{-1} year^{-1})	13.178	6.517
Retention (kg ha^{-1} year^{-1})	6.328	3.840
Return to soil (kg ha^{-1} year^{-1})	6.146	2.347
Exit through agronomic yield (kg ha^{-1} year^{-1})	0.704	0.330
Use efficiency[a]	823	1151
Back-translocation from senescent tree leaf (%)	22.62	31.37

[a] Nutrient use efficiency is the ratio between annual production and nutrient uptake.

net annual fixation was 1.57 times greater in alder-cardamom (221×10^6 kJ ha^{-1} year^{-1}). As for the net energy allocation in the under-storey, large cardamom crop was much higher (45 percent) in the alder-cardamom system than in the forest-cardamom system (31 percent) (Sharma R et al. 2002). Such figures clearly show that N_2-fixing alder is a better associate-shade-tree than mixed tree species, and creates the conditions for a higher energy allocation in the cash-crop system. In absolute terms, net energy allocation in cardamom crops was 2.3 times greater under the alder-cardamom system, as opposed to the forest-cardamom system. In capsule terms the increase was 2.2. Floor-litter energy build-up was conspicuous due to more litter production and accumulation in the alder-cardamom system with 1.6 times more than in the forest-cardamom system.

The Energy Conversion Efficiency (ECE) at the autotrophic level is expressed as a percentage and is defined as the ratio between the energy captured by vegetation and the photo-synthetically active radiation that reaches an area over a certain period of time (Sharma and Ambasht 1991). The ECE of the alder-cardamom system (1.87 percent) was higher than for the forest-cardamom system (1.19 percent). The range of 1.8 to 3.5 percent ECE in the age series of Himalayan alder (Sharma and Ambasht 1991) and 1.8 to 4.2 percent in red alder stands in Canada (Smith 1977) indicate that the 1.87 percent obtained in the alder-cardamom system is within the expected range. Rawat and Singh (1988) reported an ECE of 1.1 percent in oak forests of the central

Himalayas, which is comparable to the mixed tree species forest-cardamom ECE value of 1.19 percent. The ECE contribution of large cardamom was much greater in the alder-cardamom system (0.85 percent) than the forest-cardamom system (0.36 percent). The Energy Fixation Efficiency (EFE) is the annual net energy fixation per unit energy of leaf, and the Energy Accumulation Ratio (EAR) is calculated as the energy stored in the system divided by annual net energy fixation (Sharma et al. 2002). The EFE and EAR of the alder-cardamom system were slightly lower than that of the forest-cardamom system. The alder-cardamom system showed lower EAR, resulting from less energy accumulation in the perennial components of alder trees and also a greater annual turnover in the form of leaf and twigs of tree and cardamom components. This reveals that there are higher energy dynamics in the alder-cardamom system compared to its forest-cardamom counterpart. The EFE may be expected to decrease with increasing rates of fixation because the availability of other resources (such as water or nutrients) may become limited and will constrain production. The EFE in the alder-cardamom based agroforestry systems was generally consistent with this hypothesis: it decreased - and was lower compared to the forest cardamom system – due to the influence of N_2-fixing alder trees (3.29 GJ GJ^{-1} leaf energy $year^{-1}$ in alder-cardamom and 3.70 GJ GJ^{-1} leaf energy $year^{-1}$ in forest-cardamom). Yet, the EFE contribution of large cardamom was greater in the alder-cardamom system (3.20 GJ GJ^{-1} leaf energy $year^{-1}$) than in the forest-cardamom (3.07 GJ GJ^{-1} leaf energy $year^{-1}$) system. Energy efficiency in N_2-fixation decreased with plantation age, ranging between 58–103 g N_2 fixed 10^4 kJ^{-1} energy in the pure age series of alder stands (Sharma and Ambasht 1991), which is comparable to 68 g N_2 fixed 10^4 kJ^{-1} energy in the alder-cardamom system.

The results of the alder-cardamom system's age series showed that annual net energy fixation was highest (444×10^6 kJ ha^{-1} $year^{-1}$) in the 15-year-old stand, being 1.4 times the 5-year-old stand and 2.9 times the 40-year-old stand fixation (Sharma et al. 2002a). Regression analyses suggest that younger plantations are more productive for both cardamom and alder, with inverse relationships between stand age and production efficiency, energy conversion efficiency or energy utilized in nitrogen fixation, and a positive relationship between production efficiency and energy conversion efficiency. The energy dynamics also support the earlier finding concerning the alder-cardamom system's sustainability by adopting a 15 to 20 years rotational cycle.

Cultivation of cardamom is a relatively low input cash crop. The main requirements are labour and firewood for curing the cardamom capsules. The outputs include agronomic yield, fodder and firewood from trees. The quantum of energy input and output for the alder-cardamom system was about twice the quantum for the forest-cardamom system (Table 18.2). The ratio of output to input produced lower values for the alder-cardamom system. However the cash income from this system was more than double the cash income from the forest-cardamom system, and also the cost-benefit analysis gave better results for the former alder-cardamom system. Both the quanta of energy and higher cash return for the alder-cardamom agroforestry system support the idea that the integration of alder trees in cardamom plantations is an efficient management system.

Table 18.2 Annual input and out of energy and cash in cardamom based agroforestry systems Sharma R et al. 2002)

Input/output	Energy ($\times 10^4$ kJ ha^{-1})		Cash (US$ ha^{-1})	
	Alder-cardamom	Forest-cardamom	Alder-cardamom	Forest-cardamom
Input				
Weeding	2.1	4.2	2.8	5.6
Harvest	8.4	4.2	11.2	5.6
Post-harvest	42	21	56	28
Fire-wood collection	13	6	17	8
Fire-wood used in curing	1,064	465	35	17
Total	1,129	501	121	65
Output				
Agronomic yield	920	411	2,112[a]	954[a]
Fire-wood extraction	3,087	1,486	101	56
Fodder	–	596	–	7
Total	4,007	2,493	2,213	1,017
Output:Input ratio	3.55	4.98	18.23	15.67

Human labour per hour was calculated at 0.15 × 10^4 kJ (Freedman 1982)

[a]Calculated at US$4.65 per kilogram of cardamom and cash conversion @ US$1 = Indian Rs. 43.

18.3.2 Nitrogen Fixation and Nutrient Use Efficiencies

Nitrogen accretion through biological fixation following acetylene reduction assay, and then applying the C_2H_2: N_2 conversion factor of 2.4: 1, was used to estimate nitrogen fixation (Hardy et al. 1973; Sharma and Ambasht 1988). In pure plantations of Himalayan alder, the annual accretion was highest (117 kg ha^{-1} year^{-1}) in the seven-year stand and lowest (29 kg ha^{-1} year^{-1}) in the 56-year stand (Sharma and Ambasht 1984, 1988; Sharma et al. 1998a). The Himalayan alder fixed 65 kg nitrogen ha^{-1} year^{-1}, benefiting the associated cardamom in the alder-cardamom system (Sharma and Purohit 1996). In the age series of the alder-cardamom agroforestry system, nitrogen fixation ranged from 52 to 155 kg ha^{-1} year^{-1} (highest at the age of 15-years) suggesting a substantial input of nitrogen into the system by alder (Sharma 2001).

The nutrient use efficiency is the ratio of the annual net primary productivity and the nutrient uptake. The nitrogen use efficiency was 73 and 93; phosphorus was 823 and 1,151 for the alder-cardamom and forest-cardamom stands respectively (Table 18.1). In the case of the age series of the alder-cardamom systems, the nitrogen use efficiency was 98 for the five-year-old stand and 81 for the 40-year-old stand. Similarly, the efficiency use of phosphorus decreased with age, being 2,439 for the 5-year-old stand and reaching a minimum value of 1914 for the 40-year-old stand. The average phosphorus use efficiency in all aged stands was approximately 25 times greater than the nitrogen use efficiency (Sharma et al. 2002b).

A drop in nutrient use efficiency should be expected with ageing tree-crop systems as the utilization of a given nutrient (i.e., the nutrient uptake) increases over the years while the availability of other resources (such as water, energy, or light) becomes more limited which, in turn, will increasingly hamper production (Melillo and Gosz 1983; Bloom et al. 1985). Thus as Himalayan alder plantations age the nitrogen and phosphorus use efficiency will decrease. The latter trends are confirmed by Sharma (1993). Binkley et al. (1992) have further reported that in its use of nutrients, the red alder (*Alnus rubra*) is much less efficient than conifers. The lower nutrient use efficiency of alder trees is however beneficial to other crops in alder tree-crop associations such as cardamom because of the generally greater availability of such nutrients related to the systems' faster nutrient cycling.

18.3.3 Biogeochemical Cycling

The nitrogen and phosphorus concentrations in the tissues of alder trees were higher than those of forest mixed tree species (Sharma et al. 1994). This finding is consistent with the higher concentrations of nutrients found in the red alder, compared with conifers in mixed stands (Binkley 1983; Binkley et al. 1984). Both nitrogen and phosphorus re-translocation from leaf before abscission was lower in alder than mixed tree species. This was because of the higher availability and uptake of these elements in the alder-cardamom system. The general concept of an inverse relationship between availability and conservation is clearly applicable to alder-cardamom and forest-cardamom agroforestry systems. The higher availability of nitrogen and phosphorus for the alder trees resulted in lower re-translocation which is indicative of its poor conservation strategy. However, this strategy is beneficial for the associated crops in the alder tree plantations, i.e., cardamom.

The nutrient re-translocation of senescent alder leaves was positively related to stand age for nitrogen, but negatively with phosphorus. The nitrogen re-translocation in young alder trees was minimal because it was sufficiently available through fixation. However the demands for nitrogen increased with age while the contribution from fixation decreased, causing greater translocation. In the case of phosphorus, its need for tree growth was high in younger stands where effective re-translocation was recorded (Sharma et al. 2002b). Yet, its need and re-translocation decreased with increasing stand age. The alder thus displayed contrasting physiological behaviour for nitrogen and phosphorus at different ages; it was mostly governed by the demand and availability of these nutrients.

The annual uptake and return of nitrogen to the soil in the alder-cardamom stand was higher than the forest-cardamom stand, which can be attributed to nitrogen fixation by the alder tree (Table 18.1). The rates of phosphorus uptake and return through litter-fall and decomposition were also higher in alder-cardamom than the forest-cardamom stand. This was probably a result of an increase in the rate of phosphorus supply, attributable to geochemical and biological factors influenced by the alder. Potential geochemical factors could be rhizosphere acidification (Gillespie and Pope 1989) and biological factors could be rooting depth (Malcolm et al. 1985), soil enzyme activity (Ho 1979) and organic chelates (Ae et al. 1990).

The total uptake of nutrients in the age series of alder-cardamom systems varied from 90 to 239 kg ha^{-1} year^{-1} for nitrogen and from 4 to 10 kg ha^{-1} year^{-1} for phosphorus (Sharma et al. 2002b). Values were lower for nitrogen and higher for phosphorus when compared to the monoculture of the same species of alder in the region (Sharma 1993). Rawat and Singh (1988) estimated the nutrient uptake in a Himalayan oak forest to be 230 kg ha^{-1} year^{-1} for nitrogen and 13 kg ha^{-1} year^{-1} for phosphorus. These comparisons show that pure alder forests have higher nitrogen and lower phosphorus uptake, but that in the mixed stands, cardamom nitrogen uptake decreases while phosphorus uptake increases. The low phosphorus uptake in pure alder stands was attributed to a negative effect of alder on the phosphorus economy, mostly by increasing soil acidity (Sharma 1993). This caused phosphate to react with iron and aluminium to form less soluble phosphate compounds (Brozek 1990; Sharma et al. 1997). Furthermore, a heavy accumulation of organic matter in soils of pure alder stands could have shifted phosphorus from a plant-available pool to an organically bound pool (Sharma 1993). The combination of alder with cardamom is a system in which nitrogen and phosphorus uptakes are balanced, unlike in either pure stands of an N_2-fixing species such as alder, or a non-N_2-fixing species.

The nitrogen and phosphorus cycling in the cardamom agroforestry system appeared to be very malleable (flexible) under the influence of the N_2-fixing alder. Binkley et al. (1992) have also reported that alder results in a generally higher uptake and return of all nutrients, and a greater magnitude of malleability of nutrient cycles are consistent with the findings from the alder-cardamom system. We have observed that the agroforestry system was more productive when alder was integrated into the system, resulting in faster rates of nutrient cycling. The poor nutrient conservation, low nutrient use efficiency and the malleability of nutrient cycling in alder systems make the alder tree an excellent associate that promotes higher availability and faster cycling of nutrients.

18.3.4 Biodiversity Values and Conservation

Biodiversity is an important indicator for sustainability. Biologically diversified systems have a greater adaptive capacity for resilience and show greater sustenance. The cardamom is native from Sikkim in the Eastern Himalayas, and the occurrence of five species of wild cardamom (*Amomum linguiforme*, *A. kingii*, *A. aromaticum*, *A. carynostachym*, *and A. dealbatum*) shows high genetic reserves. *Amomum subulatum* is a cultivated species of cardamom and its cultivation system supports a highly diverse range of shade trees (Sharma and Sharma 1997). Our study supported this since up to 23 species were found. The Shannon and Weaver diversity index of trees in a cardamom dominated system was 4.1. This indicates that there is a fairly good composition of trees providing fodder and firewood to farming families. Most of the cardamom agroforestry have alder as shade trees. However, small patches are maintained with mixed trees so as to meet the fodder requirements of households.

Table 18.3 General bird characteristics in three gradient forests with and without cardamom in Sikkim (Nakul Chettri, unpublished)

Bird variables	Alder-cardamom	Forest-cardamom	Natural forest without cardamom
Species recorded	48	40	50
Species per sample (mean + SE)	5.9 ± 0.2	7.0 ± 0.5	5.1 ± 0.5
Individual per sample (mean + SE)	23.6 ± 1.7	28.3 ± 3.6	24.4 ± 2.7
Shannon Weiner's diversity (H')	2.9	3.1	3.4
Margalef's species richness	12.2	10.6	12.6

This enhances the richness of tree species in a cardamom dominated system. Trees from cardamom agroforestry have multiple uses for farmers, such as fodder, firewood, timber, materials for field implements and residues for animal bedding. These trees also support birds and other wildlife, which has a direct bearing on the ecosystem structure and enables it to function in a sustained manner.

A study of bird characteristics was carried out in three gradient forests in the Khecheopalri and Yuksam areas of west Sikkim: (1) a natural forest without cardamom, (2) a forest with cardamom and (3) an alder forest plantation with cardamom. The general characteristics of the bird community revealed that an alder-cardamom field is an equally good habitat for biodiversity as natural and mixed forests (Table 18.3). A greater richness of bird species and diversity was observed in the natural forest without cardamom, and the species richness in the alder-cardamom stand was also greater than in the mixed forests with cardamom. There were no significant differences in the variables of these three gradient forests. Interestingly, a higher number of species per sample was observed in the alder-cardamom field where insectivores (flycatchers, laughing-thrushes, woodpeckers) and omnivores (drongos, crows, mynas) were the dominant bird species. In a promising surrogate, the pattern of species richness, diversity and the guilds of birds are indicative of the habitat's quality (Anand et al. 2005; Fleishman et al. 2005; Padoa-Schiopa et al. 2006). Since most of the alder-cardamom fields in Sikkim are contiguous to the natural forest, they have a dual function being a feeding habitat on the one hand, and leading to a well developed habitat mosaic which enhances overall biodiversity on the other hand (Chettri et al. 2005). Our results revealed that alder-cardamom is equally good for forest birds, particularly insectivores and omnivores. Also, the high species richness compared to the mixed forest is mainly due to the openness of the upper strata that creates visibility for feeding species. If age groups of alders are maintained so as to enhance different succession stages, then diversity might also be enhanced as reported by Shankar Raman et al. (1998).

18.3.5 Soil and Water Conservation

The overland flow (percentage of rainfall during the rainy season) as estimated in temperate and subtropical forests, cardamom agroforestry, mandarin agroforestry, traditional agriculture areas and fallow land, was the highest (9.6 percent) in the traditional agriculture area and the lowest (2.2 percent) in cardamom agroforestry (Rai and Sharma 1998). The amount of soil loss from cardamom agroforestry was also the lowest, although it proved to be slightly higher than in temperate forests. Records on soil organic carbon, total nitrogen and total phosphorus showed the same trend, with the lowest losses for the cardamom system.

In another experiment, with five dominant types of crops or vegetation (maize, finger-millet, mixed cropping, cardamom, broom grass), covers and bare land were compared so as to determine the *in situ* soil and water conservation values. The data showed here that the lowest losses of water and soil were recorded for the cardamom fields. Likewise, the conservation of both water and soil in cardamom fields was 81 percent and 87 percent respectively (Sharma et al. 2001).

Soil fertility levels have a considerable influence on plant productivity. A comparison between the cardamom dominated system and the maize-potato dominated system revealed higher levels of soil nutrients, particularly of organic carbon and total nitrogen in the cardamom dominated system (Sharma and Sharma 1997). The soil erosion rate measured during the rainy season was about 16 times lower in the cardamom agroforestry system. The loss of nutrients through soil erosion and overland flow suggest that the cardamom agroforestry system provides a much better protective cover. The low volume of soil erosion and consequential low nutrient loss indicate that the cardamom system is ecologically viable when compared to the maize-potato dominated system. Measurements of the distribution of the incidental rainfall into the various pathways revealed that the canopy interception was much higher in the cardamom system. The amount of incidental rainfall contributing to overland flow was only 2.17 percent in the cardamom system, whereas 9.2 percent in the maize-potato system. These values suggest that the cardamom system retains more water from incident rainfall in its various sub-components than the maize-potato system. This was attributed to the presence of trees in the cardamom systems.

18.3.6 Carbon Budget and Flux

Globally, changes of land-use are transforming land cover at an accelerating rate. In mountain ecosystems, such changes are closely linked to the issue of sustainable socio-economic development. Since this can affect essential elements of natural capital such as climate, soils, vegetation, water resources, and biodiversity, land transformation may result in wide ranging changes, many of which are significant on a global scale. These changes include an increase in greenhouse gases and potential global warming, the loss of biodiversity and soil resources, and also other regional impacts which contribute to climate change. In the mountains, watersheds can be considered to be functional units of natural resource management for sustainable development. Understanding the dynamics of watershed functions requires knowledge about physical characteristics such as hydro-ecological links between land uses, resource dimensions and socio-economic conditions. Socio-economic demands and natural resource use are interactive (Rai and Sharma 1998; Sharma et al. 1998b). Increasing stresses on the use of natural resources have an impact at the watershed level which can also result in a cumulative impact at a regional level. Carbon is an important indicator when studying the mechanisms of change in watershed functioning. Therefore, cardamom agroforestry is becoming an important land management practice which is related to economic activity. Its role in climate change could be assessed using carbon as an indicator.

The land-use change over 13 years (1988–2001) in the Mamlay watershed resulted in a net release of 305×10^3 t of carbon into the atmosphere (Rai and Sharma 2004). The reduction of forest biomass contributed to 119×10^3 t of carbon being released by vegetation and 186×10^3 t being released by soil, amounting to a release of about 8 t of carbon from a hectare of land every year in the watershed. The stock of carbon in vegetation and soils in the watershed amounted to 577×10^3 t in 2001 (Table 18.4). A comparison of cardamom agroforestry with mandarin and open cropped areas revealed that carbon stocks per unit were five times greater in the cardamom agroforestry system. This system provides an opportunity to sequester substantial amounts of atmospheric carbon and mitigate greenhouse gases. Soil carbon sequestration, as a means of mitigating climate change, was reported by Lal (2004) to be substantial, and the carbon sequestration in the soils of cardamom systems was likewise substantial.

18.3.7 Aesthetic Values

Sikkim in the Eastern Himalayas has established itself as a recommended destination for contemporary tourists in recent years (Rai and Sundriyal 1997). The scenic beauty, rich biodiversity, friendly people and rich culture attract two million tourists every year from all over the world. The mixed ethnic groups (Lepcha, Bhutia and Nepali) who reside in the area have extensive traditional knowledge blended with their culture and religion, which has lead them to be great nature lovers. Inspired by the Sikkim Biodiversity and Ecotourism project (Sharma E et al. 2002), the state is taking a leading role in diversifying and promoting ecotourism with ‘Home Stays’ in remote areas as ‘model villages’.

Table 18.4 Area under different land use and carbon storage in the Mamlay Watershed in Sikkim (Rai and Sharma 2004)

Land use/cover	Area (ha)	Carbon storage (t C ha^{-1})	Area-weighted carbon storage (×10^3 t C)
Temperate natural forest dense	160	191	107
Temperate natural forest open	982	86	304
Subtropical natural forest open	362	90	80
Cardamom agroforestry system	115	47	35
Mandarin agroforestry system	17	6	3
Open-cropped area temperate	413	9	19
Open-cropped area subtropical	506	8	29
Total of land use	2,555	–	577

The cardamom agroforestry landscape is rich in biodiversity and has a high aesthetic value for ecotourists. Its wilderness and natural settings are maintained by agroforestry and cardamom farmers who have a extended traditional knowledge. These areas encourage activities such as bird watching and trekking to the higher mountains through cardamom forests. The Ecotourism and Conservation Society of Sikkim have reported that Home Stay destinations such as Kewzing in the south, Yuksam in the west, Dzongu and Pastanga in the north of Sikkim which have a substantial area under cardamom cultivation are being promoted as a part of an ecotourism package.

18.4 Conclusion

Cardamom is a perennial cash crop grown beneath the forest cover on marginal lands in the Eastern Himalayas. Cardamom growers in smallholdings predominantly use N_2-fixing alder as a shade tree. Cardamom is a low volume, high value and non-perishable crop. Furthermore, it is non-nutrient exhaustive and demands little input while giving high returns in the form of an agroforestry system. The combination of alder and cardamom in an agroforestry system has shown to generate both an economically and ecologically sustainable land use system. The values and services of cardamom agroforestry are enormous, especially when grown under N_2-fixing alder as a shade tree. The efficiencies of alder in terms of energy fixation, production and nutrient use and alder's accelerating effect on nitrogen and phosphorus nutrient cycling have a beneficial impact on cardamom and thereby to the ecosystem as a whole. The cardamom system also provides non-farming opportunities with additional income from home stays and ecotourism as a result of valuing landscapes towards wilderness. Biodiversity values and the conservation of species, soil and water are highly relevant in the context of current regional and global demands for ecosystem services, which are fulfilled by the cardamom system as a potential farming practice that combines cash crop with trees. Alder in the cardamom system sequesters carbon efficiently and the proposed rotation cycle of 15–20 years for alder-cardamom plantations would result in a continuous contribution to carbon sequestration. Thus, the higher productivity and carbon fixation rates of the alder-cardamom system would contribute to the mitigation of climate change.

The ecosystem services resulting from multi-functionalities of N_2-fixing alder and cardamom agroforestry systems in the Eastern Himalayas will enhance the well being of the upstream and downstream beneficiary communities. This would also ensure the supply of ecosystem services to the wider region and for future generations.

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Chapter 19
Perceptions of Ethnic Minorities on Tree Growing for Environmental Services in Thailand

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Abstract The aim of this chapter is to shed light on how local people view the role of trees in environmental conservation and how this is reflected in forest management practices at the community level. The discussion is based on a study was undertaken among three ethnic minorities (Karen, Hmong and Lawa) in Thailand's northern forested uplands. The results indicated that trees and forests were regarded as essential for environmental services, and the products and services the surrounding forest provided were considered fundamental for upland people. All three groups' traditions included elements of conservation, although more strongly reflected in Karen and Lawa culture. The villagers regarded reforestation as a tool for forest conservation, but government reforestation projects also faced disincentives related to the tree species planted, insufficient economic benefits and competition for land. Government and NGO projects also encouraged the growing of trees on farms, and farmers themselves experimented with new tree crops, particularly fruit trees, and with farming systems by their own initiative. Means to intensify land use were necessary due to increasing pressures on land resources, and alternatives to slash-and-burn cultivation methods were sought. However, lack of resources, small farm sizes and insecure land rights posed constraints on adoption of agroforestry. Development of participatory approaches in reforestation, agroforestry projects and improved political and legal foundations for community forestry are necessary for sustainable management systems but also to ensure future environmental benefits.

Keywords Forest conservation, forest management, Hmong, indigenous people, Karen, Lawa

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D.J. Snelder and R.D. Lasco (eds.), *Smallholder Tree Growing for Rural Development and Environmental Services.*

19.1 Introduction

Deforestation is still considered a serious problem in Thailand, although the rate has significantly slowed down during recent decades. The most rapid deforestation rates occurred from the 1960s until the early 1980s. A total logging ban in all natural forests was enacted in 1989, which shifted the focus from forest policy and management to conservation. The national forest policy approved in 1985 already emphasized forest protection and reforestation. During the 1990s, the annual forest loss was −0.7 percent and between 2000 and 2005 it dropped to −0.4 percent, while from 1990 to 2005 the area covered by forest plantations increased by almost half a million hectares (459,000 ha). Forest cover in 2005 was estimated to be 28 percent of the land area (FAO 2006).

All forest land in Thailand belongs by law to the state. The Royal Forest Department (RFD) was responsible for the forests and their management since its establishment in 1896 until 2002, when forest administration was reorganized. Since 2002, production and community forest management have been the responsibility of the RFD, whereas conservation forests are administered by the Department of National Parks, Wildlife and Plant Conservation and mangrove forests by the Department of Marine and Coastal Resources. Furthermore, the TAO (Tambon Administration Organization) Act of 1994 and the Decentralization Act of 1999 have transferred the rights and responsibilities of natural resource management to the subdistrict (*tambon*) level. Moreover, the logging ban has increased the significance of local communities in forest management (Poffenberger 2000). After 17 years waiting, the Community Forest Bill was passed in the National Legislative Assembly on 21 November 2007, and it is waiting for the royal assent to take effect. Before, community forestry could be legally practised only in production forests, but after enacting the new law, community forest rights can be given to communities fulfilling certain conditions in protected areas.

This chapter examines local perceptions on the role of trees and forests in environmental conservation among ethnic minority groups in the forested uplands of northern Thailand. In addition, local views on reforestation and tree planting are discussed, including existing agroforestry practices, current constraints and needs for future development. Important questions are raised regarding the ability of current activities to ensure future levels of forest products and services, but also concerning policy and its implications regarding forest conservation, landscape rehabilitation and reforestation. Results are based on fieldwork conducted within the framework of the author's doctoral dissertation in 2002 and 2004 (Hares 2006).

19.2 Study Area

Forests cover more than half the land area of northern Thailand (RFD 2005). The main forest types are dry dipterocarp, mixed deciduous and evergreen forests. A tropical monsoonal climate prevails with a distinct dry season from November to May.

The terrain is mainly upland with narrow alluvial valleys. The slopes of the hills are often steep, and the soils are commonly of poor or medium fertility on steep slopes (Turkelboom and Van Keer 1996). Arable land is very limited. Adjacent to the study area is Thailand's highest peak Doi Inthanon (2,565 m), both situated in Chiang Mai Province. The fieldwork material was gathered from five villages within two districts, Mae Chaem and Chomthong (Figure 19.1).

Ethnic minority groups also called hill tribes, constitute the majority of the population in upland areas, whereas the ethnic Thai (the dominant ethnic group in Thailand) tend to occupy the lowlands. Three upland minority groups were included in this study: the Karen, Hmong and Lawa. Of these, the Lawa are regarded as people indigenous to Chiang Mai. After them arrived the ethnic Thai in the 13th century approximately, while the Karen arrived in significant numbers

Fig. 19.1 The location of study area in the Chiang Mai Province, northern Thailand

as from the early 19th century only. However, in remote upland areas such as Mae Chaem, the Karen may have settled before the Thai. The Hmong have inhabited Chiang Mai in considerable numbers for less than a hundred years (Renard 1981).

A variety of slash-and-burn cultivation methods has prevailed as a source of livelihood among the upland ethnic minorities. Transformation in terms of farming methods and cultivated crops has, however, occurred. Rotational slash-and-burn cultivation is still practised, but on a smaller scale than before and often with shortened fallow periods. The common shifting cultivation method used among the Hmong in which the same field was not necessarily reused is no longer practised. The government has worked actively to replace slash-and-burn with other farming methods based on permanent fields in order to avoid encroachment onto forest land. New forms of agroforestry have been encouraged as alternatives for slash-and-burn cultivation. Another change has occurred in the types of crops grown. Whereas some farmers were formerly involved in/committed to growing opium poppies (*Papaver somniferum* L.), these have almost disappeared due to eradication campaigns which were particularly vigorous in the 1980s. Opium poppies were then replaced with new, often temperate crops, such as cabbage (*Brassica oleracea* var. *capitata* L.). Rice (*Oryza sativa* L.) is still the main crop for subsistence but the importance of cash crops (such as potato, cabbage, carrot and cut flowers) has increased.

The study area's upland forests are largely protected by law. Two national parks extend into the area (Doi Inthanon and Mae Tho) and for the most part the uplands are classified as first-priority watersheds and are therefore strictly protected. The Mae Chaem watershed is regarded as important since it contributes to 16 percent of the flow of the Chao Phraya River which is the largest river in Thailand and flows through the central regions to the Gulf of Thailand.

The study used qualitative methodology for data gathering and analysis. The primary material was gathered by interviews in villages (totalling 77 interviews in five selected upland villages; see Table 19.1): semi-structured interviews with open-ended questions were complemented by thematic individual and group interviews but also informal discussions. Representatives of various age groups, both men (53 percent) and women (47 percent) were interviewed. Other villages in the area were also included for complementary information. In addition, local non-governmental organization (NGO) staff of CARE Thailand and forestry, watershed and district officials were interviewed. The interviews were conducted with the assistance of interpreters in three different languages.

19.3 Local Perceptions on the Role of Trees in Environmental Conservation

A general consensus that the forest and trees are vital for people's livelihood in the upland villages and their protection is therefore essential prevailed among each ethnic group in this study. The interviewees acknowledged the forest as a place for

Table 19.1 Socio-cultural and land use characteristics of the five villages in Mae Chaem and Chomthong districts, Chiang Mai province and the associated numbers of semi-structured and group interviews conducted in each village

	Ban Yang San	Ban Pang Hin Fon	Ban Ho Kao	Ban Phui Nua	Mae Ya Noi
Main ethnic group(s)	Karen	Karen, Hmong	Lawa	Hmong	Hmong
Number of households[a]	48	55	74	70	60
Number of individual interviews	14	10	13	8	15
Number of group interviews	6	2	3	3	3
Altitude (asl.)	800 m	1,220 m	1,030 m	1,200 m	1,000 m
Community forest area	1,120 ha[b]	865 ha[c]	412 ha[c]	n.a.	n.a.
Conservation forest area	726 ha[b]	378 ha[c]	n.a.	n.a.	n.a.
Agricultural land (% of land area)	166 ha[b] (8%)	192 ha[c] (13%)	140 ha[c,d] (12%)	(65% of land area)[e]	n.a.
Main farming system	Transition from swiddens to permanent fields	Permanent fields, cash-crops	Rotational slash-and-burn	Permanent fields, cash-crops (cabbage, formerly opium)	Permanent fields with crop rotation (formerly opium)

n.a.: not available

[a] Estimation given by the village headman

[b] From Uparasit and Isager 2001

[c] From CARE 2001

[d] Swidden area 571 ha

[e] From Badenoch 2006

humans and animals to live and as a provider of land for agriculture. They described the forest as the land covered by many trees and the good forest as a stand of large trees. The role of trees in balancing water and microclimatic conditions was viewed as most significant. The Karen have a saying that trees give water, and they have specific traditions protecting trees in important watersheds. The Lawa also have a specific watershed protection ceremony, whereas Hmong traditions, in contrast, lack restrictions regarding the use of land in watersheds.

Furthermore, the villagers thought that the water in trees and moisture they could maintain in the soil aided in preventing wildland fires from spreading. Not all the trees, however, were regarded as equally valuable in preserving water balance. Eucalyptus and pine, for instance, commonly used in reforestation projects, were blamed for diminishing water resources. The interviewees viewed a pleasant microclimate with fresh and cool air as a general benefit from surrounding trees.

The significance of trees was also related to the products they provided. The most important products included building material for houses, stores, fences and firewood. For firewood, cutting living trees was usually unnecessary because deadwood could be gathered. Wood for construction could be cut from the defined community forests, but only after permission from a village committee. Edible products, such as fruits leaves and herbs, and material for handicrafts and furniture were also obtained from trees in the forest.

In addition to products and services, forests and trees have a spiritual meaning. Animism is still widely practised in the villages and many Buddhists also practise animist rituals. Trees are commonly believed to be the abodes of spirits. Both animistic traditions and Buddhism have their sacred trees. Humans and trees have a close connection in Karen culture; for instance, already at birth the spirit of a newborn baby is united with the spirit of a tree by a ritual. The Karen believe that people and nature are harmoniously united. In addition to religious and spiritual meanings, the interviewees also indicated the significance of aesthetic aspects, such as beautiful scenery and pleasant environment.

Trees were seen as playing a crucial role in environmental conservation. In addition to the importance of trees for water resources, forest services for soil protection, shade and humidity were appreciated. One example given by a respondent was that herbs were unable to survive without the protection of trees. Erosion was apparently a minor problem in the area, but some interviewees mentioned the role of trees in maintaining the productivity of agricultural land. Moreover, the protection that natural forests provided to villages from storms and fires was acknowledged.

19.4 Traditions of Tree and Forest Protection

The villagers tended to emphasize that the tree cover remained around their villages because of their efforts, not in spite of them, as was often suggested in political and public discussions. In certain contexts recently, the conservation orientation of the Karen and Lawa has received increasing focus. The Hmong, however, have been labelled as a people having no traditional ways of protecting the forest. The results suggest, however, that today these stereotypes are no longer applicable. Each community studied made efforts for forest conservation and had the motivation to do so. They also had traditions through which trees were protected and which still play a role in relationships between people and the forest. Taboos, sacred trees, ceremonial sites and burial grounds are examples of the traditions that have kept certain areas in the forest or individual trees protected. The Hmong, for instance, practise a traditional *teev ntoo xeeb* ceremony (or *dong seng* in Thai), in which the spirits of trees are sacrificed animals so that they will protect the forest, the Hmong people, their animals and the entire village from all misfortune. This ceremony requires an area with tall, robust trees, and only villages that have access to such forests can perform it. The Hmong also follow a tradition believing that ‘beautiful, big trees around the village’ should be protected.

The Karen and Lawa tend to have even more traditions in environmental conservation than the Hmong. They apparently perceive these traditions as particularly significant for their lifestyle and ethnic identity. Many rituals, rules and taboos are linked with the slash-and-burn cultivation cycle, starting with a ritual to ask permission from spirits to cultivate the land. Furthermore, rules and taboos were set down for burial grounds that are located in the forest. These areas are under strict rules that forbid trees cutting, cultivating and hunting. In addition, the Karen have various other types of protected forest, including watershed forests of three types, forests for spirit pathways on mountain ridges and wind channels (Trakarnsuphakorn 1997). Certain tree species or individual trees with peculiar features, such as dichotomous branching, are also protected.

Traditions were also forged recently. A Buddhist ceremony to symbolically ordain a tree as a monk was originated only in the 1990s, after an initiative of some environmentalist NGOs and Buddhist monks, and it has been widely adopted to this date (Isager and Ivarsson 2002). For this ceremony, a vigorous tree growing on a site that the villagers want to protect is selected. The ritual can also include planting trees in a temple area (Darlington 1998). The Karen and Lawa villages studied perform this ritual regularly and have thus included it in their traditions.

19.5 Current Measures for Conservation

The traditionally protected areas were integrated into the current forest management system, which divides the village forest area into separate conservation and resource forests, also known as community forests. The variety of traditions has been incorporated in new demands and methods of conservation. Figure 19.2 shows the measures the villagers perceived necessary for forest conservation.

In each village, the importance of fire control in conservation was highlighted. Villagers in each village prepare and maintain firebreaks on hilltops, which is also practised in the Karen traditional system. Individual farmers, moreover, prepare firebreaks around the fields they intend to burn. Although traditional ways of fire control exist, it is currently carried out in a systematic way and it covers larger areas. Fire control is today carried out in cooperation with villages in the same watershed and with the assistance of authorities. In addition to firebreaks, a protective belt of healthy forest around a village is one means to prevent fire from spreading to the village or at least delay its progress to give more time to stop it.

Other important measures for forest protection to which villagers referred to were local cooperation, division of land into separate agricultural and forest lands, rules and control of forest use, and education. The actions taken by communities and individual villagers were regarded as the most important for conservation but government and NGO activities were also recognized as playing a role in protecting the forests. The villagers emphasized cooperation, particularly within a community and also between communities, as the most important forms of collaboration. The main emphasis was placed on collaboration in preventing fire and illegal logging.

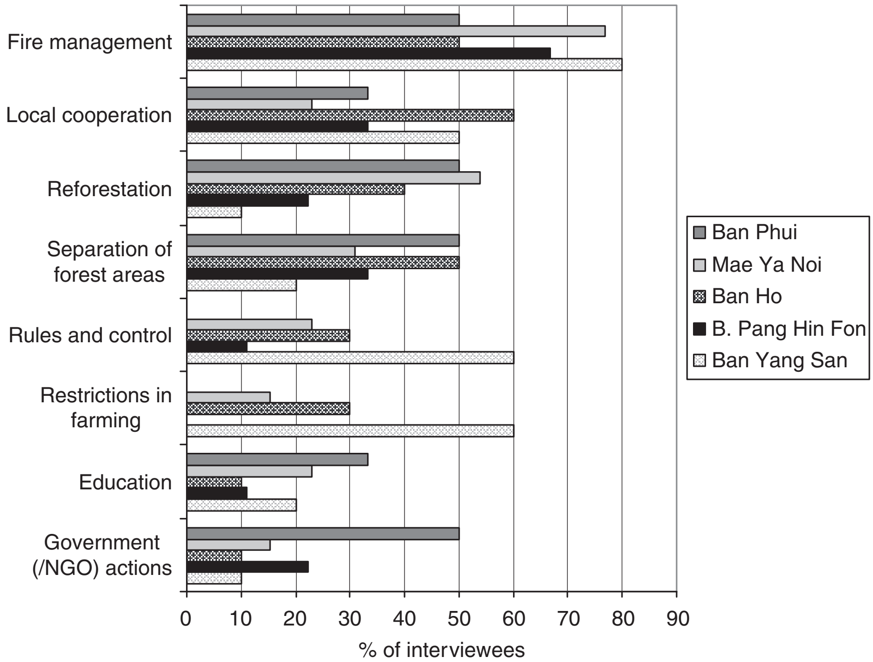

Fig. 19.2 Villagers' perceptions on the means of forest and natural resource conservation by percentage of responses per village in the Mae Chaem and Chomthong districts, Chiang Mai province (Modified from Hares 2006)

Some interviewees acknowledged the necessity of working together with authorities, especially in controlling the activities of outsiders entering the village territory and for financial support. In the Karen and Lawa villages, people generally seemed to be content with existing levels of local cooperation, while in the Hmong villages a need for improved cooperation was sometimes expressed. The villagers regarded themselves as competent to manage and conserve the forest without outside help. Some interviewees viewed the involvement of the government as unwelcome, for example in reforestation, because they preferred natural regeneration as a means to restore and rehabilitate the forest.

Division of village land use in resource and conservation forests and agricultural land was considered an efficient way to prevent logging in conservation areas, since people could obtain the wood they need for household purposes from the community forest. In addition, the division was viewed as a tool to control the expansion of agricultural land. On the other hand, opposing views on the need and ability to restrict farming areas referred to population growth, inheritance of land, and landlessness. However, the relevance of rules for forest protection in general was commonly acknowledged, in particular the rules set by the villagers themselves. Each village had a rule that regulated village life, including the use of natural resources. The Karen tended to stress the significance of rules more often than the Hmong. It was viewed that the rules for the conservation forest regarding the cutting of trees needed to be strict, while for other land uses sustainable use was emphasized. Furthermore, several interviewees mentioned education as a means to promote the sustainability of forest use.

19.6 Reforestation to Maintain Environmental Services

Reforestation was regarded in the villages as one measure for keeping land under forest cover. Reforestation was initiated in Thailand during the early 20th century. Since the 1990s it has focused on protective purposes, particularly in the northern watersheds (Nalampoon 2003). The main species planted in the North have been the native pines Benguet pine (*Pinus kesiya* Royle ex Gordon) and Sumatran pine (*P. merkusii* Junghuhn & de Vriese), and teak (*Tectona grandis* L.f.) (Griffen 2001). In the area studied, trees planted in the Royal Forest Department projects included benguet pine, which was favoured for its fast growth, and some twenty other species. The objective in these projects was to reforest severely degraded hillsides in the important watersheds. Often, reforestation was carried out in former swidden areas and opium poppy fields. The villagers had been involved in planting and maintenance as a labour force in these government reforestation activities, in which usually one member from each household participated. All capable villagers, however, participated in the small-scale tree-planting activities within villages taking place on the King's and Queen's birthdays. In addition, an NGO Care Thailand organized reforestation activities in the area. Furthermore, the Royal Project, started by the initiative of the King, included training of local people to plant trees on their own land.

Motivation of the villagers for reforestation was principally based on ecological benefits. Reforestation was perceived as one method of natural resource conservation and a way of 'helping the environment'. Maintenance of water balance was suggested to be the most important environmental benefit of reforestation. Another incentive for reforestation was that the villagers were commonly allowed to gather non-timber forest products from the reforested areas, whereas the natural forests were usually protected by stricter rules.

Disincentives for local participation in reforestation were also apparent. The sites for tree-planting activities were sometimes outside the village territory, which lowered the motivation of villagers to participate in activities. If the sites were in the vicinity of the village or in the fallow lands, people regarded these areas as potential farming land, and using these lands for reforestation means a decrease in farming area. Thus, reforestation was viewed as competing for land resources with agriculture (see also Lakanavichian 2001). Furthermore, reforestation projects were not perceived as actual sources of income: compensation paid to the villagers for their participation, in addition to covering the expenses, was usually regarded as low and infrequent.

Moreover, ecological concerns arose. Firstly, monocultures were blamed for lacking biodiversity. The villagers had observed poor undergrowth and decreased numbers of wild animals in the plantations. Secondly, another concern was related to water resources. Although trees were generally appreciated for their ability to maintain water balance, the species used in reforestation, eucalyptus and pine, were suspected of decreasing surface waters and even of lowering the groundwater table. Thirdly, concern was expressed over the susceptibility of plantations to forest fires. Pine forests, in particular, burned regularly and fire spread easily within the forest, which was regarded as a hazard for villages and the surrounding environment. Fire in natural pine forests was perceived to be less hazardous because they were predominantly located on mountaintops and covered a rather small area. Moreover, the problem with government reforestation sites was that the villagers lacked control over the area and therefore felt unable to manage fires there.

Discontent focused on two planted tree species: eucalyptus and pine. People had observed decreases in water flow in adjacent streams and rivers and consequently blamed these species for diminishing water resources. One interviewee explained how waxy leaves and needles that decompose slowly prevent water from soaking into the soil and running straight to the river. Eucalyptus was also blamed for insufficient shading and inability to withstand hard winds (for local opposition to eucalyptus see also Rayanakorn 2000). In comparison to natural forest landscapes, straight rows of trees, furthermore, lacked aesthetic values, which were also significant for the local people.

In general, the ecological benefits of reforestation were acknowledged when local species were planted. The RFD had for forest landscape rehabilitation purposes experimented with planting other species instead of pine and eucalyptus, mixing species at the same site instead of a monoculture, and also providing seedlings of multipurpose tree species, such as fruit trees, for villagers. People wished that reforestation activities could also provide benefits for their livelihood, income and in addition, increasing numbers of non-timber forest products. They moreover wanted to participate more in the selection of planted species. Some people, however, regarded reforestation as unnecessary because of the capability of the forest to regenerate naturally. In places, natural regeneration was indeed promoted by protecting the area from disturbances.

19.7 Trees Planted by Communities

The reforestation projects were chiefly government initiatives but communities and individual farmers also planted trees on their own initiative. The RFD and NGOs often provided seedlings for these purposes. A common principle was, to quote one interviewee: ‘If a villager cuts ten trees from the community forest, he or she has to replant ten trees’. While the government’s main objective in reforestation was to increase tree cover in watersheds, the villagers’ objectives also included multiple uses of trees and aesthetic aspects, in addition to the variety of ecological services (cf. Griffen 2001). From the local people's point of view, environmental protection was a significant benefit from planting trees, but economic profits could also be gained from planting fruit trees on farms.

Planting trees was not a common practice in the traditional slash-and-burn cultivation systems that had been practised in the villages; fallows were typically left to regenerate naturally. The Karen and Lawa, however, reported that sometimes bamboos were planted to accelerate natural regeneration and for their multiple uses. Moreover, in some traditional swidden systems large trees were left standing in the fields when the sites were prepared for cultivation.

Fruit trees and other trees providing commodities have traditionally been planted in home gardens and within the village. Planting trees in permanent fields, however, was fairly infrequent, although in each village some farmers planted fruit trees. The main reasons for the somewhat infrequent adoption of agroforestry systems included small farm sizes, insecure land rights, and better short-term profits from other cash crops (cf. Ekasingh and Ekasingh 2001). Furthermore, in a protected area the cutting of trees would be technically illegal. On the other hand, fruit production for commerce requires road connections to markets. Another reason for the low adoption rates may be the lack of information on the advantages of agroforestry among former swiddeners (Douglas 2006). Nevertheless, agroforestry practices and tree planting were often adopted spontaneously by those farmers who had the necessary resources. Hmong farmers, in particular, were active in experimenting with new crops and farming systems. Fruit trees were most often the focus of farmers' interest. In addition, both government and NGO projects had been initiated to encourage tree growing in villages and farms.

Agroforestry practices found in the area, in addition to the type in traditional swiddens, typically included home gardens, trees or bamboos on farms as shelterbelts, living fences and farm boundary markers, and systems combining fruit trees with other crops, such as cabbage, maize (*Zea mays* L.) or taro (*Colocasia esculenta* (L.) Schott). The fruit trees in permanent fields were often introduced temperate or subtropical species, such as litchi (*Litchi chinensis* Sonn.), peach (*Prunus persica* (L.) Batsch) and mandarin (*Citrus reticulata* Blanco), which were becoming increasingly popular. In addition, tropical species, such as mango (*Mangifera indica* L.) and longong (*Lansium domesticum* Corr.), were grown on fields.

Fruit trees are also common in home gardens but mostly local species have been favoured and have typically been mixed with field crops and vegetables. Species found from home gardens included mango, jackfruit (*Artocarpus heterophyllus* Lam.), tamarind (*Tamarindus indica* L.) and pomelo (*Citrus maxima* Merr.). Home gardens have traditionally been common among the Karen and Lawa (FAO 1996). The Hmong have traditionally had a communal herb garden in the village, where the frequently used herbs are grown with other valuable plants. Among all forest dwellers, one traditional agroforestry system formerly practised was letting domestic animals find their food from the surrounding forests, particularly fallows, but today the practice is forbidden in areas protected by government law.

19.8 Discussion and Conclusions

Agroforestry is a way to intensify agriculture and make cultivation in permanent fields more sustainable and diverse. It could offer a viable alternative to slash-and-burn cultivation and also encourage organic farming methods. Furthermore, agroforestry could provide an incentive for landscape restoration and reforestation (Lamb et al. 2005). Legal restrictions in protected areas, however, pose an obstacle to agroforestry implementation on upland farms. For administration, the difficulty with agroforestry is that it falls between agriculture and forestry and would require good coordination between the two sectors. A further challenge is to adapt agroforestry practices to prevailing circumstances and cultural contexts of various ethnic groups.

Constraints for adopting agroforestry also exist from the farmers' point of view as already discussed. The higher initial labour and capital requirements of agroforestry systems compared with monocropping (especially at the beginning), inadequate technical support and marketing problems can also contribute to the adoption rates in Thailand (Vergara 2001). The central problems to overcome, however, are related to farm size and land tenure. Ekasingh and Ekasingh (2001) reported that in their four study areas in northern Thailand, farms oriented towards long-term investment were more than three times larger (average size 4.7 ha) than subsistence farms (average size 1.3 ha). The authors concluded that despite small farm sizes, planting trees on farms has a potential to intensify land use while reducing environmental risks and meeting farmers' short-term and long-term needs.

Fruit cropping is an attractive option for farmers because it provides products for markets and household use. In addition to economic benefits, fruit trees provide ecological services, and fruit-based systems are highly adaptable (Withrow-Robinson et al. 1999; Withrow-Robinson and Hibbs 2005). Furthermore, no cutting of fruit trees is necessary for benefits, which is why it is also encouraged by the authorities. In general, farmers may be reluctant to plant trees on their farming land – which has already been restricted and is under multiple pressures from the outside – simply because some other option may be more profitable, at least in the short term.

Further research is needed on suitable trees and crops for the northern uplands in Thailand and on developing socially, economically and ecologically sound agroforestry systems. This research could utilize local knowledge and traditional systems, such as miang orchards, which are regarded as sustainable systems practised in the northern uplands (Santasombat 2003). In addition, political reformation regarding the rights to land and trees seems necessary. Although a system of granting lifetime usufruct rights to agroforestry farmers on public forest lands already exists (Vergara 2001), it is lacking in protected watersheds. Furthermore, the right to use the land is one issue and the rights for trees another, although these two may overlap (Neef and Schwarzmeier 2001). This is important to remember during the discussion of tenure security and tree planting in protected areas. Planting trees on farming land has, on the other hand, been the farmers' response to insecure land rights, because they believed that it would prevent the authorities from taking these lands for reforestation or national parks. The farmers' purpose for adopting agroforestry systems has in some cases been to show that measures to control soil conservation have been taken, even if they considered erosion only a minor issue (Neef and Schwarzmeier 2001). Another attempt to establish the rights to land has been the taking of fallows for permanent cultivation.

The shift from slash-and-burn cultivation methods to permanent farming and an increasing focus on cash-crop growing have affected natural environments, socio-economic and cultural features of local people, as well as land-use and forest management systems. These changes and the problems they have caused were reflected in several responses during the fieldwork. Pressures on land resources and decrease in utilizable agricultural area increased the need for intensifying land use with development of new farming methods and adoption of new crops, especially methods that could decrease the use of fertilizers and biocides. In addition, the government hopes that intensified land use will decrease the pressure on forests. New appropriate alternatives are thus being sought, but preservation of traditional agroecosystems, such as swidden farming and home gardens, would also be beneficial because local plant cultivars can thereby be protected, cultural diversity maintained, and local food security and self-determination supported (Santasombat 2003).

Reforestation, as well as the entire forest management system, requires improved participation of local people and the creation of adequate incentives. Finding a response to the challenge of how to protect and rehabilitate the forest and restore the landscape while ensuring people’s livelihood at the same time presumes local participation. A viable solution is to replace monocultural plantations with forest restoration by indigenous species (Elliott et al. 2003). Species selection should take local valuations apart from ecological aspects into consideration. The type of tree cover (structure and species composition) and the variety of benefits it provides matter to local people, although the government may consider any increase in tree cover to be sufficient. To gain improved local benefits, biodiversity values in existing monocultural plantations can be enhanced (Sayer et al. 2004). Furthermore, recognition of local land uses and customary land rights is necessary. Taking large areas of agricultural land for reforestation, for instance, may pose a serious threat to local livelihood.

Conservation of forests and trees can be regarded as a basis for conservation ethics. Santasombat (2003) listed factors that locally generate conservation ethics, which are largely applicable to the present study. Traditions were central to conservation practices, and forests and trees were often an integral part of culture. Management systems evolved under changing circumstances, but traditions were sustained and new ones created. Ecological balance was a goal in management systems, and natural hazards, especially drought, underlie the need for environmental protection. Collective solidarity within communities, although stronger in the past, and shared interests were sources of motivation for conservation. Strong local institutions, active participation of community members, and flexible common property regimes are, in general, factors that can help achieve sustainable management practices.

In conclusion, the forest dwellers regarded tree growing and forest conservation as crucial towards preserving the supply of forest products, both non-timber and wood products, and services. The forest was viewed as essential for both humans and animals to reside in the uplands. The role of forests and trees in maintaining agricultural production and ensuring the availability of firewood and construction material was highlighted as being essential for living in uplands. These aspects formed the foundation for local forest management objectives and priorities.

It can be asked whether the current system of forest conservation is sufficient to meet people's needs for forest products and services in the long run. Building up a management system on traditional practices has proved advantageous, and the villagers expressed their contentment with the current system. For example, efficient fire management in which villagers actively participated basically achieved positive results in the increased number of forest products and a larger area of forest intact after fire. The present results implied that community forestry is a viable option for forest conservation and rehabilitation, if its political and legal bases will be improved. Enhancement of the prevailing situation is necessary as co-management processes were insufficient, distrust between authorities and local people existed, and negative drivers such as fear of losing land, prevailed in management. In addition, increasing rivalry over land and forest resources posed a threat to the sustainability of management systems and to adequate local access to the future forest-provided benefits.

Community forestry law is one step towards ensuring local people's rights to the natural resources they are managing. The decentralization process has since the 1990s transferred power in natural resource management to the subdistrict level, but still local people's participation in all forest management activities, particularly at the community level, needs to be improved. This could also provide a further incentive to conservation and sustainable management for local people. Moreover, it is important to take into account the various interests, social and economic stratification, gender issues, and heterogeneity of ethnic groups in planning activities. Improved negotiation processes and increased dialogue between the authorities and locals would increase the sustainability of management systems.

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Part V
Smallholder Tree Growing: Potentials and Challenges

Chapter 20
Farmer Tree Planting Barriers to Sustainable Forest Management

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Abstract Agroforestry provides productive and protective forest functions valued by societies as sustainable forest management. Yet, trees planted in agroforestry systems are excluded in formal definitions and statistics and overlooked in legal and institutional frameworks for sustainable forest management. Likewise, smallholder farmers frequently face barriers when planting or re-planting trees on farms. We examine six issues that hinder a regreening revolution based on farmer tree planting, as discussed in various other book chapters. *First*, issues of terminology for forests, plantations, and reforestation are linked to land tenure and land-use restrictions. *Second*, access to high-quality planting material remains a challenge, especially at the farmer level. *Third*, management skill and information often constrain production for lucrative markets. *Fourth*, overregulation often restricts market access for farmer grown tree products, partly due to rules intended to curb illegal logging from natural forests or government plantations. *Fifth*, there is a lack of reward mechanisms for environmental services provided by agroforestry. *Sixth*, there is a lack of supportive legal and institutional frameworks for smallholder tree growing and agroforestry in general. Current relationships between agroforestry and plantation forestry are perceived as complementary, neutral or competitive, depending on the ability of (inter)national policy frameworks to provide a level playing field for the provision to society at large of productive and protective forest functions. In conditions where plantations operate with substantial government subsidies, in contrast to non-existent or minimal subsidies for agroforestry, farmers' potential to produce wood and provide other forest benefits and ecological services is placed at a disadvantage, to the detriment of society at large.

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Keywords Agroforestry, environmental services, forest policy, forest terminology, tree germplasm, tree product marketing

20.1 Introduction

Over the past 50 years the earth's population doubled to reach its current level of six billion. Today the world's population is increasing by 80 million annually, with the total projected to reach 10 billion within 40 more years. If the Millennium Development Goals are to be realized, a considerable *per capita* increase in the provision of productive and environmental service functions is needed on the same total land base. Global population growth and increasing wealth (Millennium Development Goals) exert pressure to convert forests to agricultural, industrial, or residential uses. It also results in an increase in the demand for wood fiber and other forest products (for more details, see Roshetko et al. Chapter 21, this volume), exerting pressure to increase tree production per unit 'forest' land. Forests are also expected to meet an expanding array of social objectives, like clean water, recreation, and biodiversity. Forestry as a sector is striving to meet these needs with a decreasing land base for forestry in its current form. A major opportunity to meet the challenges exist, if only we are able to break the traditional sectoral divide between 'agriculture' and 'forestry', and recognize 'agroforestry' as farmer-led efforts to meet livelihood needs on a limited land base without categorical distinctions between 'perennial' and 'annual' components of their enterprise.

Ultimately the sustainability challenge is to find ways to sustain the provision of goods and services that society derives from forests in ways that … "*meet the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland Commission 1987). Sustainability in this sense does not imply 'keeping everything as it has always been'. In fact sustainability requires a constant search for new ways to meet the overall goals, while addressing current challenges. There have been several large efforts throughout the world to identify criteria and indicators by which to gauge the progress of sustainable forest management. The Montreal Process on Criteria and Indicators for Sustainable Forest Management (SFM) identified seven criteria, of which the first six are essentially a statement of the goods and services that society derives from its forests: (1) Biological diversity, (2) Wood and non-timber products, (3) Healthy ecosystems, (4) Soil and water resources, (5) Maintaining carbon cycles, (6) Multiple socioeconomic benefits, and (7) Legal and institutional framework.

Agroforestry practices and agroforests are an important category of planted forests that have the potential to provide a wide array of forest-related benefits to society, generally meeting criteria 1–5 of this list (see the next chapter for details). There may be quantitative differences in the degree these criteria are met in 'agroforestry' compared to 'plantations', depending on tree density, species diversity of planted trees and spatial arrangement in the landscape.

Unfortunately, there are too many examples of poor performance of forest plantations associated with a parallel absence of institutional support for farmers interested in planting trees (Rahman et al. Chapter 11, this volume). There is inadequate understanding of the tree planting risks faced by smallholders, even when 'supported' by large forestry programs (e.g., Barney, Chapter 13, this volume). Violent conflict frequently occurs between the forest plantation sector and communities (see Box 20.1). These examples have been an uneconomical and hard way to learn a simple lesson: unless farmers share substantially in the long-term benefits of forest plantation efforts, the interaction between the 'agro' and the 'forestry' component remains a competitive one (Van Noordwijk and Tomich 1995). Because of land scarcity, large-scale plantations and smallholder development programmes tend to be mutually exclusive, at least in most developing countries of Asia and parts of Africa. What is needed is recognition of the crucial role of smallholder farmers in forest production with foresters starting to support and participate in farmers' tree planting efforts, rather than expecting farmers to support and participate in foresters' efforts (Bertomeu, Chapter 8, this volume; Garrity and Mercado 1994).

Box 20.1 Key threat to sustainability of large-scale plantation forestry in Indonesia

The allocation of land for plantation development in Indonesia (both timber and oil palm plantations) has often been undertaken without recognizing the rights of local people who already occupy and cultivate the land. Fires initiated by the plantation companies have often been used to force local communities from their land. The feeling of perceived injustice by smallholders decreases their incentive to control the spread of fire to large-scale tree plantations. As a consequence of land tenure conflicts, local communities frequently burn plantation grown trees that have been established by large companies. Since the start of the political reformation period in Indonesia in mid-1998, the open manifestation of the land tenure conflicts (that date back to the 'New Order' period) between local communities and large companies has increased. There are increasing visual signs of violence and burning of property, as companies can no longer rely on armed security to quell the unrest. In many cases, tenure conflicts often become a trigger for forest and land fires. The nature of partnerships between communities and companies in the development of oil palm and timber plantations is also a very important factor in reducing the incidence of fire as communities with partnerships have a vested interest in protecting their assets. Many people believe that a good partnership between farmers and companies in developing oil palm or timber plantations will reduce land tenure conflict. The result of the study by Suyanto et al. (2001) as part of the CIFOR/ICRAF project on underlying causes of forest fire supported this view and quoted examples where actual progress is being made.

Socioeconomic benefits (criterion 6) of the Montreal process may differentiate agroforestry from plantations. Perspectives on socio-economic benefits depend on the general context of 'development' and the constraints to 'livelihoods' that entails. In societies where a major part of the population still makes their living of the land, the first concern may be income – and it is here that agroforestry efforts differ from conventional 'tree plantation' efforts (Dixon 1995; Leakey and Sanchez 1997). Agroforestry can, in fact, help overcome one of the major challenges to plantation forestry in the tropics: conflicts of interest between local communities and large estates supported by governments. These conflicts can reach a stage of violent manifestation (Box 20.1). Foresters have experimented for more than a century with ways to get local farmers to participate in their efforts to plant and manage trees, in various forms of 'taungya', 'agroforestry' or 'social forestry'.

The legal and institutional framework regarding sustainable management (number 7 above) appears to be the main obstacle for including agroforestry in debates on sustainable forest management. By definition (*literally*) agroforestry is generally excluded.

Logging old-growth forest remains, from a private perspective, the cheapest way to get high quality timber. Until the forest extraction frontier is effectively closed (either by effective protection of remaining forests, strict enforcement of rules on certified timber origin down the market chain, or through sheer exhaustion and depletion), planting trees needs specific subsidies and protection to compete successfully with other land uses. Once the supply from natural forests dries up however, and the prices go up, the time lag between planting and harvesting of (even fast-growing) trees creates a gap in the supply (Fig. 20.1). Regulations aimed at curbing illegal logging (closing the forest extraction frontier) tend to obstruct the trade and transport of farm grown timber as well, and the transaction costs involved become a deterrent for what should be the logical outcome of a timber shortage: positive incentives for smallholder production systems to respond to market demand by planting trees.

Seen at the timescale of the evolution of a landscape (in the order of decades, usually), we can recognize four important questions: (1) can deforestation be avoided or halted, (2) can the process of forest degradation be deflected to a tree-based land use pattern that avoids the more serious stages of environmental degradation, (3) can degraded lands (from a forest function perspective) be rehabilitated/reforested, and (4) to what level of tree cover and forest functions can land recover in a new 'steady state', while meeting the expectations of the land managers as well as society at large.

Whereas the next and final chapter primarily gives a positive reflection on answers to these questions, in this chapter we will first look into various aspects that hinder a so-called *regreening revolution* based on farmer tree planting to support sustainable forest management:

"*There are a number of bottlenecks that need to be widened before the full potential of this new green revolution can be realized*".

These bottlenecks relate to all seven criteria of the Montreal process. We will discuss these under the six headings listed below based on the findings of the various case studies presented in this book and supported by reports from other literature sources:

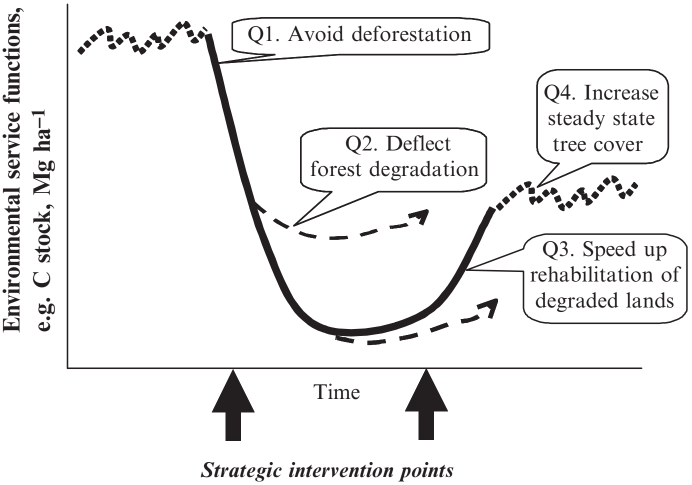

Fig. 20.1 The overall pattern of loss of natural forest followed by the increase of farmer-grown or forester-managed tree plantations, variously described as a 'U curve', 'inverse J' or inverted Kuznets curve ('it has to become bad before it can become better')

1. ***Terminology*** issues linked to the legal status of land, restricting ***access to land*** or the right to plant and benefit from trees (SFM Criterion 7)
2. Access to ***planting material of good quality*** and proven suitability for the site (SFM Criterion 2)
3. Management skill and know-how to produce ***tree products*** of the qualities recognized and appreciated in ***markets*** for tree products (SFM Criterion 2 and 6)
4. ***Overregulation*** of access to markets for farmer grown timber (SFM Criterion 7)
5. ***Lack of systematic validation and reward mechanisms*** for environmental services provided on farm (SFM Criterion 1, 3, 4 and 5)
6. ***Lack of a supportive legal and institutional framework*** (SFM Criterion 7)

20.2 Bottleneck 1: Terminology of Forestry and Agroforestry

The word 'tree plantations' to the general public combines the generally positive word 'tree' in association with the word 'plantations'. The use of the word 'plantation' often has an emotional loading depending on the audience.

When we accept a (growing) need for agricultural and tree-based production systems ('food and fibre') as well as for the environmental service functions generally associated with 'forest', we can still acknowledge a wide spectrum of landscape level configurations that potentially meet these demands (Fig. 20.2). These

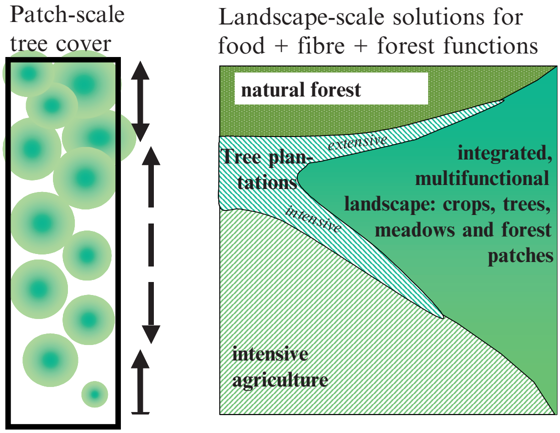

Fig. 20.2 Segregate or integrate trees, crops and natural vegetation at patch or landscape scale, to meet overall needs for food, feed and fibre production, plus environmental service functions (Van Noordwijk et al. 2001a)

configurations can be ranked on a 'segregate' versus 'integrate' axis, with multifunctionality of patch-level land cover increasing towards the 'integrate' side. The term ***agroforestry*** has generally been associated with concepts of multifunctionality (at tree, field, farm and/or landscape level), and as such it has transition zones towards food-crop based agriculture, intensive tree crop production systems, extensively managed tree plantations and natural forest.

Discussions on 'forest functions' tend to be qualitative (categorical) rather than based on measurable quantities. The concepts of 'forest' underlying the Kyoto protocols terminology of deforestation, afforestation and reforestation have been a major cause of confusion and debate. If the objective is increased storage of carbon in vegetation and soils, a terminology that is more directly linked to actual C stocks (and thus in need of more than the two classes 'forest' and 'non-forest') would have directly qualified 'agroforestry' for carbon credits without much discussion. Parallel to the Kyoto protocol discussion on 'what is a forest?', the definition used by FAO in its global forest resource assessment (Box 20.2) is equally arbitrary in its exclusion of trees planted in the context of agroforestry. Agroforestry research has since long tried to predict where 'pure crop + pure tree' systems are to be preferred over mixed ones. Situations where the mixed systems outperform the monocultures can generally be identified on the basis of complementarity in the use of labour and other farm-level resources, in the use of space (light capture) and belowground resources by differences in root distribution or phenology. Apart from these farm productivity considerations, however, existing ***land use classifications*** do not

Box 20.2 Current forest plantation definitions are an artificial mix of 'observables', presumed intentions of the managers, and legal status of land

In the definition of 'forest' from the Global Forest Resource Assessment 2000 (FAO 2001) (***our emphasis***), "forest includes natural forests and forest plantations. It is used to refer to land with a ***tree canopy cover*** of more than 10 percent and area of more than 0.5 ha. Forests are determined both by the ***presence*** of trees and the ***absence*** of other predominant land uses. The trees should be able to reach a minimum height of 5 m. Young stands that have not yet but are expected to reach a crown density of 10 percent and tree height of 5 m are ***included*** under forest, as are ***temporarily unstocked*** areas. The term includes forests used for ***purposes*** of production, protection, multiple-use or conservation (i.e. forest in national parks, nature reserves and other protected areas), as well as ***forest stands on agricultural lands*** (e.g. windbreaks and shelterbelts of trees with a width of more than 20 m), and rubberwood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantations. It also excludes trees planted in agroforestry systems."

Comments

The current set is a mix of:

Legal criteria – everything that the State claims to be forest land, regardless of tree cover ('temporarily unstocked')

Intentions of the planter – planting rubber trees for timber makes it into a 'forest', if the planter also or mainly expects to be able to tap latex, these same stands are not included

Management plans – temporarily unstocked areas can still be called forest as long as a forester has plans to replant…

Definitions of a tree – based on plant height, which does not exclude bamboo, and with a little stretch, could include perennials such as cassava or sugarcane…

The definition 'also ***excludes trees planted in agroforestry systems***' for reasons unspecified.

allow for forms intermediate between 'forest' and 'agriculture'. As there is no general consensus on operational definitions for 'forest', 'plantations' (or even 'tree'….), we propose to start by distinguishing 'natural forest' as having no (or only a few) planted trees, plantations as being dominated by planted trees and often consisting of only one or a few planted species, and agriculture as land without trees (Fig. 20.3, Box 20.3). In between these classes there are many combinations of tree cover, fraction of trees that has been planted and species richness of the planted tree combination, that all can fall under our concept of 'agroforestry'.

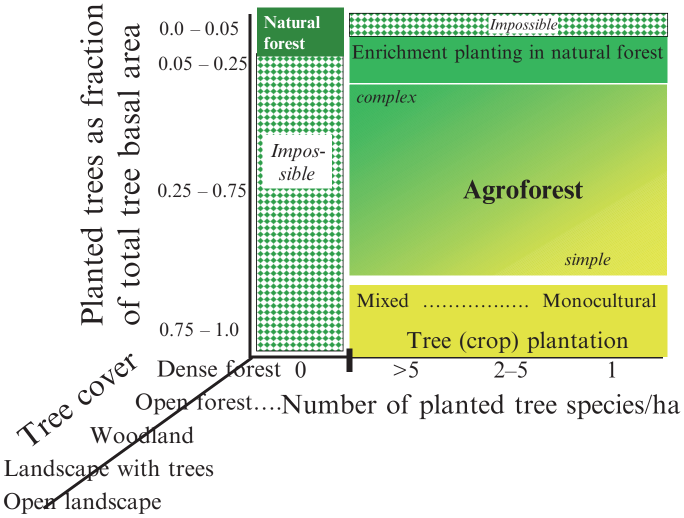

Fig. 20.3 In the continuum of landscapes with varying degree of human tree management, we can distinguish three main dimensions: the total tree cover (as observable in remote sensing), the ratio of natural regenerated and planted trees, and the number of tree species planted. In between three generally recognized landscape types ('natural forest', 'monocultural tree plantation' and 'agriculture'), a wide range of other combinations exists, for which the generic name 'agroforestry' is used; closed canopy forms of vegetation with a mix of planted and spontaneously established tress can be indicated as 'agroforest'

Box 20.3 A consistent and operational terminology for landscapes can be based on total tree cover, number of planted tree species and fraction of tree basal area that is planted (as opposed to naturally established), as follows:

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(1) Fraction of tree cover (maximum during the year)

>0.9	Closed forest
0.75–0.9	Open forest
0.5–0.75	Woodland
0.25–0.50	Savannah
0.05–0.25	Landscape with trees

(2) Number of planted tree species

0	Natural forest
1	Monoculture
2–5	Mixed
>5	Polyculture

(3) Planted trees as fraction of total tree basal area

0–0.05	Natural forest
0.05–0.25	Enrichment planting
0.25–0.75	Agroforest
0.75–1	Plantation forest (or woodlot)

20.2.1 Consequences for Legal Status and Land Tenure for Smallholders

The term ‘forest’ has meanings far beyond the presence or absence of trees, and often refers to the legal status of land, an implicit or automatic claim of ownership or full control by the state, or a domain where specific land use rights exist. This applies to the tropics as well as to the temperate zone, and is related to various schemes to regulate agricultural production.

Because agroforestry is intermediate between agriculture and forestry, it often faces challenges with this sector-based (and sector-biased) regulatory framework. This is not restricted to Asia. In Europe until recently experiments with new forms of agroforestry were prohibited because they created land use forms not covered by existing regulations (Lawson et al. 2004; Dupraz et al. 2004). In the USA discussion between ‘forest service’ and ‘natural resource conservation service’ over the boundaries of their domain focus on 10 percent versus 25 percent tree cover (http://www.pwrc.usgs.gov/brd/DefComments.htm).

In the Philippines, the legal status of “forest” lands has its roots in the so-called Regalian Doctrine of the colonial era which vested ownership and control of all natural resources including timber or forest lands to the state (Sajise 1998; Pulhin 2002). Timber or forest lands are defined as those with 18 percent slope and above irrespective of whether these lands have forest cover (Presidential Decree 705 1974). In reality, only about 6 million hectares of the total “forest lands” are forested (FMB 2005). The other 10 million hectares are under some form of cultivation or covered with grasslands. It is estimated that up to 20 million people, mostly farmers, are informal settlers in these public lands. Institutionally, forest lands are under the control and management of the Department of Environment and Natural Resources (DENR) whose main focus is forest management, production and protection. In the past, the DENR tended to view all farming activities as destructive of forest resources. The relationship between the DENR staff and farmers was frequently adversarial. More recently, there is increasing recognition that farming systems such as agroforestry can protect “forest” lands from degradation and help restore environmental services such as water and climate regulation (Lasco and Pulhin 2006). The DENR’s evolving acceptance of these advantages is demonstrated by greater participation by local farmers and other stakeholders in community-based forest management (CBFM) projects. The most recent data available from the DENR indicates that 690,691 households are involved in the implementation of the CBFM program covering almost 6 million hectares (FMB 2004).

In spite of this development, much confusion exists because of overlap of land use classification maps by the DENR and those used by the Department of Agriculture (DA) and Department of Agrarian Reform (DAR). The latter departments claim that so-called Forest Land or Protected Forest Areas under the DENR classification are in fact (partly) Alienable and Disposable Lands which can be used for agriculture and private ownership.

Likewise, the Indonesian constitution places the control (not ownership) of natural resources in the hands of the State and states that these must be managed for the benefit of the Indonesian people. Authority for the establishment of a permanent forest estate is given to the Ministry of Forestry and 70 percent of the archipelago's land base (114 million hectares) is regulated by forestry and restricted for forest protection, rehabilitation or production. Delineation is to be carried out with the participation of local government and local people and the final stage of gazettement is a legal step taken by the Minister of Forestry. There is extreme political sensitivity when linking the term 'ownership' with forest lands (Kusters et al. 2007). The result is a regulatory framework that inhibits community agroforestry in large areas. In fact, however, only 10 percent of the State Forest has completed the process of gazettement, and the legal basis of the designation as state forestland of the remaining area can be (and is) contested (Contreras-Hermosilla and Fay 2005). Considerable parts of Indonesia's closed canopy forest are actually agroforests planted by local people. Such agroforest provide approximately 70 percent of the total amount of rubber produced in the country (on about 2.5M ha of land), at least 80 percent of the damar resin, roughly 80 to 90 percent of the various marketed fruits as well as important quantities of export tree crops such as cinnamon, clove, nutmeg, coffee and candlenut (Michon and de Foresta 1995). In Sumatra alone, about 4 million hectares have been converted by local people into various kinds of agroforests (Michon and Bompard 1987). According to the forestry regulatory framework, these land use systems are illegal within the State Forest since they are considered agricultural activities. Cases of forced evictions and the destruction of these agroforestry systems by forestry officials (with assistance from the military) are well documented (Fay et al. 2000). Forestry officials often justify their actions as being in defense of "forest functions" (Kusworo 2000), without specifying what these functions are or proving that these functions are deficient in the actual land use. Proof of forest functions is based on the existence of a landuse type defined as forests. ***Exclusion by definition*** is thus the main threat to the contributions agroforestry can make to sustainable forest management, directly related to criterion 7 of the Montreal process. Improvements in this situation will require a 'negotiation support system' that is based on critical examination of claims on real environmental service function, along with recognition of the various stakeholder interests (Van Noordwijk et al. 2001b).

20.3 Bottleneck 2: Access to Good Planting Material

Scientists and extension services general make decisions regarding which species are tested and promoted (Franzel et al. 2002). In this context, Tolentino (Chapter 15, this volume) refers to "the popularity of exotic tree species" like *Gmelina arborea* that dominate plantation forestry and tree farming in the Philippines which is in strong contrast to the low-level domestication of indigenous tree species (ITS) for timber production by smallholder tree farmers. In Southeast Asia the production and dissemination of quality tree seed is most often controlled by the formal tree seed sector (research organizations, government agencies, and forest industry); farmers and the non-government organizations (NGOs) that support them have little linkage or influence over the formal tree seed sector (Harwood et al. 1999). As a result most smallholder tree production systems focus on fast-growing exotics – often timber species like *G. arborea* – for which there are reliable sources of germplasm and well-established propagation and management techniques (see Box 20.4). In the Philippines and also elsewhere, farmer preferences for species largely depend on household needs and markets (Lawrence 1999; Yuliyanti and Roshetko 2002; Schuren and Snelder, Chapters 3, this volume; Manurung et al. Chapter 4, this volume). However, farmers are not always able to plant or test those, often indigenous, tree species in which they are interested due to a lack of knowledge or germplasm (Tolentino 2000; Tolentino et al. 2001). Promising ITS planting initiatives undertaken by smallholder farmers in the Philippines show good perspectives for a wide range of indigenous timber tree species as reported by Tolentino (Chapter 15, this volume; Box 20.4).

This constraint to agroforestry system development can be overcome. Farmer-designed trials (Roshetko et al. 2005; Tolentino, chapter 15, this volume) and participatory evaluation are a low-cost method to increase farmer participation in species evaluation and agroforestry technology development process for their specific biophysical and socioeconomic conditions, as well as to enhance the effectiveness of research activities to meet farmers' needs and improve their welfare (Franzel et al. 2002).

Box 20.4 The case study in the Philippines

In the Philippines *Gmelina arborea* was the basis of farmer-led, market-oriented agroforestation and land rehabilitation efforts (Garrity and Mercado 1994; Pasicolan and Tracey 1996; Tolentino, Chapter 15, this volume). Philippine farmers grow *G. arborea* in monocultures or mixed with other timber, fruit and MPTS species. Block plantations are preferred, although border and contour plantings are also established. Most farmers establish 0.25–0.75 ha of plantations at tree spacing of 3 × 3 to 4 × 4 m (Pasicolan and Tracey 1996; Magcale-Macandog et al. 1999). In general these tree-farming systems are more profitable than annual crop production (Predo 2002; Rahman et al., Chapter 11, this volume; Predo and Francisco, Chapter 14, this volume). The development of a viable and widespread smallholder timber production system in Claveria, Mindanao, Philippines has resulted in depressed prices for *G. arborea* timber, the main species produced by smallholders. Traders respond that the size and quality of smallholder timber is often sub-optimum, so they must reduce prices to compensate for the additional risk assumed. Reliability and quantity of supply are also important issues. In Leyte, Philippines a successful smallholder timber production project has led to disappointment due to a lack of markets. A nearby wood processor prefers to procure timber from

(continued)

Box 20.4 (continued)

commercial sources on another island because of the high transaction costs and unreliable timber supply encountered when dealing with many individual smallholders (Mangaoang, personal communication 2004). The selection or existence of the right marketing channel is an important issue for smallholders. After initial reliance on fast growing exotics, smallholder farmers in many areas of the Philippines are now interested in cultivating high-value indigenous species (including, timbers, fruit, etc.) to meet market demand. Constraints that inhibit this process are a lack of germplasm, knowledge regarding propagation and management, slow growth rates and policy disincentives/ambiguities (LSU 2002; Carandang et al. 2006).

20.4 Bottleneck 3: Producing Quality Products Tailored to Markets

The marketing of planted forest and tree products provides a potential alternative for poor upland farmers seeking their way out of the poverty trap through new livelihood opportunities. In this context, Snelder (Chapter 3, this volume) and Manurung et al. (Chapter 4, this volume) discuss the need for transforming traditional subsistence tree farming systems, in the Philippines and Indonesia respectively, into sustainable, semi-commercial enterprises that yield products to meet both home and market demand. Whereas such transformations are theoretically feasible (and in fact on-going spontaneously, yet at a slow rate, driven by economic incentives; Schuren and Snelder, Chapter 3, this volume), farmers face various limitations in practice such as the absence of clear marketing channels for tree products accessible to all and the supply of high quality products that meet market specifications (Chapter 4, this volume).

Likewise, smallholder rubber production has been discussed as an economically rewarding alternative for shifting cultivators in Northern Laos (Chapter 5, this volume). Yet, the adoption of such an alternative is not risk free: for example in the latter study reference is made to threats associated with the rubber production and emerging constraints of labour and land (e.g., putting remaining forests at risk) as well as, the high dependence on the China market (and need for continued access in the future!).

In the case of timber production systems, smallholders too face various market constraints. They usually start by planting short-rotation species to meet household and local market needs. As more farmers begin producing timber, supply meets or exceeds demand and prices decline. At this point farmers can: (i) stop producing timber, (ii) continue producing timber, hoping the price decline is temporary (e.g., Bertomeu, Chapter 8, this volume), and/or (iii) diversify into long-rotation, premium-quality timbers. The dynamics of tree product supply, market demand, and marketing channels at the smallholder level are still insufficiently understood by farmers and researchers alike.

The complexity of producing quality products tailored to markets is also illustrated by in the case of Gunung Kidul, Central Java. This area was heavily deforested in the 1930s and at the bottom of the ‘inverse J’ (Fig. 20.1) till the 1960s. Then a market-oriented land rehabilitation process started where the state forestry company (Perum Perhutani) established Teak (*Tectona grandis*) and mahogany (*Swietenia macrophylla*), and smallholders focused on *Paraserianthes falcataria*. A farm inventory showed that 74 percent of the trees on smallholder farms are teak and mahogany; 22 percent are short-rotation timber species; the remainders are fruit, spice and Multi-Purpose Tree Species (MPTS) species. In 1998, in North Lampung 80 percent of homegarden trees were fruit, vegetable, medicinal and MPTS species; 14 percent were planted short-rotation timber; four percent natural regeneration and two percent planted premium quality timber species (Roshetko et al. 2002). In these areas, farmer interest in timber farming is increasing in response to access to better quality germplasm (species, provenances, clones and seed source) and increasing market demand. These farmers can maximize profitability by processing fast-growing timber species (*Paraserianthes falcataria*) trees into boards or planks, but premium quality species (*Tectona grandis*) are better sold to producers as standing trees (Roshetko and Yuliyanti 2003; Tukan et al. 2004). Unfortunately, some farmers process high-value trees into low-quality planks in an unsuccessful attempt to gain higher profits. Other smallholders sell fast-growing timber as standing trees, similar to what small-scale timber producers in Sweden, Finland or Australia do. Most often smallholder farmers serve only as the producers of raw materials. Market agents perform the important roles of linking farmers to processors and manufacturers who transform the raw materials (commodities) into finished goods (products or services). Local and regional dealers serve very important roles – collecting, sorting, grading and transporting raw materials. One of the largest risks reported by middlemen is unreliable quality and quantity of smallholder products. This uncertainty, plus the time and expense required to interact with numerous smallholder, are usually cited as the reason dealers pay low rates to individual farmers. The absence of price incentives at farmer level for higher quality products, however, maintains the status quo on quality (Roshetko and Yuliyanti 2003). Where forest-derived timber is still abundant, farm-grown trees cannot be profitably marketed (Box 20.5).

This constraint on the contribution of agroforestry to sustainable forest management can be overcome, if public domain access to market information improves. By understanding market linkages and interactions, it should be possible, at relatively low cost, to improve smallholder farmers’ livelihoods by focusing their agroforestry production towards market opportunities (Roshetko and Yuliyanti 2002; see also next chapter).

Box 20.5 East Kalimantan (Indonesia): not yet ready for farmer-grown trees

North Lampung (Sumatra) and areas in East Kalimantan have similar topography, soils and climate, but are in a different phase of the inverse J of Fig. 20.1. Former transmigration villages in both areas have similar land holdings per household, and in both most of the land surrounding the village is

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Box 20.5 (continued)

covered by *Imperata cylindrica* grasslands of low use, perpetuated by fire. In North Lampung farmers are keenly interested in planting trees on their farm, to make a transition to either labour-intensive rubber, oil palm or fruit tree stands, or to relatively extensive timber-based production systems (depending on the household level labour resources). In East Kalimantan, research by Murniati (2002) showed that technically a transition to tree-based production is feasible, but the 'opportunity costs of labour' are too high. Villagers can still easily earn income in legal and illegal logging, or make new clearings in logged 'production forest' lands. By reference to Fig. 20.1 we can conclude that this landscape has not degraded sufficiently to start the rehabilitation process. Where the local market is still 'flooded' by timber derived from natural forest, the prospects for farmer-grown timber are poor.
Murniati (2002)

20.5 Bottleneck 4: Overregulation of Market Access

Many national policies that are intended to conserve and protect natural resources discourage the cultivation – and thus conservation – of indigenous species by restricting their utilization or trade, as reported in various chapters of this book (e.g., Schuren and Snelder, Chapter 3, this volume; Manurung et al., Chapter 4, this volume; Masipiqueña et al., Chapter 7, this volume; Tolentino, Chapter 15, this volume). Selective deregulation of trade in agroforestry timber species is an attractive policy option (Tomich and Lewis 2001a; Box 20.6) that can stimulate equitable economic growth while protecting the environment.

Partly in response to market regulation, industrial timber plantation schemes, especially those linked to a pulp and paper processing plant, often develop 'outgrower' schemes, that lead to a vertical integration of production and processing, providing credit for the initial investment, linked to an obligation to sell to the factory. An overview (Mayers and Vermeulen 2002) of the experience with company-community forestry partnerships, shows that farmers appear to be best off where the

Box 20.6 Deregulating agroforestry timber to fight poverty and protect the environment

Tomich and Lewis (2001a) stated in their ASB (Alternatives to Slash and Burn) Policy brief:
"Policymakers in the humid tropics often justify export bans, taxes, marketing regulations and other controls on the timber trade in order to protect natural

(continued)

Box 20.6 (continued)

forests. … In the absence of effective mechanisms for policing forest areas earmarked for conservation, restrictions on the tropical timber trade are seen as the next best way to curb illegal logging. While they may prevent some deforestation, these restrictions are nevertheless imperfect instruments. Loggers often can evade them, cutting trees and selling timber illegally. Where the value of the timber is high enough, civil service employees are underpaid and public control imperfect, the regulations may simply add to the 'transaction costs'. Alternatively, wood is simply wasted, left unharvested when trees fall naturally or burned when forest is felled for conversion to plantations or ranches. Worse still, the policy measures aimed at protecting natural forest also are applied to agroforestry systems that are managed sustainably by small-scale farmers. The unintended result of treating all timber alike–regardless of its origin in forests or on farms–is that smallholders who plant and tend trees are unfairly penalised. They are effectively denied the opportunity to produce timber, a product that could provide them with a much-needed source of income."

"The ASB team in Indonesia identified three kinds of barrier to trade in agroforestry timber.

First are **export taxes and quotas:** intended to promote domestic wood processing, these drive down the domestic price of timber and hence, in the case of agroforestry species, reduce the incomes of smallholders. Second are **royalties,** which in theory are applicable only to products from natural forests but in practice are applied to agroforestry products as well because of confusion about the products' origin. Third are **complex bureaucratic procedures** that smallholders and local traders must follow before they can harvest or market timber and other agroforestry products. Similar barriers to trade are at work in many other countries in the humid tropics. As a result, farmers are discouraged from planting trees."

credit requirements for tree planting and tending are evaluated on financial viability criteria and de-coupled from the obligation to sell to a specific processor. Getting the dynamics of decision-making efficient, equitable, and sustainable in 'community–forestry partnerships' is not easy but examples where it has been achieved exist.

20.6 Bottleneck 5: Lack of Systematic Validation and Rewards for Environmental Services

Trees in a landscape, across the whole spectrum from natural forest to intensively managed plantations, can have positive environmental effects or 'provide environmental services'. Within this context, the determination of quality and price of environmental services is essential, yet, entails a rather complex process. The outcome for tree-based systems may differ considerably, and even contradict expectations (Van Weerd and Snelder, Chapter 16, this volume), discouraging potential stakeholders to participate in the PES field. Given ongoing land-use changes and increasing population pressure on a wide array of forest- and agro-ecosystems, broader knowledge of alternative agroforestry practices and associated services is essential and to be communicated among both farmers and scientists alike. Information is lacking on practices that offer multiple opportunities for farmers to improve farm production and incomes, and also provide productive and protective forests functions like those discusses by Sharma et al. (this volume).

Another concern is that, in the absence of a comprehensible 'reward structure', the presence or absence of environmental services is left to decision makers to whom off-farm benefits and costs are 'externalities'. Development of efficient and effective reward structures for environmental services, is thus an important way to achieve environment *plus* development goals (Tomich et al. 1998, 2001; Landell-Mills and Porras 2002; Murdiyarso et al. 2002).

In current discussions on terrestrial carbon storage in the context of the Kyoto protocol and similar efforts to slow down the increase in atmospheric CO_2 concentrations, the focus has been on reforestation with specific efforts for lands not 'forested' in 1990. For mechanisms such as these it is an important issue whether or not 'agroforestry' can qualify under the formal definitions – even though existing data show a considerable potential for increasing the 'time averaged carbon stock' of land managed by farmers, through an array of agroforestry practices (Van Noordwijk et al. 1998a, b; Palm et al. 1999; Roshetko et al. 2002; Hairiah et al. 2002; Tomich et al. 2002; Van Noordwijk et al. 2003). Apart from the lack of recognition, however, current mechanisms will provide such an administrative burden that it is likely that 'transaction costs' will form most (if not all) of what buyers of certified carbon credits pay, with little (if anything) ending up in farmers' pockets. However, enabling the establishment of viable, market-oriented smallholder tree farming systems would justify 'carbon investment' and satisfy sustainable development criteria (Roshetko et al. 2007).

The relation between trees and water continues to be subject to confusion in the public debate (though not addressed much within this book). The fact that young tree plantations, especially of evergreen species tend to use more water than established, deciduous forests or agricultural (non-irrigated) lands has gained attention in the form of the *Eucalyptus* debate. While there is no reason to single out *Eucalyptus* species in this regard, the high water use of fast growing, evergreen trees can be a concern in areas with a shortage of groundwater or subsurface flows of water. In other areas such interception of subsurface flows can be seen as the basis of an 'environmental service function', where it prevents salt movement in groundwater flows. 'Environmental service' perceptions will thus depend on the local agro-ecosystem, and should be left to local governance structures to decide.

20.7 Bottleneck 6: Lack of Supportive Legal and Institutional Framework

A constraining element shared by various case studies in this volume is the lack of institutional structures that are conducive to smallholder tree growing activities (Masipiqueña et al., Chapter 7, this volume; Rahman et al., Chapter 11, this volume; Hares, Chapter 19, this volume). It is even stated that smallholder tree-based systems may simply not form the best option for either land use planning (i.e., spatial planning) or smallholders given that institutional objectives are commonly linked to political-economic agendas that do not prioritize smallholder conditions or needs (Barney, Chapter 13, this volume).

National governments and international donors throughout Southeast Asia have made reforestation based on 'plantations' a priority, for a variety of reasons. In the Philippines the government strategy for reforestation has been to promote government and industrial plantations, primarily of *Gmelina arborea*, *Eucalyptus* sp. and *Acacia mangium*, as discussed earlier (e.g., Tolentino, Chapter 15, this volume). Official records indicate that between 1976 and 1995, 1,300,000 ha of fast-growing trees were planted. About 50 percent of this total was established under the National Forestation Programme for watershed protection. The remaining half targeted wood production. The success of these plantations is not impressive. Analysis concludes that a success rate of 30 percent is generous, if success is defined as the proportion of area planted that actually evolves into secondary forests (Lasco et al. 2001). In Indonesia, the Five-Year Development Plan, *Repelita VI 1994–1999*, targeted public and industrial reforestation of 1,250,000 ha per year. Government figures acknowledge that less than a third (400,000 ha) of this goal was achieved (Moestrup 1999). The actual existence and long-term success of these plantations, primarily industrial or government reforestation schemes, are widely questioned. The reasons for the failure of public and industrial reforestation efforts in Southeast Asia are numerous and often related to legal and institutional deficiencies. Key problems include: (1) conflicts over land often with overlapping claims by the state and local farmers, (2) the target mentality of the reforestation – or *tree planting* – activity; (3) inadequate attention given to technical details (species-site matching, plantation maintenance, etc.); (4) lack of clear management and utilization objectives for the plantation; (5) disregard of the needs and objectives of the local communities; and (6) corruption (Carandang and Cardenas 1991; Carandang and Lasco 1998). In general these plantations are established by technicians and contract laborers who have no post-planting responsibility, concern or expectations of future benefits. Central planning of reforestation schemes often assumed that local people would protect the newly established forests. However, having been excluded from the planning process, local people feel no sense of ownership and no incentive/obligation to protect plantations not intended to address their needs/priorities. Plantations are often heavily damaged or completely destroyed by fires (Suyanto et al. 2001; see also Box 20.1), grazing, or appropriation of the site for other uses.

Institutional and policy changes and a better understanding of local communities, their needs and perceptions, are clearly imperative if smallholder tree growing is to be successful in its contribution to sustainable management of forest and natural resources in general (see De Lopez 2002 for Cambodia; Springate-Baginski et al. 2003 for Nepal; Sato 2003 for Thailand; Douglas 2006 for Lao PDR, Vietnam, Thailand, the Philippines, Malaysia; Thapa and Rasul, 2006 for Bangladesh; see also Hares, Chapter 19, this volume).

Finally, in combination with bottleneck 1, the lack of institutional mechanisms for rewarding 'sustainability' and 'forest functions' indicates that criterion 7 of the Montreal process is the largest challenge facing agroforestry. This constraint, however, might be overcome at relatively low cost through policy changes, once a broader awareness is raised of the opportunities that are currently missed.

20.8 Concluding Remarks: Widening All Bottlenecks in the Conduit to Sustainability

As indicated in Fig. 20.2, the need for forest and agricultural products as well as forest functions can be met by various combinations of natural forest, extensively and intensively managed forest plantations, intensively managed agriculture, and multifunctional mosaics and patchworks generally associated with agroforestry. There is no *a priori* reason to exclude any of these options from the public debate. The smallholder agroforestry option may have been neglected so far, and remains absent from most statistics and global conventions, but in placing agroforestry on the 'mental map' we argue that balanced attention is needed, not special favors. In various parts of the world, current relationships between agroforestry and plantation forestry are perceived to be complementary, neutral or competitive. It may be difficult to judge at this stage how far we are removed from a 'level playing field', as the allocation of land to either large-scale plantations or smallholder agroforestry is essentially a political decision, with substantial economic implications. We suggest that an open-minded evaluation of the ability of (inter)national policy frameworks to provide productive and protective forest functions to society at large, through both plantation forestry and agroforestry, in the context of 'sustainable forest management'.

In the paper we discussed six constraints that currently limit smallholder tree production. Four of these six are directly in the domain of national policies, and they indicate that substantial progress towards 'sustainable forest management' can be made by widening these policy-based bottlenecks, probably at low cost. Looking back at the seven criteria of the Montreal Process on Criteria and Indicators for Sustainable Forest Management (SFM), we may conclude that criterion 7 (bottleneck 6 discussed in this chapter) on the 'legal and institutional framework' may be the largest obstacle to recognition of agroforestry as a form of sustainable forest management. Priority should be given to the removal of artificial boundaries created in legislative and institutional contexts, that are at odds with the continuum of presence of ‘planted trees’ (and ‘managed’ trees) in the landscape. Tree farming will then emerge when and where it is appropriate, as long as society at large provides the right signals and rewards.

A provocative thought to conclude this contribution: in conditions where large-scale plantations operate with substantial government subsidies (direct or indirect, partly justified by environmental service functions), in contrast to non-existent or minimal subsidies for agroforestry, the potential to produce wood and simultaneously provide for many forest benefits and ecological services with agroforestry is placed at a disadvantage, to the detriment of society at large.

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Chapter 21
Future Challenge: A Paradigm Shift in the Forestry Sector

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Abstract This chapter re-visits the facts and figures of previous chapters, augmenting the discussion with other relevant literature. It reviews trends in regional deforestation, human population growth, and demands for forest (tree) products; and provides an overview of common tree-based landuse and management systems and their potential contribution to expand the regional forest base and generate forest products and services. Emphasis is placed on the contribution of smallholder tree-based (agroforestry) systems, given their additional function of supporting rural livelihoods of the potential of smallholder agroforestry systems to contribute to sustainable forest management and rural livelihoods are identified and discussed. Enabling conditions, institutional and policy support, and market oriented strategies are all discussed as means to strengthen the development and productivity of smallholder agroforestry systems. Discussions on those topics are well supported with citations and lessons learned emphasizing the experience from the Philippines. The main message of the chapter is twofold: (1) a paradigm shift in the forest sector is required to recognize the contribution and importance of smallholder systems to achieve sustainable forest management objectives; and (2) there is a need to adopt more holistic and sustainable strategies to support and strengthen institutions and smallholder system development, including linkages with the market.

Keywords Environmental services, marketing, policy support, smallholder technology, tree plantation

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21.1 Introduction

The premise of this volume is that smallholder tree-based systems are efficient agricultural and natural resource production systems. Various papers included in this volume have amply demonstrated the common occurrence and sheer socioeconomic importance of smallholder systems. A prominent component of '*trees outside the forest*', smallholder tree-based systems are primarily 'planted' systems that rehabilitate or reforest marginal farmlands where agricultural crop production is no longer biophysically or economically viable. Smallholder tree-based systems also include forest-like systems where select priority species are integrated in natural forests. In either case, farmers cultivate trees to diversify production, produce products for home consumption, enhance income through market sales, and reduce risk. Smallholder systems tend to contain multiple species, produce multiple products, and are found in both rural and peri-urban areas. In some locations these systems are a major economic source of forest- and tree-products. In Kerala, India smallholder systems provide 83 percent of the state's wood production and up to 90 percent of its fuelwood production (FSO 1998 in FAO 1998). Sri Lankan smallholder systems produce 73 percent of the nation's timber and 80 percent of its fuelwood (Gunatilake 1994 in Gunasena 1999). Products produced in smallholder systems of Indonesia include rattan, forest honey, sandalwood, gaharu, damar, benzoin, rubber, cinnamon, cloves, nutmeg, coffee and candlenut (see Sunderlin et al. 2000; Rohadi et al. 2003; Dove 2004; Garcia Fernandez 2004). The importance of smallholder systems will only increase as the global forest resource continues to shrink and human populations expand. Yet, as discussed in the previous chapter, smallholder systems are excluded in formal definitions; lost in statistics; and overlooked in the legal and institutional framework of agriculture and natural resources. Additionally, smallholder systems could be more productive and profitable if the common barriers that limited their development were addressed in a systematic way.

In this final chapter we re-visit the facts and figures of previous chapters, with a focus on the importance, present contribution and future potential of smallholder tree growing in South and Southeast Asia. The main message is twofold: (1) a paradigm shift in the forest sector is required to recognize the contribution and importance of smallholder systems to achieve sustainable forest management objectives; and (2) there is a need to adopt more holistic and sustainable strategies to support and strengthen the development of smallholder systems and link them with the market. To set the context in terms of importance of smallholder tree growing, we first review trends in regional deforestation, human population growth, and demands for forest (tree) products. Following that review we describe current common tree-based landuse and management systems and their potential to contribute to the regional forest base and as sources of forest products and services. Emphasis is placed on the contribution of smallholder tree based systems to *sustainable forest management* and their contribution to expanding regional forest resources, producing forest products and services, as well as, forming a major contribution to local livelihoods for rural communities. Enabling conditions, institutional support and policy support that facilitation the establishment of successful smallholder systems are reviewed. Strategies to transform traditional smallholder systems towards market-oriented systems that better serve public environmental and economic goals are also discussed. The chapter is concluded with lessons learned that stress experience from the Philippines and conclusions that support the chapter's main message. As often as possible we reiterate the relevance of previous chapters, including data and citations.

21.2 Forest Loss, Environmental Degradation and a Loss of Forest Services

The forest loss projections made in the *Food and Agricultural Organization* (*FAO*) 1997 forestry sector outlook studies are clearly alarming. In the Asia-Pacific Region alone over 32 million hectares of *forests and woodlands* (*wooded lands*)[1] have been or will be lost by 2010; an additional 22 million hectares of *natural exploitable forests*[2] area, forests that can produce commercial timber, will be lost. These losses equal 3.8 and 8.5 percent of the respective 1995 area (Blanchez 1997). The projected loss is particularly distressing for Southeast Asia, where *forests and woodlands* area and *natural exploitable forests* area will decline by more than 11 percent and 14 percent, respectively, between the two benchmark dates. For South Asia respective losses are 2.5 percent of forests and woodlands and 8.6 percent for natural exploitable forests. While less severe than Southeast Asia, these rates of natural forest loss are very high and occur in a sub-region where the forest base is already greatly reduced from decades of unchecked forest conversion. The next FAO forestry sector outlook is in preparation and expected to be available December 2008 (see Nair 2006). An interim report (FAO 2005) documents an average annual net forest loss rate of 2.7 million hectares for South and Southeast Asia, which exceeds the dire projections made in the 1997 outlook study (Blanchez 1997). Since the net losses account for replanting and natural regeneration the actual rate of deforestation is undoubtedly higher.

Reforestation is being achieved through the expansions of forest plantations. Between 1995 and 2010 forest plantations are projected to increase by 21.0 million hectares (35 percent) across the Asia-Pacific region, by 6.0 million hectares (73 percent) in Southeast Asia, and 4.5 million hectares (30 percent) in South Asia (Blanchez 1997). Forest plantations are an important and efficient source of wood and non-wood products. The systems reduce production pressure on natural forests, and may have a tempering effect on the rate of natural forests loss. Globally, forest plantations

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[1] *Forests* are areas with wild flora, fauna and natural soil conditions; with a minimum crown cover of 10 percent. *Wooded lands* compose of forest fallows (all complexes of woody vegetation derived from clearing natural forest for shifting cultivation) and shrubs (vegetation types where the dominant woody elements are shrubs of more than 50 cm and less than 5 m in height in maturity).

[2] *Natural exploitable forests* are natural or semi-natural forests, composed of tree species known to be indigenous to the area, that are commercially productive and economically accessible/available for timber wood supply. Legally protected and economically restricted forests are excluded.

account for roughly five percent of forest-cover, but yield 35 percent of the world wood supply. However plantations, which are primarily monocultural systems of exotic species, are inferior to primary and secondary forests in supporting genetic- and bio-diversity, ecological resilience, economic and social services to rural communities, water and soil conservation, and carbon storage (Michon and de Foresta 1995; Lamb 1998; Murdiyarso et al. 2002; Roshetko et al. 2007a; van Weerd and Snelder, Chapter 16, this volume; van Noordwijk et al., Chapter 20, this volume). Additionally, forest plantations are frequently established by clearing primary or secondary forests (Barr et al. 2004; Sheng and Cannon 2004), thus being a direct cause of natural forest loss. Although tree plantations will expand, they will remain a portion of regional forest base in South and Southeast Asia accounting for only 5.9 percent, 16.6 million hectares (FAO 2005). Overall forest-cover – the combined area of forests and woodlands, natural exploitable natural forests, and forest plantations – remains in decline. Forest-cover is projected to decrease by 2.9 percent in the Asia-Pacific Region and by more than 10.5 percent in Southeast Asia. Forest-cover will remain static across South Asia as a result of India's large plantation expansion program, 3.75 million hectares between 1995 and 2010. The other countries of South Asia will each experience major forest loss (Blanchez 1997). Projected forest area losses and gains for the Asia-Pacific Region and individual countries in South and Southeast Asia are listed in Table 21.1.

Even if the projections above prove to be excessive, given the varied data on which they are built, the fact remains that the regional forest base is decreasing. The declining forest base, compounded by a shift from natural forest systems to plantations, will be accompanied by a loss of forest functions and services. The level of this environmental degradation becomes evident when looking at the changes in the status of various forest-related variables that are representative of functions such as biological diversity, forest health and vitality, and the productive, protective and socio-economic functions of forest resources (Table 21.4 and Photo 21.1). In the Asia region, forest carbon storage decreased by 10.5 Gt of carbon annually between 1990 and 2005 due to deforestation and forest degradation. The loss of primary forest at a rate of 1.5 million hectares per year during the same period has serious consequences for regional biodiversity. The high rate of forest loss is the result of deforestation and forest degradation, the latter primarily due to selective logging which alters natural primary forests to secondary forest (FAO 2006). Efforts to conserve forests and biological diversity are growing, as evident by an annual increase of 1.4 percent in the area of conservation forests (Table 21.4). Forests also suffer from fires (Photo 21.2), diseases and insect attacks, and other disturbances, which affect up to 93,000 ha per year. Data on forest disturbances are far from complete. The area of forests used for the production of wood and non-wood forest products declined by an average of 683,000 ha per year, while the area of productive forest plantations increased by 195,000 ha per year. Official figures on total wood removals during the period 1990–2005 suggest a regional decrease of about 3.6 million hectares per year (or two percent per year). The actual loss is likely higher as illegal wood removals and informal fuelwood collection are not included in the calculations (FAO 2006). Both the area of forest primarily designated for protection and the area of protective forest plantations have increased

Table 21.1 Projected change in forest area between 1995 and 2010 for countries in South and Southeast Asia

Country/region	Land area (000 ha)	Forest area 1995[a] (000 ha)			Projected forest area 2010[a] (000 ha)			Projected change 1995–2010[a] (%)		
		FWL[b]	*NEF*[c]	*PF*[d]	*FWL*	*NEF*	*PF*	*FWL*	*NEF*	*PF*
Bangladesh[e]	13,017	2,040	465	343	1,600	311	463	−22	−33	35
Bhutan[a]	4,700	2,916	1,242	24	2,730	1,149	54	−6	−7	125
Cambodia[f]	17,652	13,083	4,984	7	11,399	4,341	10,5	−13	−13	50
India[e]	297,319	82,464	21,935	13,250	82,044	20,613	17,000	−1	−6	28
Indonesia[g]	181,157	139,950	74,166	5,184	126,922	65,208	8,434	−9	−12	63
Lao PDR[f]	23,080	20,800	2,495	11	19,000	2,227	26	−9	−9	136
Malaysia[g]	32,855	20,327	11,255	155	15,556	8,510	305	−23	−24	97
Myanmar[f]	65,755	47,124	20,442	519	42,062	18,058	894	−11	−12	72
Nepal[e]	14,300	5,542	2,806	130	4,964	2,429	280	−10	−13	115
Pakistan[e]	77,088	4,050	1,273	865	3,388	859	1,240	−16	−33	43
Philippines[g]	29,817	12,577	2,202	761	10,125	1,605	1,511	−19	−27	99
Sri Lanka[e]	6,463	1,990	918	101	1,834	825	137	−8	−10	36
Thailand[f]	51,089	13,630	7,957	779	10,588	5,609	1,529	−22	−30	96
Vietnam[f]	32,550	23,084	3,052	1,050	22,122	2,794	1,950	−4	−8	86
Asia-Pacific	2,843,170	823,495	262,975	59,463	791,862	240,604	80,340	−4	−8	35

[a] From Blanchez 1997

[b] *Forests and wooded lands*: *forests* (with wild flora, fauna and natural soil conditions) with a minimum crown coverage of land surface of 10 percent and *wooded lands* composed of forest fallow (i.e., all complexes of woody vegetation deriving from the clearing of natural forest for shifting cultivation) and shrubs (i.e., vegetation types where dominant woody elements are shrubs with more than 50 cm and less than 5 m height on maturity)

[c] *Natural exploitable forests*: natural or semi-natural forests (composed of tree species known to be indigenous to the area) that are commercially productive and economically accessible and available for timber wood supply; forests with economic restrictions (environmental, access, health) and or legally protected are excluded

[d] *Plantation forests*: forests and forest tree plantations (i.e., industrial, communal or individual) established by afforestation or reforestation and covering at least an area of about half hectare (trees on road sides, canal banks and homesteads and also plantations of rubber, coconut and oil-palm are excluded)

[e] South Asia

[f] Continental Southeast Asia

[g] Insular Asia

Photo 21.1 Bridge along Marhalika highway collapsing as a result of high flow discharge in deforested areas in Isabela Province, the Philippines (©DJ Snelder)

Photo 21.2 Unsustainable strategies lead to forest loss and environmental degradation (©GA Persoon)

at an annual average rate of respectively 112,000 and 63,000 ha (Table 21.4). Forests within this category contribute to soil and water conservation and other sorts of protective functions. Positive trends are evident in private forest ownership (increased by 2.7 percent) and forest areas reserved for social services (increased by 0.8 percent), but in terms of land area these gains are miniscule.

Negative trends in the regional forest base are associated with a loss of forest functions and services. This is alarming as most of the world's population resides in Asia (FAO 2005; UNDP/UNEP/WB/WRI 2005). The decreases in forest area and accompanying accelerated shortages of forest products will affect both rural and urban populations throughout the region.

21.3 Population Growth, Economic Development and Demand for Forest Products

While the forest base will decrease, human population and economic development will grow, increasing the demand and consumption of forest and wood products throughout Asia and elsewhere. In 1995 South and Southeast Asia were home to, respectively, 1,109 million (23 percent of the world population) and 437 million (nine percent) people in 1995 (ADB 2004). Projections indicate that by 2010 populations will increase to 1,557 million (a 40 percent increase) in South Asia and 590 million (a 35 percent increase) in Southeast Asia, assuming medium fertility levels (Chipeta et al. 1998). Annual population growth for individual countries in South and Southeast Asia ranged between 0.8 percent in Thailand and 2.4 percent in Bhutan during 2000–2005. In 2005 *gross national income* (GNI) per capita varied between US$270 for Nepal to US$4,970 for Malaysia (Table 21.2). Increases in GNI between 2000 and 2005 varied between 17 percent for Nepal to 125 percent for Indonesia. Chipeta et al. (1998) project annual increases in *gross domestic product* (GDP) of five to eight percent throughout South and Southeast Asia. At such growth rates, it can be expected that the Asian middle class will double or triple in the next decade. It is expected that by 2010 the Asian middle class, excluding Japan, could number between 0.8 to 1.0 billion people, forming a middle class market segment to equal or surpass that of the US and Europe combined (Naisbitt 1995 in Chipeta et al. 1998).

Population and economic growth will increase the demand and consumption of forest products, which in turn will be reflected in expanded global trade of these products (Photo 21.3). According to FAO (2005) major Asian forest products traded in international markets include industrial roundwood (59 million cubic metres with 14 percent for export markets), wood-based panels (35 million cubic metres; 46 percent exports), sawnwood (32 million cubic metres; 25 percent exports), paper and paperboard (32 million cubic metres; 35 percent exports), and pulp for paper (16 million cubic metres; 17 percent export). Yet, the production and trade of forest products vary greatly across countries. Indonesia is by far the greatest producer of industrial roundwood (based on the 2002 data; see Table 21.3) but Malaysia is the largest volume exporter of industrial roundwood.

Table 21.2 Trends in annual population growth, gross national income (GNI) per capita and average net annual trade in forest products for various South and Southeast Asian countries

Country/ region	Population[a] (million)		Annual growth[a] (%)	GNI/capita[b] (US$)		Average annual net trade in forest products[c,d] ('000 US$)	
	1990	2005	*2000–2005*	*2000*[e]	*2005*[f]	*1990–1992*	*2000–2002*
Asia	1,415.4	1,848.7	n.a.	n.a.	n.a.	−14,208,400	−19,568,974
Bangladesh[g]	108.7	137.0	1.4	380	470	−17,581	−75,872
Bhutan[g]	0.7[h]	0.8	2.4	510	600[h]	7,119	−876
Cambodia[h]	8.6	13.8	1.9	290	430	41,705	7,374
India[g]	835.0	1,107.0	1.7	450	730	−547,290	−865,449
Indonesia	179.4	219.9	1.3	570	1,280	3,170,812	3,909,903
Lao PDR[h]	4.1	5.6	1.4	290	430	33,951	45,114
Malaysia	18.1	26.1	2.2	3,390	4,970	2,737,487	1,907,737
Myanmar[h]	40.8	55.4	2.0	n.a.	n.a.	291,461	231,529
Nepal[g]	18.1	25.3	2.3	230	270	−3,960	−1,514
Philippines	60.9	85.2	2.1	1,030	1,320	−134,026	−495,568
Sri Lanka[g]	16.3	19.7	1.3	890	1,160	−76,625	−86,884
Thailand[h]	55.8	64.8	0.8	2,010	2,720	−1,074,407	−301,270
Vietnam[g]	66.0	83.1	1.4	380	620	85,163	−117,044

[a] From ADB 2006

[b] GNI per capita (formerly GNP per capita) is the gross national income, converted to US dollars using the World Bank Atlas method, divided by the midyear population. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad

[c] Refers to the aggregate of all forest products, including industrial roundwood, fuelwood and charcoal, sawnwood, wood-based panels, wood pulp (including recovered paper), and paper and paperboard (see also Table 21.3); a negative trade value refers to a net expenditure derived from a net import of forest products whereas a positive value refers to a net income derived from a net export of forest products

[d] FAOStat 2007, Earthtrends Data Tables: Forest Production and trade 2005 at http://earthtrends.wri.org/datatables/index.php?theme=4 accessed 21 May 2007; World Resources Institute (WRI) 1994; FAO 2005

[e] From ADB 2004

[f] From World Bank 2007 at http://siteresources.worldbank.org/DATASTATISTICS/Resources/GNIPC.pdf

[g] Average of 1989–1991 consumption data

[h] From 2002 data

The relationships between population and economic growth and the demand, consumption, and trade of forest products are rather complex, with various other factors playing significant roles as well. Indonesia and Lao PDR have experienced enormous growth in population and per capita GNI; and realized net gains in terms of the financial value of their forest product trade during the period 1990–2002 (Table 21.2). Malaysia, Cambodia and Myanmar while all experiencing population and per capita GNI growth, showed substantial decreases in net financial gain from

Photo 21.3 Log transportation for trade from Malaysia to the Philippines (©DJ Snelder)

forest product trade during the same time period. The differences in trade trends can be explained in terms of access and availability (abundance or scarcity) of harvestable forest resources; and in the relative contribution and financial value of processed forest products. Most countries in the region experienced a decrease in forest product trade between 2000 and 2002 (Table 21.2). Bhutan and Vietnam even changed from forest-product exporters to forest-product importers. These changes can likewise be explained by an increasing financial value of imported forest products and a decreasing value of exported forest products, suggesting a mounting shortage of locally produced forest products (see Table 21.2). The export of forest products in most South and Southeast Asian countries accounted for less than one percent of 2000–2002 GDP; the exceptions being Indonesia with forest products exports accounting for 3.26 percent of GDP, Malaysia – 3.20 percent, and Lao PDR – 2.63 percent (EarthTrends 2005).

Woodfuels (fuelwood and charcoal) production is the greatest among forest products in terms of volume in Asia (782 million cubic metres in 2002; see Table 21.3 for data on individual countries in South and Southeast Asia). However, woodfuels are produced primarily for local consumption, with only 22,480 m^3 of woodfuels (eight percent) traded internationally (FAO 2005). During 1990–2002 the per capita use of woodfuels declined in countries with higher GNI levels: specifically Indonesia, Malaysia, Philippines, Sri Lanka and Thailand. During the same period, the use of fuelwoods grew in the lower GNI countries: Bhutan, India, Lao PDR, and Myanmar (Tables 21.2 and 21.3). In the near future, it is expected that woodfuels consumption will remain stable, or even increase slightly, in lower GNI countries. While fuelwood use varies both between and within Asian countries, it is a common and important energy source not only for low-income rural and urban households, but also higher income households (FAO 2003a).

Table 21.3 Trends in volumetric woodfuel consumption, net trade in industrial roundwood, and production of major forest products for various South and Southeast Asian countries (1990 data: WRI 1994; 2002 data: FAO 2006)

Country/ region	Consumption[a] of woodfuels ('000 m^3)		Net trade in industrial roundwood[b] ('000 m^3)		Production of industrial roundwood ('000 m^3)		Production of sawnwood ('000 m^3)		Production of wood-based panels ('000 m^3)		Production of paper and paper-board ('000 m^3)	
	1990[c]	2002	1990[c]	2002	1990[c]	2002	1990[c]	2002	1990[c]	2002	1990[c]	2002
Bangladesh	30,061	27,763	–87	3	882	575	79	70	8	9	95	46
Bhutan	1,254	4,348	4	0	278	134	33	31	12	32	–	–
Cambodia	5,366	9,737	56	–	681	125	79	5	2	37	–	0
India	250,089	300,564	–1,118	1,990	24,421	19,308	17,460	7,900	442	645	2,202	3,973
Indonesia	141,017	82,556	1,245	(322)	26,804	32,997	9,549	6,500	8,837	12,635	1,432	6,995
Lao PDR	3,827	5,899	20	(63)	367	392	66	182	10	13	–	–
Malaysia	8,719	3,228	20,125	(4,762)	41,219	17,913	8,684	4,594	2,071	6,803	283	851
Myanmar	17,785	35,403	669	(877)	5,065	5,539	436	381	15	20	11	42
Nepal	17,661	12,728	4	0	583	1,260	470	630	–	5	9	13
Philippines	33,447	13,328	–276	433	5,019	3,079	845	154	455	620	212	1,056
Sri Lanka	8,364	5,774	0	0	674	694	12	61	10	22	17	25
Thailand	34,585	20,250	–1,444	688	3,154	7,800	1,123	288	340	705	868	2,444
Viet Nam	24,154	26,547	262	39	4,816	4,183	782	2,950	40	40	67	384
Asia	817,437	782,395	49,527	43,312	254,245	222,563	104,587	61,157	27,515	58,768	56,357	97,823

[a] woodfuel consumption equals woodfuel production for all countries listed suggesting no woodfuels are traded at the international market;

[b] positive values represent a net income derived from export of the product in question whereas negative values represent a net expenditure derived from net import of the product in question

[c] annual average of 1989–1991 data

Table 21.4 Trends in various forest management variables in South and Southeast Asia (FAO 2006)

Variables	S and SE ASIA (regional)			
	Annual change 1990–2005			
	%	Unit	Unit	Data availability[a]
Extent of forest resources				
Area of forest	–0.12	–2,669	‘000 ha	H
Growing stock of forest	–2,01	–560	million m^3	H
Carbon stock in forest biomass	–2,69	–10,5	Gt	H
Biological diversity				
Area of primary forest	–2.08	–1,508	‘000 ha	H
Area of forest primarily for biodiversity conservation	1.37	704	‘000 ha	H
Total forest area[b]	0.80	1,113	‘000 ha	H
Forest health and vitality				
Fire-affected forest area[c]	0.88	93	‘000 ha	H
Disease affected forest area[c]	3.22	1.9	‘000 ha	L
Insect affected forest area[c]	2.25	0.2	‘000 ha	L
Area forest affected by other[c]	–2.50	n.s.		L
Productive functions				
Area of forest primarily for production	–0.55	–683	‘000 ha	H
Area of productive forest plantations	1.92	195	‘000 ha	H
Commercial growing stock	–3,05	–303	‘000 ha	M
Total wood removals	–2.03	–3,666	‘000 ha	H
Total NWFP removals	n.a.	n.a.	tonnes	L
Protective functions				
Area of forest primarily for protection	0.19	112	‘000 ha	H
Area of protective forest plantations	1.46	63	‘000 ha	H
Socio-economic functions				
Forest area under private ownership[c]	2.68	205	‘000 ha	H
Forest area primarily for social services	0.79	1.2	‘000 ha	H

M = the countries reporting data on variable represent together 50–75 percent of total forest area
L = the countries reporting data on variable represent together 25–50 percent of total forest area
[a] H = the countries reporting data on variable represent together 75–100 percent of total forest area
[b] total area of forest designated for conservation of biodiversity
[c] the data on annual change represent the period 1990–2000

Within South and Southeast Asia, there is a trend towards lower trade of unprocessed (or partially processed) forest products such as industrial roundwood and sawnwood (see Table 21.3) and a higher production and trade of processed forest products such as wood-based panels, paper and paperboard. Yet, the demand for all forest products, whether processed or not, is significant – and is projected to remain so, or even increase, from the local to international levels; with a growing number of countries being unable to meet their domestic demands. This projection stresses the urgent need to expand the regional forest base, a process that should include afforestation, reforestation, and the establishment of other tree-based systems not normally including in forest system classifications. The latter comment refers to the recognition of smallholder agroforestry systems, and agroforestation.[3]

21.4 Tree-Based Land Use Systems

21.4.1 Natural Forests

For centuries natural forests have been the cheapest source of high-quality commercial timber and non-wood tree products. Additionally, hundreds of millions of people in the tropics depend on natural forests for a significant part of their livelihoods (Sayer 1998); most of these people practice traditional sustainable forest management practices. As discussed above, natural forests are rapidly being exhausted – reduced to an area of 266.5 million hectares in South and Southeast Asia (FAO 2005). The area of natural forests is not going to increase or meet human society's growing need for forest products and services. In face of persistent loss, the question remains how long can natural forests continue to fulfill a productive role? Van Noordwijk et al. (Chapter 20, this volume) argue that once the supply from natural forests dries up the price of tree products will increase making other *tree-based land use systems* profitable and attractive investments. Due to the time lag between tree establishment and tree product harvesting (even for fast-growing species) supply gaps will occur until planted tree-based systems become sufficient and in continuous production. Thus the pressure on natural forests will likely '*become worse before it becomes better*'. Van Noordwijk et al. (Chapter 20, this volume) recognize four important questions: (1) can deforestation be avoided or halted, (2) can the process of forest degradation be deflected to a tree-based land use pattern that avoids the more serious stages of environmental degradation, (3) can degraded lands (from a forest function perspective) be rehabilitated, and (4) to what new level of tree cover and forest functions can land use recover in a new 'steady state', while meeting economic expectations of the land managers as well as society at large. The first two points address the need to protect existing forest resource. The negative impacts of deforestation and forest degradation are heightening pressure on governments to protect their remaining natural forests (FAO 2005). Efforts should be made to conserve the shrinking natural forest resource, protecting the environmental services they provide and reserving them for sustainable management by indigenous people when appropriate. The sustainable management of natural forests systems has a significant role in providing the forest products and services people require, but that role can not be expanded given the shrinking resource. The following paragraph defines and

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[3] Agroforestation is the establishment of smallholder agroforestry systems, and implies land rehabilitation through the establishment of a tree-based system and intensification of land management (Roshetko et al. 2007a).

discusses the role of sustainable forest management in meeting our needs for forest products and services. The third and fourth points above address, respectively, the rehabilitation of degrade lands, which are often former forest land; and how a combination of tree-based systems, both natural and planted forests, can be developed and sustained to meet society's needs. Both of these points are addressed throughout this chapter.

21.4.2 Sustainably Managed Forests

Sustainable forest management is 'the stewardship and use of forests and forest lands in a way, an at a rate, that maintains their biological diversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological economic and social functions, at local, national and global levels, and that does not cause damage on other ecosystems' (FAO 2000). It is often referred to as having high potential for meeting society's demands for wood and non-wood products, as well as, environmental services (also see the Montreal Process on Criteria and Indicators for Sustainable Forest Management – SFM – discussed by van Noordwijk et al., Chapter 20 this volume). There remains much debate regarding whether sustainable management can actually save tropical forests. Some scientists (e.g., Rice et al. 1997) state that sustainable forest management (with focus on sustained yields of multiple services and products and longer-term production) generally provides lower returns and damages forests more than conventional timber harvesting (with focus on short-term timber supplies and short-term profits). Others claim (e.g., Pearce et al. 2003) that sustainable forest management, although generally less profitable than conventional logging approaches, performs better in terms of carbon storage and biodiversity conservation. The latter suggests sustainable forest management has high prospects in safeguarding forests and meeting society's multiple demands as values attached to forests and associated services rise over time. In an analysis of various landuse systems Tomich et al. (1998) confirmed that community-based sustainable management provided superior biodiversity, carbon storage, and rural social/livelihood services compared to commercial logging. A global study funded by USAID found that commercial logging is a common cause of forest conflict, with local communities against companies and government agencies (ARD 2004; Forester et al. 2004). Commercial logging frequently usurps legal traditional local rights and is the major cause of forest degradation in many areas (Lasco et al. 2001; Mittelman 2001; ARD 2004; Barr et al. 2004; Wulan et al. 2004; Forester et al. 2004; Sheng and Cannon 2004). Our view is that the academic argument over 'what is' sustainable forest management is moot. Sustainable management is the only viable option to conserve the world's dwindling natural forest resource, enabling natural forests to provide the environmental services that they are uniquely positioned to supply – biodiversity conservation, soil and water conservation, and carbon storage – and contribute strongly to healthy ecosystems, multiple socioeconomic benefits, and support of social/livelihood services to poor rural communities.

Moreover, there are many examples of forest degradation being deflected to a tree-based smallholder landuse pattern that avoids the more serious stages of environmental degradation. Good markets for tree products such as fruits, resins and latex have allowed a transition of substantial areas of southeast Asian forest into ‘agroforest’, a land use that combines ‘planted trees’ with forest flora and fauna, either retained or naturally regenerated vegetation (De Jong et al. 2001). Tree planting in these agroforests can occur in an open field stage, often in between food crops, or in small gaps or clearings in existing forest. The ‘miang tea’ agroforests of northern Thailand and some of the fruit tree, cacao and coffee agroforests originated from such ‘enrichment planting’, gradually modifying the species composition and forest structure without a clear felling stage. The rubber, damar (resin) and other fruit tree and coffee based agroforestry has been through such a clear-felled (usually ‘slash and burn’) stage, but recovered their tree cover and most of the forest functions, allowing a greater population density to make a living (about 50 persons km^{-2} for rubber agroforests, versus about 10 persons km^{-2} in sustainable forms of shifting cultivation or plantation forestry). When the first generation of planted trees gets old, the choice may again be either ‘interplanting’ or a new clear-felling + planting rotation. In Indonesia, farmers use different words for these two ways of planting trees (*sisipan* versus *tanam*) (Joshi et al. 2002). The term ‘plantations’ in Southeast Asia generally refers to a form of ‘land clearing’ (conventionally ‘slash and burn’, with various forms of ‘slash and mulch’ or ‘controlled burning as more recent alternatives) to form a break with the preceding vegetation. Both from an economic and an environmental perspective, however, the ‘enrichment planting’ approach merits further interest.

21.4.3 Forest and Tree Plantations

In this section we focus on industrial, communal or individual forests or plantations established by planting and/or seeding through afforestation or reforestation activities, which are even aged stands of 1–2 species established at regular spacing (FAO 1998). As discussed above, plantations form an important and efficient source of wood and non-wood products and by reducing production pressure may have a tempering effect on the rate of natural forest loss. Yet, large scale forest plantations are a main cause of natural forest conversion and lost (ARD 2004; Barr et al. 2004; Forester et al. 2004; Sheng and Cannon 2004). Additionally, as mentioned above, forest plantations, particularly monocultures, provide limited genetic and biodiversity conservation, ecological resilience, and carbon storage services (Michon and de Foresta 1995; Lamb 1998; Murdiyarso et al. 2002; Roshetko et al. 2007a; van Weerd and Snelder, Chapter 16, this volume); and as with commercial logging of natural forests, tree plantations provide less social and livelihood services to rural communities than community managed forests and agroforestry systems (Tomich et al. 1998). Moreover, forest plantations have not been equally successful across the region; efforts to promote plantations regularly fail to achieve the expected targets and results (Moestrup 1999; Lasco et al. 2001; Lasco, Chapter 9, this volume; Barney, Chapter 13, this volume). This includes areas where timber is ‘cleared’ to provide short-term economic returns, without plantations being established (Barr et al. 2004; Sheng and Cannon 2004). When established many forest plantations operate on the premise that there are economies of scale in the planting, managing and harvesting of *trees*. In fact, the ‘economies of scale’ may derive from harvesting, marketing and processing stage and from regulatory frameworks or subsidized credit directed to large operators (Barr 2001, 2002).

Tree plantations are a paradox. They are an important and efficient source of wood and non-wood products, but are also a main cause of forest conversion and the loss of environmental services provided by those natural systems. A plantation strategy is required that maximizes their good characteristics and limits their negative impacts. Across the tropics there are large areas of deforested land in different degrees of degradation. Priorities should target degraded lands that can support tree plantations. Policies forbidding forest conversion should be strictly enforced. Government subsidies for plantation establishment should be restricted to those achieving land rehabilitation. Criteria for these measures should be developed at the national level. To avoid conflict, local communities should be informed of plantation establishment plans and given opportunity to provide input. More effective would be the simultaneous development of corporate-community plantation partnerships (FAO 2003b). Those partnerships are addressed in more detail below.

21.4.4 Smallholder Tree-Based Systems

Here we refer to land use systems that include natural forests, planted tree-based systems and systems that are a combination of both. For the purpose of our discussion the term and concept are interchangeable with *smallholder agroforestry systems*, which are small landholdings or parcels managed by individuals or groups of farmers. Depending on local needs or opportunities, smallholder systems may focus on tree crops, agricultural crops, livestock or a combination. These various systems will differ greatly in size, species component, tree density, tree longevity, and management intensity (Roshetko et al. 2007a). A shortage of local forest resources is often the catalyst of spontaneous expansion of smallholder agroforestry systems. This type of farmer-led spontaneous smallholder agroforestry development has occurred in Bangladesh (Byron 1984); Sri Lanka (Gunasena 1999); the Philippines (Luzon: Pasicolan and Tracey 1996; Schuren and Snelder, Chapter 3, this volume; Cebu: FAO 1993; and Mindanao: Magcale-Macandog et al. 1999); Kenya (Scherr 1995; Place et al. 2002); and Indonesia (Sumatra: Michon and Bompard 1987). In addition, proximity to urban centres creates high demand for timber, fruit and other forest products and stimulates spontaneous smallholder agroforestry. This is particularly true for areas far away enough from the extractive forest frontier and/or with large enough farms to support tree crops in addition to seasonal cash crops (Schuren and Snelder, Chapter 3, this volume). In other situations (e.g. in central and east Java) the (temporary) migration of the young people to cities results in extensification of land use with tree farming as a form of a ‘living savings account'. Under these conditions, smallholder farmers see tree farming as a means to diversify their production, reduce risk, and build assets to enhance family incomes and security (see also Schuren and Snelder, Chapter 3, this volume).

Smallholder farmer tree planting systems are generally successful. Smallholders have limited time and financial resources. The trees they plant represent a conscious investment for which other options have been forfeited. Farmers generally restrict plantings to the number of trees that can be maintained and integrate *tree growing* with their crop and animal production activities. The management practices undertaken to assure good food crop yields – cultivation, weed control and fertilization – also benefit their trees. The available land, labour, and other resources are allocated according to the farmer's objectives. Because landholdings are small, farmers can select the farm niches most appropriate for tree production. The combination of limited resources, small individual plantings, and intimate familiarity with the planting site result in high tree survival and good growth rates. In summary, smallholder tree-growing activities benefit from intensive management over limited areas and vested self-interest – the desire of the farmer to profit from her/his investment of time and resources.

Smallholders with diverse, risk-averse farms that include a significant tree component could be efficient tree producers of the future. Their tree farming systems have high potential to yield both wood and non-wood products and play an important role in the reforestation of degraded lands. Smallholder tree-based systems hold potential as one component of a general poverty alleviation strategy for agrarian-based poor rural communities (Krol 1992; Michon and Mary 1994; Roshetko et al. 2007a; Snelder, Chapter 2, this volume). Although the potential of tree-based systems for poverty alleviation has not been fully exploited and the extent to which these systems can alleviate poverty and enhance food security is poorly documented, the importance and potential of smallholder tree-based systems will continue particularly with the continued development of market-economies and rural infrastructure (Roshetko et al. 2002a).

To summarize, our experience is that under the right conditions smallholder farmers can and will cultivate a wide range of tree species as a component of their efficient, integrated and risk-averse livelihood and land-use systems and will effectively respond to the increased demand for wood and other tree products. To harness the potential of smallholder farmers, a *paradigm shift* is required in the forestry sector, to recognize and support farmer-led approaches to tree-based farming systems as part of the solution to achieve sustainable forest management objectives.

21.5 Technical Assistance to Support the Development of Smallholder Agroforestry Systems

Although smallholder agroforestry systems hold potential to meet demand for market products and provide household income, they have not been developed in an equally successful manner/way throughout the region. Experience indicates that besides a shortage of forests and market demand for tree products, the following factors have strong bearing on the successful development of smallholder agroforestry systems: (i) secure land tenure and land use conditions; (ii) supportive policy conditions; (iii) access to and knowledge regarding the management of quality germplasm; (iv) tree management skills and information; and (v) adequate market information and linkages (Roshetko et al. 2007b).

The first two factors, land tenure and policy support, are the basic enabling conditions required to facilitate the development of smallholder systems. Developing supportive tenure and policy conditions often requires broad-based negotiations which include participation from local, regional and national governments as well as the private sector and community organizations. A central part of such negotiations is determining just what issues require careful regulation (Fay and Michon 2005); with successful negotiations leading to consensus land management agreements and natural resource security for local farmers. More detailed decisions regarding land tenure and policy support are found below.

The other three factors: quality germplasm, tree management and market linkages, are technical issues that can be effectively addressed at the local level by government extension agencies, non-government organizations (NGOs), farmer organizations and/or individual farmers – once the enabling conditions are satisfied. Scientific research is an important means to compile and generate tree management specific technology specific for smallholder conditions and would otherwise not be available to farmers. Examples include, the studies on the alder-based cardamom agroforestry systems in eastern Himalaya, India (Sharma et al., Chapter 18, this volume) and studies how to manage the '*Imperata* regrowth window' best (i.e., the period between the cessation of food-crop interplanting and tree canopy closure which controls *Imperata* regrowth), for a range of planting patterns and tree species in Lampung (Indonesia) and northern Mindanao (the Philippines; van Noordwijk et al., Chapter 20, this volume). Moreover, efforts should be made to link smallholders with sources of quality germplasm (the formal seed sector) and technical support to effectively manage nurseries and agroforestry systems. This should include the implementation of nursery and system management training activities, linkages with *effective* institutional technical support, and the development of a cadre of farmer technical specialists. Training and participatory nursery development are proven methods of building farmers awareness, leadership, and technical skills; and independence regarding germplasm quality, production and management capacity (Koffa and Garrity 2001; Roshetko et al. 2004; Carandang et al. 2006). Specifically the development of farmer-to-farmer extension capacity is an important step towards helping local communities to create viable market-oriented smallholder agroforestry systems (Roshetko and Yuliyanti 2002; Roshetko et al. 2007b). Some strategies for strengthening market-orientation and market linkages for smallholder systems are discussed in the following section.

21.6 Strategies for Market Orientation

Access to existing markets has also been found to be a vital criterion for the development of market-oriented smallholder agroforestry systems (Scherr 1995, 1999; Potter and Lee 1998; Landell-Mills 2002; Tukan et al. 2006; Manivong and Cramb, Chapter 5, this volume). This might be more easily accomplished for high-value, high demand products such as agarwood (Heuveling van Beek and Persoon, Chapter 12, this volume) or cardamom (Sharma et al., Chapter 18, this volume), both of which are cultivated in forests and smallholder systems. Unfortunately, smallholders generally have weak market linkages and poor access to market information (Hammett 1994; Arocena-Francisco et al. 1999; Snelder et al. 2007). Successful strategies to orient smallholder systems with market demand at the local, provincial, national or international levels may vary in name, structure, intensity and approach. They all share the purpose to identify or quantify market demand and focus smallholder systems to produce products that meet that market demand. Here we discuss four such strategies: rapid market appraisals, the reforestation value chain, the certification of smallholder wood products, and equitable corporate-smallholder partnerships. All four strategies are flexible to address the conditions of target markets and local smallholder systems. Other similarities exist; a locally evolved approach may incorporate characteristics of any of the four and other strategies.

21.6.1 Rapid Market Appraisals

Experience demonstrates that besides weak market linkages, and perhaps because of that limitation, smallholder farmers often: produce products of unreliable quality and quantity, that do not match market specifications; rarely engage in grading and processing to improve product quality and value; and sell their products opportunistically as individuals – not through groups to achieve economies of scale (Roshetko and Yuliyanti 2002b; Roshetko et al. 2007b). These shortcomings can be documented and addressed through market surveys conducted using rapid survey formats (e.g., ILO 2000; Betser and Degrande 2001). Such rapid market appraisals (RMAs) seek to identify and understand: (i) the agroforestry species and products that hold potential for farmers (their specifications, quantities, seasonality, etc.); (ii) the market channels that are used and hold commercial potential for smallholder products; (iii) the marketing problems faced by farmers and market agents; (iv) the opportunities to improve the quantity and quality of farmers' agroforestry products; and (v) market integration (through vertical price correlation and price transmission elasticity) and efficiency (Roshetko and Yuliyanti 2002; Roshetko et al. 2007b).

RMAs are iterative processes. They utilize relevant information gathered from participatory approaches (both individual and group discussions) with all relevant stakeholders (farmers, collectors, dealers, processors through to the consumer), direct observation, detailed surveys, and secondary data sources. This iterative feature and the utilization of multiple sources allow all the information and data to be reviewed and checked for accuracy. Once results are consistent a summary of 'farmer marketing conditions and priorities' (priority species, marketing channels and agents, farmers' market roles, marketing problems, and opportunities) can be finalized and shared with all relevant stakeholders. Work plans are developed to identify and agree on actions that farmers, market agents and other stakeholders can take to improve the production and marketing of smallholder products. Work plans promote win-win conditions that will benefit farmers, market agents and other involved stakeholders (Roshetko et al. 2007b).

21.6.2 The Reforestation Value Chain

As demonstrated by various examples in this volume, a common failing of project-based tree planting initiatives is the short-sighted time frame and narrow focus. In many instances, farmers were encouraged and assisted to plant trees only to be frustrated by their inability to sell their tree products for a variety of reasons (e.g. low price, lack of market, lack of processing technology). This experience has left many farmers disillusioned by the false promise made by project implementers (Bertomeu, Chapter 8, this volume; Tolentino, Chapter 15, this volume). In spite of numerous failures, government agencies, donors and their partners continue to finance short-term tree farming and reforestation projects. An unforeseen backlash is that some farmers and communities may refuse to cultivate trees altogether.

To remedy this, Lasco (Chapter 9, this volume) proposes the use of the reforestation value chain (ReV Chain) which considers all the key stages in the tree farming process from land tenure to tree planting through marketing. In essence, the ReV Chain strategy acknowledged and accepts that a longer time horizon is needed for tree farming projects to succeed. This approach is best used from the project planning stage, so that the expertise and inputs required throughout the project and across the chain of activities can be provided. This requires the early involvement of all relevant institutions and individuals to not only provide relevant input, but also to help identify – and accept – their role, including contributions, responsibilities and benefits.

Most successful smallholder tree farming projects in the Philippines incorporated long-term and holistic approaches that are essential elements of the ReV Chain. For example, in the 1970s, the Paper Industries Corporation of the Philippines (PICOP) encouraged farmers in Mindanao to plant *Paraserianthes falcataria* for pulpwood (Tagundar 1984; Bertomeu, Chapter 8, this volume). PICOP provided technical assistance to farmers and guaranteed purchase of the wood biomass. Smallholder tree farms expanded quickly under this scheme. By 1997, there were 15,000 ha of tree farms in close proximity to PICOP's mill site and another 29,000 ha at further distances that sold wood to PICOP (Jurvélius 1997). In spite of some serious limitations, the PICOP tree planting partnerships with farmers is also good example of how private sector involvement can support the development of smallholder tree farming (Chokkalingam et al. 2006).

21.6.3 Certification of Smallholder Wood Products

A major challenge facing policy makers worldwide today is the development of appropriate policy instruments and regulations to address the pervasive improper and unsustainable exploitation of the world's natural forests. One such policy instrument is the certification of forest practices and derived products. Certification can be important for the range of stakeholders mentioned in RMA and ReV Chain subsections. Increasingly, market premium for certified products provide incentives for tree growers and forest owners to seek certification for their management practices and forest products. Certification is also increasingly forced upon producers through threats of boycotts by activists, buyers, and consumers.

Whereas the tendency towards sustainable forestry certification is true for developed countries, conditions in developing countries are less conducive to forestry certification. In a study addressing the global perspective on why countries certify, van Kooten et al. (2005) report that, in addition to factors such as forest export and GDP, the presence of politically, economically and socially advanced institutions has a positive effect on the likelihood that forest growers will seek certification voluntary. In addition, their results show that gender is a major factor in explaining countries' inclination to certify forest practices. In countries where women have little or no effective voice in civil society, the likelihood that tree growers and forest owners will seek certification is significantly reduced. Women in developing are mostly affected by environmental degradation and therefore more inclined to contribute to protective measures. If women's voices are hardly heard, concerns about the environment and need for environmental protection receives less attention (van Kooten et al. 2005).

Udo de Haes et al. (Chapter 10, this volume), using the Philippines as a case study discusses sustainable forestry certification for smallholder tree growing in developing countries. They conclude that there is potential for the certification of smallholder producers given that the market specifications for high-quality lumber can be met. This possibility is linked to providing smallholder access to the quality germplasm and technical assistance summarized above and details by Roshetko et al. (2007a, b). Once successfully implemented, certification of smallholder systems will create opportunities for value-adding wood processing activities that, in turn, will diversify perspectives with regards to rural economies. Other niches at the international market can be tapped, generating more income, where international consumer needs and standards are met. Before reaching this stage in sustainable forestry development, however, actions must be taken towards organizing the market and finding donor and government support in order to undertake such transition process (Udo de Haes et al., Chapter 10, this volume).

21.6.4 Equitable Corporate-Smallholder Partnerships

As discussed above, demand for forest productions continues to increase as the world human population and incomes grow. The world's area of natural forest is shrinking and there are global trends to reserve areas of natural forests for conservation purposes. Forest plantations are an effective and efficient means of producing forest products. These systems must compete with other landuse options to meet economic, social and environmental concerns. It is increasingly important that besides providing economic returns to their investors, forest industry operations should also provide opportunities for adjacent communities to enhance their livelihoods. Equitable corporate-smallholder partnerships can address these issues.

Corporate partnerships that establish agreements for industry to purchase wood produced by other entities (smaller corporations, groups or individual) are now well established and growing rapidly. Some of these partnerships are large and focus primarily on biomass production; others are small and concerned with meeting multiple objectives. Equitable corporate-smallholder partnerships function on the basis of empowering smallholders or communities in negotiation and management processes and provide economic returns based on the invested equity. The smallholders and corporations are business partners. Partnerships are based on sound financial and business principles, but with indicators for equitable social and environmental criteria (FAO 2003b). Based on negotiation and agreement, the form of the partnership may vary, with the roles, responsibilities, and returns for each partner varying accordingly. Smallholders could serve solely as landowners providing their land to the corporation, or they could be responsible for establishing and managing tree crops under regimes negotiated with the corporation. Through a series of field projects, an international workshop, and subsequent synthesis FAO, CIFOR and other partners have developed a set of guidelines that enable and support the development of viable *equitable corporate-smallholder partnerships*. The guidelines enable stakeholders to address, in a substantive and transparent manner, negotiations towards economic, financial, social, and environmental sustainability. Policy issues are also addressed. A framework is provided to facilitate joint action learning between smaller landowners, companies, research and extension agencies, non-government organizations (NGOs), and other stakeholders that leads to greater equity in negotiation, and as a consequence, greater opportunities for social and ecological sustainability. Further field testing of the guidelines under a broader range of conditions is required and being conducted. Some corporate partners have expressed interest in having the guidelines/framework recognized as an international accreditation scheme, after further testing and development (FAO 2003b).

21.7 Environmental Services

While smallholder tree-based systems are typically less diverse than native forest, they may act as a catalyst for recovery of degraded habitats into naturally regenerating forest with higher biodiversity conservation value (provided hunting is banned and native species are added to the stands; van Weerd and Snelder, Chapter 16, this volume) or contain a much greater number of plant and animal species than most large-scale forest plantations; the latter is particularly true for the so-called agroforests (Michon and de Foresta 1995; Murdiyarso et al. 2002). This diversity can, at times, provide ecological resilience and contribute to the maintenance of beneficial ecological functions. Participation by local communities in forest, including agroforest, management is often critical to successful forest conservation (Suyanto 2006; Tarigan et al. 2007). Agroforests, similar to plantations, are "working forests" and they can help relieve some of the pressure to harvest native forests (although their presence as such is not a sufficient condition for protection of old growth forests (Angelsen and Kaimowitz 2001; Michon and Bompard 1987; Tomich et al. 2001; Tomich and Lewis 2001). Linked systems of upland and riparian tree-based buffer systems, designed in regards to other landscape practices and features, can optimize soil and water conservation in the watershed (van Noordwijk et al. 1998), along with other economic and social services. Much of the opportunity to store carbon through afforestation will occur on agricultural lands due to the vast land area devoted to agriculture throughout the world (Brown et al. 1996; Watson et al. 2000; Smith and Scherr 2002).

In societies where the majority of people live in (sub)urban areas, concerns over the accelerating loss of open and green space tend to become prominent. This is a quality-of-life issue to many and raises the potential for agroforestry applications at the agricultural/community interface to restore ecological functions that provide for storm water management, wildlife habitat, recreational opportunities, and aesthetic enhancements.

Converting environmental services (ES) of tropical forests from public goods to tradable services is a promising strategy in safeguarding forests' ecosystem functions and services in tropical regions and elsewhere. Yet, the development of markets for such services depends on the various actors that operate within this marketing field and the criteria they use for engaging in tropical forestry projects providing environmental services. For example, Sell et al. (2006) conducted a survey among experts of 45 institutions in Latin America and Europe, representing various key market-actor groups of, respectively, the supply side (developing countries) and the demand side (developed countries) in terms of markets for environmental services. They found that experts from Latin America emphasized criteria related to markets and information/knowledge management whereas experts from Europe put more emphasis on social and environmental benefits and sustainability. These variances likely reflect the differences in social-economic development of the respective regions. It is equally likely that similar differences exist between experts from Asian and European institutions, suggesting there is a need for developing appropriate support mechanisms and enabling conditions in order to match criteria and facilitate tradable environmental services in developing countries. The latter is also true when addressing the question of how to integrate the role of smallholder tree growing in environmental services.

In a recent provocative piece Wunder (2007) suggests that smallholder communities are not the most likely beneficiary of most environmental service programs. The most likely beneficiaries are those who currently practice unsustainable management or represent a potential threat to the environment. Smallholder communities who already practice sustainable management are not likely to attract environmental payments, as those payments would not result in additional environmental services. Additionally, an environmental services program involving communities of smallholders would have high transaction costs and thus be less attractive to investors. The tier system discussed by Lasco et al. (Chapter 17, this volume) makes distinctions regarding how environmental service payments are justified and determined. The system acts as a guide in comparing the quality of the environmental services offered for "sale" by various projects or providers; increasing competition between buyers and sellers. Such sobering analysis demonstrates that environmental service programs are not necessarily beneficial to smallholder communities. Many efforts may have negative impacts for local communities, particularly the poor, by restricting land access or landuse options. Unless local residents receive additional benefits, they are not likely to accept restriction on their current activities or options. Such a logical response threatens the success of environmental services program. It is important to identify the enabling conditions that will favor a flow of local benefits from an environmental service program, thus facilitating program success. Reviewing various types of smallholder tree planting systems to address carbon storage, Roshetko et al. (2007a) identify four enabling conditions that are of universal application to all environmental service programs: integrated planning and project design; establishing clear, stable and enforceable rules for access to land and trees; managing high transaction costs; and ensuring dynamic flexibility for co-generating other environmental services. Their discussion is summarized here along with additional relevant citations.

21.7.1 Integrated Planning and Project Design

Smallholders invest in trees as one component of their overall on-farm and off-farm income/livelihood generation system. The following factors are found to be positively correlated with successful smallholder tree planting activities – adequate food security; off-farm employment; sufficient household labor; higher education levels; access to land that is not needed for food crop production, and lower risks (Predo 2002; Yuliyanti and Roshetko 2002; Tyynela et al. 2002; Schuren and Snelder, Chapter 3, this volume; Barney, Chapter 13, this volume). As smallholders are not likely to be solely interested in environmental services, such a program should integrate its activities into the household's and community's broader development plans (Bass et al. 2000; Desmond and Race 2003; Tyynela et al. 2002), particularly agriculture and agroforestry productivity. Efforts should be made to identify the community's development priorities, even when such priorities do not formally exist. While an environmental service program might not be able to directly address priorities regarding infrastructure, health care or education, it should show awareness of these issues and when possible provide support or at least not impede those priorities. The program should also help to strengthen community institutions and build their capacity in relation to: agroforestry;

negotiations; planning and leadership, and possibly in the concepts of environmental services (CIFOR 2000; Tipper 2002). In the long-term, this type of community-level capacity building may be the most significant contribution to the development of a successful, low-cost smallholder tree planting process that supports local livelihoods and environmental services (Roshetko et al. 2007a).

21.7.2 Establishing Clear, Stable and Enforceable Rules for Access to Land and Trees

Clear land tenure and tree use rights are imperative for the successful implementation of any tree planting activities or environmental service program (Scherr 1995; Scherr 1999; Potter and Lee 1998; Desmond and Race 2000; Predo 2002; Tomich et al. 2002; Yuliyanti and Roshetko 2002; Barney Chapter 13, this volume; van Noordwjik et al. Chapter 20, this volume). Without guaranteed rights to utilize the trees, smallholders are not likely to plant nor tend trees. Delineating and defining land and tree access rights, whether individual or commonly held, must be a high priority for the program. Securing tenure rights can be one reward resulting from the program; however it should not be the only 'carrot' to get people to plant trees. Tenure rights must be part of a wider negotiation process that addresses the communities' broader development needs. Such a negotiation process should be a fundamental part of the project design, as discussed below (Roshetko et al. 2007a).

21.7.3 Managing High Transaction Costs

A successful environmental services program will require close collaboration between various types of partners – program staff, governments (both local and national), communities of smallholder farmers, and independent local institutions. All parties should be treated as equals and actively participate in the project design. The objectives and activities of the project, as well as the responsibilities and benefits of each party should be determined through negotiation – not unilaterally set (Brown et al. 2001; Desmond and Race 2000; Mayers and Vermeulen 2002; Tyynela et al. 2002). This negotiation process must be participatory, transparent and agreeable to all partners. Specifically, farmers must understand the services they are providing and agree with the benefits they are to receive. The terms of engagement should be equitable, realistic and formalized in a legal contract. It is likely that there will be misunderstandings and conflicts. Thus, the contract should be flexible and renegotiable (CIFOR 2000; Desmond and Race 2002; Tyynela et al. 2002; Fikar 2003). With these requirements and the likely engagement of numerous smallholder farmers, the single largest hindrance to program development is high transaction costs that include: (a) the costs associated with making information (e.g., on technology, markets and market players) accessible to multiple clients; (b) facilitating and enforcing smallholder agreements; and (c) designing feasible monitoring systems. While these (high) costs are justifiable as the *extra costs* required to achieve more equity and welfare, they are not likely to be underwritten by investors who are primarily interested in an environmental service and may have other investment options. Thus, to attract investors to smallholder-oriented program, co-funding mechanism are needed such as multilateral or bilateral support to cover the higher costs that assure significant social benefits (CIFOR 2001; Wunder 2007).

21.7.4 Ensuring Dynamic Flexibility for Co-generating Other Environmental Services

The development of various smallholder agroforestry systems is likely to generate more than one environmental product and service, such as biodiversity conservation, eco-tourism, carbon sequestration, and watershed protection. These services generate benefits to different sectors of society, and as such, could warrant payments to reduce scarcity and ensure sustainability. Markets for these environmental services are in different stages of development and it is necessary to assure that they benefit smallholders. The development of pro-poor payments for any of these environmental services requires the same enabling conditions. Hence, program design, tree product marketing, tenure arrangements, and institutions for underwriting transactions costs need to be flexible to allow for the inclusion, addition, of the multiple products and services generated by the same tree-based systems (Roshetko et al. 2007a).

21.8 Institutional and Policy Support

Institutional changes and a better understanding of communities, their needs and perceptions, are clearly imperative if smallholder tree growing activities are to successful support sustainable forest management and contribution to livelihood development. Within this context, Kant and Berry (2005) point at the need for institutional analysis that takes into account interactions between both factors of internal relevance to institutions (i.e., the rules, norms, and codes that, whether formal or informal, define the rights, privileges and obligations of various groups under a regime) and organizations (i.e., the physical manifestations of institutions) as well as factors of external relevance (i.e., the "external setting" defined by social, economic, environmental, and international features). Their recommendation is based on an analysis of failed forest regimes in India: the ineffectiveness of past forest regimes proved to be related to the non-complementarities between formal (government-based) and informal (local, community-based) institutions, leading to adaptive inefficiency, and the unconstructive organizational culture and perceptions of forestry organizations' members. Organizational inertia appeared to be one of the main factors impeding institutional changes in this case and, thus, institutional change alone, without complementary change in the attitude of member of forestry organizations and organizational culture, failed to provide the desired results.

Similar conclusions may apply to the smallholder tree-growing constraints in the case studies referred to in this book. Policy and management prescriptions for sustainable forest management should address the institutional and organizational aspects and the external setting in an integrative manner. Hence, a clear challenge lies in the development of supportive institutions and organizations together with a fundamental policy rectification that can lay a basis for a free and fair tree product market making smallholder tree-growing systems more sustainable and equitable.

21.9 Lessons from the Philippines and Implications for Other Asian Countries

Several lessons emerge from the papers presented in this volume. First, the Philippine experience has shown that smallholder tree farmers in developing Asian countries are capable of producing large quantities of timber and they can efficiently supply local, national and international markets (Bertomeu, Chapter 8, this volume). There is a caveat to this however. Government agencies and NGOs who promote tree farming must be careful not to oversell its financial benefits. Experience from other countries stress that appropriate technical support most also be provided (Roshetko et al. 2007a; Manurung, Chapter 4, this volume). Farmers may feel short-changed when the expected financial windfall does not happen. This may lead to disenchantment with tree farming and could make it harder to convince farmers to go into it in the future. Another important lesson is that market forces need to be taken into account in promoting tree farming and the kind of species to plant. There is a tendency to focus only on a few species because of a number of reasons (fast growth, readily available planting materials, high survival rate, high demand at the time of planting). This could result to oversupply driving the prices down.

Second, bioeconomic analysis showed that tree-based land use systems have significantly higher financial profitability and environmental benefits than pure cash crops (Predo and Francisco, Chapter 14, this volume; Snelder et al. 2007). However, the risk of tree farming appears to be higher as reflected in the wider variation of economic returns which could prove to be a significant barrier to small farmers who are typically risk-averse. There is therefore a need to find ways to mitigate the risk. One way of doing this is to diversify income sources from tree farms. New opportunities such as payments for carbon sequestration should be explored.

Third, while most tree farms rely on exotic species, there is a rising interest in the use of indigenous species for tree farming (Tolentino, Chapter 15, this volume). The current interest in biodiversity conservation provides additional incentives for planting indigenous species. However, significant constraints remain such as the supply of quality germplasm, lack of information of cultural management, and unstable forest policy. There is a need to evaluate which of the numerous indigenous species in tropical countries should be prioritized for research and development. Preliminary works for the Philippines, Indonesia, Vietnam, Thailand and Southeast Asia in general have been completed (Roshetko and Evans 1999; Gunasena and Roshetko 2000).

Fourth, the Philippine government should remove policy restrictions curtailing the use of planted trees and provide incentives appropriate to smallholder farmers (Bertomeu, Chapter 8, this volume; Masipiqueña et al., Chapter 7, this volume; Chokkalingam et al. 2006). The Philippine government has been slow in acknowledging the importance of timber production by smallholder farmers. Existing policy disincentives constrain the establishment of tree farms and the use of trees by the wood processing industry. These include permits and regulations governing cutting and transport of farm-grown trees. Current policies favor big commercial tree farms and utilize terminology relevant to natural forests – although harvesting in natural forests is now widely banned. Efforts must be made to simplify policies and provide other incentives for smallholder farms. At the same time, farm forestry extension programs should invest in training programs aiming at improving management and marketing.

21.10 Conclusion

The papers in this volume demonstrate that smallholder tree-based (agroforestry) systems play significant roles in the livelihoods of local communities, yield both wood and non-wood products for commercial markets, and provide environmental services for the public good. The importance of smallholder systems will continue to increase as the global forest resource shrinks further and human populations expand. Yet, smallholder systems are ignored in formal definitions, statistics, and legal/institutional frameworks. The messages of this chapter and the entire volume are that there is a clear need for a paradigm shift in the forestry, development, and extension sector to:

1. Recognize the contribution and importance of smallholder agroforestry systems *as part of* the solution to achieve sustainable forest management and production objectives
2. Adopt more holistic and sustainable strategies to support and strengthen the market orientation of smallholder agroforestry systems
3. Provide technical support to smallholder farmers that enable them to improve their success, productivity, and profitability of their agroforestry systems
4. Develop supportive institutions (rules and organizations) together with a fundamental policy rectification which would lay a basis for sustainable and equitable regional tree product markets
5. Implement enabling conditions that support the success of smallholder agroforestry systems and their potential to provide environmental services

An additional overarching message is that natural forests, forest and tree plantations, sustainable management, and smallholder agroforestry systems all have a vital role in stabilizing and expanding a new level of tree cover and forest functions that meet economic, social, and environmental expectations of land owners/managers and broader human society.

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