Agroforestry and Land Use in the Philippines

Edited by Rodel Lasco and Alexander Flor

Nestor T. Baguinon
Rodel D. Lasco
Damasa B. Macandog
Paulo N. Pasicolan
Virgilio T. Villancio

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

and Land Use in the Philippines

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Published by the World Agroforestry Centre
Southeast Asia Regional Office
Jalan CIFOR, Situ Gede, Sindang Barang, PO Box 161, Bogor 16001, Indonesia

Printed in the Republic of the Philippines
First Printing, January 2007

Cover Design and Artwork by Felix Marlo Flor

This book was prepared by national experts commissioned by the World Agroforestry Center. The analyses and assessments contained herein do not necessarily reflect the views of the World Agroforestry Centre or the governments and agencies they represent.

ISBN No. 978-971-93153-4-6

PREFACE

In 2002, the World Agroforestry Centre (ICRAF) published a series of 15 research-based lecture notes inspired by the Alternatives to Slash-and-Burn or ASB initiative. Center partners in Southeast Asia received the materials enthusiastically. The materials were all in English, however, and the need was felt to make them available in the major Southeast Asian languages. Thus, a regional project was initiated to adapt and translate teaching materials on agroforestry and environmental services in Southeast Asia, using the ASB lecture notes as the main material supplemented by national research results. The project was conceived as a collaborative writing project of national experts in five key themes related to environmental services. These themes were: land use issues and options to address them; local benefits and impacts; carbon; watershed functions; biodiversity; and environmental service and land use trade-offs and policy aspects.

Six countries were identified to participate in this undertaking: Indonesia; Philippines; Thailand; Lao PDR; Vietnam; and China. In December of 2002, contingents from these six countries converged in Chiang Mai, Thailand to agree on the framework, draft the content outline and develop the country specific work plans for the undertaking. The Philippine team was composed of the authors and editors of this volume. Due to certain considerations, the team's output would differ in form and in substance from those of the other country teams.

Firstly, the intended readers or users, if you will, of these materials are teachers and students of undergraduate agroforestry courses. Since English is the medium of instruction in Philippine educational institutions, the team proposed not to translate the ASB lecture notes but to rewrite them within the appropriate scientific, historical and policy contexts relevant to the Philippine situation. Thus, some of the chapters contained herein may differ substantively in perspective from the original ASB notes.

Secondly, it was initially planned that the teaching materials will be made available via the ICRAF and ASB Websites. However, opportunities for co-publication of the materials at the national level were also explored. Among the members of the Philippine writing team was the Vice Chair of the Southeast

Asian Network for Agroforestry Education or SEANAFE, Dr. Virgilio T. Villancio, who suggested that the team develop a textbook for undergraduate agroforestry students in the country instead.

This volume represents the output of the team, composed of some of the leading lights in Philippine and Southeast Asian Agroforestry: Dr. Rodel Lasco, Dr. Virgilio Villancio, Dr. Nestor Baguinon, Dr. Paulo Pasicolan, and Dr. Damasa Macandog. Their collective expertise is found between the covers of this book. The agroforestry student would profit well from the insights and analyses contained herein.

ALEXANDER G. FLOR
National Coordinator, Philippine Team

ACKNOWLEDGEMENTS

We would like to acknowledge the contributions of the following:

The World Agroforestry Centre provided the conceptual and technical inputs for this book which was financially supported by the Swedish International Development Cooperation Agency (SIDA). Mr. Per G. Rudebjer served as the Project Coordinator. Dr. Meine Van Noordwijk, Dr. Bruno Verbist, Dr. Horst Weyerhaeuser, and Dr. David Thomas provided us with intellectual inputs that guided our work.

Ms. Glo Acaylar of ICRAF Philippines office with the help of Ms. Amy Quintos facilitated the administrative arrangements of this undertaking. Ms. Ruby Lynn Salac prepared the layout and led in publishing coordination tasks. The cover design, artwork, and monoblocs were conceptualized and illustrated by Felix Marlo Flor.

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Dr. Baguinon's research and publications are all in line with his field of specialization, Forest Ecology and Conservation Biology, which includes Biodiversity Conservation.

Aside from teaching, Dr. Baguinon also serves as consultant in various corporate and government projects which deals with forestry matters and the environmental services sector. Simultaneously, he also serves as volunteer for environmental advocacy and capacity building of upland communities with non-government organizations. Since 2003, he sits as member of the board of directors of the Philippine Federation for Environmental Concerns.

Dr. Rodel D. Lasco has over 25 years of experience in natural resources research, conservation, education, and development at the national and international levels. He serves as the Philippines Programme Coordinator of the World Agroforestry Centre (ICRAF) since April 2004. Prior to that, he was full Professor of Forestry and Natural Resources at the University of the Philippines Los Baños (UPLB).

He has over 40 technical publications in national and international journals dealing on the various aspects of natural resources conservation and management. Recently, he has pioneered a research study on the role of tropical forests in climate change/global warming. He also spearheaded the Philippine component of the global Millennium Ecosystems Assessment which was designed to assess the role of ecosystems and its biodiversity in providing services for human well-being.

In 1997, he was recognized as one of the 10 outstanding young scientists of the Philippines by the National Academy of Science and Technology. In 2006, he was awarded outstanding scientist by the Forest Research Society of the Philippines.

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Dr. Macandog has led the implementation and completion of internationally funded projects such as the Smallholder Agroforestry Options for Degraded Soils (SAFODS-Philippines) Project (2002-2006) funded by the European Commission, improving estimates of biomass of secondary forests in Southeast Asia, and bioeconomic modeling of smallholder farms in Imperata-grasslands.

Dr. Macandog also headed the implementation of an information support project for the Southeast Asian Regional Network on Soil Fertility and Improved Fallow Management from 2001to 2004. Moreover, Dr. Macandog coordinated NAPIID, a network of greenhouse gas (GHG) inventory experts in Asia that focused on improving GHG inventories. She organized the UPLB-wide Bioinformatics Awareness seminar series and National Agricultural Bioinformatics Convention in 2003-2004 and served as Chair of the UPLB Bioinformatics Committee.

Dr. Paulo N. Pasicolan is Professor of Environmental Science and Social Forestry, Isabela State University (ISU), Cabagan, Isabela, Philippines. He is the Founding Director of the Upland Resource and Development Center, ISU Cabagan. He has been involved in many community forestry and farm forestry projects with focus on tree growing and upland farming systems.

Dr. Pasicolan finished his BS in Forest Products Engineering at UPLB in 1978, MS in Environmental Studies at UPLB in 1988, and PhD in Environmental Science and Management, Leiden University, the Netherlands in 1996. He authored many technical papers on farm forestry mostly circulated in international publications and refereed journals.

Concurrently, he is working as Forestry Research Adviser of the Lao-Swedish Upland Agriculture and Forestry Research Programme, National Agriculture and Forestry Research Institute, Lao PDR (June 2005-March 2007).

Dr. Virgilio T. Villancio is University Researcher at the Farming Systems and Soil Resources Institute of the Agricultural Systems Cluster of the College

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His current involvement includes the development of extension modalities to support disaster stricken communities in Infanta, Quezon and the integration of *Jatropha curcas* in agroforestry and agricultural systems with support from the World Agroforestry Centre (ICRAF). He is coordinating the development of an Integrated Research and Development Program for *Jatropha curcas* as Biodiesel with support from the Philippine Council for Agriculture, Forestry and Resources Research and Development (PCARRD), Department of Science and Technology (DOST), and the PNOC- Alternative Fuel Corporation.

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Alienable and disposable (A&D) Lands
Assisted Natural Regeneration (ANR)
Before Present (B.P.)
Community-Based Forest Management (CBFM)
Community-Based Forest Resource Management (CBFRM)
Community Environment and Natural Resources Office (CENRO)
Clean Development Mechanism (CDM)
Community Forestry Program (CFP
Certificate of Stewardship Contract (CSC)
Department of Agriculture (DA)
Department of Agrarian Reform (DAR)
Dichloro diphenyl trichloroethane (DDT)
Environmental Research and Development Bureau (ERDB)
Farming System and Soil Resources Institute, College of Agriculture (FSSRI-CA)
Forest Development Center (FDC)
Forest Management Bureau (FMB)
Forest occupancy management (FOM)
Greenhouse gases (GHG)
Gross national product (GNP)
High yielding varieties (HYV)
International Board for Soil Research and Management (IBSRAM)
Integrated social forestry (ISF)
Integrated Social Forestry Program (ISFP)
Intergovernmental Panel on Climate Change (IPCC)
Land use, land use change and forestry (LULUCF)
Master Plan for Forestry Development (MPFD)
Management of Soil Erosion Consortium (MSEC)
Mean annual increment (MAI)
Methane (CH_4)
National Irrigation Administration (NIA)
National Integrated Protected Area System (NIPAS) law
National Power Corporation (NPC)
New England Electric System (NEES)
Non-government Organizations (NGOs)
Overseas Development Administration (ODA)

Preferred crop trees (PCTs)
Presidential Decree (PD)
Pressure-state-response (P-S-R) framework
Sloping Agricultural Land Technology (SALT)
Short-term financial and food security needs (SAFODS)
Sediment Delivery Ration (SDR)
Science and Technology (S&T)
Sustainable land management (SLM)
Soil organic matter/carbon (SOC)
Philippine Selective Logging (PSL)
Third Assessment Report or TAR
Timber Licenses Agreement (TLA)
Timber Stand Improvement (TSI)
Universal Soil Loss Equation (USLE)
World Resources Institute (WRI)
United Nations Environment Programme (UNEP)
United Nations Development Program (UNDP)
University of the Philippines Los Baños (UPLB)

CHAPTER I

ASSESSMENT OF NATURAL RESOURCES MANAGEMENT IN THE PHILIPPINES

Nestor T. Baguinon

OBJECTIVES

After studying this chapter, the reader should be able to:

1. describe aspects of Philippine history and culture which have influenced contributions to the current environmental situation of the country; and
2 enumerate the different factors that have detached Filipinos from their environment.

INTRODUCTION

The first half of the chapter provides a historical perspective of the Philippines to help understand the present environmental problems of the country. This makes possible the crafting of solutions that address different perspectives. In an expository style, the natural terrestrial ecosystems of the Philippines are presented here as a product of millions of years of evolution. This nurtured the Philippines to become one of the megabiodiversities of the world.

This chapter further cites the equally diverse culture of the Philippines. It shows how Filipinos learned to adapt to a diverse environment (Jocano, 1975) and were able to develop farming technologies that are in harmony with the natural forests (Olofson, 1981).

The second part of the chapter describes how institutions and social processes have led to the alienation of the Filipino from his environment. A consumer-oriented value system, patent system of owning land, the green revolution agriculture and environmentally pervasive forestry (e.g., mechanized logging, introduction of alien bioinvasive species, and ecosystem substitution with tree-based agroecosystems) are to be expounded here to bring a social dimension to the seemingly pure ecological problem. The chapter also posits that such alienation is a function of an educational system that has promoted ecologically destructive agriculture and forestry. The chapter concludes that there is much to be done to address the urgency of the Philippine environmental situation.

THE PRISTINE PHILIPPINE SETTING

The Philippines is an archipelago of about 7,100 islands and a total land area of 30 million hectares or 300,780 square kilometers. It is bounded by Taiwan on the north, Celebes and the Moluccas on the south, and Borneo on the southwest (Fig. 1-1).

Climate varies as an effect of north-south trending mountain ranges (Fig. 1-1) such as the Sierra Madre Mountain Range with its parallel in Northern Luzon, the Cordillera Mountain Range, the Samar backbone mountains and the Surigao Mountain Range. Thus, on the extreme eastern seaboard its climate has a uniformly distributed rainfall. Western Luzon and Visayas, on the other hand, have seasonal climates such as dry from October to April (Fig. 1-2a) and wet from May to September (Fig. 1-2b). Intermediate climates exist in between (Oldeman and Frere, 1982).

Philippine soils are relatively young compared to older islands and continents. There are alluvial soils characteristic on floodplains and valley floors (Fernandez and de Jesus, 1980). Alluvial soil intergrades with a variety of soil types depending upon the parent material. There are calcareous soils in limestone, andosols around and near volcanoes, yellow podsols on sandstones especially on high elevation areas to podsols on quartz-dominated sand near seacoasts, serpentine soils from ultramafic and ultrabasic rocks, and the usual oxisol derived from granite or basalt (Burnham, 1976).

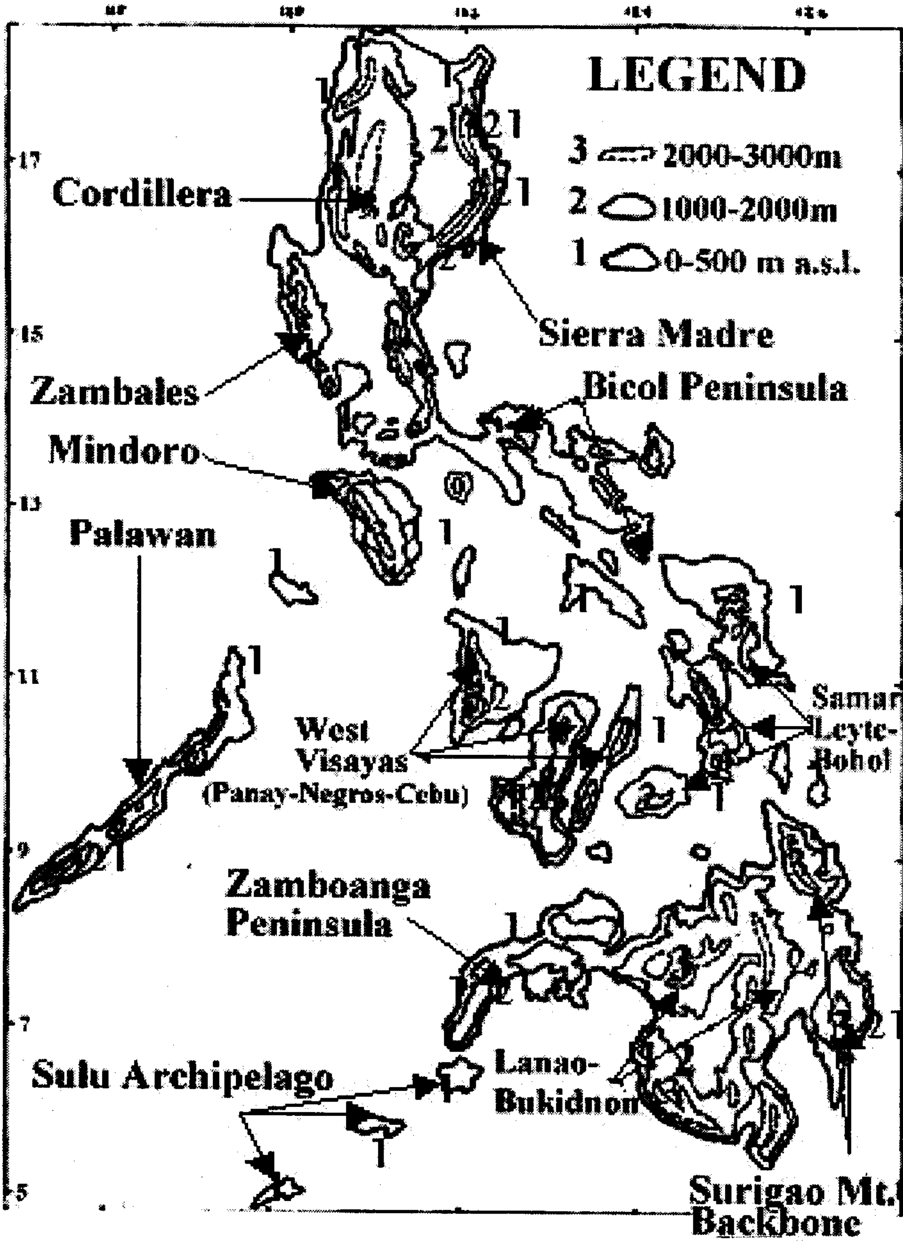
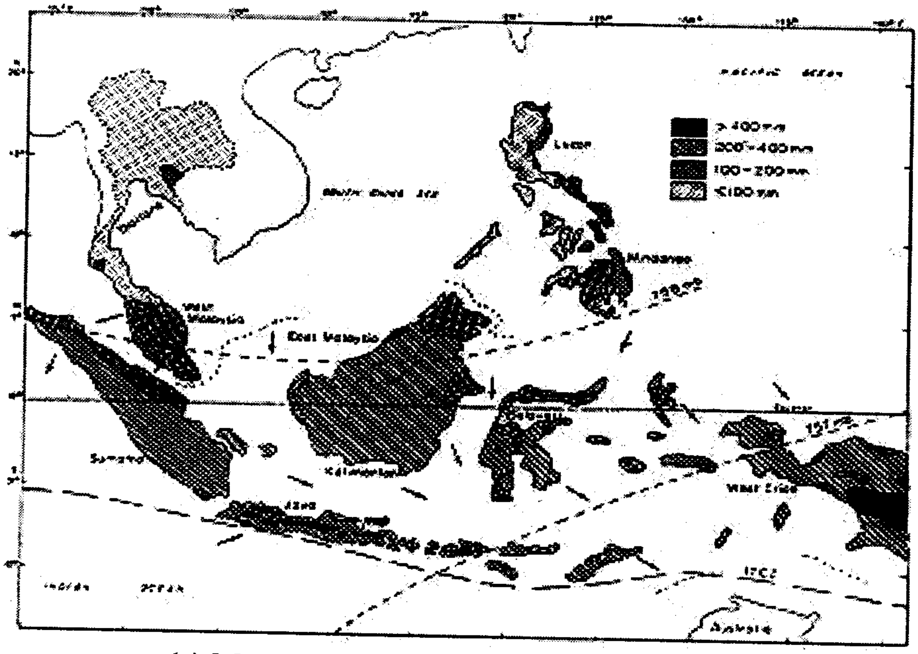


Fig. 1-1. General relief map of the Philippines.

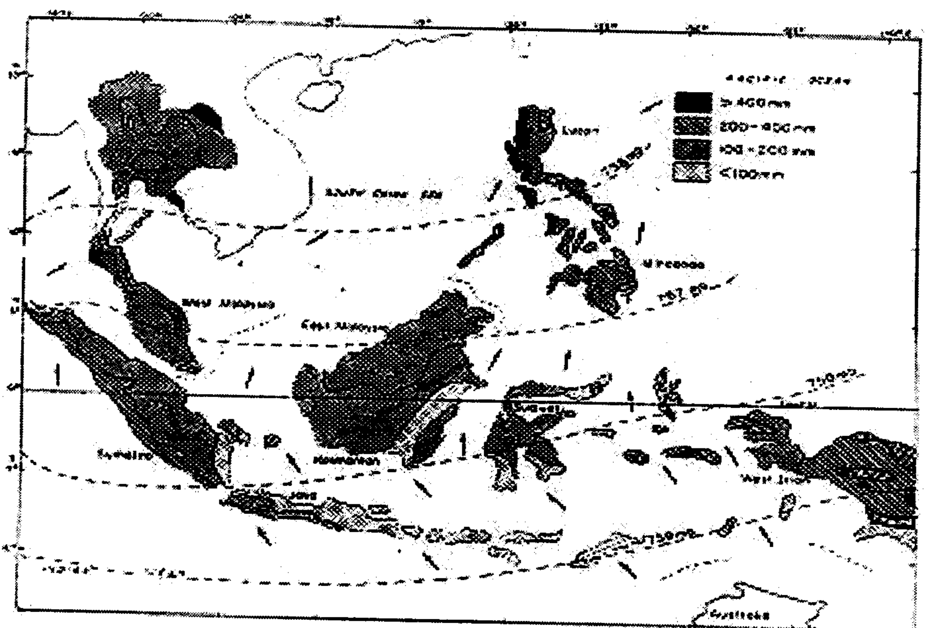
Philippine forests and other vegetation are intimately associated with underlying soil substrate, climate, and topography (Whitford, 1911). Thus, throughout the country on estuarine deltas, one finds **mangrove** forests (Dickerson, 1928; Knox and Miyabara, 1984) that abruptly change into **beach** forests above the intertidal zone (Merrill, 1945). Lowland **dipterocarp** forests consists of dipterocarp genera, namely: *Anisoptera*; *Dipterocarpus*; *Hopea*; *Parashorea*; *Shorea;* and *Vatica.* Common on volcanic soil, this forest type develops between and up to about 1,000 meters sea level. **Evergreen dipterocarp forests** are found at the rainy eastern seaboard. The slightly deciduous **semi-evergreen dipterocarp** forest develops at the western seaboard in Western Luzon and Southwestern Tagalog (Newman, et al., 1996; Whitford, 1906). Where the parent material is limestone, one finds **molave** forests, the Philippine's version of the tropical deciduous forest. In serpentine soils derived from ultrabasic rocks, **ultramafic forests** are semi-open and most trees are stunted (Hilleshog, 1984). In **montane forests** above 1,000 meters, oaks, laurels, and tropical conifers replace the dipterocarps. In the Cordillera and Zambales highlands, 600 to 2,000 meters above sea level, disturbed forests are succeeded by gregarious **pine forests** and in worse cases, into **grasslands** (Kowal, 1966). On the other hand, areas with uniform rainfall have their disturbed montane forests succeeded by **brushlands** and even into grasslands in extreme cases.

Summits of high mountains are covered with **mossy forests** but in Mt. Pulog at 2,900 meters above sea level, **alpine vegetation** dominated by short grasses covers its summit (Merrill and Merritt, 1910). Palawan features heterogenous vegetation. Dipterocarps there belong only to the genera *Dipterocarpus* and *Vatica* (Hilleshog, 1984) although the presence of *Shorea* and *Hopea* is possible (Baguinon, 1997).

Various fauna are associated with different Philippine vegetation types. There are obvious differences among the major islands such as Luzon, Visayas, Mindanao and Palawan because of their unique geological histories (Dickerson, 1928). For example, no squirrel, flying squirrel, flying lem,ur, bearded pig and tarsier occur in Luzon, the Panay-Negros-Cebu complex and Mindoro. Palawan fauna is more Bornean than Filipino (Rabor, 1977). Civet cats and long-tailed macaque are found throughout the Philippines except the Batanes and Babuyan islands. On the other hand, both the Philippine deer and warty



(a) Monsoon winds and rainfall pattern, March.



(b) Monsoon winds and rainfall pattern, August.

Fig. 1-2. Rainfall patterns of Southeast Asia.

Source: Oldeman and Frere, 1982.

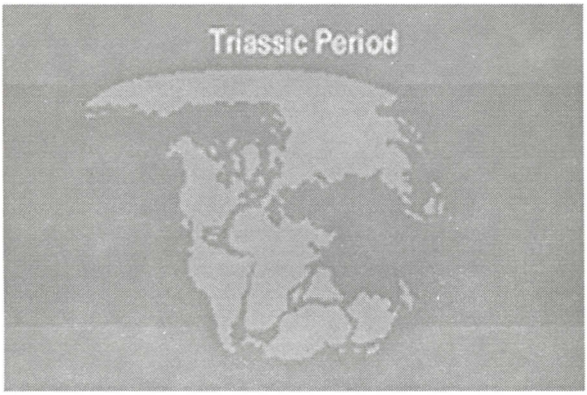
pigs are found from Luzon to Mindanao except in Western Visayas and Palawan. West Visayas has unique species of deer and warty pigs while mainland Palawan has bearded pigs only.

The previous description of the biophysical setting of the Philippines approximates the pristine conditions before humans dominated the archipelago (Punongbayan, et al., 1998). The whole archipelago is clothed with natural vegetation from the seashore to the highest summits (Jocano, 1975). For thousands or even millions of years, it was intact except when volcanoes erupted (Van Leeuwen, 1936) or earthquakes occurred and created significant breaks in a seemingly unbroken canopy adding to the small gaps created by the fall of over-mature trees. In time and space, random creation of gaps and subsequent closure into forests occurred in endless cycles (Kellman, 1970; Whitmore, 1976). Thus, there is a mosaic of habitats for all indigenous and endemic animal and plant species. High patchiness supported high biodiversity, as well as high cultural diversity when humans invaded the archipelago.

EVOLUTION OF THE PHILIPPINE ECOSYSTEM

To understand Philippine biodiversity, it must be told from an evolutionary context and perspective. Fossil pollen dating back to **Oligocene** (20 million years ago) proves mangrove and beach forests developed first (Muller, 1972). They helped build up soil in island arcs such as those of ancient Luzon (e.g., Sierra Madre).

Fig. 1-3a, Frames 1 and 2 show the earth during the Triassic (245 million years ago) to Cretaceous (70 million years ago) periods when dinosaurs dominated the earth and the Philippine archipelago was non-existent. Gondwana broke into five continents, India and Australia moved northwards. Frame 3 represents the Quaternary (last 2 million years ago) when India collided with Asia (the Himalaya Mountain Range was formed) while Australia closed-in against the Malay Archipelago. Fig. 1-3b includes Frame 4 (Early Oligocene or 35 million years ago) and Frame 5 (Late Oligocene or 40 million years ago) while Fig. 1-3c shows Frame 6 (Late Miocene or 5 million years ago). In Frame 4, the Philippines was still underwater but Palawan-Mindoro were part of Asia. In Frame 5, Bicol-Eastern Visayas-



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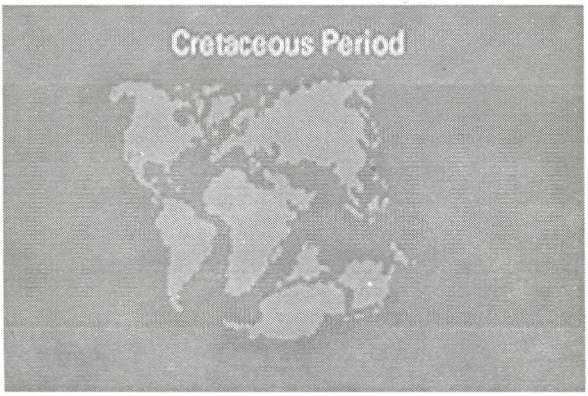

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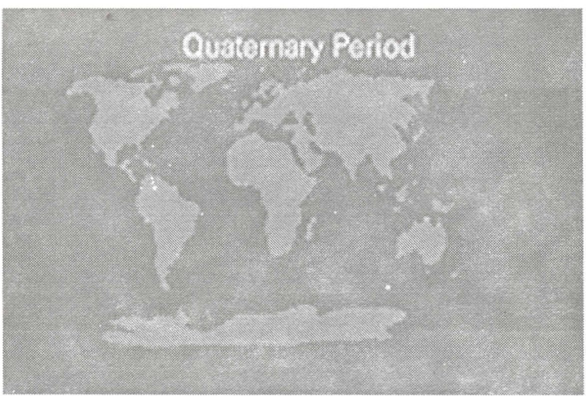

Source: Hall, 1997 and 1998

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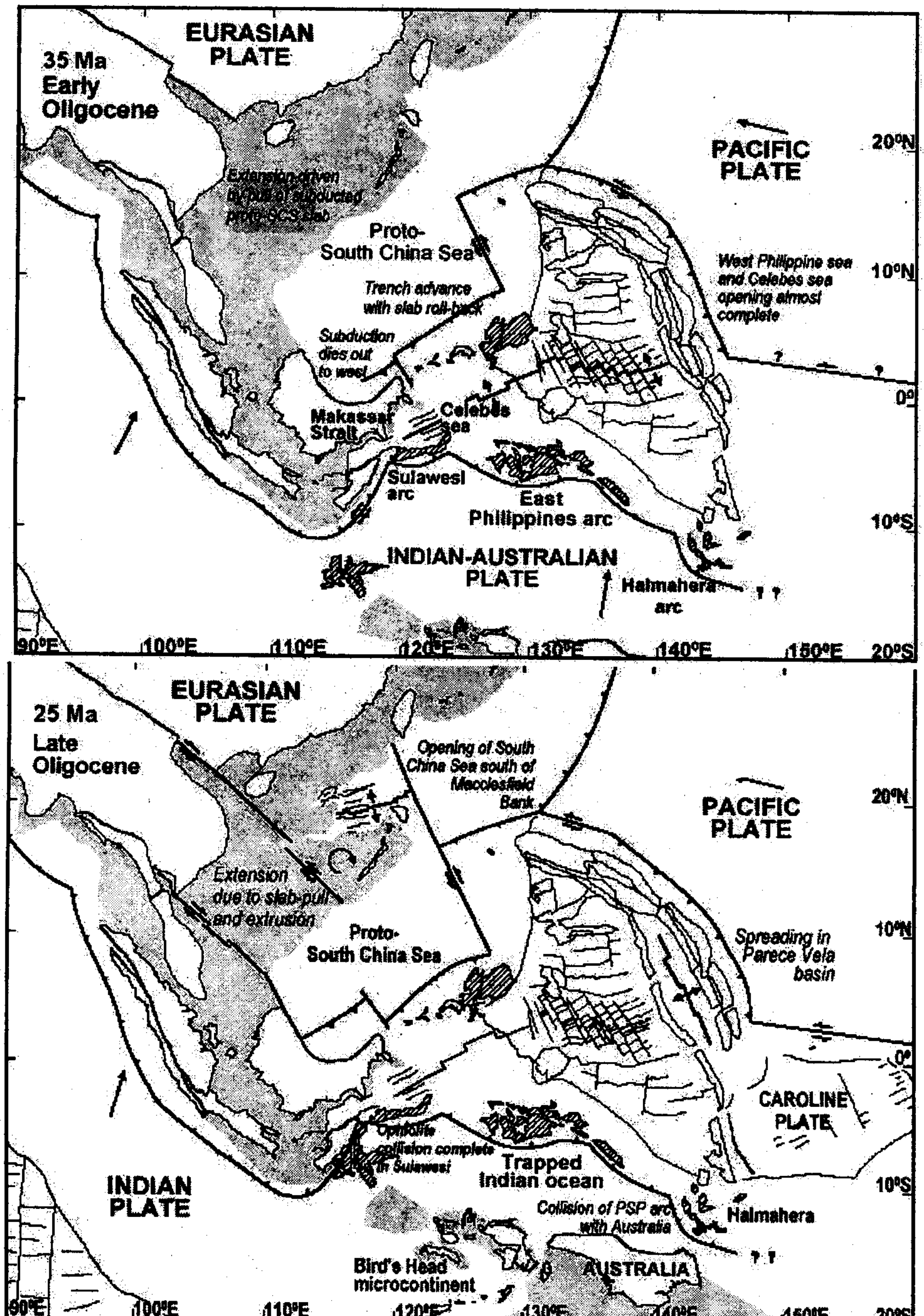
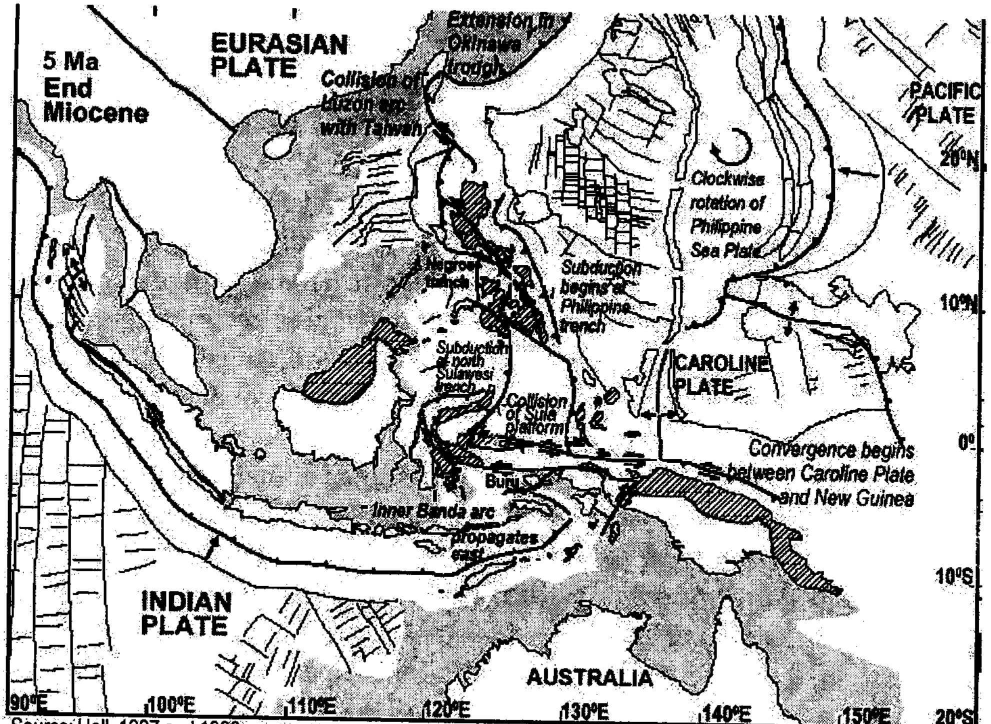
Fig. 1-3a. Tectonic origins of the Philippine archipelago (Frame 1-3).



Source: Hall, 1997 and 1998

Fig. 1-3b. Tectonic origins of the Philippine archipelago (Frame 4 and 5).



Source: Hall, 1997 and 1998

Fig. 1-3c. Tectonic origins of the Philippine archipelago (Frame 6).

Mindanao formed independently at latitudes south of the equator. South China Sea opened and pushed Palawan-Mindoro southwards. In Frame 6, South China Sea widened, Palawan-Mindoro collided with the proto-Luzon arc. At about the same time, Bicol-Eastern Visayas-Mindanao linked with Sierra Madre forming landbridges with Celebes-Moluccas-New Guinea (Celebes, Moluccas, and New Guinea) but not with Borneo.

How the Philippines received its flora (Baker, et al., 1998 and Morley, 1998) and fauna (Groves, 1985; Tougard, 2001) can best be understood by the tectonic origins of the Philippine archipelago (Fig. 1-3). A micro-continental raft from the Australian crustal plate strike-slipped with the pre-existing Luzon arc in **late Oligocene** and permitted the entry of biota from Papualand (Australia-New Guinea) and Sundaland (via Sulawesi). Meanwhile, the opening of the South China Sea caused a slab of continental Indochina to drift southwards. It collided with Luzon during the **late Miocene**. In effect, a

one-way transfer of Asiatic biota ensued.

During the late **Miocene**, Mindoro-Palawan complex with Zambales-Cordillera slammed into Luzon from Continental Asia because of the opening of the South China Sea. Benguet pine (*Pinus insularis*) and Himalayan flora (oak, laurels, magnolias, tea, rose, thistles, lilies, buttercups, dwarf bamboo, etc.) mostly confined now in the Cordillera highlands came through this route. Mindoro pine (*Pinus merkusii*) and Benguet pine are together in Zambales. Cordilleran endemic birds of pine and montane forests such as bullfinches, tits, crossbills, water-redstarts and nuthatches may trace their ancestors from this rafted Asiatic slab. This event coincided at a time when climates were drier than at present. Savanna with semi-evergreen forests abound. Lowland flora adapted to monsoonal climates came including drought resistant dipterocarps, such as the hairy leaf apitong (*Dipterocarpus alatus)*, apitong (*D. grandiflorus*), panau (*D. gracilis*), Hasselt's panau (*D. hasseltii*), and guijo (*Shorea guiso*) including the ancestor of white lauan (*Shorea, Pentacme contorta*) whose nearest relative is *Shorea (Pentacme siamensis*) of Indochina (Fig. 1-4). Most first wave dipterocarps avoided Borneo.

Part of this Asiatic biota filtered into Celebes and dispersed further south into New Guinea. At this time, Borneo was not anymore connected with Celebes and not yet with the Philippines. Thus, the range of Palosapis (*Anisoptera thurifera*) extended to New Guinea while Manggasinoro (*Shorea assamica*) extended from Mindanao to Celebes as subspecies *koordersii*.

Fossils of prehistoric elephants (two *Stegodon* spp. and one *Elephas* sp.) and Rhinoceros show that these species avoided Borneo (Grove, 1985). They spread out from the Philippines southward into Celebes, Lesser Sunda Islands and Java (Tougard, 2001). Ancestors of endemic Philippine deer (*Cervus* spp.) and warty pig (*Sus philippensis*) belong to this wave. Warty pigs avoided Borneo but ranged from Celebes to Java as *Sus verrucosus*. The bovine Tamaraw (*Bubalus mindorensis)*, the Indochinese *Bubalus arnee* and Celebesian *Bubalus depressicornis* diverged into separate species (Tanaka et al., 1996). Philippine teak (*Tectona philippinensis*) of West Southern Tagalog is a vicariant relative of Indochina's teak (*Tectona grandis*) and Burmese teak (*T. hamiltonii*) (Fig. 1-5).

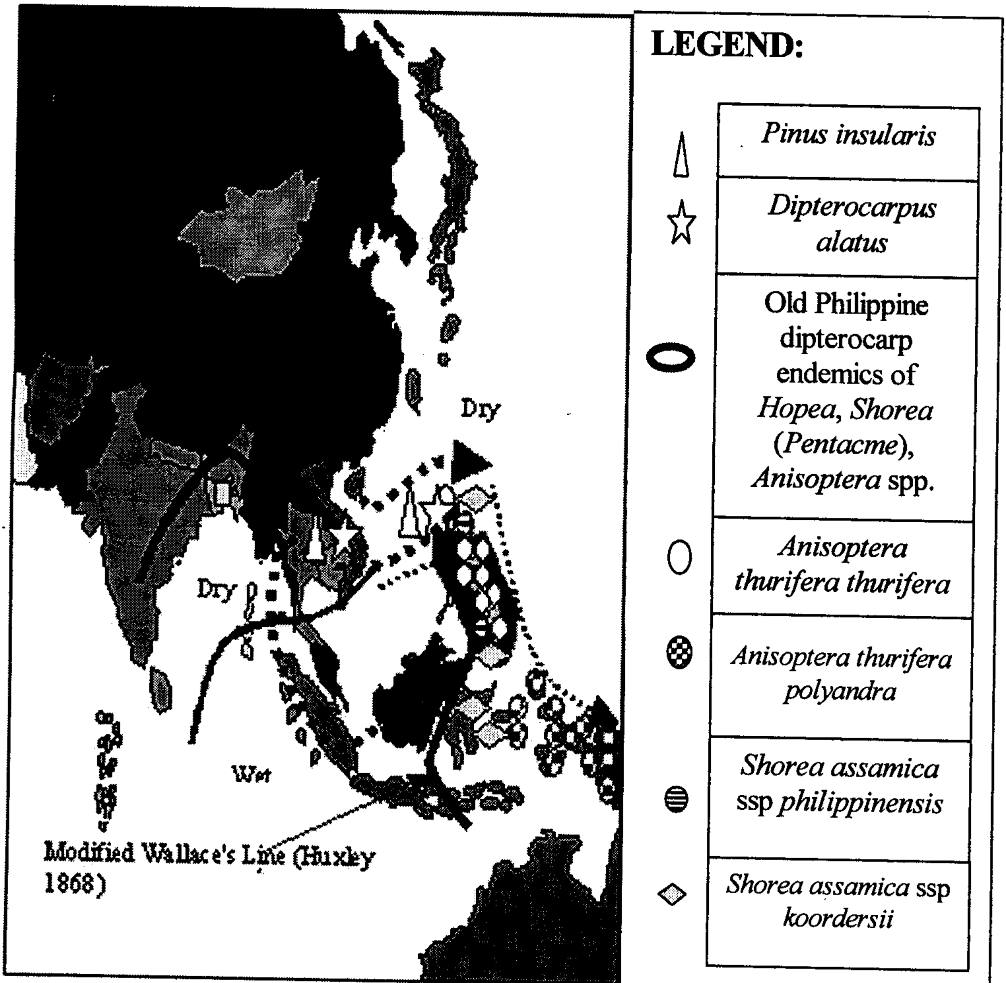


Fig. 1-4. Vicariate distributions in the late Miocene.
Pinus insularis and *Dipterocarpus alatus* between the Philippines and Indochina; *Anisoptera thurifera* ssp. *thurifera* and *A. thurifera* ssp. *polyandra* between Philippines and New Guinea; *Shorea assamica* ssp. *globifera* of Sundaland separated from Philippine-Celebes ssp. *koordersii*.

The Talaud arc (e.g., Bicol-East Visayas-Greater Mindanao) drifted northwards in late **Miocene** (between 10 to 15 million years ago) and gave the Philippines its Papuasian biota. Fig. 1-6 presents Papuasian elements of Philippine flora as evidenced by their distribution, taxa such as of Bagras

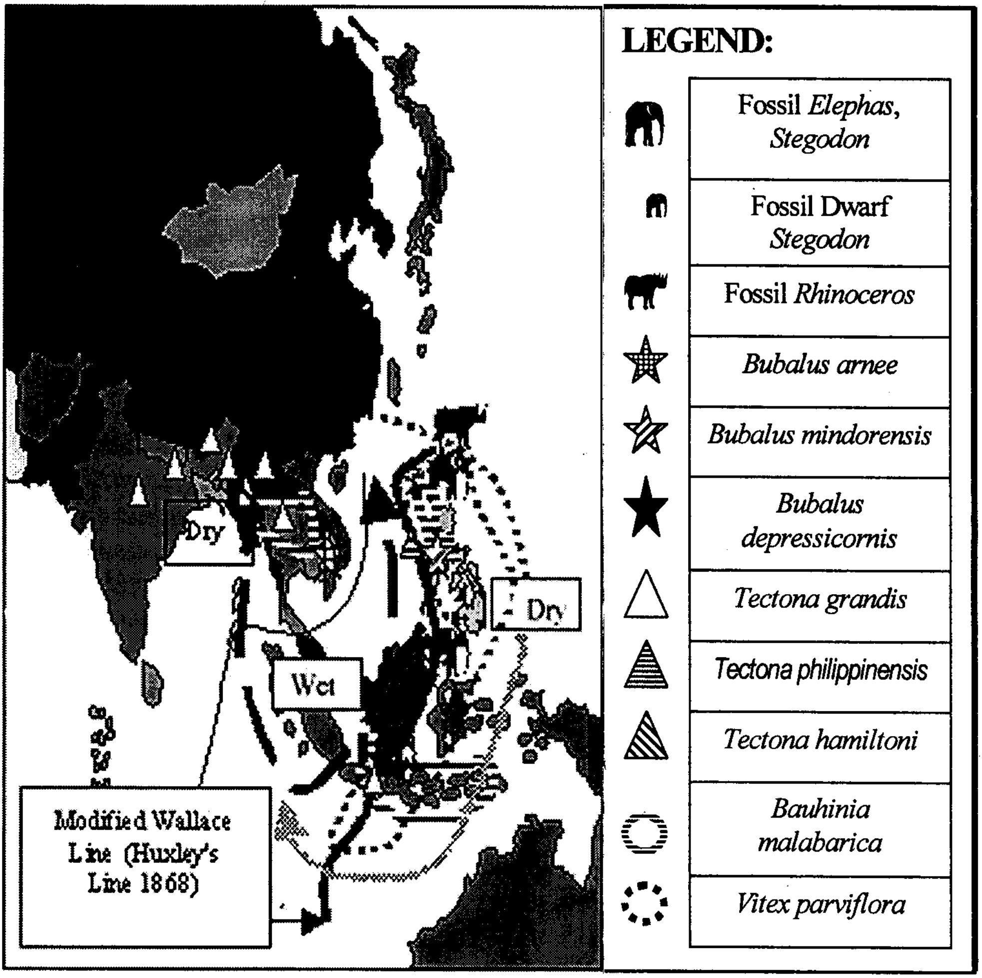


Fig. 1-5. Tracks of the prehistoric dry monsoon savanna as plotted by the distribution of fossil elephants, rhinoceros, bovines, and vicariate distribution of *Bubalus* spp., *Tectona* spp., and *Bauhinia malabarica*.

(*Eucalyptus deglupta*) and its myrtaceous relatives, genera such as *Tristaniopsis*, *Xanthostemon*, *Mearnsia*, etc. along with phyllodinous *Acacia*, species of she-oak *Casuarina* and the relict magnoliid (*Drimys piperita*). These taxa were probably passengers in this raft (Heads, 2003) including palms namely, *Heterospathe*, *Metroxylon*, *Veitchia* and the pandan *Sararanga* (Whitmore, 1981). The patterns of distribution of Southern Conifers (*Araucariaceae* and *Podocarpaceae*), inferred by the pattern of

Drimys piperita, member of a primitive magnoliid family *Winteraceae*, is distributed from New Caledonia to Luzon to North Borneo.

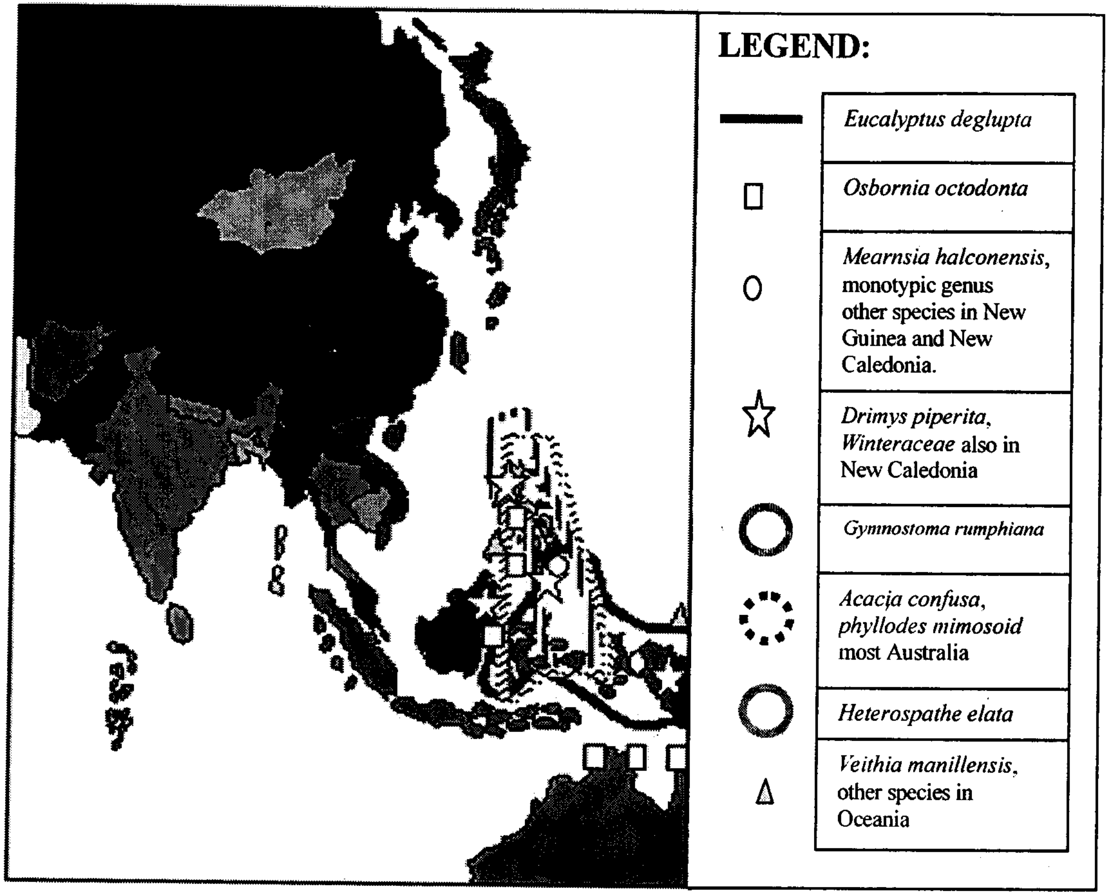


Fig. 1-6. Taxa that are distinctly Australia-New Guinean and their distribution in the Philippines.

their geographic distributions (Fig. 1-7), are decidedly Australasian. The following bird species, parrots, cockatoos, megapod some wild doves, including the Philippine eagle *Pithecophaga jefferyii* (Dickinson, et al., 1991) are faunal counterparts.

Flora (Morley, 1998) and fauna (Heaney, 1985) from the opposite Asian and Australian continents converged in the Philippines. Twice the Philippines became a staging station for dispersal in two opposite directions, the Australian and the Asian. Old endemic rodents and their relatives moved south

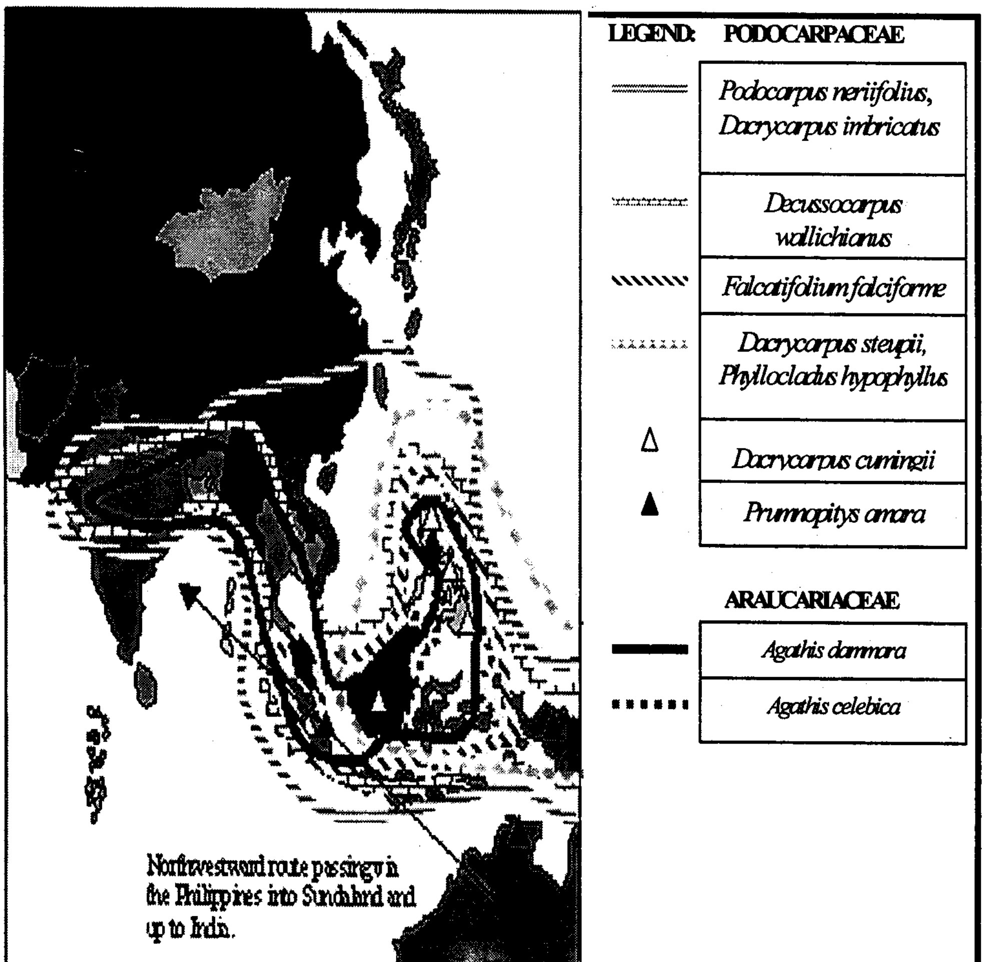


Fig. 1-7. Distribution of southern conifers *Araucariaceae* and *Podocarpaceae*.

to Celebes, New Guinea and as far as Australia (Jansa, et al., 2006). Rodents and bats are the only placental mammals in Australia (Steppan, et al., 2005).

The Philippines' link with Celebes and Moluccas was finally cut during the **Pliocene** (c. 2 to 4 million years ago) when Celebes Sea was formed. The Philippines was then isolated from the rest of the world. This was cooking time for the evolution of Philippine endemics (Jansa, et al., 2006). Thus, the old endemic rodent fauna of the Philippines such as *Phloeomys*, *Crateromys*, *Crunomys*, *Batomys*, and others evolved. *Anisoptera thurifera* in the Philippines and New Guinea diverged into endemic subspecies *thurifera* and *polyandra*, respectively. Mindanao bagras (*Eucalyptus deglupta*) developed resistance to the varicose borer unlike its counterpart in New Guinea.

With the full opening of the South China Sea, Philippine climate changed from dry to very wet during the **late Pliocene** (c. 3 million years ago). Consequently, alternating Pleistocene glaciation and interglaciation caused climatic shifts from wet to dry and from dry to wet, respectively. Increasingly, wet climates advanced and squeezed the savanna habitats of elephants, rhinoceros, and antelope leading to their extinction. Mindoro became a **refugia** to the Tamaraw (*Bubalus minodrensis*). Together with the Philippine teak (*Tectona philippinensis*) it serves as a relic of a drier climate during the Pliocene-Pleistocene.

Pleistocene (2 million years ago) ended the long geographic isolation of the Philippines. It was connected several times with Borneo via the Sulu landbridge. This connection was in harmony with the lowering of the sea as ice piled up in the poles following glaciation. At different time intervals, polar caps melted and the rising sea submerged isthmian landbridges. Large single islands become many islands. West Malesian flora led by second wave dipterocarp trees (mainly *Dipterocarpus* and *Shorea* spp.) crossed Sulu into Mindanao and northwards to Luzon via Visayas along the wetter corridors of the Philippine eastern seaboard (Fig. 1-8). This eastward West Malesian traffic of flora and fauna through the Sulu landbridge was barred by the Balintang Channel into Formosa and by the Celebes Sea into Celebes, Moluccas, and New Guinea.

As a result, exchanges of flora and fauna with Borneo occurred. However,

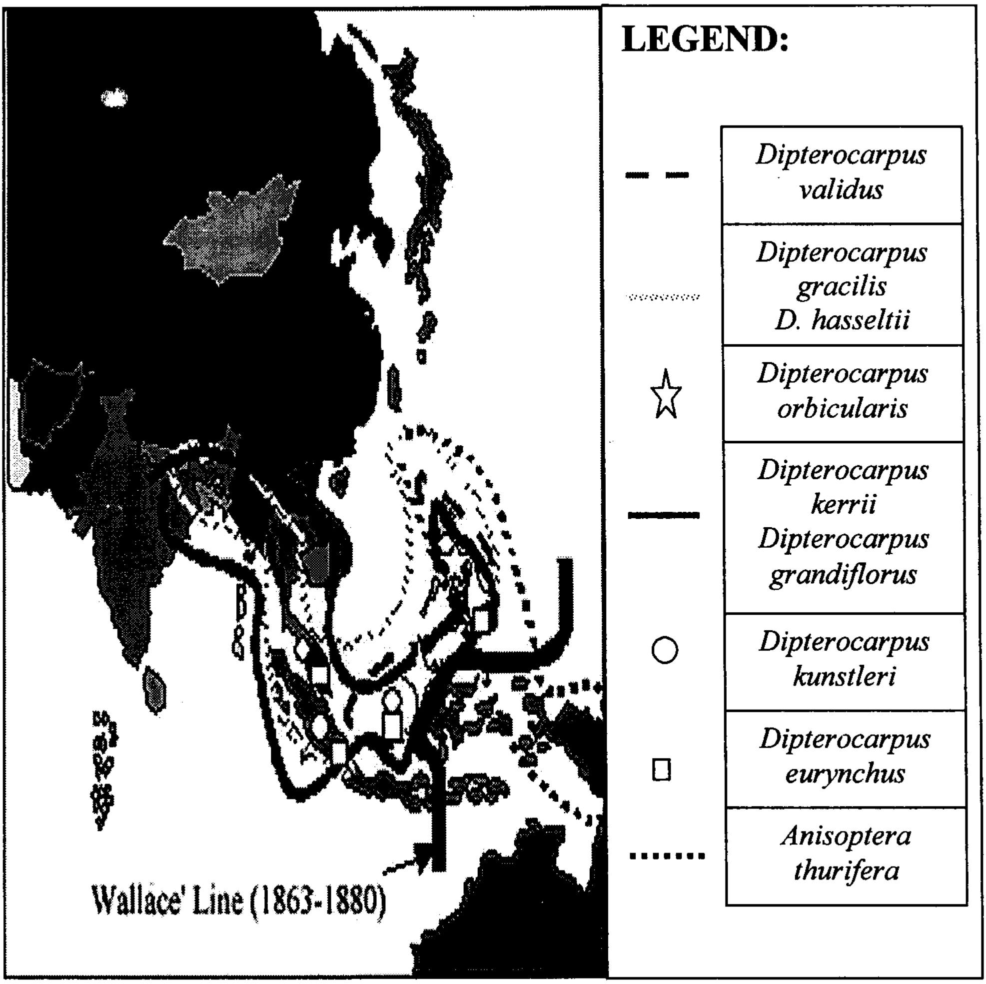


Fig. 1-8. Dipterocarps from Sundaland found the right ever wet climatic corridor into the Philippines but were barred in Formosa and Celebes.

more West Malesian biota came into the Philippines than the reverse. Some Philippine-based Papuasian plants such as *Agathis* and *Podocarpaceae* were able to filter into Borneo and fanned-out into Sundaland and beyond (e.g., Indochina then to India and East Asia). Philippine-based dipterocarps like Almon (*Shorea almon)*, Bagtikan (*Parashorea malaanonan)* and Gisok-Gisok (*Hopea philippinensis)* were limited only in Sabah (North Borneo) while Guijo (*Shorea guiso)* reached drier parts of Borneo, Sumatra, and Malay Peninsula.

Using this route, the long-tailed Macaque (*Macaca fascicularis)* and Civet cats (*Paradoxurus hermaphroditus* and *Viverra tangalunga)* were able to migrate throughout the Philippines. The flying lemur (*Cyanocephalus volans)*, flying squirrel (*Petinomys* sp.) and tree shrew (*Urogale* sp.) were limited only in Mindanao, while the slow loris (*Nycticebus coucang)* was limited only to Sulu.

At the end of **Pleistocene** (50 to 100 thousand years ago), Palawan was linked with Borneo. This route gave Palawan its bearded pig (*Sus barbatus)*, stink badger (*Mydaus marchei)*, otter (*Amblonyx cinerea)*, *binturong* (*Arctictis binturong)*, scaly ant eater (*Manis javanica)*, porcupine (*Hystrix pumilus)*, and others. Bornean birds include talking mynah (*Gracula religiosa)*, peacock pheasant (*Polypectron emphanum)*, hornbills (*Anthroceros* spp.), etc. Although considerable Bornean plants such as Manggis (*Koompassia excelsa*), Maranggo (*Azadirachta excelsa)*, Repetek (*Kokoona ochracea)*, Kalas (*Carallia borneensis)*, etc., crossed into Palawan, Borneo dipterocarps such as *Vatica* spp. and *Dipterocarpus* spp. in Palawan are minimal. Humans like the Tabon Man were among the last to arrive. They came by foot and today believed to be represented by local negroid peoples such as the Aetas, Bataks, and Dumagats.

BIOGEOGRAPHIC REGIONS OF THE PHILIPPINES

Evolution exacted in the Philippine archipelago variations of floristic and faunistic assemblages. Hence, biogeographers divided it into biogeographic regions (Ong, et al., 2002), namely: (1) Batanes; (2) Babuyanes; (3) Cordillera Highlands; (4) Northern Sierra Madre; (5) Southern Sierra Madre and the Bicol Peninsula; (6) Lowland Northwestern Luzon, Central Luzon, and Southwestern Luzon; (7) Zambales-Bataan; (8) Mindoro; (9) Busuanga-Palawan-Balabac; (10) Western Visayas (Panay-Romblon-Masbate-Guimaras-Negros-Cebu); (11) Greater Eastern Mindanao (includes Bohol-Leyte-Samar); (12) Zamboanga-Basilan; and (13) the Sulu Archipelago. A sound sustainable development scheme for the country should consider this biogeographic variation. This can be achieved through knowledge of biogeography, proper preservation, and conservation of biodiversity.The northernmost part is **Batanes**, which is composed of small islands. It has a

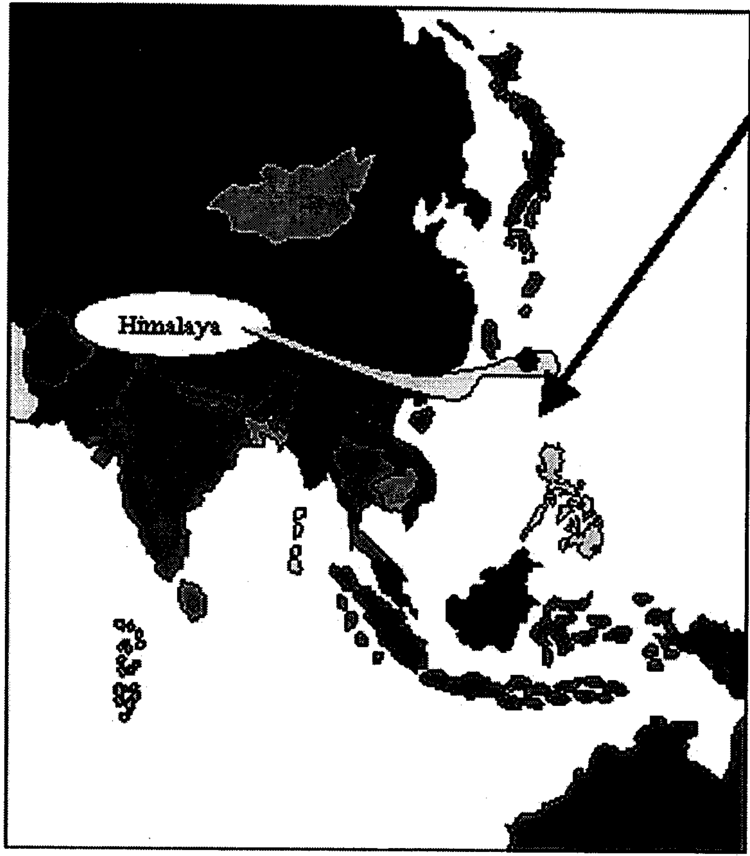
unique flora like the Bakul (*Phoenix hanceana* var. *philippinensis*). Babuyanes are more related with Luzon biogeographic regions than they are with Batanes. Such isolated islands bear only few land mammals. One exception is the Indochinese shrew (*Crocidura attenuata*), a species found also in Indochina (Dickinson, et al., 1991).

Northern Sierra Madre, with its lush evergreen rainforest, is home to the Philippine eagle (*Pithecophaga jefferyii*). Unlike similar forests in Samar-Leyte to Mindanao, Sierra Madre has no flying lemur, tree shrew nor tarsier. Southern Sierra Madre-Bicol Peninsula presents familiar Mindanao plants such as Pili (*Canarium ovatum*), Toog (*Petersianthus quadrialatus*), and Abaca (*Musa textilis*). The endemic round-leaved Apitong (*Dipterocarpus orbicularis*) is also confined here (Newman, et al., 1996).

The Cordillera highland is known for its Himalayan flora and its Benguet pine (*Pinus insularis*) forest (Fig. 1-9). Forests are mainly montane and mossy while disclimax forests are those dominated by pines (Kowal, 1966). This pine region is home to the slender-tailed northern cloud rat (*Phloeomys pallidus*) and the bushy-tailed cloud rat (*Crateromys schandenbergi*). Climate is monsoonal like the rest of the lowland Western and Central Luzon. Diversity of the old endemic rodent fauna in Cordillera is especially noted with genera like *Apomys*, *Bullimus*, *Carpomys*, *Chrotomys*, *Crateromys*, *Celaenomys* and *Phloeomys* (Heaney, et al. 2005 and Dickerson, 1928).

Influenced by monsoon climates, **lowland Western and Central Luzon** have semi-evergreen dipterocarp forests with the hairy leaf apitong (*Dipterocarpus alatus*) as Indochinese vicariate element (Smitinand, et al., 1992). It has disclimax savanna vegetation dominated by Alibangbang (*Bauhinia malabarica*) interrupted by semi-evergreen dipterocarp gallery forests along the drainage systems. **Lowland Southwestern Luzon** where the Philippine teak (*Tectona philippinensis)* is confined is an extension of its northern monsoon counterpart.

Zambales-Bataan is a separate biogeographic region similar floristically to the preceding but with pine forests containing both Benguet and Mindoro Pines. One unique large rodent lives here, the southern slender-tailed cloud rat (*Phloeomys cumingiana*). Mindoro is recognized as unique because of its Tamaraw and its pine.



Luzon highlands in the **Cordillera Mountain Ranges** is the home of the Benguet pine *Pinus insularis* Endl. The following set of genera are strikingly **Himalayan**, namely *Agrostis, Aniselytron, Yushania, Brachypodium, Bromus, Calamagrostis, Chionachne, Deschampsia, Microlaena, Monostachya, Poa, Luzula, Aletris, Asparagus, Disporum, Lilium, Liriope, Saururus, Thesium, Arenaria, Muehlenbergia, Sagina, Stellaria, Anemone, Ranunculus, Thalictrum, Berberis, Mahonia, Sedum, Astilbe, Deutzia, Fragaria, Rosa, Dumosia, Lespedeza, Shuteria* .... Also the species *Limnanthemum cristatum, Engelhardtia colebroekeana, Cardamine regeliana, Rubus ellipticus.*

These taxa are confined in the Luzon highlands and have not been found south of Baguio city.

Fig. 1-9. Map showing the disjunct distribution of some of the Cordillera highland flora that do not occur south of Baguio but their nearest relatives are found in the Himalayas. For this reason the Cordillera is recognized as a biogeographic region.

The Palawan biogeographic region includes the Calamianes, Palawan and Balabac. Calamianes is home of the Calamian deer (*Axis calamianensis*). Palawan has mostly semi-evergreen forests with very impoverished dipterocarp flora but enriched with considerable Bornean flora and fauna. Balabac is home of the Malaysian mouse deer (*Tragulus napu*). The Flying squirrel (*Hylopetes* sp.) lives in mainland Palawan and the tree squirrel (*Sundasciurus*) is well represented. One species is also present in Mindanao. Forest rodents of Palawan are also related to Bornean forms (e.g., *Sundamys*, *Haeromys,* and *Maxomys*) instead of old Philippine endemic rodents. No deer exists in mainland Palawan (Dickerson, 1928).

Western Visayas is unique because of its semi-evergreen dipterocarp forests and the presence of a unique assemblage of mammalian fauna, such as the Visayan warty pig (*Sus cebifrons*), Visayan spotted deer (*Cervus alfredi*) and a wild leopard cat (*Prionailurus benghalensis*). The leopard cat is also present in Palawan (Rabor, 1977). Although Western Visayas is divided into islands of Panay, Guimaras, Negros, Cebu and Masbate, they are but one Pleistocene island in the past (Heaney, 1985).

Eastern Visayas (Samar-Leyte-Bohol) and Greater Mindanao have been combined on the basis of similarity in fauna such as the common tarsier (*Tarsius syrichta*), *kaguang* (*Cyanocephalus volans*) (Ong, et al., 2002). Mindanao is the home of the shrew (*Podogymnura* spp.) and the tree shrew (*Urogale everreti*). The range of the Philippine eagle extends to this biogeographic region and may be determined by the evergreen dipterocarp forests common in all eastern seaboard Philippines that have evenly distributed rainfalls throughout the year. *Eucalyptus deglupta* is unique for Greater Mindanao. Compared with the rest of the Philippines, this region has by far the richest Papuasian flora such as the pandan (*Sararanga*), *Metroxylon sagu*, many *Heterospathe* spp. and mountain agoho (*Gymnostoma rumphiana*) and in ultrabasic forests mankono (*Xanthosthemon verdugonianum*). It has also the tree *toog* (*Petersianthus quadrialatus)* and *sudiang* (*Ctenolophon parvifolius*). The Zamboanga peninsula and Basilan forms a unique portion because of the large Sundaic element of Bornean origin in its evergreen dipterocarp forests.

It contains Bornean dipterocarps such as *Anisoptera costata*, Malayakal (*Shorea seminis*), Tawi-tawi narig (*Vatica umbonata* ssp. *umbonata*) and its

endemic Kaladis narig (*V. elliptica*). Its rivers contain the Sundaic cyprinid freshwater fish (*Rasbora* spp). Finally, Sulu Archipelago has the prosimian slow loris (*Nycticebus coucang*) as among the more recent arrivals from Borneo.

THE PHILIPPINES AND ITS PEOPLE

Man arrived in the Philippines during the last Ice Age. A fossil skull of the Tabon man of Palawan, has been dated as 22,000 years old (Fox, 1962). Among the existing native Filipinos, the dwarf **Negroid people** (Aeta) and the much taller Palanan are believed to be the earliest men, who like the Tabon man, arrived by foot through land bridges (e.g., Sulu and Palawan land bridge). They are hunting and gathering peoples. They lived in the Sierra Madre Mountains, Zambales-Bataan, and other mountains along the eastern seaboard as well as Panay and Palawan. Strictly subsistence living, they are one with nature. Their populations are kept low by deaths caused by diseases like malignant malaria.

Later immigrants were the Austronesian speaking people, **racial kindred of Indonesians and Malays** who came by outrigger sailing boats (Jocano, 1975). They use swidden agriculture (*uma*) in uplands, practice irrigated rice agriculture with lowland and upland versions, introduced carabao-driven tillage, cut timber to build upraised houses and boats, and open rainforests to establish permanent lowland farms. They use the bow and arrow as well as employ plant poisons, traps and contrivances in hunting for fish and game. Austronesian cultures are animists and much of their agriculture and use of natural resources are associated with their beliefs of forest dwelling spirits (*anito*) and nature deities (*diwata*). These indigenous cultures consider land a common good among the members of the village and tribe. Their population is also low due to certain diseases. Hence, the swidden rate has been always less than the rate of natural forest regeneration. Swiddens were just anthropogenic gaps added to the forest succession cycle (gap:building-up:mature).

Pre-hispanic Filipinos that Spaniards first met were mainly **coastal dwellers** (Bureau of National and Foreign Information, 1976) such as Ilocanos,

Pangasinense, Kapampangan, Bicol, Waraynons, Bisaya, Ilongo and others. Although they grow rain-fed wet rice varieties, they also practice upland or swidden farming. Most are maritime people except for those in the Cordillera highlands of Luzon who developed sedentary upland agriculture that is coupled to natural forests like the famous Ifugao rice terraces (**payo-pinugo**). The council of elders usually makes important decisions for the community, although the local shaman (*babaylan*) may be consulted for religious reasons and for healing the sick. Together, they determine decisions that involve resource use (e.g., opening a new swidden, cutting timber for construction of boats, houses, etc.). Ethnic Filipinos developed indigenous varieties of farm crops that fit the environment and tribal rituals.

Pre-hispanic Filipinos traded with Arabs, Chinese, Japanese, Indians and fellow southeast Asians (Jocano, 1975). Some degree of acculturation and amalgamation made the pre-Hispanic Filipino culture more oriental. These early Asian contacts introduced new agricultural crops of continental African and Asian in origin including their weeds. Some pre-Hispanic Filipinos became Hindus and later embraced Islam (Muslims). Thus, the Tagalogs of Maynilad, Tausug, Samal, Yakan, Maranao, and Maguindanao became culturally different from the rest of the ethnic Filipinos who remained animists.

On March 16, 1521, Magellan claimed the archipelago for the Spanish crown naming it Las Islas Filipinas in honor of King Philip of Spain. Later, Spanish conquistadors gained control of most of the islands. The term **Filipino** referred to island born Spaniards while natives were *indios*. Then, the Americans wrested the Philippines from Spain. Today, Filipino refers to any Filipino citizen (Agoncillo, 1990).

Unlike minority **indigenous peoples** (IP) who are still animists and living under a subsistence economy, mainstream Filipinos aspire, behave, and think like their Western conquerors. Spain institutionalized the private ownership of land with the **land patent or title** as proof of ownership. Among the *indios*, only the few elite owned large parcels of land. However, during the American regime, the homestead policy provided Filipinos the right to claim lands they cleared from the forests and to have them patented or titled. Filipinos also enjoyed greater access to college education. This prepared them for independence, which became a turning point (Agoncillo, 1990) indeed.

THE MEGADIVERSITY STATUS

Botanical and zoölogical collections retrieved from the wild during the Spanish and American periods approximate pristine Philippine biodiversity. This large number of biota with its extraordinary high number of endemic species did not go unnoticed. Hence, the Philippines was included as among the megadiversities of the world (Mittermeier, et al., 1997).

According to Merrill (1923-1926), 80 percent of the Philippine plants are in the lowlands from coastal areas to 1,000 meters above sea level. The rest occurred above 1,000 meters above sea level. Plant species was estimated to be 13,500 of which 76 percent were believed to be endemic. However, revisions in the flora *Malesiana* reduced this number to 12,000 species, of which 8,000 are flowering plants (Madulid, 1985) with only 30 percent endemism.

An estimated 1,139 species are land vertebrates, 49 percent of which are endemic (DENR-UNEP, 1997). For invertebrates, the figures must be intimidating. For insects, there are about 20,000 records. Philippine invertebrates are poorly known.

It is believed that biodiversity known to science in the Philippines can still be augmented. More botanical and zoological expeditions in unexplored islands and uplands may yet yield additional taxonomic novelties.

THE WEST IN THE PHILIPPINES

For thousands of years, Filipinos lived in harmony with nature but by the end of the 20th century, most lowland dipterocarp rainforests were rapidly converted to agroecosystems or man-made ecosystems. Agroecosystems spread while natural forests rapidly shrunk within a period of only 100 years. This fact reveals the alienation of the Filipino from his natural environment.

Luzon and West Visayas absorbed the heaviest pressure (DENR-UNEP, 1997) as centers of human population expansion. Only the seaward side of North Sierra Madre near Palanan, Isabela remains to have continuous evergreen

rainforests. There are small patches of refugia in the rest of Luzon such as forests around Subic, small montane and mossy forests of the higher mountains of the Cordillerra highlands, Mt. Banahaw, Mt. Makiling, and Quezon National Park. Samar Island has greater undisturbed forests than the rest of East Visayas. Only a few parks with relatively intact forest were spared in West Visayas. Mindanao, very much pristine during the American period, received settlers from Luzon and the Visayas. Today, Mindanao's forests are gone except for particular protected areas and rebel-infested forests. Before the war, Palawan was almost 80 percent forest. Now this has been reduced to about half, in spite of the whole province having been declared as a protected area. Today, mining remains a threat after it was shown that it overlaps with 56 percent of the declared forested protected areas and is poised to destroy 60,000 hectares more forests (Kool, et al., 2003). A high extinction rate follows the wake of tremendous deforestation with habitat loss and subsequent extinction of native flora and fauna.

Succeeding topics discuss the process of alienation within the context of global and national history. By briefly revisiting the past and contextualizing the problem of ecology in the uplands with current globalization, this text material goes beyond just teaching agroforestry, poverty alleviation, and environmental services. This process of alienation has to be understood if a meaningful process of de-alienation has to be started to reunify the Filipino with his culture and environment. In this way, agroforestry as an alternative to swidden farming, can be better placed in its proper ecological and biogeographical context.

Private land ownership. Spaniards institutionalized private ownership of land guaranteed through titles or land patents. This disenfranchised *indios* from lands they commonly owned (Lynch, 1984). Land can be sold or transferred to heirs. The practice of owning hundreds of hectares of land as a reward from the Spanish king in exchange for his loyalty and service to the crown is a vestige of feudalism that prevailed in Medieval Europe. All lands, other than those privately owned, were declared property of the Crown.

The origin of Western concept of progress. Europe emerged from the turpitude of the Dark Ages to the Renaissance that saw the rapid growth of science and political reforms. Science grew and European colonizers used it to develop technologies that would make them conquerors and subsequently

more powerful and wealthier. Monarchies gave way to a democratic system of government. Serfs and fiefs became citizens enjoying equal rights before the law. Government guarantees this right by the enactment of laws. Thus, people are protected from potential aggression by other people. Their properties were likewise protected from being illegally taken away. Thus, land as a property or possession is non-transferable except by inheritance or by sale. Furthermore, governments in the interest of maintaining peace and order and preventing anarchy, employ the services of the police and military to protect the private land ownership system. Corollary to this, governments protect the utilitarian system of satisfying the unlimited human wants of society and guarantee private pursuit for material happiness (Lekachman and Van Loon, 1981). Incidentally, this Western worldview of happiness is the antithesis of the oriental ways of moderation and frugality in reverence for Mother Nature (Mei, 1971; Hwa Yol Jung, 1971; Chakravarty, 1971).

Western progress –how it operates, what are the gains and costs? Wealth promotes science, science precedes technology, and technology produces more wealth in a seemingly endless cycle. Wealth is begotten by those who own the factors of production, who in turn justify their system as the only way to create jobs so that the greater number enjoy happy lives. Cities grew while the countryside teeming with peasants were freed from fiefdom. Education was opened/offered to the poor. In effect, many joined the ranks of the middle class becoming educators, scientists, technologists, and entrepreneurs. They were better paid than ordinary members of the labor class and far better than dehumanized peasants. Their services kept the agroindustrial complex alive and healthy.

However, surpluses were spent for the invention of machines that in many instances have replaced human labor in production. Machines reduced labor demands and increased unemployment but were used by rich or poor countries, to justify greater economic development and growth. This relation intensified the export of raw materials by poor countries (e.g., minerals, timber, and agroindustrial products) to rich countries and the buying of finished products (tractors, trucks, chain saws, pesticides, chemical fertilizers, etc.) from rich countries. In spite of economic growth, the rate of new jobs has always been outpaced by the rate of unemployment (Porritt, 1985).

Rich and the "not-so-rich" people become the targets of aggressive advertising and are conditioned to buy new, better but more expensive products. Advertising does not only inform the buying public on the presence of a new products in the market. Advertising also makes people unsatisfied with what they have and coaxes them to buy the latest model or version of a product. Advertising keeps the market healthy and industries active, for the benefit of the sellers of manufactured goods and satisfaction of the wants of acculturated minds.

Likewise, science and technology (S&T) simultaneously improve medical science and human nutrition. As a result, it has been increasing the average human life expectancy such that there have been more births than deaths resulting in the rapid human population growth (Subcontractor's Monograph, The Philippines). For example, in 1591 there were 667,612 souls counted, this did not change much, so in 1735 only 837,182 were accounted for. It was only during the 18th century when vaccines were invented. After 100 years, the population dramatically increased to 3,096,033. In 1903, the population was about 7 million and about 19 million in 1948.

The natural response to population growth, at a time when natural resources were pristine and seemed inexhaustible, was economic development. More jobs and more goods must be produced to beat unemployment and inflation. This also meant more mining, more use of fossil fuels, faster means of transportation, more machines and agrochemicals to augment agriculture. The burning of fossil fuel is justified by the demand for goods by an exploding population, but it also pollutes the earth (Porritt, 1985).

The World Resources Institute (WRI), United Nations Environment Programme (UNEP), and United Nations Development Program (UNDP) (1990-91) described pollution by carbon dioxide as follows. During the last warm interglacial period (130 million years ago), it was estimated that the carbon dioxide (CO_2) level in the atmosphere was 300 ppm. Concentrations during the last Ice Age (about 40 million years ago) dropped to around 200 ppm. By the beginning of the Industrial Revolution, CO_2 emissions have climbed back to 280 ppm. The Mauna Loa Observatory in Hawaii has been observing atmospheric CO_2 since 1958. In 1988, it reported a rapid climb of atmospheric CO_2 to 351 ppm. This figure is 20-25 percent higher than its level during the

last 160,000 years B.P. The chapter on carbon stocks, sequestration, and global climate would take off from this point.

Origin of monoculture agroecosystems. Faster sailing ships and naval superiority contributed in the colonization of most regions in the tropics. Because of this, agriculture was never the same again. A large demand for quality ropes for shipping gave way to the first monoculture plantation of abaca (*Musa textilis*), a Philippine endemic wild banana plant that gives very strong fiber popularly known as the Manila hemp (Ofreneo, 1980). Demand for abaca declined when ironclad ships replaced sailing ships, however, ropes made from Manila hemp continued until synthetic ropes replaced them in the 1960s.

Coconut, sugar, cotton, coffee, cocoa, indigo, and tobacco were among the monocrops raised aside from abaca (Ofreneo, 1980). Rice fields also increased to meet food demands of the expanding urban centers. Monoculture plantations became a normal land use system in response to the growing global economy. The monoculture plantation became a trend for profitable agriculture during and beyond the Industrial Revolution. The more land an individual has, the richer he becomes. However, given the increasing population growth rate, the more land one acquires, the more one deprives other people of owning land. Poverty increases as the proportion of privatized land is distributed only to a few people. Monoculture became almost equated with economically rewarding agriculture, while polyculture exists only in the backyards of common people as depicted in the immortal Filipino folk song *Bahay Kubo*.

From monoculture to the green revolution. The problem with monoculture agriculture is that it also nurtured its pests and diseases. Since the crops are already food to the pests, so many crops in one place mean so much food for pests. These in turn increase in numbers to epidemic proportions. The advent of pests and diseases has inflicted havoc to agriculture and is seen as a threat to national and international economy. International research organizations and international chemical companies worked together to combat pests and diseases. Among the first of a long line of pesticides was *dichloro diphenyl trichloroethane* (DDT). Research on crop protection is paralleled by research on artificial breeding that soon produced a long list of high yielding varieties (HYV). Scientists launched stereotyped studies that aimed to determine how

these varieties respond to oil-based inputs such as pesticides, herbicides, chemical fertilizers, economics, etc. Astonishingly, high gross agricultural production was the result of international research efforts. Pragmatic S&T has always provided the means to improve comfortable lifestyles. The same pragmatic S&T increased the capacity of farms to enhance production per unit area with the help of oil-based inputs -- pesticides and inorganic fertilizers. This is the *green revolution*, the sequel to the industrial revolution. Such victories gave the green revolution a reputation as being scientific while traditional farming systems as antiquated. HYVs that are products of applied genetics and artificial breeding, are lauded as good while indigenous varieties are uneconomical.

Agricultural universities towed the line of the green revolution philosophy in a consumerist set-up. Since then, agricultural curricula have not changed much. However, when Rachel Carson (1962) published her book *Silent Springs*, an urgent alarm has been sounded that reverberated worldwide. For the first time, the green revolution was exposed as a polluting technology. The green revolution directly and indirectly kills instead of promoting life.

Forestry comes to the picture. Forestry initially developed from an international trade that demanded more wood for shipbuilding and later pulpwood for paper making. Demand for wood continued to increase because wood is a major material for housing and for the construction of infrastructures. American/European foresters succeeded in producing timber from tree farms in temperate settings instead of harvesting them from inaccessible natural temperate forests. Since then, the term forest meant a source of timber either from natural or artificial means (U.S. National Science Board, 1972) such as tree farms. However, its original meaning as an English word borrowed from French was an estate owned by the nobility with or without woods (Bakuzis, 1972).

Forestry as an art and science was born in temperate countries and later introduced to tropical countries. A subset of forestry, silviculture is the art and science of raising timber and pulpwood products through plantations and managed forests. Trees that bear timber and pulpwood are forestry or silvicultural crops and when raised successfully are to be considered artificial forest. Later, trees mixed with annuals came to be known as agroforestry.

Formally defined, agroforestry is any system that combines (either spatially or sequentially) the production of woody perennials on the same unit of land as agricultural crops and livestock (Kirchhofer and Mercer, 1984).

In the Philippines (Rayos, 1967), a Spanish law known as "Inspeccion General de Montes" per Superior Government Circular dated September 3, 1863, provided the government to open up virgin lands and to grant concessions of mountain lands. Then, the Americans through the Spooner Amendment to the Army Appropriation Bill of March 21, 1901 provided an American version of the Regalian Doctrine that all public lands must be owned by the State. Following this was the Organic Act of July 1, 1902 authorizing the Forestry Bureau to certify public lands fit for agriculture and not needed for forest reserves as basis for land classification.The Forestry Bureau claimed jurisdiction on all uplands with or without forest as forestlands.

Agriculture and forestry became equated with a country's economic growth. Unprocessed logs joined other raw materials exported to affluent countries. It increased the country's gross national product (GNP). Agriculture and forestry became a means to feed and house people but more especially to satisfy the needs of those that control and operate the global economic and industrial machinery. Intensified agriculture and forestry meant greater GNP, but this also meant greater pollution and deforestation. The concept of sustainable development exists merely as around but it is a theory that is yet to be practiced.

NEW EDUCATIONAL SYSTEM

Liberal education combined with pragmatic development leads to progress. Progress is the road to satisfy unlimited human wants. This is what all post-Industrial Revolution countries would like to achieve. Filipino *illustrados* saw the impact of industrial progress in Europe. They wished Western progress would also come to the Philippines but the Spanish colonial master was a hindrance to it. The Spanish government was not serious in educating the Filipinos as Dr. Jose Rizal vividly presented in his novels *Noli Me Tangere* and *El Filibusterismo*. Besides, Filipinos saw the Spaniards as alien oppressors for which reason Andres Bonifacio started the Philippine

Revolution. This attempt for self-determination was short-lived having been thwarted by the Americans with sheer superiority in arms. The rest is history (Agoncillo, 1990). The Americans educated Filipinos and were trained to adopt the ideal of progress through education. Western progress became an obsession and a leisurely lifestyle was aspired for.

ALIENATION FROM NATURE

Private land ownership. Land use in the Philippines changed from communal land ownership to one that is privatized. Americans introduced the homestead concept to the delight of land hungry *indios*. It was an outright emancipation. Each family could clear a patch of tropical rainforests and have it titled.

During this early part of the 20th century, Philippine population was about 7 million, or 1 person per 2 hectare of arable land. Some peasants became landowners in an instant. Incomes increased and the children of economically emancipated *indios* mingled with the children of affluent families in the same universities. Other peasants were not as lucky. They remain landless or their descendants get jobs in towns and cities.

Rapid population growth in a finite natural resource setting. In 1960, the population rose to 27.6 million or 1.8 person per hectare arable land. This figure doubled to 62.4 million in 1990 or 4 people per hectare arable land. At present, Philippine population is pegged at 80 million or a density of about 5 people per hectare arable land. Under an unrealistic equal distribution of land, this is equivalent to each person owning a 2,000 square meters farm. At present, the Philippine population growth rate is increasing; the World Resource Institute (1990-1991) expects this to increase to 111.4 million or a density of 7.4 people per hectare arable land in year 2025.

However, the lowlands have been parceled into haciendas, small farmlots of a few farm owners, agroindustrial farms, residential areas, resorts, built-up areas, economic processing zones, expanded urban areas, etc. Most lands other than roads and public places are off-limits to unauthorized people. Thus, one who has no land is disadvantaged. Only a few alternatives are available for the landless poor to survive in a society that has become very competitive,

sophisticated, and politically complex.

The upland migration of lowland farmers at the expense of natural forests. It is probably desirable to give each person a piece of land to farm. However, this is merely a dream in a modern cash-economy that protects private landownership. Landless Filipinos find the uplands as a place to escape an oppressive tenancy system. They sweat it out by farming and aspire for the amenities of modern living, such as owning lands, buying a house and lot, sending children to college, and acquiring appliances. Annual cash crops were the logical crops to grow since they have no security of land tenure (Sajise and Baguinon, 1982).

During the pre-hispanic times, indigenous peoples were still under a subsistence economy while swiddening was a cycle of forest clearing by burning, upland farming, fallow, transfer and return (Olofson, 1981). The fallowing period was long enough to return the forest by ecological succession. But among cash economy-oriented upland migrants also known as *kaingineros*, swiddening became a plain hit-and-run operation, instead of an ecologically oriented upland farming. They clear, burn, farm, and go (Sevilla, J.C.C., 1981).

Natural forests near market centers must have been the first to be destroyed by cash-economy oriented swidden farmers. Eventually some of the converted lands were later classified as alienable and disposable A & D lands. Remote natural forests were safe as long as they are not made accessible to the market.

Shift to natural resources exploitation. The Philippines became an apprentice in the management of the state through the sponsorship of American benefactors. The state had to earn revenues through taxes to support national government agencies that offer services such as education, health services, public works, transportation, and communications, national defense, internal peace, and order, etc. Such government spending is expected to establish a healthy business climate that would spur economic growth and in turn stimulate economic production to increase exports, and thus, increase foreign exchange. The natural resources of the country were opened for mining, logging and agroindustrial projects guaranteed by the government through a license system. Accountability for harming the environment after a project was poor and

penalties by cancellation of the license seldom happened. Abandoned mines and logging concessions left bleak scenes of environmental destruction. However, off-site impacts are unnoticeable such as species extinction and heavy metal poisoning. Gains in taxes were accounted for but environmental and social costs were not.

Mining (started by the Spanish mainly for gold) proposed during the American period to include other metals such as copper, chrome, iron, etc. Agricultural products like abaca, copra, tobacco, and sugar were among the first dollar earning exports. Americans recognized the importance of forestry as a major dollar earning industry. In fact, American companies were among the first to conduct logging operations.

The role of education. Since education is the key to economic progress, it therefore paved the way for new academic courses such as agriculture and forestry. The American administrators established the University of the Philippines Los Baños (UPLB) by launching the College of Agriculture in 1909 and the Forestry School in 1910. The latter was under the management of the Bureau of Forestry until the 60's before it was finally turned-over to the UP system. Eventually, the Forestry School became the College of Forestry, which later on assumed the name College of Forestry and Natural Resources. Since then, agriculture and forestry schools increased in number and were very much influenced by their original predecessor at UPLB.

Graduates of agriculture and forestry supply the much-needed manpower for increasing agricultural and forestry exports. Unlike the Spanish, the Americans adopted a policy to educate Filipinos so they could provide the needed manpower that would catalyze economic development. Economic growth was seen as the only alternative. Agriculture and forestry graduates were employed and played important roles in the economic transformation of the country. Economic growth justified the importation of tractors and logging/farming machinery. To compensate imports, the country exported raw materials like logs and agricultural products. The volume of heavy equipment and fuel correlated with the volume of timber and ore extracted. The overall revenue was used to pay for the services of agriculturists and foresters, personal profits, and taxation.

Agriculture. The design of the agricultural curriculum took off from the assumption that graduates will play specific roles in the development and management of big scale farms. As experienced in developed countries, the bias for large but cost-effective farms is based on economics of scale wherein mechanization, irrigation, intensive inputs of chemical fertilizers, and crop protection backed-up by aggressive crop breeding programs have given immediate economic rewards. Even large-scale farms can hire specific expertise in agriculture.

With this, agricultural education was compartmentalized into many disciplines. The soil scientist handled soil amelioration and fertilizer problems. Crop protection appeared in three disciplines such as pathology, entomology, and weed science. Agronomy specialized on grains and leguminous seeds while horticulture focused on fruits, agroindustrial crops, vegetables, cut flowers, and plants for landscaping. Agricultural engineers attended to irrigation, agroclimatology, and invention of agricultural implements and machines. Animal husbandry took poultry, swine, and livestock as subdivisions. Applied genetics through plant and animal breeding occupied special niches in the fields of agronomy, horticulture, and animal husbandry. Agriculture has not only become compartmentalized but also commoditized. Thus, research and development in agriculture have been structured according to specific crops, so that agriculture branched out into the science of producing sugar, coconut, rice, corn, etc.

A farming systems approach to agricultural education with emphasis on ecological organic farming was unheard of until only recently in response to the detrimental effects related to the use of HYV's, pesticides, herbicides, and chemical fertilizers. In spite of this paradigm shift in agricultural philosophy, the organization of educational institutions offering agricultural programs barely changed. Being specialized, a graduate in agriculture would be unable to effectively backstop a farmer with a polyculture farm. During academic year 2004-2005, the UP College of Agriculture reorganized itself by clustering related fields. Hence, compartmentalization in agricultural education was reduced or modified.

Forestry. The introduction of the bizaare concept that forest can be natural or artificial was very unfortunate. The United States National Science

Development Board (1972) defined forest as a natural or artificial vegetation unit encompassing many different tree associations and harboring a multitude of other life forms, which use it for food or shelter or both.

It also defined forestry as the scientific management of forests for the continuous production of goods and services. American teachers trained Filipinos to think the same way. Note the use of the word "scientific", having been applied to green revolution agriculture, is also invoked for forestry as taught by the West. Tamesis and Sulit (1937) wrote,

> ...reforestation has a definite and specific meaning, it is the restoration of an area to forest either by artificial or natural means while afforestation is the planting of a forest on land which has not previously borne forests.

The more serious consequence of the ambiguous definition of forest and forestry is the myth that artificial forests also represent ecology much like its natural counterpart. Thus, during the First ASEAN Forestry Congress in 1983, Domingo wrote,

> ...when we convert a dipterocarp forest to pulpwood plantation, what we are doing is just transferring the jungle regrowth onto a tree species of our choice for pulpwood. Substituting the economically unnecessary but ecologically necessary jungle regrowth with an economically important pulpwood plantation does not change, it might even enhance the normal ecological pattern. The plantation can provide the same ecological benefits that the jungle regrowth provides. . . . the power of jungle regrowth has to be artificially controlled to prevent it from choking the planted species.

For a century, forestry schools graduated thousands of foresters who think like their mentors, most of whom joined the Bureau of Forestry (now Forest Management Bureau or FMB) and became company foresters or holders of Timber Licenses Agreement (TLA).

The forestry curriculum produced foresters who snugly fit as managers of big logging, sawmill, and plywood operations. Mechanized logging depended much on machines that are used to harvest, transport, and process forest products at a rate they claim sustainable. This claim of sustainability was an

a priori assumption. It was not tested if it was detrimental to natural biodiversity. American foresters transferred their timber harvesting technology that worked well in a temperate forest condition to a tropical rainforest condition. Their aim was to produce timber or pulpwood either from natural or artificial stands. Serevo (1949) proved, however, that mechanized logging is destructive (e.g., 60 percent of the natural forests is bare mostly due to logging roads) while carabao logging does not inflict significant damage. Even with this warning by Serevo (1949), scientific forestry prevailed over the antiquated Carabao logging.

After a logging experiment in Basilan, a forester named Martin Reyes introduced the Philippine Selective Logging (PSL) system for uneven-aged mixed dipterocarp forest (Tomboc and Bruzon, 1985). The system recommends the cutting of over mature and mature timber (>80 cm dbh) and leaving residuals (e.g., 70 percent of trees with 20-60 centimeters diamter breast height and 40 percent of trees with 70 centimeters diamter breast height) as future crop. An extreme form of the PSL is to subject the residual stand under Timber Stand Improvement (TSI) by liberating residual stock or preferred crop trees (PCTs) from competition at the expense of killing nearby non-commercial tree species (Von der Heyde, 1987).

PSL includes the survey of boundary limits of the concession, followed by a timber inventory that would estimate the total merchantable volume that can be harvested annually and the residual stock to be spared from damage due to logging operations. Tree markers earmark timber to be harvested by painting their stems that include recommended direction of fall. If timber is cut down in accordance with the appropriate direction of fall, minimum damage is inflicted against residuals. If implemented well, the residuals should constitute the future crop after some prescribed rotation period.

Commercially mechanized logging inflict unavoidable bare areas through the construction of main roads, spur roads, log landing, tractor paths, yarding paths, skid ways, and openings created by the crowns of fallen timber. Together, they sum up to 60 percent of the total logging set-up area. Thus, after mechanized logging, only 40 percent of the area would comprise actual residual stands while the rest are man-made gaps that are vulnerable to soil erosion during rain events (Serevo, 1949). Given that the logging concessionaire effectively protects residual forest stands, there is no guarantee that the degree

of disturbance would not significantly hurt natural biodiversity. Foresters observe that a forest naturally heals itself after being logged. Foresters enrich residual forests with exotic tree species (Caguioa, 1953). Apparently, foresters until recently were not keen on the problem of bioinvasion. Since they believe forests can either be artificial or natural, they plant exotic tree species at will even in national forest parks. The forestry curriculum was not designed to enable foresters to study the impact of logging on biodiversity and ecosystem health at the local and landscape levels. The curriculum trained them well to conduct economic feasibility studies of selective logging and the determination of cutting/rotation cycles. PSL and TSI were recommended even under the serious uncertainty that these may irreversibly affect natural biodiversity and ecosystem health.

Lai Food See (1992) found out that logged watersheds have over 90 percent storm sediment yield of the total load while unlogged watersheds are much lower 60 percent. There is evidence that conversion of natural forests to rubber and oil palm plantations (analogue forests impair hydrologic properties of watersheds (Daniel and Kulasingan, 1975; David, 1984). Heavy shifting cultivation (Bengyawan, 1990; Mendoza, 1980) and badly managed grasslands (David, 1978) cause decreased flows that may lead to drying up of creeks and rivers. Baconguis and Jasmin (1984) also observed in selected watersheds that dipterocarp and mossy forests yielded 55 percent and 294 percent more water than grasslands. Furthermore, the proportions of mean annual stream flow to mean annual rainfall were 18 percent for grasslands, 27 percent for secondary dipterocarps and 63 percent, for mossy forest watersheds.

At first, foresters mixed exotics and indigenous trees in reforestation (Makil and Ancheta, 1953; Lopez and Cunanan, 1954; Buenaventura, 1958). Later on, reforestation became almost equivalent to planting exotic trees in formerly forested lands (Lansigan, 1941; Lizardo, 1960; Claveria, 1953). Reforestation is expensive. The government spent,P18 M in 1975, P129.8 M in 1978 and P214 M in 1979 in reforestation prospects. The National Forestation Program in 1990 used foreign loans amounting to US $240 million for the same purpose.

Some of the introduced "reforestation" species like the large leaf mahogany king (*Swietenia macrophylla*) is bioinvasive to secondary dipterocarp forest (Castillo, 2001and Alvarez, 2001) and aggressively competes with indigenous tree species (Thinley, 2002). A very gregarious bioinvasive thicket is paper

mulberry (*Broussonetia papyrifera*), which was introduced in Mt. Makiling in 1935 (Delizo, 1951). Once established, it forms pure stands difficult to remove because of its underground runners. If Mahogany beats dipterocarps in partial shade, paper mulberry does the same against pioneer species in the open. Both species disrupt the normal ecological succession of an area.

In practice, timber production in the Philippines has not been sustainable because timber licensees fail to protect residual forests from swidden farmers or *kaingineros*. The network of logging roads connected erstwhile inaccessible rainforests to market centers and cash economy driven swiddens use them to market farm produce. Forests became grasslands. Since then, solutions to deforestation is pragmatic. Exotic trees are used instead. Foresters were trained to identify commercial trees as well as log and process timber into finished products. Unfortunately, scientific restoration of natural forests and natural biodiversity is not in the curriculum of forestry schools.

Forestry administration had nothing to do with biogeographic zones because of the centralized set-up. It was common for the Bureau of Forestry head to instruct regional directors and district foresters to use the same logging formula and reforestation strategies in the regions despite the differences in climate and biota. Later, the annual allowable cut formula was adjusted to consider climatic variation and its effect on the rotation cycle.

However, this was short-lived. There was the go signal to log residual forests and a total log ban for old growth forests. Reforestation and logging were not tailored to suit unique biogeographic zones and local ecological succession patterns.

Community-based Forest Resource Management (CBFRM). During the peak of logging in the Philippines from 1960 to 1980, landless people were hemmed in between the fences of private lands and forestlands. Many prefer to eke a living in natural forests than squeeze themselves in private lands because of the low risk of being caught by forest guards. The ratio of forest guards to forests is something like 1 to every 4,000 hectares of forestlands. In effect, the number of *kaingineros* has increased (National Task Force Population Foundation Center, 1980).

Relative to this, there were very few prison cells to accommodate all illegal

Relative to this, there were very few prison cells to accommodate all illegal *kaingineros*. Running after them and rounding them up was understandably futile. Hence, the government launched the forest occupancy management (FOM) or integrated social forestry (ISF), a new approach to solve the *kaingin* problem (Duldulao, 1981). Experiences from FOM and ISF were used to craft the Community Forestry Program (CFP) evolving finally into Community-Based Resource Management (CBRM).

The exit of the TLA made forests more vulnerable to illegal loggers and *kaingineros* (Malayang, 2000 and Vitug, 2000). Thus, the government opted implementing CBRM. In this approach, the burden of forest protection was transferred to communities. In exchange for protecting the forest, the government gives the stakeholders certain conditions with which they are allowed to use the CBRM area for livelihood, either to harvest forest products from the residual natural forest or to farm some areas therein, or both.

One institutional package in support to the FOM, ISF, and now the CBRM is the Certificate of Stewardship Contract (CSC). It gives its holder the right to develop a parcel of forestland for 25 years and renewable for another 25 years. The CSC gives security of land tenure to coax farmers to plant timber, fruit trees, and practice agroforestry. This should reduce poverty and defuse human pressure against natural forests.

The CSC is a modified system of private land ownership. Portions of the forestland are subdivided into parcels and each parcel has a "temporary owner". Unlike land titles, however, CSC does not allow transfer of land by selling. Holders transfer it only to heirs if the latter agrees to serve as steward to the CSC.

Many degraded grasslands were produced at the wake of the combined effects of mining, logging, and *kaingin*. One newspaper reported wanton destruction of natural forests by CBRM holders in Southern Mindanao. One destructive CBRM could only be the tip of the iceberg. If other CBRM holders are as destructive, then Philippine ecology is in trouble. CBRM holders are operating with former TLAs and what they are logging are residual forests. Residual forests are for future harvesting and not for the present. Mauricio (1982) warned that to force the issue destroys the residual stand. It threatens natural biodiversity, destroys watershed functions, and subverts carbon sequestration efforts.

CBRM has other problems. Foresters implicitly or explicitly educate CBRM holders that forest is an artificial or natural entity. Any timber-producing tree species, alien or native, is a reforestation species. Recommendations to plant fast growing tree species after cutting natural forests is expected. Foresters believe that exotic tree species are less expensive because they can be mass-produced with a quick return on investment, on top of fostering ecology just like natural forest.

Since forests can be artificial or natural, the issue of segregating exotic tree plantations from natural forests is trivial. It is common thinking among foresters to simplify and regard any land planted with trees as reforestation and if mixed with farm crops become agroforestry. The classic forester tends to consider exotic tree plantations, analogue forests, and agroforestry farms as the means of restoring forests. This pragmatic thinking could have been the stumbling block for the development of a truly scientific forestry – one that aims to restore natural forest ecosystems by considering the unique biogeography and ecological succession pattern of any given landscape. Realities in the field are more on the substitution of natural forests instead of their restoration.

The closest to the restoration of natural forest is the Assisted Natural Regeneration (ANR) which was recommended for implementation between 300 to 500 hectares of upland in every region in the Philippines as per DENR Memorandum Circular No. 17 CY 1989 and accompanying guidelines (Dalmacio, 1989). The objective of the ANR strategy is to liberate wildlings from competing vegetation, encourage faster growth, and facilitate their domination over the site. ANR will result in a multi-storey, and multi-species forest stand, which is more effective for watershed protection and wildlife habitat than a traditional plantation. However, Dalmacio (1989) did not mention gathering biogeographic and ecological succession data in the landscape to support mitigating measures against gregarious exotic tree species that may be competing with indigenous pioneer tree species. In practice, ANR allows any tree species growing wild as long as they develop canopy which could serve as nurse trees to timber species to be planted and later tended in the TSI approach. ANR has yet to evolve into a science by using biogeography and ecological succession as basis.

CBRM stakeholders execute their upland farms much like their predecessors in the lowlands. Large tracts of upland areas are parceled. Hence, each stakeholder is a temporary landowner. Farms surround farms. Farmers do not see direct relations between their farm with a nearby natural forest. Natural forests are expansion areas when the family or even the community becomes very big. Like lowland farmers, upland farmers are both spatially and culturally alienated from natural forests. Expansion is justified by replacing secondary forests with economically important tree plantations and agroforestry. These are claimed to reduce poverty in the uplands on top of providing ecological benefits such as increased biodiversity, watershed functions, and carbon stocks in the biomass.

Poverty reduction has become a catchword. Poverty is used to justify more loans and international aid. If projects do not realize profits to pay back loans, then debt servicing would exacerbate the situation and poverty is aggravated. In a way, loans used in forestry projects are like poison that is used to treat poisoning. Furthermore, trade liberalization undermines local agricultural products due to stiff competition offered by imports. CBFM farmers find themselves economically disadvantaged. Poverty reduction in the uplands is therefore remote under the preceding circumstances.

Unchecked population growth among CBFM holders would aggravate poverty and environmental problems.

More people means greater demand for land and for privatization by CSC. As in the case with land titles, CSCs will again create two classes of people in the uplands — the landed and the landless. There is a limit as to how much the landless can squeeze themselves in CSC lands. Hence, the landless eventually would create new farms including agroforestry at the expense of the remaining natural forests. Proponents justify conversion of secondary forests into agroforestry as a better option to swiddens becoming grasslands. Either way, natural biodiversity shall have suffered irreversible losses.

Agroforestry (Q) however can be coupled with natural forests (P) so they should share finite space together i.e., **P+Q=1**. This book therefore puts into proper context the limit to which agroforestry and tree plantations could reduce poverty, conserve/preserve biodiversity and sequester carbon for better management of upland natural resources.

MUTUAL EXCLUSIVITY OF AGROECOSYSTEMS AND NATURAL ECOSYSTEMS

From the above historical background, it can be deduced that the natural ecosystem is mutually exclusive with all kinds of agroecosystems. This mutual exclusivity can be written as an equation with **P** representing the natural ecosystem while **Q**, its opposite, represents all kinds of agroecosystems. Thus,

$$\mathbf{P = 1 - Q}$$

P (Natural Ecosystem) = **1** – **Q** (Agroecosystem), where an increase in **Q** means the inevitable decrease in **P**. Since, natural biodiversity (**p**) is in **P** and agrobiodiversity (**q**) is in **Q**, therefore p decreases as q increases, and vice-versa. To appreciate this mutually exclusive relationship, it is necessary to enumerate the dichotomy of the two.

First, agroecosystems are established by land preparation, while natural ecosystem comes about through ecological succession. Second, the weeds that farmers remove are the actors of ecological succession. Third, tillage is often a must in agroecosystems, but not in natural ecosystems. Fourth, soil amelioration maintains productivity in agroecosystems but productivity is sustained in natural ecosystems through efficient nutrient cycling. Fifth, the farmer and economic forces decide which animal or plant crop should be raised, but in the natural ecosystem this is due to forces of biogeography, evolution, and succession. Corollary to this, people use artificial selection/breeding, biotechnology, and genetic engineering to improve crop, but in the natural ecosystem only the fittest among populations survive through natural selection. Consequently, gene pools of domesticated animal and plant crops are very narrow, but the genetic spectrum of wild populations is many times broader. Sixth, due to the low genetic diversity of crops leading to susceptibility to pests and diseases, crop protection has become a must, unlike in natural ecosystems. Seventh, most agroecosystems are anthropocentrically tied to the global consumerist economic system, while natural ecosystems harmonize with people who regard nature with awe and respect.

Based on the cultural argument, agroforestry, forest analogues, and tree plantations should not be confused with the Filipino "gubat" concept. "Gubat" refers to a natural entity. Similarly, "wald" used by the Anglo-Saxons in Great Britain is the Teutonic counterpart of "gubat". The etymology of the word "forest" is from the word "*forestal*" loaned from the Norman French which meant vast estate owned by the nobility with or without woods (Bakuzis, 1971). Indeed, in the Legend of Robin Hood, the word forest (e.g., Sherwood Forest) meant an estate while the word "forester" referred to soldiers guarding the forest. Now, forest is any vast tract of land, natural or artificial, dominated by trees (regardless of origins) that serve man with goods and services. The present legal term "forestland" means virtually "forestal" except that ownership changed, instead of one owned by the nobility, it is now owned by the state. The modern English words, *foresters*, *forest*ry, agro*forest*ry, de*forest*ation, and re*forest*ation, are modern derivatives.

This book proposes a definition for the natural forest (equivalent to the Philippine's *gubat*-concept). A natural forest is any community dominated by trees and a product of evolution and coevolution, thus possessing a unique flora and fauna characteristic to the biogeography of the land or region. This definition should not be confused with artificial forest, which is a community dominated by trees anthropocentrically established and maintained for reasons other than the restoration of natural biodiversity.

SUMMARY AND CONCLUSION

The estimates of forest cover in the Philippines from 1890 to 2000 are plotted into a graph (Fig.1-12) based on the data in Table 1-1. From this data, one can see the rate of forest cover change during the century. For the nation, the P/Q ratio decreased from 1.38 in 1890 to only 0.24 in 2000. As of 1990, old growth dipterocarp forest dwindled to only 800,000 hectares with a 3.8 million hectares loss during the last 40 years. FAO reported a loss of 262,000 hectares between 1990 and 1995. In 2000, only 5.79 million hectares natural forests remain.

According to the Environmental Research and Development Bureau (ERDB), there are now 24 million Filipinos living in the uplands composed of mainly migrants and indigenous people. Government is implementing the CBRM

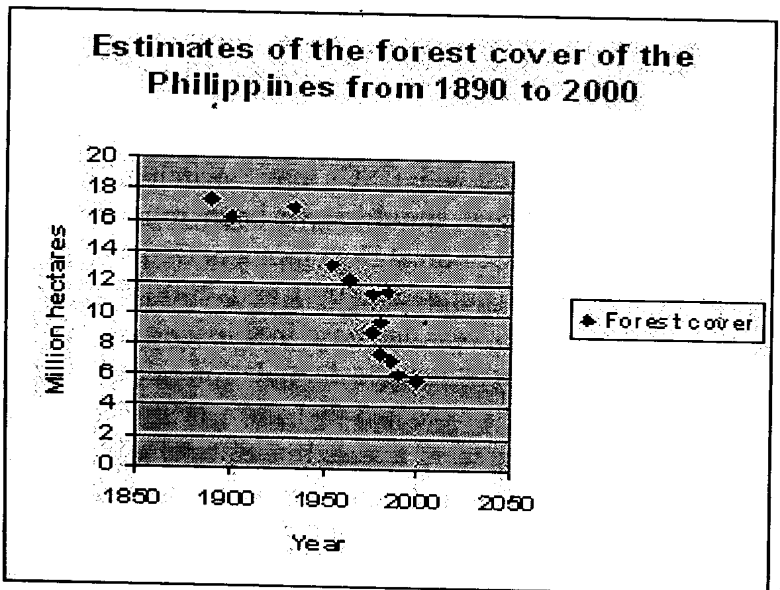
Table 1-1. Forest cover estimates from 1890 to 2000 and nationwide P/Q ratio.

YEAR	FOREST COVER (M ha)	P/Q RATIO	SOURCE
*1890	17.4	1.38	Fernando Castro (1890)
*1900	16.2	1.17	Philippine Commission (1901)
1934	16.8	1.27	Philippine forest map (1934)
*1954	13.2	0.79	Proceedings, National Conference on the Kaingin Problem (March 1964, Manila)
*1964	12.3	0.69	-do-
*1976	11.4	0.61	BFD Forestry Statistics
*1984	11.5	0.62	-do-
*1976	8.9	0.42	1976 LANDSAT, Revilla and Bonita (1976)
*1980	7.4	0.32	1980 LANDSAT in Revilla (1985)
*1980	9.5	0.46	World Resources Institute (1990-91)
1987	7.1	0.31	SPOT Satellite cited Philippine Biodiversity (1997)
1990	6.1	0.25	Philippine Biodiversity (1997)
2000	5.789	0.24	Food Agriculture Organization (2000)

strategy as replacement of TLAs. While this is presently so, CBRM whose land hungry membership armed with CSCs may "switch on" an irreversible problem of claiming lands that should have been returned to nature as biodiversity corridors. Thus, the Forest Development Center (2002) reported that in a span of 10 years (between 1990 and 2000), the Philippines experienced a 1.42 percent per year decrease in forest cover as compared to the 0.05 percent and 0.24 percent average degradation rate of Asia and of the whole world, respectively. It is expected that from 1990 to 2000, degraded open grasslands must have increased approximately to 4 million hectares.

Can the government reverse the rate of natural forest decline as a result of on-going anarchy in the uplands? The writers of this book are challenged by this fundamental question and are therefore obliged to write the many ways agroforestry can be of practical application to help reverse deforestation. The

pressing national problems on poverty, deforestation, and ecological degradation in the uplands are not at all hopeless. The authors of this book hope to convince the reader that agroforestry, if properly coupled with natural ecosystems, will bring sustainable development in the uplands. Doing this will provide fixed spaces for both agroecosystem and natural ecosystem in a finite land. Their interdependence will make the uplands an additional "bread basket of the country" and at the same time provide the needed space for endemic flora and fauna to reclaim lost grounds and fragmented natural forests interconnected. A land use policy applicable at the level of forest-edge communities should lay the cornerstones that divide "land for man" and "land for nature" on the ground and map to enable the making of a new ecological covenant. This is difficult because parties to the covenant have to first undergo a "de-alienation process" that will guarantee an unambiguous "ecological governance" that insures intergenerational harmony between people and nature in the uplands. Ecological governance and human population management will make this harmony achievable and a true environmental justice will be attained. Nature's lost ground in the Philippines will be restored once again in accordance with the uniqueness of its biogeographic zones and patterns of ecological successions, at the same time governance metamorphoses from pure politics to one that is also scientific.



Source: Proceedings National Conference on Genetic Resources and Development, 1987

Fig 1-10. Declining Philippine natural forest between 1890 and 2000.

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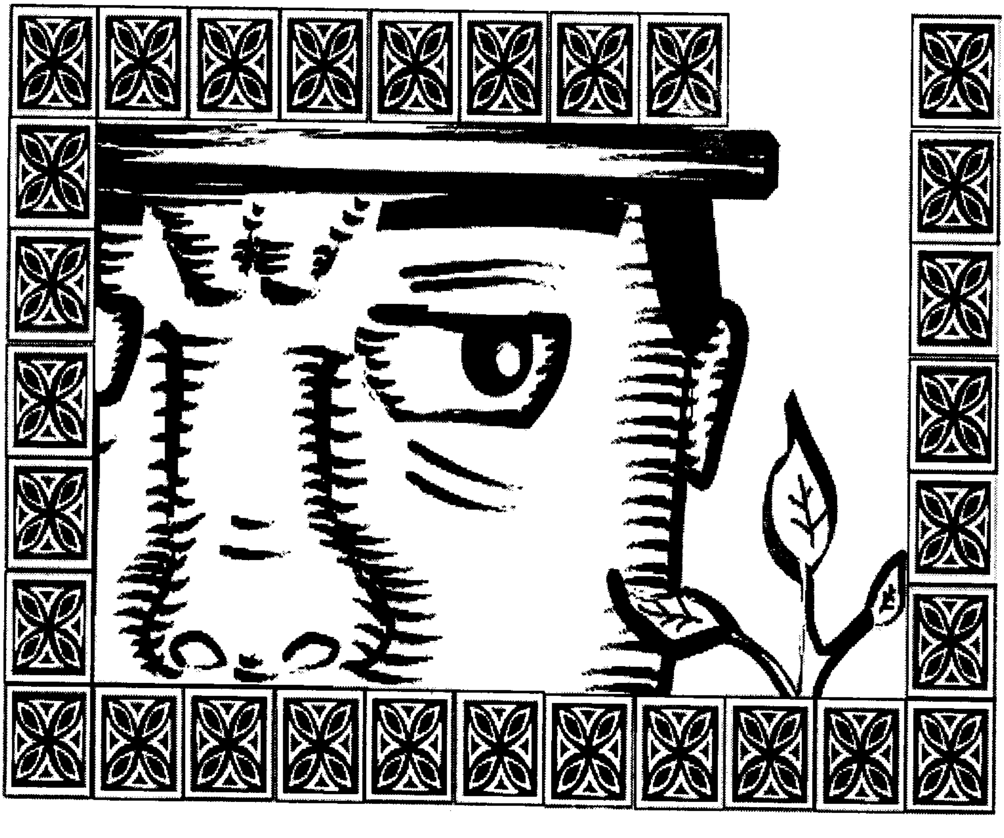

CHAPTER II

FARM FORESTRY AND AGROFORESTRY OPTIONS, LOCAL BENEFITS, AND IMPACTS

Paulo N. Pasicolan

OBJECTIVES

After studying this chapter, the reader should be able to:

1. broadly describe the dynamics and impacts of forest land use change in the Philippines;
2 identify the issues related to sustainable land use adoption;
3. describe farmers' constraints and dilemmas in tree growing; and
4. highlight the potential of agroforestry land use systems in addressing farmers' food and cash needs, and in improving environmental services for greater societal welfare.

INTRODUCTION

Gross poverty plaguing the countryside creates continuous ecological havoc that further marginalizes the rural poor. As the natural landscape is going through rapid transformation due to increasing demographic pressure, it has far-reaching adverse social, economic, and environmental consequences in the lowlands. This vicious cycle of poverty and environmental degradation becomes a hindrance to redeeming the value of the Philippine uplands.

Exacerbated by sprawling urban growth in industrial centers, continuous pressure on the land increases. Many of the country's prime agricultural lands are now being converted to residential and industrial complexes. In turn, forestlands are gradually being transformed into agricultural lands to meet the growing population's food demand. Such competition in land use does

not only bring about imbalanced development in the agricultural sector. It also heightens environmental vulnerability caused by the increasing/intensifying influx of more people to the uplands, where many landless and poor peasants rush in to make a living. Each land user tries to maximize what he can obtain from the already degraded resource beyond its carrying capacity. Under such worsening condition, the balance between burgeoning population and food supply threatens to collapse.

Securing the "food basket" of a typical farm household and ensuring resource base sustainability at the same time becomes the core concern of every development intervention working in the uplands. However, there is the convergence of interests of both the poor and the rich. As an important agroecological zone along the landscape continuum, it does not only serve as a production area to many but also a source of environmental services for the general public. For instance, well-vegetated uplands would result to improved water yield for downstream users. Likewise, fresh air and regulated climates from rehabilitated vegetation can benefit society. Protected biodiversity can improve the local and national economy through ecotourism. These are environmental services that one can get from well-managed uplands.

But who will safeguard the ecological integrity of the uplands? Who will shoulder the cost of protecting and maintaining the ecosystem? How can we motivate "on-site" small farmers to adopt sustainable land use systems, knowing that their efforts in doing so may not pay off immediately? Is there a mechanism to spread out the cost of conserving the uplands among downstream and upstream users?

Considering these concerns, the first part of the chapter describes the status of Philippine uplands in terms of forest vegetation and land use cover. Furthermore, six selected case studies are presented in the second part of the chapter to support the discussion on Philippine uplands. In addition, agroforestry was defined and classified towards the end of chapter.

STATE OF PHILIPPINE UPLANDS*

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 million hectares out of 30 million total land area). By the year 1900, there were still 70 percent or 21 million hectares of forest cover (Garrity, et al., 1993; Liu, et al., 1993). However, by 1996 there were only 6.1 million hectares (20%) of forest remaining (FMB, 1997). Thus, in the last century alone, the Philippines lost 14.9 M ha of tropical forests. The average deforestation rate from 1969 to 1973 was 170,000 hectares per year (FDC, 1987). For the past 20 years, it was 190,000 to 200,000 hectares per year (Revilla, 1997).

However, in the last few years it was estimated to be near 100,000 hectares (Lasco and Pulhin, 1998). In the Philippines, the direct and indirect causes of deforestation include shifting cultivation, permanent agriculture, ranching, logging, fuel wood gathering, and charcoal making (Kummer, 1990). Forestlands are important sources of water for irrigation, hydroelectric power, industrial use, and household use. They are also home to millions. There are about 20 million Filipinos living in upland watershed areas, half of which are dependent on shifting cultivation for livelihood (Cruz and Zosa-Feranil, 1987). Soil erosion and degradation are serious problems in the country where it is estimated that 8.3 million hectares out of 30 million hectares of land are severely eroded (EMB, 1990).

Philippine forests have extremely high floral and faunal diversity. They harbor 13,000 plant species, which comprise 5 percent of the world's total plant species (DENR/UNEP, 1997). With continued deforestation, some species previously occurring in certain areas are now endangered or even extinct. According to McNeely, et al., (1990), the Philippines is one of the biodiversity "hot spots" of the world. The main strategy in biodiversity conservation is through the implementation of the National Integrated Protected Area System (NIPAS) Law. At present, 18 terrestrial and marine reserves have been proclaimed as initial components of NIPAS. However, many of these areas are protected merely on paper because of lack of resources.

* In the Philippines, uplands denote land areas that are above 18 degrees in slope which are typically hilly and mountainous terrains. By law, they are supposed to be under forest cover.

FOREST VEGETATION AND LAND USE COVER

Forest vegetation in the Philippines is fast changing overtime. Today, about six major land use covers characterize our forestlands, namely:

a. *Old-growth and other protected forests.* Since 1992,the Philippines has banned logging on all old-growth forests, mossy forests, and those forests above 1000 meters above-sea level and with less than 50 percent slope. These forests are now part of NIPAS. In 1995, the forest area under protection was estimated at 2.7 million hectares. This includes mainly mossy (1.1 million hectares) and old-growth forests.

b. *Dipterocarp forests (0.8 million ha).* Pines, mangroves, and sub-marginal forests make up the rest. Sub-marginal forests are defined by government statistics as "tropical forests dominated by *Luguminosae* and lesser used species that are mainly restricted to shallow and excessively drained limestone soils" While pine forests are naturally occurring in highly elevated areas composed mainly of *Pinus kesiya.*

   With the enactment of the NIPAS Law in 1992, there is now a stronger legal basis for the establishment and management of protected areas. However, the perennial lack of resources poses a big problem in the short- and medium-term.

c. *Secondary forests.* As of 1997, there were 2.8 million hectares of secondary forests in the Philippines (FMB, 1998). The policy of the government since 1992 has been to rely on these forests as the main source of wood. Logging in natural forests are allowed only in post-extraction secondary dipterocarp forests. The dynamics of post-extraction secondary forest and swidden-fallow secondary forest formation are discussed in more detail below.

d. *Upland farms.* Approximately, there are 5.7 million hectares of upland farms in the Philippines. This area includes both forest tree-based farms, including swidden-fallow secondary forests as well as coconut plantations (typically intercropped), and fruit orchards. However, a great portion of these areas is likely to be devoted to annual crops and is thus, not true

swidden-fallow systems. In response to the problem of shifting cultivation in the uplands, the government is promoting agroforestry as the main alternative production system (Nera, 1997; Lasco and Malinao, 1993; Agroforestry Comm., 1986). Agroforestry involves the raising of woody perennials with agricultural crops and livestock. The most common agroforestry systems in the Philippines are alley cropping and multistorey systems (Lasco and Lasco, 1989). There is great uncertainty as regard to the total area under upland farms, and related swidden fallow secondary forests, since they are highly dynamic.

e. *Brushlands.* As of 1997, there are 2.4 million hectares of brushland areas in the Philippines. Essentially, these are remnants of tropical forests, which were progressively degraded by excessive tree cutting. Forest cover in these areas is less than 20 percent and the vegetation consists of relic trees, shrubs, and grasses. Given adequate protection, these areas are expected to regenerate back to mature forests.

f. *Tree plantations.* The main strategy of the government to rehabilitate vast denuded areas is government reforestation activities and private commercial tree plantation establishments. Typically, fast-growing species such as *Gmelina arborea, Acacia* spp. and *Eucalyptus* spp. are used. In government reforestation activities, trees planted are intended solely for establishing a permanent forest cover and are not to be harvested. On the other hand, private developers establish commercial tree plantations on farms, which are harvested after 10-15 years. The current rate of tree plantation establishment is estimated at 65,233 hectares in 1995 (FMB, 1996). There is no accurate estimate of the total area actually planted. Official records show that from 1976 to1995, 1.3 million hectares was planted while 0.6 million hectares are assumed to exist (Lasco and Pulhin, 1998).

g. *Grasslands.* Except in limited high-altitude areas, there are no natural grasslands in the Philippines. The existence of about 2 million hectares of grasslands are man-induced and man-maintained ecosystems. Previously forested, these grasslands are the product of severe land degradation associated with deforestation and land tillage. If protected, they will regenerate into tropical forests. However, regular burning prevents plant succession from progressing.

SELECTED CASE STUDIES OF FORESTLAND USE CHANGE

The pattern of forestland use change in the country over the years normally started from forest cover to *kaingin*, then to grassland or permanent agriculture, and back to tree cropping or agroforestry. This cycle, however, does not always apply in all cases, as there are certain intervening conditions that may allow the permanence of one land use type more than the others. An example is the sustained climax stage of grassland ecosystem in many degraded areas due to seasonal grassfires, purposively or unintentionally being perpetuated over time.

The case studies review the interplay of various enabling conditions that may favor the dominance of one land use cover over the other.

Five cases of land use transformation are presented with the corresponding dominant features:

1. Market-driven (Salingdingan)
2. Government-initiated (Villa Meimban)
3. Local demand-directed (Lacab)
4. Farmers' enterprising option (Salinas)
5. Institutional partnership-motivated (Bukal del Norte)

Case 1: Successful Grassland Transformation in Salingdingan*

Salingdingan is an upland village of Ilagan, Isabela with a land area of 173 hectares, located at the foothills of the Sierra Madre Mountain Range, Northeastern Luzon. Its terrain is rolling with mild undulating slopes and its soil texture is sandy to clay loam, suitable for corn and upland rice production.

In the 1940s, dipterocarps and other premium species thickly covered the area. Four big logging companies operated in the area from 1950 to early 1970. The

* Taken from the author's paper titled: Productive Management of Swidden Fallows: The Interplay of Market Forces and Institutional Factors in the Philippines. In: Malcolm F. Cairns (ed.). *International Conference on: Indigenous Strategies for Intensification of Shifting Cultivation in S.E. Asia*, June 23-27, 1997, Bogor Indonesia.

first settlers practiced shifting cultivation at the forest fringes with upland rice (*murong)* as their first crop. No plow or draught animal was used but only a dibble or hoe for planting. As logging moved further afield in the 60s, the influx of migrants to the area also increased. The logged areas were almost cleared and cultivated. One logging firm cleared about 200 hectares, in a year. The 60s and 70s were the haydays of the logging industry in the Philippines. The government gave incentives to logging companies to go even beyond their allowable yearly cut. This accelerated forest clearing.

Population increase in the area was insignificant compared to the pace of deforestation. The uncultivated logged-over areas slowly turned to grassland savanna. Shrubs, *Imperata* and *Sacharum* dominated the area.

In the late 60s, more people from nearby provinces migrated to the area in search of arable lands. There was continuous farmland expansion as population doubled. The *Imperata* dominated areas turned into croplands. However, the *kaingin*, which was earlier opened, were abandoned due to decline in soil fertility. While under fallow, they were used for grazing and later on became pasture-lease areas. As the community grew and became a more functional political unit in the 70s, government basic infrastructures and social services came in. People got more organized. Farm zoning and boundary demarcation were done.

The 60s was also the peak of white corn production, mainly for subsistence. Farmers usually intercropped it with legumes, vegetables, and even tobacco as a source of income. In 1975, the first yellow corn was introduced as feeds. Its promising price, along with the presence of capital lenders, encouraged farmers to shift to yellow corn production. However, most of the profit goes to the supplier of hybrid seeds and the creditors. Dependence on inorganic fertilizers increased overtime as soil fertility declined. Because of this, farmers became more indebted. Driven by the need to redeem their loans, they were forced to expand their clearings resulting to less or unused grasslands.

In 1989, the Integrated Social Forestry Program (ISFP) was introduced as supposedly the "spring board" for the spontaneous tree growing in the area. However, the emphasis was on hedgerow contour farming such that very few farmers were able to grow trees in their farmlots.

Meanwhile, in 1994, some farmers got a chance to visit a wood cement board manufacturing plant in Cagayan through a sponsored educational trip. As a result, the farmers were challenged to grow *Gmelina arborea* in their farmlots due to high wood demand and production support inputs offered by the Plant.

Shortly after the trip, the farmers began to interplant *Gmelina* with corn. Later, most farmers converted portions of their croplands to tree plantations. Further, the Government imposed a cutting ban on 'narra' (*Pterocarpus indicus*), a premium species for furniture making and house construction. Since then, local furniture shops resorted to using *G. arborea* as alternative wood for material making because of its comparative qualities, thus increases all the more the local demand for the said species. Today, the planting of such tree crop in most farmers' lot in the area is now a common thing as more and more farm households benefit from the wood species overtime.

Over the years, the Salingdingan land use shifts illustrate the effect of changing market commodity (towards what gives the highest return to investment) on farmers' choice of crop. This, in turn, determines the dominant land cover at certain time horizons.

Case 2: Unsustained Tree Growing Efforts in Villa Meimban*

Villa Meimban is a remote upland community, isolated from the town proper of Cordon, Isabela by networks of small streams. The rugged and steep terrain of the area requires a special kind of vehicle to make a trip which usually run twice a week during dry season and seldom in the rainy days.

Farming boomed in the 70s because of the surplus harvest from newly opened *kaingins*. But life began to be difficult for most households in the 90s as population increased with decreasing arable lands and declining soil fertility overtime. The community became an ISFP area in 1984, but the farmers just participated because of the cash incentives they would receive from the DENR for every lineal foot of contour hedgerows they constructed in their farmlots. When payment was withdrawn, they went back to their erosive farming practice and some even continued to open new *kaingins*.

The government tree-growing project that hired people to plant trees in public lands in 1988 came at the right time when the harvest for the past 3 successive years failed due to long drought. The first 2 years of the project went well; Local

* Lifted from the author's PhD dissertation: Tree Growing on Different Grounds: An Analysis of Local Participation in Contact Reforestation in the Philippines. Centre of Environmental Science, Leiden University, The Netherlands.

participation was high and seedling survival reached 90 percent, which was rare in the area's history of reforestation being a fire prone zone. This was because 60 percent of the total contract payments were given in full that bolstered the confidence and motivation of the locals to participate.

The following years, payments got delayed and the climate improved. The manual labor that farmers supposed to give to the project was invested instead to farm labor as the demand for it increased because of the start of the rainy season.

Disgruntled by the delays in their payments, alongside the need to attend to their farms, most participants abandoned prematurely the project, while some allegedly suspected to have set fire to the project.

The abandoned reforestation project turned back to grassland and some portions were converted to *kaingins*. *Sacharum* and *Crisopogon* grass species once again dominated the area. All that remained were saplings of *G. arborea*, a reminiscence of the millions of pesos the government invested in the project over the past years.

The Villa Meimban case exemplifies the impact of problematic government reforestation projects on the pace and direction of land use change towards a desired vegetative cover. Oftentimes, the resulting land use in degraded areas is mainly influenced by the success or failure of government intervention projects operating in the site. Forest restoration ranks top in the government's environmental priorities. However, when tree growing projects are poorly carried out, they cannot bring about improved land use systems even with the application of cash incentives for community participation.

Case 3: *Kaingin* as an Agroforestry System in Lacab*

Normally, rural farmers are reluctant to introduce long-term improvement s or soil conservation measures in areas where they have no security of tenure. The upland farmers at Lacab reforestation project, however, acted quite differently.

Participants were highly motivated to plant and maintain tree seedlings on their

* Lifted from the author's PhD dissertation: Tree Growing on Different Grounds: An Analysis of Local Participation in Contact Reforestation in the Philippines. Centre of Environmental Science, Leiden University, The Netherlands.

kaingin farms because of the prospect of one day owning and sustaining usufruct practice in the project area.

The people were squatters and subsistence farmers in the logged-over area, before its conversion into a reforestation site. Faced with the possibility of losing their usufruct access if the project would be turned over to outsiders in the future, they were prompted to protect and maintain the planted seedlings as a condition for longer use through FLMA. Their exemplary performance clearly demonstrates their willingness to work, even amidst irregular payments and under compensation. Maintaining their usufruct mattered more than the wages from tree planting and protection.

This case study tries to highlight the positive effect of assured access or property rights in stimulating local people's sustained participation in tree growing in an area under threatened ownership or illegally squatted.

Captive actors became contractors

By virtue of their initial position in the project site, farmers at the Lacab reforestation project can be seen as 'captive actors' to reforest their *kaingin* farms, while simultaneously raising agricultural crops for their subsistence. Since the 70s, the project site has been cultivated by migrant farmers from Ifugao, Cagayan, and other northern provinces. All were landless peasants pushed from their original settlements by unequal land rights or population growth, and tried to find a living in the new place.

The site is considered the community's primary production area, where both subsistence and cash needs can be met. On average, a farmer has at least 5 ha of arable land in which the effective area under cultivation for rice or corn is 0.5 ha. The remaining portions were all planted with bananas, papayas, coffee, and other subsidiary farm crops for cash needs. Only a few farmers have paddy rice fields. As such, the project site serves as the only income of a one-hectare *kaingin*.

At first, all 12 family contractors resented the conversion of the area into a reforestation site. Being in the site since the 70s, they felt that land informally belong to them as squatters of the area.

Most of them recalled the punitive measures adopted by the Forestry Department in the mid-70s to curb the increasing upland encroachment in the area. With such traumatic experiences in mind, the 1989 introduction of reforestation within the *kaingin* area was perceived by them as a signal of a renewed struggle over the land.

Table 2-1. Average yearly gross production of one-hectare *kaingin* at Lacab reforestation site (Personal Interview, 1993).

Source	Ave. gross income/ annum (Php)	Remark
1. Banana	12,000	Year-round production for market
2. Upland rice	1,800	One season; mainly for home use
3. Corn	3,500	One season; for market & home use
4. Vegetable & Coffee	1,000	Year- round production for home use
Total	18,300	

Contrary to their fears and uncertainties, there was a totally different social climate compared to their oppressed condition in the 70s. Instead of ejection, they were recruited as contractors within their respective landholdings inside the newly-declared reforestation area. With this approach, they sensed the government's sincerity to involve them in forest development. This pacified their doubts concerning the uncertainty of their continuous stay in the area. In principle, they willingly cooperated with the DENR project management team not because of the cash incentive for tree planting but more for land tenure security.

The Lacab case shows the interplay of tenurial security and enabling project management approaches in motivating farmers to shift from agricultural monocropping to tree-based system in usufruct areas. Likewise, it highlights the importance of being guided by local-demand or the felt-need driven approach in bringing about the desired land use cover in open public lands.

Case 4: Farming Options vs. Tree Growing Income in Salinas*

One objective of contract reforestation is to provide economic incentive for the rural poor to motivate them to participate in tree growing projects. This strategy is based on the assumption that the poor have limited economic option. With the cash earnings the program could offer, massive participation of rural farmers would likely be expected.

* Lifted from the author's PhD dissertation titled: Tree Growing on Different Grounds: An Analysis of Local Participation in Contact Reforestation in the Philippines. Centre of Environmental Science, Leiden University, P.O. Box 518,2300 RA, Leiden, The Netherlands.

In Salinas, rice farming and vegetable production are the main year-round preoccupation of people in the area. Participation in the project is just one among various income sources available. The project's relative financial profitability is rated against that of the other income patterns in the community. It is interesting to examine how the project's earnings would rate with respect to other income options in the community. Likewise, it is important to know the context in which the project's income may be regarded as an incentive or not.

This section highlights the effect of the level of economic security on the participants' behavior and quality of project's performance. Having a stable subsistence or being in the state of cash surplus appeared to be a plus factor for project success in the case of most contractors in Salinas.

Most of them recalled the punitive measures adopted by the Forestry Department in the mid-70s to curb the increasing upland encroachment in the area. With such traumatic experiences in mind, the 1989 introduction of reforestation within the *kaingin* area was perceived by them as a signal of a renewed struggle over the land.

Contrary to their fears and uncertainties, there was a totally different social climate compared to their oppressed condition in the 70s. Instead of ejection, they were recruited as contractors within their respective landholdings inside the newly-declared reforestation area. With this approach, they sensed the government's sincerity to involve them in in forest development. This pacified their doubts concerning the uncertainty of their continuous stay in the area. In principle, they willingly cooperated with the DENR project management team not because of the cash incentive for tree planting but more for land tenure security.

Comparative economic advantage

Joining the reforestation project was more of a part-time livelihood activity than the main occupation among subsistent farmers. The presence of diverse income sources in the community made participation in the project just another economic option for the people (Table 2-2).

On-farm labor was in continuous demand year-round because rice and vegetables are raised on three and two cropping cycles, respectively. At P75 a day on the average, a farmer with a household of five can subsist at a minimum food level. On the other hand, some farmers engage for an even better rate in contract jobs like road and drainage construction during off-farm season.

Table 2-2. Livelihood options for an average farmer in Salinas, Bambang, Nueva Viscaya.

Income source	Ave. yearly net earning (Php)	Man-day labor	Time engagement	Cash regularity
Rice production	32,000	100	seasonal	low
Vegetable sales	30,000	120	seasonal	low
Off-farm labor	15,000	varied	intermittent	high
On-farm labor	10,000	144	seasonal	high
Reforestation	22,376	240	full time	very low

Source: Personal Interview, 1993.

A vegetable farmer can earn an average net income of P30,000 in one year from his 0.5 hectares *kaingin* in two cropping cycles. This was in contrast to the expected income of P33,284.50 for the first year, P16,923.00 for the second year and P16,923.00 for the third year in a five-hectare reforestation project. Furthermore, there were higher labor and man-day inputs for seedling establishment, maintenance, and protection. Full time attention was needed especially during dry months to prevent grassland fires in the project area. However, despite the comparative profitability of other livelihoods over the projects' earnings, many farmers still participated in the reforestation.

Some farmers preferred to spend their off-season in improving and cleaning their fields rather than joining the project. On the other hand, most daily wage earners preferred work that ensured daily take-home pays.

In practice, most participants had more than one income source. Those who were not dependent on the project for subsistence can endure late payments from DENR as often as it was the case. However, few subsistence laborers who cannot wait any longer for their delayed payment dropped out easily from their participation. The local residents near the project area found it more convenient to work in the reforestation project than search for off-farm jobs. But, unless there was regular cash flow for their participation, the residents' continued involvement was not guaranteed. For the participants who were above-subsistence level or already in a cash surplus status, joining the project was an incentive. However, for the below-subsistence level participants, it was a disincentive when they cannot avail of their immediate payment. Cash regularity, therefore, defined their sustained participation.

The Salinas case presents the effect of the farmer's cash and subsistence level in determining his range and land use options in degraded open public lands. Cash surplus and above subsistence households are more likely to invest in sustainable land use systems than the marginal ones. Thus, the direction and pace of land use change in certain areas is influenced partly by farmers' financial capacity under a favorable government policy climate.

Case 5: Tree Growing Partnership in Bukal del Norte*

Bukal del Norte is an upland village of Dinapigue, Isabela. It is situated in the eastern coastal zone of the Sierra Madre Mountains.

The area was once covered with virgin forest. Commercial logging increased/ expanded from the 1970s to early 1980s. During these years, members of almost all of the village's 200 households worked for the logging companies as forest guards, scalers, haulers, and mill workers. Only two of the five logging companies that began work in the area in the 1960s are still operating. The Government allowed the remaining companies, Luzon Mahogany Timber Corporation (LUZMATIM) and Pacific Timber Export Corporation (PATECO), to continue operating because of their good record of strict adherence to forest regulations, particularly in reforestation activities.

The closure of the other three logging companies in 1993 brought a major setback to the livelihood of the people in Bukal del Norte. The two remaining companies also scaled down their logging activities and intensified reforestation, so that the main source of cash income in the community was drastically reduced.

As a part of a community livelihood outreach program, one of the companies, PATECO, initiated a tree-growing program at the household level in 1993. This was in line with the company's desire to establish a community forest plantation to meet its future raw material needs.

A massive campaign began to disseminate information about the prospects and benefits of the proposed livelihood program. It was conducted in collaboration with

* Taken from the author's paper: Productive management of swidden fallows: The interplay of market forces and institutional factors in the Philippines. In: Malcolm F. Cairns, ed, *International Conference on Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia*, June 23-27, 1997, Bogor Indonesia.

the Community Environment and Natural Resources Office (CENRO), the local unit of DENR. Aside from outlining tree growers' responsibilities, the campaign offered incentives to prospective participants. PATECO offered to provide the starting capital and seedlings, while tree growers would contribute labor and land. In return, PATECO agreed to buy wood from the growers at a fair price.

Then the CENRO released more public land for farm-based tree growing, on the basis that this would save a large amount of government money being spent on reforestation. To safeguard each party's interest, a tripartite agreement was forged among PATECO, the tree growers, and the CENRO.

In the first year, only five farmers entered into agreement with PATECO. They planted *G. arborea* and *Swietenia macrophylla* on areas of land that had been idle for many years. Much of it was abandoned swidden fallow. In the second year, after the CENRO started providing additional tree growing areas, the number of participants increased to 30, then to 105 in the third year. The project has been so enticing that almost all of the households in the community are now growing *G. arborea* on their farmlots, even without direct government financial support. The size of the individual farmlots planted with *G. arborea* ranged from 1 to 5 hectares.

With market security and starting capital for seedling establishment provided by PATECO, tree growers in Dinapigue successfully converted idle lands into tree-based systems.

The Bukal del Norte case conveys the importance of addressing the small farm households' basic constraints to tree-based cropping systems through partnership among the government, private sector, and farmers. Apparently, under a favorable tri-partite agreement, small farmers may likely convert uncultivated but productive open public lands into forested areas.

CONSEQUENCES OF DEFORESTATION

Deforestation is considered as the main antecedent of further land use changes that cause tremendous environmental degradation in the country. Aside from the alteration of the natural landscape, the following are its subsequent effects and impacts:

a. Loss of potential commodities and services. With the severe forest

cover loss our country is experiencing, shortage of primary wood products has resulted. This significantly decreased our dollar earnings from exporting timber products in recent years. Among the products and services affected are:

- industrial timber;
- wide assortment of non-timber products and services;
- high quality pulp and paper; and
- constituted or fiber board products.

b. *Decreased fuel wood availability.* Deforestation over the past decades also affected many rural communities that are heavily dependent on the forest for materials, food, and fiber. The most evident effect is the shortage of readily available fuel wood for people living in onetime heavily forested areas. Among the impacts of fuel wood deficit are:
   - increased time and money costs of obtaining fuel wood;
   - increased man-day labor in obtaining fuel wood; and
   - increased dependence on fossil fuel and other non-renewable forms of heating energy.

c. *Impacts on agriculture.* Another concomitant consequence of forest loss is its long-term impact on agriculture as manifested by the following:
   - erosion and soil compaction reduce on-site productivity;
   - irregular water flow jeopardize lowland irrigation; and
   - desertification reduce arable cropping and grazing areas.

d. *Impacts on downstream infrastructure and human life.* Indirectly, the loss of forest cover also results in the following disasters:
   - sedimentation that fills irrigation systems, canals, and reservoirs;
   - floods and landslides which damage roads, bridges, buildings, and crops; and
   - floods that claim personal property and human lives.

e. *Impacts on natural habitats and biological resources.* The continuous shrinking of the forest area due to indiscriminate logging threatens to:
   - reduce genetic resources to extinction;
   - disturb domesticated plant and animal breeding; and
   - lessen opportunities for research and education.

f. *Negative impacts on indigenous culture.* With continuous deforestation, indigenous communities are marginalized and disfranchised as a result of the following:
   - loss of lands for hunting, fishing, firewood gathering, and farming;
   - vulnerability to diseases and human rights abuses;
   - physical displacement; and
   - loss of traditional technical knowledge.

g. *Global impacts.* The alteration of the natural landscape to barren vegetative cover does not only affect the immediate environment but has also far-reaching regional and global consequences in terms of the following:
   - release of carbon into the atmosphere causing climate change;
   - changes in local and regional rainfall patterns; and
   - effects to global commons such as oceans, air, and the lithosphere.

MAJOR DETERMINANTS OF FOREST LAND USE CHANGE

The transformation of forest landscape into varied land use types is attributed to the following factors:

a. *Ownership and control.* Land and tree tenures are important determinants of forestland use change. In most cases, upland farmers may likely invest in tree-based cropping system, if land or tree tenure is assured. In instances where there are no clear ownership rights, some farmers may be motivated to introduce tree crops or physical development to strengthen their legal claims over the lands they currently cultivate.

b. *Type of governance.* The type of management arrangement also determines the extent in which certain public lands can spontaneously be transformed into desirable land use systems. Past experience with purely government-administered reforestation programs required a huge amount of public investment to rehabilitate, protect, and maintain degraded forestlands,

yet with a dismal outcome. Under private initiatives, however, highly motivated small farmers can gradually shift from monoculture annual cropping to tree-based farming systems if given the right incentives and support systems. Likewise, under community-based forestry, tree growing can become a collective effort, especially among indigenous communities.

c. *Technology.* The type of farming technology being introduced to upland farmers also determines the kind of land use change. Agroforestry as a potential alternative land use type for small farmers, helps increase the likelihood of making forest restoration more spontaneous, cumulative, and sustainable. This is because it can ensure the farm household with food and cash on a sustainable basis under a favorable policy environment.

d. *Urban pressure.* The need for more space for human settlements, commercial establishments, and other infrastructure build-up in nearby urban centers puts the remaining natural wilderness under constant pressure. As more prime agricultural lands are given up for real estate, commercial centers and other industrial areas, forest margins keep shrinking to more clearings for agroindustrial expansion.

e. *Upland migration.* The ever-increasing population growth continuously exerts demographic pressure on the country's remaining natural resources. As more lowland peasants are squeezed from their onetime settlements due to agrarian problems, they are forced to flee to the uplands and make a living. Others are being displaced from their ancestral homes because of government projects, such as hydropower dams, road construction, and other major infrastructure build-up.

f. *Market forces.* The presence of a promising market for certain agro-based products is a powerful force that dictates the type of land use system prevailing in a certain locality. A good example of this is the case of the vegetable producers at Benguet province in the north. Despite the steep sloping terrains of the area, farmers opt to grow vegetables year round because of the high market demand for the products. With the Philippines' growing participation in world trade, there is the propensity that the type of change in our natural landscapes will be determined by market forces. The crops that the global market defines as our selling point will make a mark on our natural landscape.

g. *Upland poverty.* The high poverty incidence in the uplands is another factor to the continuous degradation of the environment. Since the poor have limited economic options, they tend to depend greatly on public goods like the forest. In most cases, in their attempts to meet the subsistence needs of their households, the poor are prompted to extract resources beyond the carrying capacity. As the resource base gets degraded, however, the poor becomes more marginalized.

FORESTLAND USE ISSUES AND CONCERNS

Having described the dynamics and factors of forestland use transformation in the country, it can be deduced that the pattern of change overtime is mainly driven by either local or supra local demands and is being orchestrated by existing government policies and programs. To further authenticate this claim, the following are major issues and concerns related to forestland use change:

a. *Competing/conflicting use.* The absence of a common land use classification system among the different government line agencies in the country makes it difficult to delineate forestland boundaries from agricultural lands or alienable and disposable (A&D) lands.

   The Department of Agrarian Reform (DAR), Department of Agriculture (DA), DENR, and the Housing Settlement and Urban Development Board have different criteria for determining what lands should be considered agricultural lands, for housing settlements and for forestry. This apparent lapse in determining which type of land is under the domain of control of a particular agency results in continuous conflicts and competition in land use.

b. *Determination of the forest margin.* With regard to forest cover, DENR has yet to determine what or where exactly is the forest margin. Despite the advent of modern sophisticated tools in determining forestland use cover like satellite aerial photogrammetry, the issue of forest cover extenthas not yet been fully or officially determined by the concerned agencies. This information is important for planning, as it will

be the basis for determining the right proportion between forestry and agriculture.

c. *Slope classification for forestland (18 percent and above).* Forestland has been broadly defined under Presidential Decree (PD) 705 as lands with 18 percent and above in slope, regardless of altitude and location. This sweeping categorization brought much confusion among various types of land user because of the legal implications, especially when one applies for ownership rights.

d. *Conflicting and unsustainable policies.* Even within the DENR, there are many conflicting land use policies regarding the type of programs/projects being implemented in certain watershed areas. A glaring example, for instance, is the Kaliwa watershed located in the towns of Tanay, Rizal, and General Nakar, Quezon. The area has been proclaimed as ancestral domain during the Marcos regime in the 70s and a certain portion was declared for stock farming. Later on, the same area was declared under the Integrated Protected Area Management. Just recently, it was proclaimed as a critical watershed because of its great potential to become the next source of potable water for Metro Manila. However, a closer look inside the watershed shows there are eight *barangays* with a total population of about 7,000 households who have settled down in the area even much earlier than the aforementioned proclamations.

e. *Externality/transboundary issues.* It is difficult to mobilize upstream communities to adopt sustainable land use systems because of the non-participation of other stakeholders, particularly the downstream water users in maintaining the watershed. The downstream water users and other indirect stakeholders do not share in the cost of protecting and maintaining the watershed but benefit much from the environmental services generated.

Restoring the Degraded Landscape through Tree Growing

For the past years until now, the Philippine government has been investing huge amounts of public funds to rehabilitate degraded areas in the country. The private sector, particularly the wood industry, had its own share of the burden. Table 2-3 presents both the government and private sectors'

accomplishment in reforestation from 1986 to 2000.

However, actual field verification shows that the performance of government reforestation programs was much lower than what was officially reported. At an average of 100,000 hectares yearly with a total budget of US $440 million, only about 10 percent of the 6.5 million hectares of degraded lands were rehabilitated from 1988 to 2000 (Pasicolan, 1996).

Aside from government administered reforestation programs, farm forestry and agroforestry are the two other tree-growing modalities at the farm level. These farm-based tree-growing schemes are integral components of another government program, Community-Based Forest Management (CBFM). In most cases, these two tree-growing practices are also spontaneously being carried out by private initiatives even without the government's direct support. To distinguish one from the other, they are broadly described as follows:

a. *Farm forestry.* Raising of trees at the farm level either in monoculture or mixed stand intended mainly for timber products. Many farmers are now venturing into timber production at the farm level, especially in Mindanao because of the acute shortage of commercial timber coming from natural forests. The total log ban imposed by the government on the country's remaining primary forests in recent years makes it difficult for our country to meet our growing timber needs. Thus, farm forestry becomes a lucrative rural livelihood for most and at same time, helps improve environmental services by restoring degraded landscapes.

b. *Agroforestry.* This is an approach to land use in which woody perennial (trees, shrubs-palms, and bamboos) are deliberately grown on the same land management unit as agricultural crops and animals, either on some form of spatial arrangement or temporal sequence (Lungren and Raintree, 1983). It is a sustainable land management system that increases the overallyield of the land due to combined production of crops (including tree crops) and forest plants and animals simultaneously or sequentially on the same unit of land. It applies management practices that are compatible with the cultural patterns of the local population (Bene, et al., 1977).

Table 2-3. Area reforested by the government and private sector.

GRAND TOTAL	GOVERNMENT SECTOR				PRIVATE SECTOR				
	TOTAL	DENR	OGAs	PAF (II&III)	TOTAL	TLA*	ITP/TF/AFF	PD1153	OTHERS
27,632	23,740	19,059	19	2,662	5,892	1,989	3,421	–	482
42,167	31,184	30.831	353	–	10,983	6,904	–	–	4,079
42,368	33,219	32,643	576	–	9,149	8,236	–	–	913
66,237	49,301	48,490	811	–	16,936	14,357	–	–	2,579
46,096	13,869	18,869	–	–	27,227	20,005	–	–	7,222
65,233	21,841	7,840	14,001	–	43,392	30,380	–	–	13,012
49,551	18,032	18,032	–	–	31,519	9,468	18,729	–	3,322
19,211	6,347	6,347	–	–	12,864	12,692	172	–	–
40,593	24,304	24,304	–	–	16,289	11,683	4,606	–	–
93,039	73,602	72,238	1,364	–	19,437	18,089	1,348	–	–
191,663	153,949	146,718	7,231	–	37,714	33,443	3,749	–	522
131,404	89,452	82,966	6,486	–	41,952	32,087	6,526	–	3,339
64,183	31,226	30,890	336	–	32,957	23,126	9,831	–	–
39,811	28,843	27,558	1,285	–	10,968	7,956	1,118	1,296	598
32,998	24,426	22,495	1,931	–	8,572	6,572	1,625	368	7
952,186	626,335	589,280	34,393	2,662	325,851	236,987	51,125	1,664	36,075

Note: 1990-1994 Including enrichment planting of timber licensees; accomplishment of TTPLA & IFMA holders; and private lands and other organizations.

* Source: Philippine Forestry Statistics (Year 1986-1997); PPSO, DENR (Years 1998-2000).

Agroforestry is the planting of tree crops with agricultural crops and whose tree produce may either be intended for lumber, fodder, food, and fiber. For upland farmers, agroforestry is the most appropriate farming system because it addresses both concerns for increased productivity and enhanced ecological stability. This tree-based farming system can maintain its dual functions for crop production and environmental protection over time. However, some agroforestry systems are just a transition towards farm forestry. One example is the *Taungya*, in which agricultural crops are being planted in between strips of timber tree species. However, by the time the timber species reach a certain height and maturity so that intercropping may no longer be feasible, trees become the main crop of the farmer. In this case, the tree farmer does not only benefit from the timber produce but is also contributing to the improvement of environmental services.

FARMERS' TREE GROWING MOTIVATION IN FARM FORESTRY

After briefly describing the two farm-based tree growing modalities, it is interesting to examine the driving factors that motivate farmers to grow trees. The first thing to look into is their experience in farm forestry.

Growing trees at the farm level is a common practice in most developing countries. However, among rural farmers, growing trees seldom stem from the need to generate environmental services. This may be prompted by one or more of the following reasons/conditions:

a. *Direct household needs.* When tree products and other related uses meet a farmer's direct household needs, growing trees at the backyard or farmlot can become spontaneous i.e., without government support. For most farmers, their immediate need for fuel wood, fodder and foodcan be the primary reason for growing trees. Senegal, Tanzania, Indonesia, Panama and Nepal are examples of places where people plant trees primarily for wood, fruit or fodder (Jones, 1982; Campbell andBhattarai, 1983; Skutch, 1983 as cited by Foley and Barnard, 1985). In other places, people

grow trees spontaneously for windbreaks, fences, shades and other benefits.

A number of case studies attest that tree growing projects in public lands which likewise meet immediate household uses are more successful than projects which do not simultaneously address planters' tree needs. The Bangladesh Rural Advancement Committee Project, for instance, has sustained the farmers' interest in planting and protecting *Leuceana leucocephala* in single rows along roadsides because of the fodder that they receive for their livestock (Hasan, 1990).

b. *Direct cash from wood products sale.* Earning an income is one of the strongest incentives in eliciting widespread participation in tree growing, as evidenced by projects in Haiti, India, Kenya, Philippines, and the Republic of Korea (Gregersen, et al., 1989). Arnold (1987) noted that nearly 40 percent of the rural households in the Kakamega District in Kenya maintain small nurseries and 80 percent have planted trees on their land to produce poles for sale. Likewise, in Kovilur, Trichurapalli, India, many resource-poor farmers planted cashew and eucalyptus species on their small land holdings for the market. The high profit gained from tree crop production motivated farmers to invest in such (Malmer, 1987 as cited by Chambers, et al., 1989).

In Uttar Pradesh, India, many farmers were encouraged to convert part of their agricultural fields to eucalyptus plantation because of the ready market with a promising price for wood, along with the soft loans and subsidies given by the government (Chowdhry, 1985).

c. *Land tenure security.* Land tenure appears to be another crucial factor in motivating local people to plant trees. In Bong Country, Liberia (Harbeson, et al., 1984) and in the Babati District, Tanzania (Johnson, 1991), local people were induced to plant trees to demarcate property boundaries and to pronounce a legitimate symbol of their right over adisputed area. In areas where governments are likely to expropriate land for public projects, landowners seldom plant perennial tree crops because they know that they would not benefit from them. It appears from theseexamples that aspirations for land rights can become a strong incentive for spontaneous

tree growing on disputed or public land, but also that an unclear tenure situation may prevent people from planting trees.

Likewise, security of land tenure affects the spontaneity and sustainability of the farmers' tree growing efforts. Sellers (1988) noted that in Tucurrique, Costa Rica, the type of tenurial arrangements greatly determines farmers' preference for forest plantations over short-term crops. Growing coffee, peach palms, and other woody perennials was a spontaneous practice among farmers with secure titled land while those with less secure use rights or those under tenancy opted for short-term crops. Jones (1982) observed that the lack of security of land tenure in most farms in Honduras discouraged peasants from introducing fruit trees or plantation crops despite the prospect of high economic benefits from them.

d. *Autonomous management arrangement.* The degree of management responsibility given to local people is another factor that affects their motivation to participate in organized tree growing programs. There are a number of successful forestry projects resulting from local initiatives. Leach and Mearns (1988) described the villagers in Um Inderaba, Sudan as the people who established a tree nursery, planted and protected a tree windbreak, fenced-off a small area to allow for the regrowth of woody vegetation, and planted trees for shade, fuel and fodder. These spontaneous activities were carried out by highly motivated farmers who were directly involved in project design, implementation, and management despite its being a government-initiated endeavor.

McGaughey and Gregersen (1988) observed that most forestry projects with the farmers' direct involvement, from tree management to tree harvesting, usually succeeds. As such, it appears that one factor in the failure of government tree growing projects is the fragmented or discontinuous enlisting of the public from tree planting up to harvesting (Gregersen, 1985). Where farmers merely execute government plans, quality and sustained participation cannot be guaranteed especially if the benefits will be realized in the distant future.Skutch (1983) discovered that around 44 percent of the village woodlots, which she sampled in Tanzania, had low farmers' project participation as

a result of the Forest Service's 'prescriptive' and coercive management style. There was a risk that the real needs were not being addressed.

e. *Access to future produce.* Ownership right or usufruct practice over the land is not the only way to sustain farmers' motivation to grow trees on public lands. In the absence of land tenure, tree tenure may fulfill farmer's striving for ownership rights over the future produce.

A number of field cases revealed that when there is no provision for farmers' rights over the trees they planted, they shy away from involvement (Jones, 1982). When people are assured of direct benefits from the projects they more likely participate (Campbell and Bhattarai, 1983). Sen, et al. (1985) observed that farmers in West Bengal participated more actively in a farm forestry project when the benefits they would receive were clearly defined.

In summary, farmers' motivation to grow trees voluntarily stemmed from their immediate needs or desires to earn an income. This can be enhanced by the effect of certain incentive systems or be suppressed by incongruent institutional arrangements. Table 2-1 summarizes the conditions in which farmers may or may not participate in tree growing at the farm level. Table 2-4 shows the basic conditions in which a rural farmer may or may not participate in tree growing activities (Chambers, et al., 1989).

Small Tree Farmholders' Constraints and Limitations

Farm-based tree growers usually go for short-term annual monocropping than investing in permanent crops. Their dilemma in growing trees as a main crop spring from the following inherent limitations of farm forestry:

a. long gestation period of tree crops;
b. competition for space of trees and annual crops;
c. lack of alternative or support livelihood during transition;
d. wood products market uncertainty;
e. ownership rights;
f. risk associated with crops; and
g. big investment requirement: capital plus labor.

Table 2-4. Farmers' reasons for growing and not growing plant trees in their farmlots.

FACTOR	DO NOT PLANT/ PROTECT	PLANT/PROTECT
1. Land tenure	Insecure	Secure/aspire for security
2. Access to usufruct	Priority for government or subject to taxation	Vested primarily in the household regularly exercised without restriction or rent
3. Security to future produce	Uncertain or not included	Provide and binding
4. Tree ownership	Owned by or shared with the government or local authority or ambiguous	Owned by the household by law or in practice
5.Management system	Centralized and prescriptive	Participative or semi-autonomous
6. End-use	Social welfare	Specific household or communal needs
7. Production objective	Conservation and for wood industry needs	Equity and immediate household needs

If tree growers consider venturing into commercial scale, they are constrained by the following conditions:

a. *Low capacity to expand.* Cash-deficient tree growers cannot easily expand their woodlots into large commercial scale plantation without full government support. Going big requires private sector financial assistance. Furthermore, the small size of land holdings, absence of tenure security, and sure wood market pose big limitations to farm forestry expansion.

b. *Farmers' limited options.* Resource-poor tree growers have limited capacity to respond to risk associated with tree growing e.g., outbreak of forest pest, grassland fire, and other episodical hazards that tend to destroy their woodlots. Hence, many of them are just contented with thelittle trees they plant. As much as possible, they avoid risking their limited resources to something that cannot meet their instant need at the time.

c. *Lack of a support system.* Rural farmers have limited institutional linkages where they can outsource technical and other logistical help for expansion, such as credit assistance, crop protection insurance, market information, training, and other necessary support systems.

d. *Non-bankable.* Besides the problem of cash flow, resource-poor tree growers could hardly borrow from private banks because they are not bankable in terms of their capacity to redeem their loans. The banks require stricter conditions or collateral from them compared to those who are cash sufficient.

e. *Not profitable at a certain kilometer radius from processing plants or markets.* The proximity of the market from the wood source is a crucial factor to consider in commercial scale farm forestry. Recent wood market studies conducted in Mindanao claimed that forest plantations beyond 100 kilometer radius from the market or processing plant are no longer financially profitable because of the heavy transport cost.

f. *Relatively higher production cost per hectare.* Small tree farms tend to have higher production costs per hectare than bigger or commercial size plantations because of economies of scale. This applies in all aspects of tree business operations, from site establishment to plantation maintenance up to harvesting.

g. *Lack of adequate planting areas.* Land availability remains a big constraint for small tree farm holders to venture into commercial size tree plantation. Despite government efforts to democratize the use of forestlands through leasehold or stewardship agreements, small farmers could hardly avail of these privileges because of the stringent legal requirements beyond their reach.

Agroforestry for Food and Environmental Service

After confronting farmers' tree growing motivations and options in farm forestry, there is a need to examine farmers' incentives in integrating trees with annual crops in an agroforestry system.

Generally, the uplands in the Philippines are home to the rural poor who have been pushed uphill because of agrarian tension and social injustice pervading in the lowlands. To characterize upland poor socioeconomic and institutional circumstances, most of them are described as:

- resource poor farmers with small farms (0.5-5.0 hectare);
- low farm income with a daily income of ≤ P50.00;
- labor shortage during peak cropping activities;
- farms with nutrient depleted soils and considerable risk to erosion;
- geographical location that is vulnerable to further deforestation;
- physically and politically isolated;
- high vulnerability to any kind of disaster; and
- seldom possess savings and surplus.

Given this background, any change in the farmers' traditional livelihood pattern that leads to a more sustainable land use system should be one that can meet both immediate food and cash needs. To be specific, the transition into tree-based farming systems by poor farmers has to be gradual to cater for short-term financial and food security needs (SAFODS).

It is in this context that agroforestry comes in perfect tandem with monoculture annual cropping because it addresses both short-term and long-term temporal needs of the farm household. However, smallholder agroforestry options for degraded soils have to balance short-term profitability and a medium term escape from further soil degradation occurring under pure crop-based land use systems, while combining on-farm and off-farm activities with their respective SAFODS. As such, certain forms of agroforestry will allow for transition to permanent tree-based cropping that are compatible with farmers' livelihood strategies.

Objectives of Agroforestry

As a resource system and a development intervention, agroforestry has the following objectives:

a. *Production.* Securing farm households' direct and immediate needs for food, fiber, fodder, fuel, post, and poles is the main reason for farmers to interplant trees with annual crops.

b. *Environmental/ecological.* Soil and water conservation in sloping agricultural lands is one reason why trees or any vegetative cover are intercropped with the annuals. This significantly helps in controlling soil sedimentation that reduce the life service of irrigation and power supply systems. Likewise, as farmers increase the density of tree cover in their farmlots, they help sequester air pollutants from the atmosphere. Thus, agroforestry can help regulate global climate change by creating a carbon sink in the biosphere. Further, enhancing biodiversity in a purely annual crop dominated agroecosystem. There is now a growing emphasis not only on tree-annual crop interaction but also flora-fauna symbiosis in agroforestry.

c. *Social.* The practice of agroforestry is also directed to empower small farmers. By enabling the farmers to become self-reliant in food and cash through increased farm productivity, gives them a sense of confidence and self-worth. Likewise, as small farmers begin to recognize their great contribution in improving environmental services through agroforestry practice, they become politically aware of their global relevance and role in nation building.

Criteria of a Good Agroforestry System

The following are criteria for a sound or well-designed agroforestry system (ICRAF, 2000):

a. *Productivity.* The system should be able to increase and satisfy benefits (food, fuel wood, fodder poles, etc) as well as indirect benefits (soil and water conservation, fertility improvement, microclimate amelioration, etc). It should also be able to increase the farmer's income. It therefore requires proper choice and combination of crops and technologies.

b. *Sustainability.* The system should be able to sustain the provision of benefits through time so that the needs of future generations are not compromised. To attain this, soil and water conservation strategies are necessary in the uplands. Related to this is the issue of insecurity of land tenure. Farmers will most likely not put up or plant permanent structures if land tenure is not secured. Since conservation structures require a lot of inputs, assistance and other forms of incentives are necessary especially to farmers

who operate close to the margin of subsistence. A sustainable system is one that does not only have the ability to withstand sudden changes in weather and epidemics but also sudden changes in market prices. Hence, crop diversity is an important consideration.

c. *Adoptability or acceptability.* The system should not only be culturally acceptable (compatible with customs, traditions, beliefs) but also consistent with existing technical, financial, and manpower capabilities of the people. To ensure adoption, it is important that the farmers are directly involved as early as during the planning phase of the project (e.g., involved in rapid rural appraisal surveys).

Classification of Agroforestry Systems

Based on the classification method of the World Agroforestry Centre (ICRAF), the different forms of agroforestry can be classified into three major classes based on crops raised or mixed, dominant role of the tree, interaction in time and space between or among species in the mixture, and distribution pattern of species.

a. *Agri-silvicultural.* This refers to an agroforestry system wherein both agricultural and forest crops are raised simultaneously. The different forms and examples of each are:

   Alley cropping (hedgerow intercropping system). Hedgerows of trees, usually double hedgerows, are grown at certain distance intervals (usually 4-6 meters) along the contours. The strips or alleys in-between these hedgerows are planted with agricultural crops (annual or perennial crops). A good example is the Sloping Agricultural Land Technology (SALT).

   The hedgerows should be regularly pruned back to 0.5m height to minimize shading of agricultural crops in the alleys. Biomass from pruning can be used as green manure or mulch to the alley crops or as fodder to livestock. Through time, natural terraces can be formed at the base of the hedgerows thereby minimizing soil erosion and surface runoff.

The ideal characteristics of hedgerow species are: 1) easy to establish (from seed or cutting); 2) fast growing; 3) good coppicing ability; 4) nitrogen fixing (N-fixing); 5) deep-rooted; and 6) with multiple uses (e.g., green manure, fodder, etc.). Some species recommended for hedgerows are: *Gliricidia sepium*, *Flemingia congesta*, *Laucaena leucorephala*, *Desmodium resnonil*, *Cassia spectabilis*, *Calhandra calothyseus*, and some grasses such as napier (*Pennisetum purpureum*), vetiver (*Vetiveria zizaniodes*, *Guinea* ( ) and setaria (*Setaria* sp.).

Multistorey system. The crop components occupy different canopy levels with the upper layers occupied by trees or other woody perennials providing partial shade to agricultural crops in the lower layers. In essence, this system mimics the structure (multilayer) and composition (diversed species) of a tropical rainforest. Examples of crops are coconut-coffee-pineapple mix in Cavite, *Albizia*-coffee or cacao in Mindanao, kakawate-coffee-mix in many areas and home gardens.

Some of the desirable characteristics of upper canopy trees are: small crown/sparse foliage to allow some light to pass through; preferably N-fixing and deep-rooted. The most common species used as nursetrees for coffee and cacao are *G. sepium*, *Alnus japonica*, *L. leucocephala*, *Erythrina orientalis*, *Albizia falcataria*, *Pterocarpus indicus*, *Albizia procera*, *Samanea saman* and *Swietenia macrophylla*.

Improved fallow system. Cultivated areas grown with agricultural crops are abandoned and allowed to fallow for some time to allow rejuvenation of the soil. To shorten the fallow period, the fallow areas are grown with leguminous trees or vines. Once the soil has been rejuvenated, these areas are again cleared for growing agricultural crops. An example is the Naalad style farming unique in Barangay Naalad, Naga, Cebu.

In the Naalad-style farming system, the native *ipil-ipil* (*L. leucocephala*) used as fallow species was able to shorten the fallow period to only 5-6 years. At the end of this period, the *ipil-ipil* are cut and the branches are piled along the contours to form a fascine-like

structure known locally as *balabag* or *babag* which function on trapping the eroded soils. Through time, natural terraces are formed, thus, establishing the steep slopes.

Taungya system. Newly established reforestation areas are allowed to be interplanted with agricultural crops. Crop production is done until tree canopies close such that light intensity becomes critically low for crop production.

Trees along farm boundaries. Trees are planted along farm boundaries for several reasons: as 1) boundary marker, 2) fences hedges, 3) live fence post for tying barbed wires, and 4) shelterbelts or windbreaks. When mature, some of these trees can be for post or light construction material. Prunings can also be used for fuel wood fodder or green manure.

Trees as live trellises. Trees are top-pruned (pollarded) to serve as live trellises for climbing crops. Examples are *kakawate*, *ipil-ipil* or *malunggai* as live trellis for black pepper, ubi, beans etc.

b. *Silvi-pastoral system.* The different forms and examples of an integration of forest trees and animal production are:

Tree-crop-grazing system. Animals such as cattle, sheep, etc. are allowed to graze freely underneath relatively mature tree plantations. These plantations may either be for wood or fruit production. This scheme proved to be practical and economical because the land has been fully used while being maintained and protected.

Protein bank (fodder bank) system. *Leguminous* fodder trees or shrubs such as *ipil-ipil*, *kakawate*, *Desmodium*, etc. maybe established as small plots on certain portions of the farm or pasture areas. These plots serve as supplementary fodder production. They are also fenced off and regularly pruned. The top and branch prunings are then fed to animals through a 'cut-and-carry' system.

Live fence systems. Rows of palatable trees or shrubs are grown around a certain grassland areas enclosing the grazing animals inside. Aside

from the trees' role as a fence, it can be managed (e.g., regular top pruning to encourage more lateral branching) such that the enclosed animals can browse on low-lying branches serving as fodder supplement.

Alley cropping with improved pasture grasses and other fodder trees or shrubs. Hedgerows of fodder trees or shrubs (e.g., *Desmodium rensonil*, *ipil-ipil*, *kakawate*, *Flemingia congesia*, *Seshan* sp., etc.) are planted along contours at certain distance intervals. The hedgerows are grown with improved pasture grasses and other fodder trees or shrubs. Prunings from the hedgerows, grasses and fodder trees/shrubs are stall-fed to animals.

c. *Agri-silvi-pastoral system.* Production of agricultural crops, tree crops, and animals in the same unit of land. Different types of an agri-silvi-pastoral system can be developed through the transformation or integration of the different forms of agri-silvicultural and silvi-pastoral systems.

Agri-silvicultural transformed to silvi-pastoral system. In this system, the original cropping combination is a tree seedling annual agriculturalcrop like in taungya system. However, as the trees close their canopies, it will no longer be possible to grow annual agricultural crops. Instead, grasses and vines will take over the forest floor where animals are allowed to graze freely as in tree-crop grazing system

Multistorey system and animals. Example is the coconut-lanzones mixture with horses (or cattle) grazing under them as observed in Laguna and Quezon provinces.

Alley cropping with pasture grasses and agricultural crops. This is similar to alley cropping with pasture grasses except that in here, some of the alleys are also planted with agricultural crops.

Benefits from Agroforestry

Agroforestry as an alternative land use system in the uplands provides multiple benefits both for the farm households and the society in general.

a. *Farm household benefits.* The following are common benefits that a farm household can derive from Agroforestry farming practice:

Increased food production and income. As a land use practice by small farmers, it can benefit the farm households in terms of increased production of food, fodder, fuel, fiber, and income. In many parts of the country, this land use system has been, in many ways, providing the farmer household's main food and cash needs under favorable institutional and climatic conditions.

Improved soil and water conservation. By agroforestry technology, soil and water conservation becomes a major technical concern. Farmers who practice conservation farming or introduce vegetative and structural measures minimize soil erosion in their farmlots, which redounds to increased farm yields overtime.

Enhanced biodiversity at the micro-level. As farmers continue to diversify the species of tree crops they introduce in their farmlots, the farm households can be assured of multiple products and improved plant–insect interaction. With increased biodiversity, the farmers canmake use of biological control to arrest pest problem in their farms. Likewise, with proper matching of crops, they can improve soil microbiology and nutrient budgeting, which is necessary for plant growth and biomass production.

b. *Greater societal welfare.* The following are the benefits that the general public can obtain from an agroforestry system:

Improved watershed functions. The practice of agroforestry does not only benefit the individual farmers but its wide-scale application in the uplands would enhance soil hydrology. This would result into improved water resource yield, quality, and regime.

Regulated climate change. Good vegetative cover combining annual crops with trees increases the absorptive capacity of the biosphere to sequester carbon and other air pollutants. This significantly helps in minimizing "green house" effect and accumulated magnitude at the global scale. It can also help arrest climate change.

Increased biodiversity at the community/ecosystem level. Agroforestry system may not only increase crop diversity with improved flora and fauna interaction within the farmer's plot. On a bigger scale, if it is tried as a buffer to connect patches of natural forests to facilitate habitat interconnectivity, this can help the flow of wild plants' genes as well as increase fauna population size and diversity in protected area corridors.

Mainstreaming Spontaneous Tree Farming

In the past years, the government put so much investment in reforesting degraded lands in an effort to restore the ecological balance. Much have been said about the dismal performance of past government reforestation programs because of unsustainable public participation.

Apart from government reforestation programs, spontaneous tree growing activities also exist at the household or farm level independent from outsidesupport. Unfortunately, these have hardly been considered in designing reforestation strategies. For instance, in Misamis and Bukidnon, Northern Mindanao, rural farmers successfully transformed idle and abandoned lands into tree plantations. A number of upland farmers in Cagayan Valley intercropped *Gmelina* with corn and continuously expand their woodlots because of the advent of local chipboard processing plant (Imperata Project Paper, 1996/10). The provincial government of Quirino initiated the formation of a province-wide tree growing cooperatives among small farmholders, in an attempt to transform the 38,000 under-utilized A&D lands into farm forestry (Personal Interview, 2000). The provincial government of Nueva Viscaya also evolved a new version of countryside reforestation through its *Tree for Legacy* program. Every citizen is encouraged to grow trees in public lands through a certificate of tree ownership.

If private tree growing initiatives are given equal government attention and support, such phenomenon can spread out easily. Time may come when the government does not need to launch another heavily funded reforestation program anymore. The following are some pointers to consider on how to make tree growing at farm level become spontaneous:

a. *Efficient cost sharing mechanism.* There should be cost-benefit sharing arrangement between farmers and interested private finance groups. Likewise, the government should serve as a broker and facilitator of the partnership for the former to be assured of a ready market.

b. *Compensation for upland farmers.* Implement market-based instruments to spread out the cost of maintaining the watershed among "off-site" and "on-site" resource users. The upland farmers should get incentives from the users' fee collected from the downstream stakeholders, if they adopt soil and water conservation measures in their farms.

c. *Balance between livelihood goals vs environmental goals.* Tree growing programs at the farm level should address the food security needs of the farm households before anything else. Likewise, it is important to address the transition needs of the farmers as they shift from traditional annual monoculture cropping system to tree-based system.

d. *Provision of institutional incentives for upland farmers.* Tenure rights, support systems, such as credit assistance, crop insurance, access to information and technical assistance are necessary conditions for spontaneous tree growing.

e. *Wood market security.* Contract growing can boost small farmers' confidence of making a good income from their tree growing investment.

f. *Improved physical infrastructures.* Farm to market roads, bridges and other physical build-ups that can facilitate the transfer of farmers' tree produce to the market are also important institutional incentives for small tree growers.

g. *Tax exemptions or rebates.* Tree growers should be given tax exemptions

or at least tax reductions as incentive for the environmental services they generate.

SUMMARY AND CONCLUSION

The natural landscape is presently going through rapid transition due to the growing demographic pressures and urban growth at all sides. However, the most serious threat to the sustainability of our remaining resource base is rural poverty. The link between poverty and environmental degradation has long been recognized as an impediment to upland development in the past years.

From a broader perspective, the dynamics of land use change in the Philippines can be viewed as the result of the continuous interplay of biophysical, socioeconomic, institutional, cultural, and political forces that tend to favor the transition or permanence of certain land uses overtime. The various land use transformation modes may either fall under one or more of the following driving mechanisms: 1) market-driven; 2) government-project initiated; 3) local demand-directed; 4) farmers' enterprising option; 5) institutional partnership motivated; and 6) farmers' cash flow considered.

Over time, the continuous transformation of the natural landscape to what is now a mosaic of various land uses has significantly altered the ecological balance. This is besides the socioeconomic and cultural consequences. The compounded effect of which resulted to impaired hydrology, global climate change, destruction of biodiversity, and impending disruption of other environmental services.

In response to this, farm forestry and agroforestry have been recommended as the most appropriate alternative farming systems to address the problem. Such technical solution, however, is not sufficient to convince the rural poor, particularly the upland farmers to shift so easily to the desired land use system.

To make tree growing spontaneous at the farm level, it is important to understand the dynamics of local participation in environmental restoration activities. Great attention should be given on the role of institutional incentives

and rewards in motivating rural people to participate. In other words, if we want to actively mobilize the upland poor in improving environmental services for greater societal welfare, there is a need to compensate their efforts of safeguarding the quality of the resource base through their improved land use practices.

The big challenge for the government is how to institutionalize and come up with a mechanism for equitably spreading the cost of maintaining the quality of the resource bases among the various stakeholders. Development of market-based instruments and institutions as mechanisms for generating environmental funds from resource users are indeed necessary. The resource users downstream and the general public should be taxed for the water, fresh air, cool climate, aesthetic beauty, and biodiversity resources they use and enjoy.

Apparently, if this scheme becomes institutionalized, the gradual, massive, and spontaneous rehabilitation of degraded areas in the countryside by the grassroots can be expected. The practice of farm forestry and agroforestry may become a fashionable upland farming system that will spread out like a wild fire.

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CHAPTER III

WATERSHED FUNCTIONS

Damasa M. Macandog

OBJECTIVES

After studying this chapter, the reader should be able to:

1. enumerate and discuss watershed concepts and functions;
2. discuss watershed management; and
3. identify government policies related to watershed management and assessment of watershed functions.

INTRODUCTION

This chapter discusses the following:

- Importance, extent, and present status of watersheds in the country.
- Watershed concepts where watershed is presented as an ecosystem with characteristic components, structure and function.
- Watershed as a social system with its human interventions such as logging activities, slash-and-burn farming system, irrigated crops and fields, built-up infrastructures such as roads, villages, and dams.
- Objectives and framework of watershed management.
- Outputs of watershed management are assessed through the watershed's water supply, flood control and erosion control. Watershed protection and rehabilitation are also presented in this section.
- Philippine legislations related to watershed management issues and concerns arising from these policies.
- Field measurements (include monitoring daily fluctuations in microclimate, stream flow and soil erosion at each rain event) of

watershed functions through WaNuLCAS and PCARES models. Both models are based on soil erosion equations including USLE and GUEST.

WATERSHEDS IN THE PHILIPPINES

Watersheds are hydro-ecologically significant areas because they are the primary sources of forest products, freshwater and other natural resources. The Philippines has a total land area of 30 million hectares (M ha) and about 90 percent are considered watersheds (PCARRD, 1999). These watersheds are economically important, as they are the sources of livelihoods for many rural households that depend on natural resources within watersheds for their farming and forestry activities. More than 20 million Filipinos are living in the upland areas described as "environmentally fragile" areas. Population growth in the uplands is double the national average (Tacio, 2000). The surging population in the uplands threatens the survival of the remaining forests, despite government efforts at protection.

More than 8 million hectares of the 11.9 million hectares classified as uplands in the country are under some kind of cultivation (Guiang, 1998 as cited by Tacio, 2000). The Department of Environment and Natural Resources (DENR) warns that the corresponding expansion of upland cultivation may result to further degradation of the watersheds, increased soil erosion, flooding, sedimentation, and siltation..

Watersheds supply the major water needs of various irrigation facilities, hydroelectric power reservoir, and domestic as well as industrial water systems in the country. Some of the most important watersheds are the Agno River Basin, Cagayan River Basin, Pampanga River Basin, Ilog Hilabangan River Basin, Cotabato River Basin, and Agusan River Basin. These watersheds cover around 7 million hectares of land.

Despite the significance of these watersheds, many are now in poor condition due to land use change and forest cover removal (Veracion, 1995). Specifically, land use options in watersheds include forestland, grassland, brushland, agroforestry area, and quarrying/mining areas. The common watershed and management problems are watershed occupancy/area expansion,

kaingin-making, illegal cutting, soil erosion/sedimentation, slack forest protection, water shortage for domestic and irrigation uses, peace and order, insufficient funds, and unemployment.

Why should we care?

Rapid population increase in the country triggers upland migration resulting in increased pressure on watershed resources. Deforestation, shifting cultivation and fallow cycles, and forest conversions are the major causes of degradation of watershed functions in the Philippines. These activities have brought about various environmental problems such as: rainstorm runoff; accelerated soil erosion and siltation/sedimentation of rivers; lakes and other water bodies; and water pollution causing a decline in soil productivity and deterioration in water quality and quantity (PCARRD, 1999). Degradation watershed and hydrological changes in the watershed pose serious threats not only within the watershed, but also to other ecosystems down the continuum including rivers, lakes, lowland areas, mangroves, seagrass and coral reefs (Veracion, 1995).

Over the years, the country's watersheds have been under severe pressures from people's demand for land, water, wood, and other natural resources. At present, the annual recurrence of big floods and prolonged drought attest to the disturbed condition of our watersheds (Peralta, 1989).

The destruction of the forests has also put many species on the endangered list and brought some to the verge of extinction. A large number of endemic species in the Philippine tropical rainforest and the forest itself are now threatened with complete destruction, making the country a 'hotspot' (Tacio, 2000).

WATERSHED CONCEPTS

Watershed as an Ecosystem

Watersheds are among the vital components of ecology. Our country has a vast network of watersheds wherein about 70 percent of its total land area are

considered watersheds. There are 419 river basins in the country that supply the major water needs of several irrigation systems, multimillion-peso hydroelectric dams, and domestic as well as industrial water systems (Peralta, 1989).

a. Definitions. The following are some of the concepts related in understanding watersheds:

- *Systems.* The system concept is a way to break down any large, complex problem into smaller, more easily studied subsystems. A system can be defined as any portion of the universe that can be isolated from the rest of the universe for observing and measuring changes (Skinner, Porter and Botkin, 1999). System can be large or small, simple or complex.

- *System boundary.* Boundaries of a system are defined by the observer. Energy and matter can be exchanged across the boundaries of an open system. A watershed is an example of an open system.

- *Watershed.* PCARRD (1999) defined watershed as: 1) a discrete geographical unit capable of providing water, timber and non-timber products including food, fiber, minerals, medicines as well as intangible goods such as aesthetics and wholesome environment with solar radiation, precipitation, land labor, and capital as major inputs; or 2) a topographically delineated area of land from which rainwater can drain as surface runoff, via a specific stream or river system to a common outlet point which may be a dam, irrigation system or municipal water supply take off point, or when the stream/river discharges into a larger river, lake or the sea.

b. Typology or Hierarchy. Watersheds vary greatly in size and often extend over the boundaries of one or more political administrative units. Table 3-1 shows the typologies of watersheds in the Philippines.

c. Components. The components of a watershed are its area, boundary or divide, and stream or river system (PCARRD, 1999).

Table 3-1. Watershed typology in the Philippines.

Type	Area extent (km²)	Topographic boundaries
River basin	Over 1,000	land occurring within three or more provinces and two or more regions.
Large watershed	500-1000	land occurring within three or more provinces and one to two regions.
Medium watershed	100-500	land occurring within one to two provinces
Small watershed	10-100	within one province and include land occurring within one or more municipalities.
Micro watershed	Below 10	fall within one municipality and include land occurring within one or at most two barangays

The boundary or divide of a watershed determines the inflow and outflow of water. The two types of divide are topographic and geologic. The topographic divide is the ridge connecting the highest points near and around the drainage ways of two adjacent watersheds. It defines the path of overland flow or surface runoff. The geologic or phreatic divide defines the path of subsurface flow to or from a watershed. It is affected by the impregnable rock formation below the soil surface. Watershed technicians commonly use the topographic divide for watershed management purposes, as it can be easily delineated in a topographic map.

A drainage network is composed of a river or stream and its tributaries. Streams may be ephemeral, intermittent or perennial. The ephemeral stream has water immediately after a rain event. Water flowing through ephemeral stream is derived from surface runoff. Intermittent stream has water during the entire rainy season, but has no water during the dry season. During the rainy season, the soil becomes saturated and the water table moves up, thereby contributing to stream flow. The perennial stream has water during the entire year with a constant supply of water from base flow because the water table lies above the streambed.

d. *Ecosystem Structure.* Ecosystem is defined as a partially or completely self-contained mass of organisms together with their physical environment, and all the energetic interactions and material cycling that link organisms in a community with one another and with their environment (Smith, 1992). It is an energy-processing system with components that have evolved together over a long period of time. Plant and animal populations within the system are the objects through which the system functions.

Aquatic and terrestrial ecosystems consist of three basic components – the producers, the consumers, and abiotic matter (Smith, 1992). The abiotic inputs – CO_2, O_2, H_2O, nutrients derived from weathering of materials and from precipitation, and sunlight - are considered as abiotic components of the system.

The producers or autotrophs, the energy-capturing base of the system, are largely green plants and algae (in the case of aquatic ecosystems). They fix the energy of the sun and manufacture food from simple organic and inorganic substances. Autotrophic metabolism is greatest in the upper layers of the ecosystem – the canopy of the forest and the surface water of lakes and oceans.

The consumers or heterotrophs, use the food manufactured by autotrophs, rearrange it, and finally decompose the complex materials into simple inorganic compounds. Consumers regulate the rate of energy flow and nutrient cycling to stabilize the system.

Watershed Functions

Watershed functions include maintenance of high quality water, regulation of water quantity, and maintaining water-sediment balance in watershed.

Factors affecting watershed functions

Vegetation. Trees are better at maintaining transpiration rates throughout the year than most other plants, and their annual water consumption often exceeds that of other vegetation. Tree canopies intercept more rainfall than other vegetation and this is returned to the

atmosphere by direct evaporation (nitrobenzene in specific conditions, however, 'cloud forest' vegetation (trees plus their epiphytes) can intercept water from clouds and mist and thus generate net water flows into the soil. But these forests can only account for a very small percentage of global forest cover (Calder, 1999).

b. *Soil conditions.* Forest soil, which typically have a high surface infiltration rate and substantial macroporosity (due to soil biological activity and tree root turnover) facilitate deep infiltration, and sub-surface lateral flow of water.

c. *Landscape.* A landscape with a rough, uneven surface, including depressions and swamps, provides temporary water storage and sediment filter functions and very few channels (pathways provide for rapid surface runoff).

These three aspects of the forest differ in their impact on total annual flow, dry season flow, storm flow, and water quality. They differ between forest types and in the way and rate at which they are affected by forest conversion and can be subsequently recovered in 'reforestation'. The generic term 'forest watershed functions' thus needs further specifications before the impacts of forest conversion can be judged. Both the type of forest converted and the type of land use to which it is converted determine whether the overall impact on 'forest watershed functions' is negative, neutral or even positive. With regard to the 'broad' definition of 'forest' given above, 'deforestation' can be considered as a loss of forest function.

Physical characteristics of watershed affecting its functions

There are several physical characteristics of the watershed affecting watershed functions. These include watershed area, shape, slope, elevation, aspect, drainage net, stream density, and drainage density.

a. *Area* is the extent of the catchment basin of a watershed. It affects the magnitude of the flow characteristics like flood flow and minimum flow.

b. *Shape* is the configuration or outline form of a watershed. It affects the

stream flow pattern of a watershed, or the rate at which water is supplied to the main stream.

c. *Slope* is the general degree of inclination of the surface of a drainage basin. It affects the surface and groundwater hydrology of a watershed. It has some influence on infiltration, surface runoff, soil moisture and groundwater contribution to stream flow. It also affects the time of overland flow, concentration of rainfall in stream channels and flood magnitudes.

d. *Elevation* is the vertical distance of any point in the watershed above or below a standard reference point like sea level. It affects the temperature and precipitation patterns of a watershed. Temperature and precipitation in turn affect the different hydrologic processes in the watershed.

e. *Aspect* is the general orientation of the watershed with respect to the cardinal directions. It affects the transpiration and evaporation losses due to its influence on the amount of heat received from the sun. In general, southern exposure receives more heat from the sun than others.

f. *Drainage net* is the pattern or arrangement of natural streams on a watershed. It affects the efficiency of the drainage system and therefore its hydrographic characteristics. A well-drained basin has short overland flow, the surface runoff concentrates quickly, flood peaks are high, and minimum flow is low.

g. *Stream density* is the ratio of the number of streams and the total area of the basin. The number of streams only include perennial and intermittent.

h. *Drainage density* is inversely related to the length of overland flow and therefore, provides an indication of the drainage efficiency of the basin.

Watershed as a Social System

Because of population growth, there are more than 20 million watershed occupants or settlers in the Philippines. In the various watersheds reported,

the number of settlers ranged from 4,559 (Region XI) to 783,172 (Region VIII) (Veracion, 1995). Watershed occupants rely on the watershed resources for their livelihood and thus, they increase pressure on the watershed. Because of this, social forestry evolved.

Social forestry is a branch of forestry which deals with the involvement of people in forestry activities designed to promote the socioeconomic well-being of the people as well as the conservation of the soil, water, and other forest resources. It is a concept of forest creation, management, and use of goods and services generated for the benefit of the society. The different forestry activities under this include purposive growing of trees, application of crop production technologies, and soil and water conservation measures.

These activities are aimed toward self-sufficiency in forest resources while lessening the pressure on the resources of the natural forest through more efficient and more intensive use of the land (Olofson, 1983). Specifically, the objectives (Rebugio, 1993) of social forestry include: (a) increasing village income by producing fuel, fodder, forage, food, fibers, and forest goods; (b) stabilizing and strengthening rural communities and institutions; (c) conserving forest and land resources by minimizing local ecological degradation; and (d) promoting sustained forest productivity and stability.

Social forestry ultimately hopes to achieve the following: (a) raise the standard of living of the rural dweller; (b) involve the rural dweller in the decision-making process which affect his very existence; and (c) transform the rural dweller into a dynamic citizen capable of contributing to a larger range of activities than he was used to and of which he will be the direct beneficiary.

Social forestry is in effect an integral part of economic growth and community development. Its success depends on large-scale participation of the people. Thus, social forestry is more precisely defined as forestry for the people and by the people.

Livelihood opportunities in the watershed

There are many possible livelihood projects that can be introduced or strengthened in the upland communities. Pilot communities can participate in

Community Forestry Program (CFP)-related pump-priming activities, timber stand improvement (TSI), assisted natural regeneration (ANR), road construction, and CREF through contract with DENR. Other possible livelihood projects are small-scale livestock raising (goat, cattle, poultry, duck, etc.); basket weaving, wood carving and other handicraft; mushroom cultivation; harvesting forest species such as rattan, bamboo, tiger grass, etc.; and food processing. For all these projects, technical, financial, and marketing support is very important.

HUMAN ACTIVITIES WITHIN THE WATERSHED

a. *Logging.* The effects of logging on watershed functions have more to do with land disturbance and soil degradation than with the tree cutting. Access roads to the forest may act as channels, which in cases of heavy rain act as sediment transporters, as well as increasing runoff. In the humid tropics, logs are transported via streams, causing damage to riparian strips. One of the consequences of this is increased sediment in the streams, which has implications for watershed users downstream, in terms of providing good quality water and in terms of reservoir sedimentation.

b. *Slash-and-Burn Forest Conversion, Crop/Fallow Systems and Degradation.* Shifting cultivation as in most humid forest margins involves clearing the land, usually using slash-and-burn techniques, for agriculture and food production, followed by periods of fallows when the land is left uncultivated to 'rejuvenate'. After a number of years, depending on the length of the fallow, the land is plated again. During the cropping phase of shifting cultivation or after conversion to pasture (or grasslands), depletion of soil nutrients manifests itself in a more or less rapid decline in crop yields. Fallowing the land allows it to 'rest', and the soil fertility can be restored. The length of the fallow needed to restore fertility depending on the climatic and soil factors with longer periods needed in areas of high erosion and leaching potential. Shortening fallow periods or intensifying land use will eventually result in the degradation of the hydrological process as discussed earlier. Removal of forest cover during the land-clearing phase results in a disruption of the following hydrological processes: canopy evaporation, evaporation, transpiration, interception, and stem flow.

c. *Roads and Villages.* The presence of roads and villages can have several cumulative effects. The people, livestock and agricultural activities associated with a village all require water (of different quantities and qualities) and for transport of waste product from the village. Drainage systems are generally used for irrigation transport of wastewater and for transport of storm-water thus they act as channels. Roads can act as channels for transporting water and sediment downstream. In the presence of degraded or 'poor' soils, this type of transport may lead to rill erosion and increased sedimentation downstream.

d. *Irrigated Crops.* Intensive temperate vegetable growing systems in the Cordillera Region of the northern Philippines require high quantities of water affecting the water supply in the headwaters of the region. These systems are also the main sources of excessive fertilizer and pesticide pollutants that greatly deteriorate the water quality of the river systems in the watershed. Excessive inorganic fertilizer use in these systems renders the soil very acidic and unproductive.

e. *Dams.* Dams and their associated reservoirs are constructed to capture (and store) water for different purposes, such as irrigation and hydroelectricity generation. Dams are dependent on both the water quantity and sediment load of the water entering the dam. Whereas, increased volumes of water (as in increased runoff) are desirable for dams, reduced flows may result in a reduced quantity of water behind the dam. The implications of this are in the generation of hydroelectricity. An example is in Kenya, wherein due to droughts in most of the country, the reservoir supplying water to the city of Nairobi, among others, was so reduced that water and electricity supply to the city of tap water became the norm.

Sedimentation is a major concern for dams and reservoirs. Increased sediment loads flowing into the reservoir reduce the volume of a reservoir, and thus its capacity. Over time, this shortens the lifetime of reservoir, as it becomes filled up with silt. Silt also reduces the lifetime of electricity generating turbines, in cases of hydroelectricity power generation.

e. *Irrigated Rice Fields as Potential Filters.* Overland flows of water and sediments can be intercepted by wide range of vegetative filters, and thus a non-forest landscape with strategically placed filters can maintain acceptable water flows. Rice fields can act as vegetative filter by intercepting sediment flow and using the fertile silt as a source of nutrients. In this way, sediment eroding from upland areas may be captured by rice fields. This is not only beneficial for the rice farmers, but it also helps reduce the amount of soil that will reach the downstream users. However, soil erosion in the upland areas is still a problem as it reduces soil nutrients (topsoil is lost), and causes land degradation. More research is still needed to investigate up to what extent rice fields are effective during major rainfall events, as these usually cause the most damage.

WATERSHED MANAGEMENT

Watershed management is defined as the process of guiding and organizing land and other resource use in a watershed to provide desired goods and services without affecting adversely soil and water resources (Brooks, et al., 1990). Watershed management is an integrated and holistic approach of viewing the various human activities in the watershed which affect and are affected by water. It involves important sets of physical, biological, socioeconomic regulatory measures for responding to existing and potential problems related to land use water interaction. The different watershed management strategies included in the Master Plan for Forestry Development (MPFD) are soil erosion control, rehabilitation of denuded watersheds, law enforcement, resettlement, incentives system improvement, land use monitoring, and integrated protection program enhancement (PCARRD, 1999).

Objectives of Watershed Management

The basic objectives of watershed management may include the following (PCARRD, 1999; Baconguis, 2000):

1. Improved rainwater management for the sustainable supply of quality water from surface and groundwater sources for different water users, and increased protection from flood and sedimentation damage downstream.

2. Improved standard of living by maintaining, enhancing or developing existing/ new livelihood opportunities using watershed resources.

3. Improved maintenance, enhancement, and protection or biodiversity resources.

4. Improved care and management of the watersheds resources for the sustainable production of goods and services.

Framework for Watershed Management

In an integrated framework for watershed management, the various biophysical features of the watershed and socioeconomic and political realities are equally important. These include the body of knowledge, technologies, people, non-government organizations (NGOs), government, industry sectors, and the environment (Cruz, et al., 1999).

The key phases of watershed planning and development are (PCARRD, 1999) preparatory planning, preliminary watershed characterization, comprehensive watershed characterization, identification of alternatives and uses, evaluation and selection of best land uses, identification and analysis of problems and opportunities, development of management options/solutions, implementation, and monitoring and evaluation.

Changes in vegetation or land use cover in a watershed can result in a chain of impacts downstream. Deforestation leads to increases in surface erosion, gully erosion and mass wasting (land sliding), leading to increases in annual sediment yield downstream and on-site soil fertility depletion. Increases in surface runoff from steep watersheds result in more intense storm flows and flooding downstream. In watersheds with more gentle terrain, reduced evapotranspiration leads to higher soil moisture storage, higher groundwater tables, increased baseflow, increased annual stream flow and increased river channel degradation (Baconguis, 1991).

Outputs of Watershed Management

Water supply, flood, and erosion control are the main outputs of watershed

management. Other benefits of watershed management are biodiversity conservation and increased tree biomass production through various approaches like the community-based forest management (CBFM).

Water supply. Vegetative cover affects significantly the stream flow in a watershed. Water yield is higher in mossy forest and lower in grasslands (Table 3-2).

Table 3-2. Mean annual water yield of three major forest vegetations.

Ecosystem	Mean annual water yield (%)
Grassland	18.12
Secondary dipterocarp forest	27.62
Mossy forest	62.50

Source: Baconguis and Jasmin, 1984.

The quality and quantity of water supplied by a watershed is highly dependent on the state of the watershed. Well-protected watershed yields good quality and sufficient quantity of water. However, a complete knowledge of the hydrologic cycle and a thorough understanding of the physical characteristics of the watershed are required before taking any steps about manipulating forest cover for water yields.

Flood control. Watershed management for flood control is mainly concerned with: (1) slowing down the rate of water movement from land surface into the stream; (2) reducing the amount of runoff; and (3) reducing stream channelaggradations (Baconguis, 1991).

Erosion control. This is the major objective of watershed management. Human activities such as cultivation, logging road construction, mining, and grazing in a watershed will cause varying degrees of erosion. The degree of erosion depends on climate, slope, soil, vegetation and land use. Control of erosion includes control of sheet erosion, rill erosion, gully erosion, channel erosion and landslides.

Watershed Protection

The main purpose of watershed protection is to protect the present condition, so that the water quantity and quality as well as soil stability will be sustained and maintained. Protection work may include the following:

1. Protection of forested lands: fire prevention control; prevention of indiscriminate or illegal cutting; and insect and disease control, etc.

2. Protection of cultivated lands: proper land use; maintenance of soil fertility; maintenance of various conservation treatment, etc.

3. Protection of roads: proper design and layout; protection of cut and filled banks; maintenance of road surface and road ditches, etc.

4. Protection of grazing land: proper rotation; deferred and zero grazing, etc.

5. Protection of streams: stream bank protection; establishment of buffer strips along streams; channel maintenance, etc.

Watershed Rehabilitation

Watershed rehabilitation is applied to those watersheds where deterioration has existed, or erosion has been accelerated. The main purpose is to treat watershed so that it will regain its stability both in its water and soil aspects. The following are the main activities of watershed rehabilitation:

1. Rehabilitation of forest lands: afforestation; tree planting in eroded areas; erosion control in logging areas; treatment of abandoned roads, etc.

2. Soil erosion practices; including (a) agronomic method such as contour, close planting, mulching, cover crops, rotation, green manuring and composting, minimum tillage, etc. (b) engineering methods such as terracing, hillside ditching, diversion, protected waterway, drainage itching, etc. and (c) proper grazing and range management.

3. Gully, road bank and landslide control: (a) channel stabilization such as check dam, submerged dams, training dykes; (b) debris control work such as debris dams or soil saving dams; (c) flood structures such as flood retarding structures, levees drainage channels, etc.

PHILIPPINE POLICIES ON WATERSHED MANAGEMENT

Current Legislation

Philippine Constitution. The State is mandated to protect and advance the right of the people to a balanced and healthful ecology, in accord with the rhythm and harmony of nature. In keeping with this mandate, and in an effort to stop the further destruction of our watersheds, the government enacted several laws and adopted some policies (Peralta, 1989). The general policies of the State on watersheds as mandated in the 1986 Philippine Constitution are the following:

a. *Act. XII. Section 2.* All lands of the public domain, waters, forests or timber, and other natural resources, are owned by the State. As a consequence, our watersheds, which are categorized as forestlands, can be explored, developed, and utilized only under the full control and supervision of the State.

   The State may directly undertake, through its agencies and instrumentalities, the exploration, development, and utilization of our watersheds. A good example of this set-up is the activities of the National Irrigation Administration (NIA) and the National Power Corporation (NPC). The NIA presently maintains a number of irrigation dams using the Philippines' major watersheds. The NPC, on the other hand, has tapped some of the country's watersheds to generate hydroelectric power.

   The exploration, development, and utilization of Philippine watersheds may also be undertaken by private persons or entities, through co-production, joint venture, or production-sharing agreements. These agreements generally last for a period not exceeding 25 years, renewable

for not more than 25 years, and under such terms and conditions as may be provided by law. The individual must be a Filipino citizen and the association or corporation must be at least 60 percent Filipino-owned.

b. *Act XII. Sec. 3.* Under this provision, lands of the public domains are classified into agricultural, forest or timber, mineral lands, and national parks. Of these four land categories, only agricultural lands may be alienated to private ownership. The significance of this provision is that Philippine watersheds, being forestlands, cannot lawfully be alienated to private ownership and hence, they remain the property of the State.

c. *Act XII. Sec. 4.* This provision impliedly recognizes the problem of destruction facing watersheds in the Philippines. It enjoins Congress to provide measures to prohibit logging in endangered forests and watershed areas.

PD 705, as amended (Revised Forestry Code of the Philippines)

a. *Sec. 16 – Areas needed for forest purposes.* Presently, our land classification uses slope as its sole criterion. If the slope is 18 percent or over, the area cannot be classified and released as alienable and disposable land. Conversely, if the slope is lower than 18 percent, the area may be classified and released as alienable and disposable. However, under Sec. 16 of PD 705, as amended, the following areas may not be classified and released as alienable and disposable even if the slope is below 18 percent.

   1. Isolated patches of forest of at least 5 hectares with rocky terrain, or which protect a spring for communal use;

   2. Ridge tops and plateaus regardless of size found within, or surrounded wholly, or partly by, forest lands where headwaters emanate;1.

   3. Twenty-meter strips of land along the edge of the normal high waterline of rivers and streams with channels of at least 5 meters wide; and

   4. Areas proclaimed as watershed reservations.

The law prohibits the classification and release of the above areas as alienable and disposable lands due to the imminent danger of despoliation should these areas be later on acquired by private individuals.

a. *Sec. 19 – Multiple-use*. This embodies our policy of adopting the multiple use forest management concept. It is provided here that a given forest land must be devoted to more than one use. By way of exception, though, it strongly prohibits the use of our critical watersheds for commercial logging or grazing operations.

b. *Sec. 33 - Lands to be reforested or afforested.* As a matter of policy, the State, being the owner thereof, conducts reforestation of bare and denuded forestlands. Mostly, this is done through the establishment of reforestation projects funded by the government. Under this provision, the specific areas to be reforested include critical watersheds, riverbanks, swamps, former riverbeds, and beaches.

c. *Sec. 68 – Cutting, gathering or collecting timber or other products without license*. This provision penalizes any person who cuts, gathers or collects timber or other forest products without license from watershed areas. The offender is liable to imprisonment depending upon the use of timber or other forest products taken without license from the watersheds. In addition, the timber or other forest products unlawfully cut and gathered including the tools, equipment, and implements used will be confiscated and forfeited in favor of the government.

Related Laws and Regulations

Pres. Decree No. 1067 – Water Code of the Philippines. All waters belong to the State. The use, exploitation, development, conservation and protection of waters are subject to the control and regulation of the government. Created to perform this undertaking is the National Water Resources Council.

National Water Crisis and Execution Order No. 222 of 1994. Water conservation through demand management, institutional reforms, protection against pilferages and the cooperative action of the executive and legislative

branches, and of the government and private sectors. Multi-sectoral approach to water and watershed resources management is essential for sustainability.

Execution Order No. 192 – Reorganization Act of the DENR. This law reorganized the government machinery involved in natural resources and paved the way for the creation of DENR. As provided therein, the DENR is the primary government agency responsible for the conservation, management, development and proper use of the country's environment and natural resources which includes watersheds.

Executive Order No. 224. Vesting on the NPC the complete jurisdiction, control, and regulation over watershed area and reservations surrounding its power generating plants, and properties of said corporation.

Some watershed areas serve as sites of power generating plants. Under this law, these watershed areas fall under the complete jurisdiction, control, and supervision of the NPC. This was deemed necessary considering that the operational capability of hydrothermal and geothermal plants depend on the productive condition of the watersheds. With its expertise, the NPC was believed to be in better position to be the steward of these watersheds. The specific watersheds which are under the complete jurisdiction of NPC are:

1. Upper Agno Watershed reservation
2. Angat Watershed Reservation
3. Caliraya-Lamot Watershed Reservation
4. Makiling-Banahaw Geothermal Reservation
5. Buhi-Barit Watershed
6. Tiwi Geothermal Reservation

Republic Act No. 6657 – Comprehensive Agrarian Reform Law. Perhaps the most popular law enacted by the Congress, so far, is the present Comprehensive Agrarian Reform Law (Peralta, 1989). The law seeks to free the tenants from the bondage of the soil. In a sense, forest occupants are also tenants because they occupy and cultivate lands not belonging to them.

Does this mean therefore that if there are forest occupants in our watersheds, these forest occupants can own their lots someday?

The answer is no. The law itself removes land directly and exclusively used and found to be necessary for watershed purposes from its coverage. This exclusion of watersheds from the coverage of the agrarian reform law is again recognition of the policy treatment of the government to watersheds as resources to be conserved.

The Philippine Mining Act of 1995 (RS No. 7942). This act provided that proclaimed watershed reserves, old growth or virgin forests, wilderness areas, mossy forests and National Integrated Protected Area System (NIPAS) areas among others are closed to mining applications. Mining contractors are also required to undertake environment protection and enhancement programs to include revegetation, watershed development and water conservation.

NIPAS Act or RA No. 7586 and its implementing rules and guidelines (DAO No. 25 of 1992). It is the policy of the State to secure for the Filipino people of present and future generations the perpetual existence of all native plants and animals through the establishment of a comprehensive system of integrated protected areas. The protected areas include national parks, birds and wildlife sanctuaries, wilderness areas, mossy forests, old growth or virgin forests and critical watersheds.

Issues and Concerns on the Philippine Watershed Management Policies

Many watershed management policies in the Philippines are sectoral policies, which have been formulated in isolation resulting to conflict and competition for the limited watershed resources. This emanates from the many intended uses of the country's watersheds. The absence of an integrated framework compounded the disintegration of watershed management in the country (PCARRD, 1999).

The most important and most relevant policy to watershed management is the Revised Forestry Code (PD 705) since most of the country's forests are within watersheds. PD 705 embodies the general mandate of the Philippine Constitution to conserve and use the country's natural resources properly. It provides for the adoption of integrated and sustained multiple use forest management approach. Under this approach all the resources (i.e. range,

water, timber) in a land management unit (e.g., watershed) are to be managed in an integrative manner in order to provide various mixes of goods and services on sustained basis. However, the country lacks an integrated watershed management plan (Cruz, et. al., 1999).

The government does not have the capacity to manage all the country's watershed resources. Thus, all people in the watersheds including farmers, loggers, ranchers, miners, indigenous peoples and other stakeholders should be actively involved in the management of the watersheds. This can promote social justice and equity by granting all sectors equitable access to watershed resources (Cruz, et al., 1999). Active participation of the different sectors will ease the burden of the government to manage the vast areas of watersheds in the country.

Occupancy management is also an important policy in watershed management. In areas vulnerable to sedimentation, erosion, reduction in water yield and impairment of other resources, occupancy is not allowed. Occupancy in areas with steep slopes (50% +) may be allowed, if the sufficient trees are planted and appropriate conservation measures are adopted. This policy is significant for indigenous peoples and settlers whose livelihood is very much dependent on watershed resources. Alternative sources of livelihood are critical components of occupancy management.

Biodiversity conservation is complementary and supplementary to the predominating concern for water in watershed areas. Technical capability of local communities for biodiversity conservation is critical to the success of NIPAS areas (Cruz, et al., 1999).

Another issue is the mining claims in watershed reservations. Potential siltation impacts should be incorporated in the watershed planning for identifying possible mining areas.

FIELD MEASUREMENTS OF WATERSHED FUNCTIONS

Microclimate (Mini-Weather Station)

Instruments to measure the different elements of climate include photometer to record solar radiation (foot candle), sling psychrometer (Bacarach model) to determine relative humidity (%), and mercury thermometer to record air temperature (^{0}C). Daily readings can be taken, one in the morning and one in the afternoon. Amount of rainfall can be determined using standard eight-inch rain gauges and the amount of rain can be read after each rain event. The amount of evaporation can be determined using a pan evaporimeter. These parameters should be determined at several locations across the watershed.

Stream Flow and Soil Erosion Determination

A mini-basin can be used to determine stream flow and soil erosion. This approach entails construction of a weir at the base of a basin along the slope where water flows and accumulates. An automatic recorder is installed to determine stream flow every rainfall event. Sediment trapped in a mini-drum is determined at each rainfall event to determine the amount of soil eroded in each basin (FSSRI-CA-SESAM, 2003).

Watershed-Scale Measures of Soil Erosion

Soil creep model. The soil creep model is best used in watersheds with high topographic relief and a relatively small amount of alluvial bank cutting and when sediment yield data from the watershed or other nearby comparable watersheds are sparse. Watershed sediment yield can be calculated using the equation:

$$SY = C*2*L*D*SD$$

Where: SY = sediment yield (ton/yr)

C = creep rate (m/yr)
L = length of stream (m)
D = average soil depth (m)
SD = average bulk density of soil (tons/m^3)

The creep rate is multiplied by the total stream length times two to account for creep on both sides of the channel. Average soil depths can be estimated using soil survey information for the watershed.

Empirical sediment yield approach. The empirical sediment yield approach relies on available data collected on larger rivers. It can provide accurate estimates of sediment production from watersheds. The sediment yield data should extend at least a few years and should especially cover times of higher stream flow, when the majority of sediment is transported. If these data are to be used as estimates of natural sediment production, the history of land use during the period of record should also be investigated (WAM, 2000).

MODELS

Biophysical and bioeconomic models of watershed are useful research tools to understand watershed dynamics such as water flow, fate of nutrients, and soil erosion. This section will present models to understand vertical and lateral movement of water in watershed systems, nutrient dynamics, and scaling up soil erosion in the watershed.

Watershed models are also useful tools in watershed management.

Model of Vertical and Lateral Flows of Water

Well-spaced trees or other permanent vegetation along the contours can be effective in reducing erosion. What is their effect on crop production?

The overall effect is likely to be a balance of short- and long-term changes and will include negative effects through competition between the hedgerow/ woody vegetation on the contours and the crops, as well as positive effects via maintenance of soil fertility. Tree-soil-crop interactions in hedgerow intercropping on flat land already are a complex of positive and negative interactions (van Noordwijk, et al., 1998). Whereas hedgerow intercropping on flat land has not lived up to previous expectations, contour hedgerows on sloping land are supposed to have positive effects on crop fields (Sanchez, 1995) although the yield increase may still not be worth all the labor invested

in pruning the trees (Garrity, 1996). The WaNuLCAS model for predicting water, nutrient and light interactions in agroforestry systems (van Noordwjik and Lusiana, 1998) can be used to explore some of the interactions at process level. The model is set up for spatially zoned tree-crop systems and can be easily adapted to sloping lands, to model vertical and lateral flows of water. Another model that can be used to measure these interactions is the 'FALLOW' model. These are both discussed below.

WaNuLCAS Model

WaNuLCAS is a process-based model of water, nutrient and light capture in agroforestry systems developed by van Noordwijk, Lusiana and Khasanah (2004). A key feature of the model is the description of uptake of water and nutrients (N and P) on the basis of root length densities of the trees and the crop, plant demand factors and the effective supply by diffusion at a given soil water content (Fig. 3-1). It is the most all-around model currently available for evaluating different management options in agroforestry systems based on site-specific information and farmer management objectives.

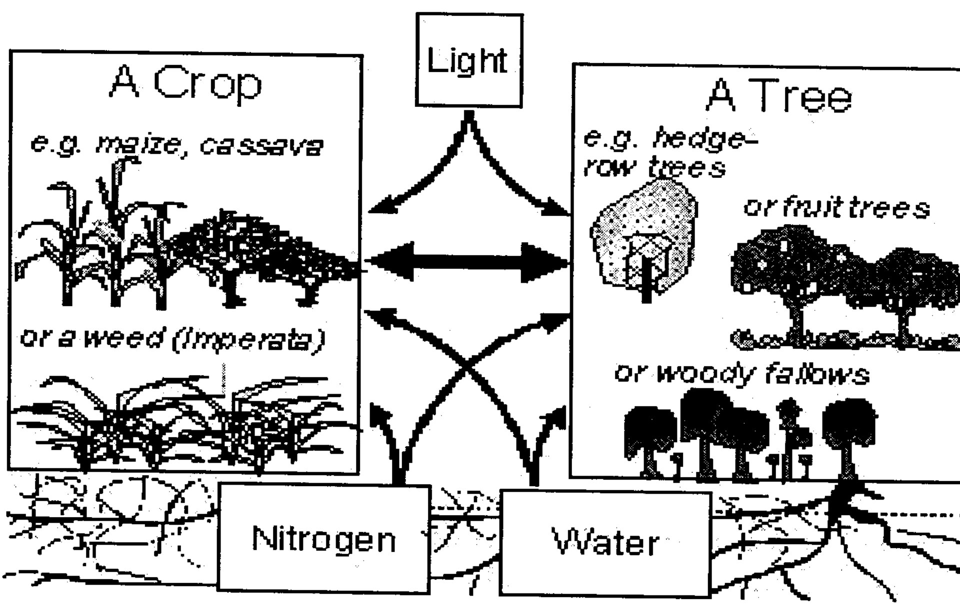

Fig. 3-1. Framework of the WaNuLCAS model.

The model has three types of control which can determine the pathway of water flows, and which can be modified by the user to explore the effect of different factors. These controls are:

- soil surface and its restrictions to infiltration, if rainfall intensity exceeds current infiltration rate, water will accumulate on the surface and as soon as the storage capacity determined by local 'roughness' and slope is exceeded, it will start to runoff over the surface (infiltration-limited runoff').

- The soil profile with its macropores that allows water to reach deeper layers, recharge the soil to field capacity and percolate to the subsoil; in May, tropical soils clay content increases with depth, and saturated conductivity decreases. This situation leads to the possibility of lateral subsurface flows on slopes that can contribute to the 'quickflow' of streams. 'Saturation overland flow' occurs if the local storage and percolation capacity of the soil is exceeded. Under certain conditions a 'perched water table' may be formed, leading to saturation overland flow before the whole soil profile is rewetted.

- Subsoil hydrological properties, leading to 'baseflow' of streams and/or recharge to deep aquifers.

The first two of these processes are under direct influence of land cover and can change from a 'forest' to a 'degraded' condition.

USLE and GUEST Equations: Scaling up soil erosion quantification from the plot to the watershed level

As mentioned before, quantifying erosion and especially the scaling up was a tricky thing to do. Commonly, the empirical Universal Soil Loss Equation (USLE) is used to quantify erosion:

$$SY = R * K * L * S * C * P$$

Where: SY = sediment yield;

R = rainfall factor;
K = soil erodibility factor;
L = slope length;
S = slope gradient;
C = crop-management factor;
P = erosion control practice factor

Mostly, USLE is based on American research at plot level on moderate slopes.

Application of the USLE to quantify erosion at the watershed level generally overestimates erosion and gives notoriously high errors of up to 2000 percent (Van der Poel and Subagyono, 1998). Scaling up from plot to slope or (sub)-catchment level is done using the (again empirical) Sediment Delivery Ration (SDR) equation.

$$SY = SDR * A$$

Where: SY = Sediment yield;
SDR = sediment delivery ration;
A = area in km^2;
$SDR = 33.65 * A^{-0.23}$

This approach does not take into account the spatial distribution of various land-use types, thus effects of filters can hardly be measured with this method. USLE was in fact designed to quantify erosion at plot level. The SDR itself does depend on scale, and when we consider larger areas it may only be 5 percent. In case, one would like to know where the other 95 percent of sediment stays behind in the landscape and how likely it will remain there.

The physical Griffith University Erosion System Template (GUEST) equation is expected to be more accurate and uses a set of equations that describe the underlying physical processes of erosion (Rose and Yu, 1998). GUEST stands for.

$$\bar{c}_t = k^{\beta} Q_{eff}^{0.4\beta} \exp(-k_s C_s)^{3/5}, \quad \text{With } k = \frac{F\sigma S L^{0.4\beta}}{(\sigma / \rho - 1)\,\phi} \left(\frac{\sqrt{S}}{n}\right)$$

Parameters are β = Erodibility parameter; Q_{eff} = effective runoff rate; C_s = surface cover contact fraction; n = surface roughness coefficient (Manning); F = fraction of stream power of overland flow used in erosion ($\approx$0.1); σ = sediment density (kg/m^3); ρ = water density (kg/m^3); S = slope; V = flow velocity (m/s); ϕ= mean settling velocity of sediment (m/s).

This equation is unfortunately more complex and more 'data hungry.'

A Case Study: Scaling up using the USLE and GUEST equations

In a case study for Sumberjaya watershed in Lampung, Sumatra, both equations were compared at different levels of scale; 20 x 20 m plot and 2 x 4 km (sub)-catchment () level (Schmitz and Tameling, 2000).

Both methods were compared in a virtual environment in the form of PCRaster, a dynamic GIS-program, which is suitable for modeling overland flow. All three levels of scales were modeled in this program, with a grid size of 20 x 20 m.

Scenarios were created to be able to compare the results for the land-use types at each level of scales of both equations in PCRaster (a dynamic GIS-software developed at the University of Utrecht, Netherlands). Different scenarios represented different combinations of land-use types.

Input data for the models were mainly derived from literature, since there was little information available for the Sumberjaya area itself. Thus, the run-results should be interpreted in a *more qualitative, rather than quantitative* way.

Plot level scenarios

At plot level, various land use scenarios were compared for a constant slope of 15% and same soil type or K-value (0.15). The GUEST equations seem systematically to underestimate the erosion (in ton/ha) for all land uses, which can be attributed to the inaccuracies of how some of the parameters (Manning coefficient, erodibility β, ...) could be determined from the literature.

However, it could also be that the USLE is systematically overestimating erosion levels. Accurate measurements in the field should give us some stronger conclusions. The modeling exercise revealed which parameters it is important to measure accurately.

The following plot level scenarios were chosen because they occur regularly in the study-area:

(1) Clean-weeded coffee
 (a) Without filter
 (b) With filter 1 (terrace)
 (c) With filter 2 (grass-strips)
 (d) With filter 3 (two months weeded)
(2) Unweeded coffee
(3) Coffee in multistrata
(4) Natural forest
(5) Sawah = irrigated rice field
(6) Calliandra forest
(7) Belukar = young secondary growth of forest
(8) Vegetables
(9) Bare soil

Slope level scenarios

The slope used each time was 500 m long and 20 m wide, so consisted of a downhill sequence of 25 grid cells of 20 x 20 m (equivalent to the plot size used above).

The list below represents the slope level scenarios. One scenario consists of a combination of land-use types considered above. The combinations are given from the top of the slope down to the valley bottom.

1. natural forest/bare soil/clean weeded coffee/sawah; with different subscenarios for the different types of clean weeded coffee mentioned above.
2. natural forest/bare soil/clean weeded coffee/multi strata coffee/sawah.
3. natural forest/multistrata coffee/sawah.
4. natural forest/unweeded coffee/sawah
5. natural forest/calliandra/sawah
6. natural forest/vegetables/sawah
7. natural forest/belukar/sawah

The different types land-use are distributed over multiple plots, for instance in scenarios 1a, the distributions is:

Land-use Type	Length of slope (m)	No. of plots
Natural Forest	80	4
Bare Soil	180	9
Cleanweeded coffee without filters	200	10
Sawah	40	2
Total	500	25

For the same slope the GUEST equation always give a very low (almost incredible) erosion yield; very close to 0 ton/ha. This was mainly due to the large sedimentation capacity of the last two sawah plots at the end of the almost flat slope. Hardly any sediment would 'leak' through these 'filter' plots. Especially the gentle slope in the last two grid cells seemed to plot a crucial role.

The USLE does not account for these effects, because the result is based on an average erosion value over the whole area. It would not make a difference if the filter elements were located at the bottom of the slope or on top of the hill.

Catchment level scenarios

The catchment level simulations involved scenarios, whereby the different land use map scenarios were overhid with a digital elevation model..

Scenario 1 was made to compare the USLE and GUEST equation. Scenarios 2 and 3 were developed to study filter elements with the GUEST equation. Scenario 3 had strips of two cells sawah (as filters) along the rivers.

Comparing results following observations can be made:

- The difference between both equations is far less at the catchment level then at the plot or slope level. This is largely because of t he increased sediment yields for the physical equation. The higher figure is caused by the large amount of runoff on the steep slopes without 'filter elements' near the outflow points at rivers.
- The erosion 'hot spot' are in completely different areas depending on which equation one uses. This would imply dramatic consequences if and where soil

and water conservation interventions should be undertaken, as until now these interventions are only based on one approach.

- The USLE is sensitive to convex slopes and catchment size: the larger the catchment, the larger the absolute erosion result. The USLE is completely insensitive to the spatial distribution of land use types.
- The GUEST equation is sensitive to convex slopes, the distribution of land use types and filter elements and the frequency of big rainfall events. Catchment size is far less important for the GUEST equation.

Scenario 2 gave a higher total sediment yield (57,456 ton/yr compared to 47,656 ton/yr) because of the lack of filter elements. Scenario 3 gave only a marginal higher figure (48.338 ton/yr), although it had far less filter elements (sawah) than scenario 1. This is a clear indication that it is not so important how may filter elements there are in the landscape, but far more important is where they are spatially located. It seems crucial that filter elements are close to the inflow points to the river.

This type of approach could be modified e.g. by adding roads, small footpaths, ... to the virtual landscape.

<u>Conclusions from this study:</u>

1. USLE is relatively an easy equation to use, but scaling up is problematic. It doesn't capture spatial heterogeneity or landscape mosaic. The output is a sum of erosion from homogeneous units corrected for the area by SDR.
2. The more complex GUEST equation needs more accurate data in this case study, but is more promising in being able to help answer the questions posed in the introduction. It captures flows and spatial heterogeneity. It needs better and more reliable data, than are currently available in many areas.
3. At plot level: e.g. erodibility of various soil types and their infiltration capacity.
4. At the catchment level: More research is needed to find out to what extent sawah or irrigated rice fields can operate as an effective filter. The approach illustrated (with 'hot spot' locations) above can help in locating where the most effective place in the landscape would be to put those filters. More research is needed to small roads and footpaths function as channels or even 'highways' for sediment transport.

PCARES is a GIS-assisted physical model that simulated runoff and soil erosion of a catchment during each erosive rainfall event. It can predict the spatial

and temporal distribution of soil erosion rates thus can be used to identify erosion "hotpots" in a watershed (Lanuza and Paningbatan, 2000). Also, it can predict the runoff and sediment discharge rates at the outlet of a catchment, thus it could be a handy tool to study the effect of land use change and management options on water quantity and quality.

The model uses PCRaster and GIS software package capable of cartographic and dynamic modeling that allows easy simulation of the hydrologic and sediment transport processes occurring on a three-dimensional landscape. The concept, structure, and script are simple to understand even by a researcher with minimal expertise in programming. The basic input parameters to run the model include raster maps of digital elevation, land use, soil, rain station, runoff monitoring station, time serried rainfall amount, and infiltration capacity. Its hydrology component includes the calculation of water flow velocity using the Manning's equation that allows the calculation of discharge rate at shorter time intervals. It also incorporates a system of calculating sediment transport.

The hydrology comprises the interrelationships of rainfall, infiltration and runoff during each erosive rainfall event. The model first considers how rainfall influences overland flow and eventually the erosion processes of entrainment and deposition. With a given soil infiltration capacity for each cell, the model calculates overtime the amount of excess rainfall that becomes runoff using the equation;

$$R = P - I$$

Where: R = excess rainfall (mm) that becomes runoff, P = amount of rainfall (mm), and I = infiltration (mm) over a specified time step(s).

Water discharge (Q, in m^3/s) at the downslope portion of each cell area is calculated from the amount, direction and velocity of water inflow or outflow to the neighboring cells. A water routing subroutine called local drain direction (LDD) of PCRaster calculates the direction of water flow while the velocity of overland flow is calculated using Manning's equation;

$$V = (1/\eta)\ S^{1/2} R^{2/3}$$

Where: V = flow velocity (m/s); η = Manning's roughness coefficient;

S = slope gradient (fraction); and R = hydraulic radius (m).

The process of soil erosion was modeled following the concept developed by Rose and Freebairn (1985) which calculates the amount of soil loss (SL) from the product of sediment concentration (c, in kg/m^3) and water discharge rate (Q). Sediment concentration is estimated using the simplified equation by Rose and Freebairn (1985) which is written as:

$$c = 2700\ \lambda\ S\ (C_r)$$

Thus, the sediment loss (kg/s) at each cell is calculated from the equation:

$$SL = 2700\ \lambda\ S\ (1 - C_0)\ (Q)$$

Where: λ = efficiency of sediment entrainment, S = sine of slope angle, $(1 - C_0)$ = Cr where C_0 is the ratio of the area not exposed to runoff or the contact cover fraction, and Q = water discharge rate (m^3/s).

It is imperative from the above equations that the attributes needed to run the model and simulate soil erosion and water discharge in a watershed include rainfall rates (P), soil infiltration characteristics (I), surface crop cover (C_0), surface roughness (η), slope steepness (S), and efficiency of entrainment (λ). Spatial and temporal representation of these attributes in raster maps are important parameters to run the model. Time series rainfall rates (mm/minute) for each runoff generating rainfall event is also necessary to run the model. On the other hand, runoff discharge, sediment concentration and soil loss at the outlet of a watershed or spatially represented in raster maps for the entire catchment study area are important outputs of the model.

The model has limited validation only in one catchment in Barangay Alanib, Lantapan, Bukidnon, Philippines and is being validated at the Management of Soil Erosion Consortium (MSEC) and the World Agroforestry Center (ICRAF) research sites to note that based on sensitivity analyses conducted the parameters surface crop cover, infiltration characteristics and Manning's roughness coefficient effect significant changes in sediment concentration and runoff discharge and hence, sediment yield. These parameters are highly affected by the kind of crop management and conservation practices, and

land use change which may assist in the application of such a model to many research undertakings in Manupali watershed.

Parameterization of PCARES for Mapawa Catchment

The input parameters for Mapawa catchment area were prepared in order to run PCARES. A geo-reference elevation map was prepared by digitizing a 1:50,000 topographic map which was converted into a raster map called dem.map using SUPFER and PCRASTER GIS software. Similarly, a GIS procedure was performed to produce the following spatial watershed attributes presented in raster maps; soil.map, land use.map, monitoring station.map, and rain station.map. The land use map includes the spatial distribution of agricultural lands, grasslands, forestlands, barangay road, footpath, stream and its tributaries in the study catchment area. Other raster maps like slope.map local drain direction.map, infiltration.map, crop cover map, were generated while running the model PCARES and using some decision tables.

Infiltration capacity which is highly dependent on soils and land use were estimated from a data set determined in the field using a double ring infiltrometer. Rainfall hydrographs were prepared from an automatic rain gauge capable of measuring depth or rainfall every minute. Stream flow was monitored using water stage height recorders, while sediment load was measured during each erosive rainfall event at several stream flow monitoring. In addition, catchment attributes in the form of maps like slope, elevation, and drainage channels are obtained from secondary sources while cropping patterns and cultural practices, surface vegetation and other land were also measured, noted or described, whenever appropriate. These measurements and monitoring activities are not only valuable in establishing the interrelationships of the watershed parameters but also could be used to calibrate and validate simulation models at catchment scale.

Effect of land surface cover on water and sediment discharge

The effects of surface cover on water and sediment discharge at the outlet of the catchment were predicted using the PCARES. Three scenarios were used, bare surface, current vegetative cover with minimum conservation measures

and forest vegetation or with full soil conservation measures. A measured rainfall data of a very strong rainstorm (130 mm in about 1 hour), occurred on 18 July 1999 was used in the simulation in addition to the parameterized Mapawa catchment.

The peak flow of water that discharged at the outlet of the catchment was highly affected by the imposed treatment. The height of water in the outlet of Mapawa creek is 1.2 m if surface is bare and 0.1 m if land surface is forest covered. The simulated hydrographs show that water and sediment discharge rates were significantly lesser in the current and forest vegetation compared to a bare surface. Peak sediment yield which appeared much earlier was 480 kg/l in the bare surface while almost zero in the forest cover. The results demonstrate the important positive effects of surface cover in managing soil erosion and runoff in a watershed.

SUMMARY AND CONCLUSION

Watersheds are hydro-ecologically significant areas because they are the primary sources of forest products, freshwater and other natural resources. The Philippines has a total land area of 30 million hectares and about 90 percent of this is considered watersheds. Despite the significance of these watersheds, many of them are now in poor condition due to land use change and removal of forest cover.

Deforestation and the resulting shifting cultivation and fallow cycles as well as forest conversions are the major causes of degradation of watershed functions in the Philippines. These activities have brought about various environmental problems such as rainstorm runoff, accelerated soil erosion and siltation/sedimentation of rivers, lakes and other water bodies, and water pollution causing a decline in soil productivity and deterioration in water quality and quantity.

Watershed management is critical to maintain the it's structure and function despite human interventions. Outputs of watershed management are assessed through the watershed's water supply, flood control, and erosion control. The Philippine government has enacted several laws and policies to

protect and advance the right of the people to a balanced and healthful ecology, in accord with the rhythm and harmony of nature.

Field measurements of watershed functions include monitoring daily fluctuations in microclimate, streamflow and soil erosion at each rain event. Vertical and lateral flows of water in a watershed microcatchment can be simulated using models such as WaNuLCAS and PCARES models.

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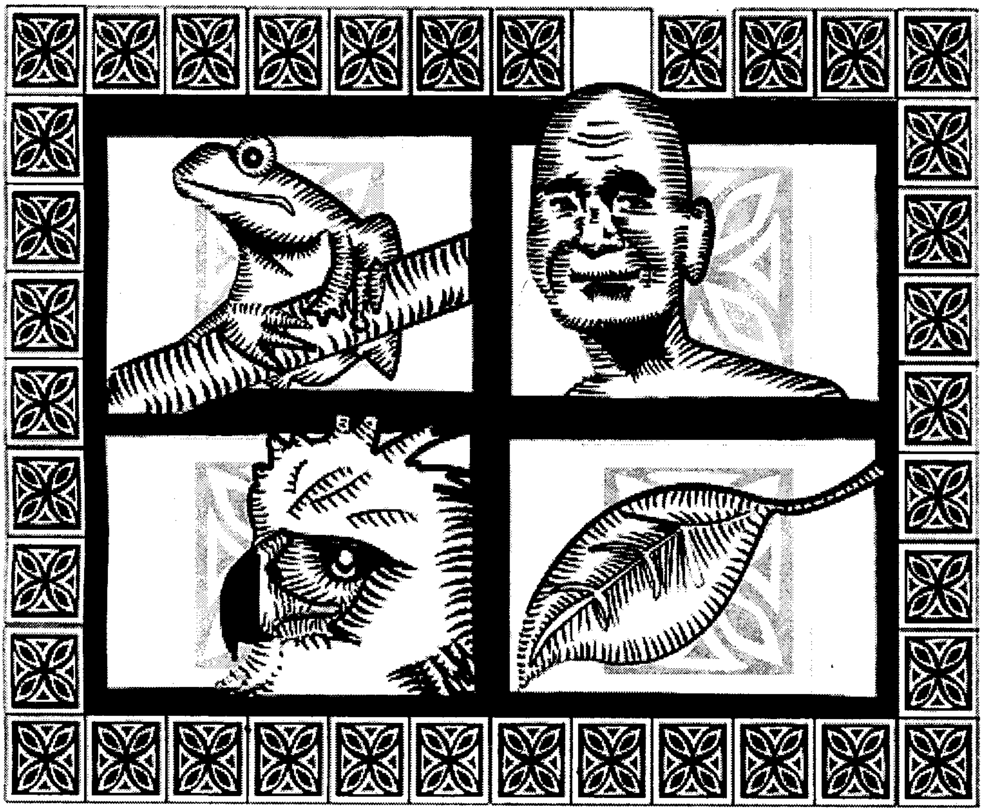


CHAPTER IV

CARBON STOCKS AND SEQUESTRATION OF PHILIPPINE LAND USE SYSTEMS

Rodel D. Lasco

OBJECTIVES

After studying this chapter, the reader should be able to:

1. describe the concept and causes of climate change with focus on the role of land use change and forestry in the tropics;
2. discuss the impacts of land use changes in the Philippine uplands on carbon stocks;
3. identify methods for measuring carbon stocks and sequestration rate of the various land uses in the Philippine uplands;
4. discuss the international policy context of climate change and how farmers may benefit from projects designed to mitigate it; and
5. illustrate ways by which the Philippine uplands can help mitigate climate change.

INTRODUCTION

This section explores the relationship of land use and land use change activities in the Philippines with climate change. Special attention is given as to how these activities affect the global carbon cycle.

The first part provides a brief overview of what climate change is all about. The second part provides a national perspective on how Philippine forestlands have affected the global carbon cycle in the last century up to the present.

CLIMATE CHANGE

The earth's climate has been stable for about 10,000 years (mean temperature not >1°C per century). The UN Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is *attributed directly or indirectly to human activity* that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". In contrast, the Intergovernmental Panel on Climate Change (IPCC) defines it more broadly as "any change in climate over time, whether due to natural variability or as a result of human activity."

For about 1,000 years before the Industrial Revolution, the amount of greenhouse gases (GHG) in the atmosphere remained relatively constant. Since then, the concentration of various greenhouse gases has increased (Fig. 4-1). The amount of carbon dioxide has increased by more than 30 percent since pre-industrial times and is still increasing at an unprecedented average rate of 0.4 percent per year, mainly due to the combustion of fossil fuels and deforestation. Methane (CH_4) concentration in the atmosphere increased from 700 ppb in pre-industrial times to 1,700 ppb today due to agriculture, waste treatment, and fossil fuel use.

The increased concentration of greenhouse gases in the atmosphere enhances the absorption and emission of infrared radiation. The atmosphere's opacity increases so that the altitude from which the Earth's radiation is effectively emitted into space becomes higher. Because the temperature is lower at higher altitudes, less energy is emitted, causing a positive radiative forcing. This effect is called the enhanced greenhouse effect.

Radiative forcing refers to any change in the average net radiative balance at the top of the atmosphere. IncreasingGHG concentrations in the atmosphere will reduce radiative cooling of the earth, resulting in positive radiative forcing (i.e., global warming). Any radiative forcing will alter atmospheric and oceanic temperatures, weather patterns, and the entire hydrologic cycle.

The relationship of atmospheric carbon dioxide (CO_2) concentration to air temperature has been established by scientists through ice core measurements,

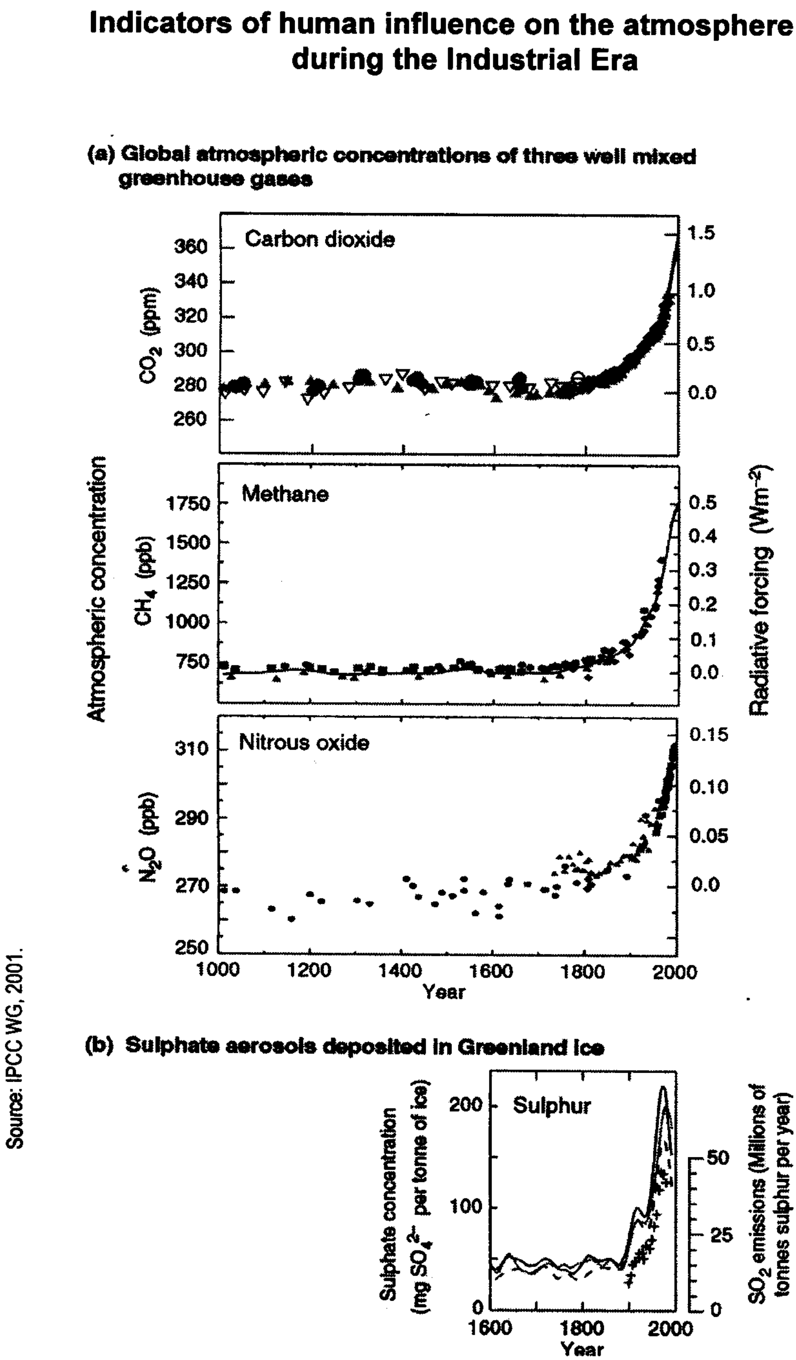


Fig. 4-1. Influence of industrialization on GHG and aerosol emissions.

i.e., air temperature rises and falls with CO_2 concentration (Fig. 4-2).

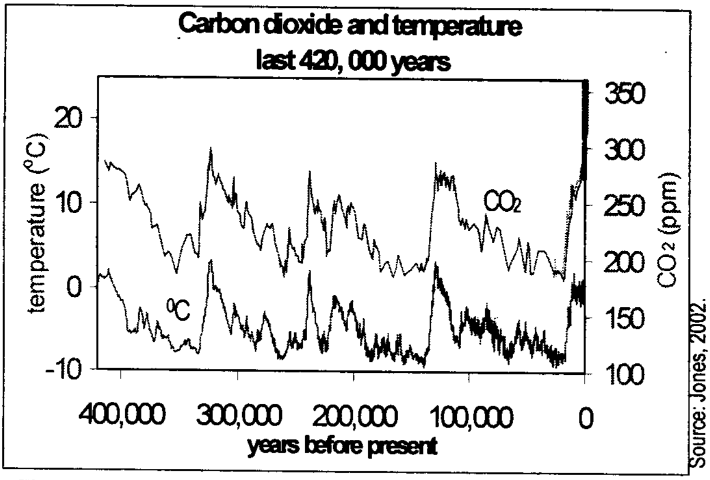


Fig. 4-2. Relationship of CO_2 concentration in the atmosphere and air temperature.

Models project that there will be a rapid rise in CO_2 emissions leading to a corresponding increase in CO_2 concentration in the atmosphere (Fig. 4-3). It is not hard to imagine that such an increase will have dire repercussions to the Earth's climate.

The IPCC Third Assessment Report or TAR (2001) provides compelling evidence that the Earth's climate is indeed changing because of human influence. Its major conclusions are the following:

- The global average surface temperature has increased over the 20th century by 0.6°C. Globally, it is very likely that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record since 1861.

- Temperatures have risen during the past four decades in the lowest eight kilometer of the atmosphere. Since the late 1950s (the period of adequate observations from weather balloons), the overall global temperature

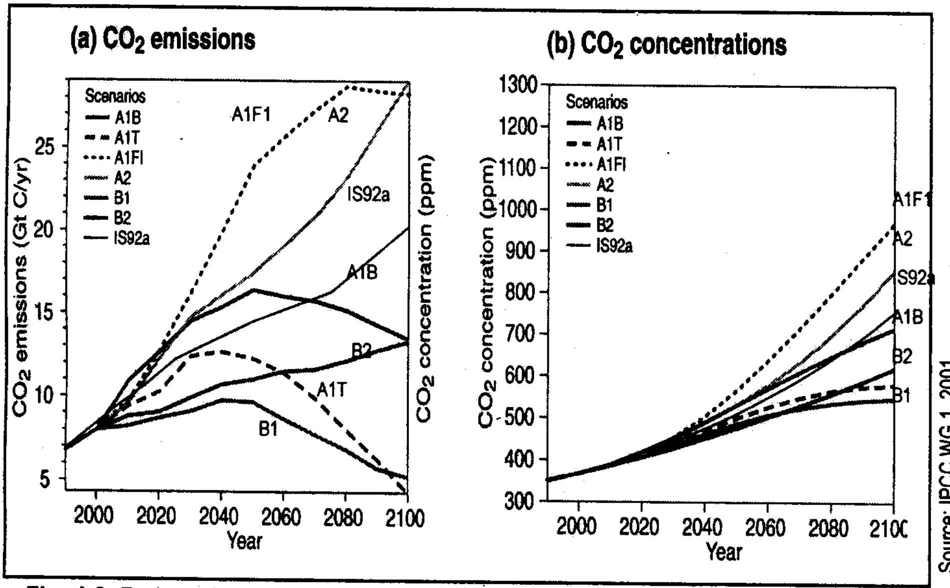


Fig. 4-3. Projected increase in CO_2 emissions and atmospheric concentrations in the next 100 years.

increases in the lowest eight kilometer of the atmosphere and in surface temperature have been similar at 0.1°C per decade. Since the start of satellite records in 1979, both satellite and weather balloon measurements show that the global average temperature of the lowest eight kilometer of the atmosphere has changed by 0.05°C ± 0.10°C per decade, but the global average surface temperature has increased significantly by 0.15°C ± 0.05°C per decade.

- Snow cover and ice extent have decreased. Satellite data show that there are very likely to have been decreases of about 10 percent in the extent of snow cover since the late 1960s. There has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century. Northern hemisphere spring and summer sea-ice extent has decreased from 10 percent to 15 percent since the 1950s. It is likely that there has been about a 40 percent decline in Arctic sea-ice thickness during late summer to early autumn in recent decades and a considerably slower decline in winter sea-ice thickness.

- Global average sea level has risen and ocean heat content has increased. Tide gauge data show that the global average sea level rose between 0.1 meters and 0.2 meters during the 20th century. Global ocean heat content has increased since the late 1950s, the period for which adequate observations of sub-surface ocean temperatures have been available.

Overall, the IPCC TAR report concluded that based on new and stronger evidence, most of the warming observed over the last 50 years is attributable to human activities.

In the next century, the globally averaged surface temperature is projected to increase by 1.4°C to 5.8°C over the period 1990 to 2100 (Fig. 4-4). The

Source: IPCC WG 1, 2001.

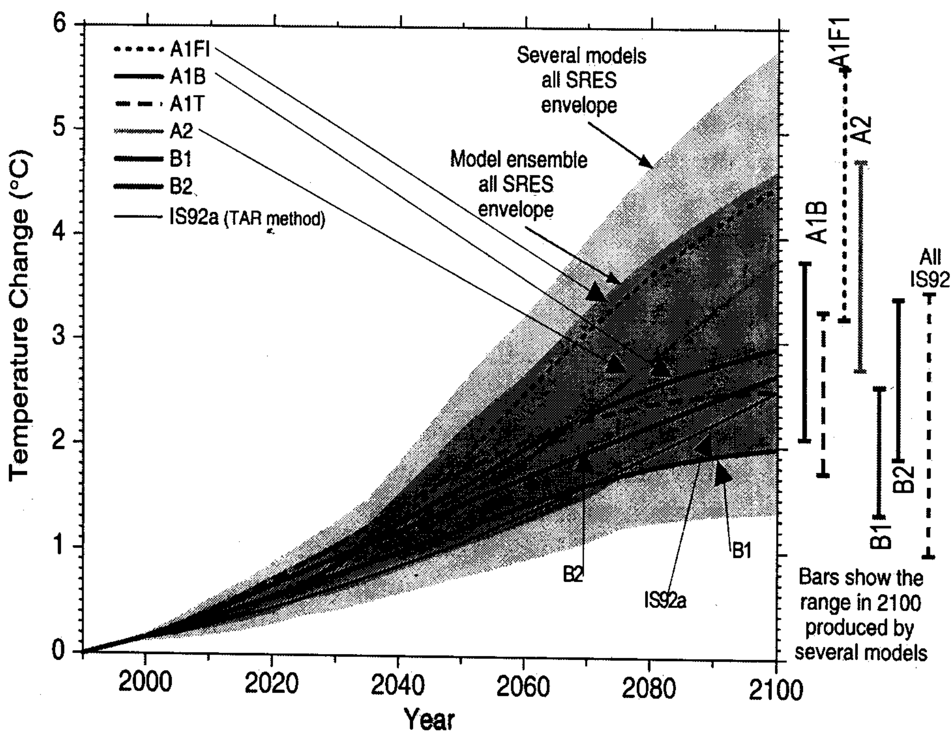


Fig. 4-4. Projected temperature rise in the 21st century.

last 10,000 years, based on palaeoclimate data. Global mean sea level is projected to rise by 0.09 to 0.88 meters between 1990 and 2100, for the full range of SRES scenarios (Fig. 4-5). This is due primarily to thermal expansion and massive loss from glaciers and ice caps.

Initial projections in the Philippines show that under a $2xCO_2$ scenario, temperature may rise by 2 °C to 3°C while rainfall will generally increase with some regions experiencing up to 200 percent increase (Table 4-1).

Global importance of forests to climate change

There is considerable interest on the role of terrestrial ecosystems in the global carbon cycle. The world's tropical forests covering 17.6 million km² contain 428 gigaton carbon (Gt C)* in vegetation and soils. It is estimated that about 60 Gt C

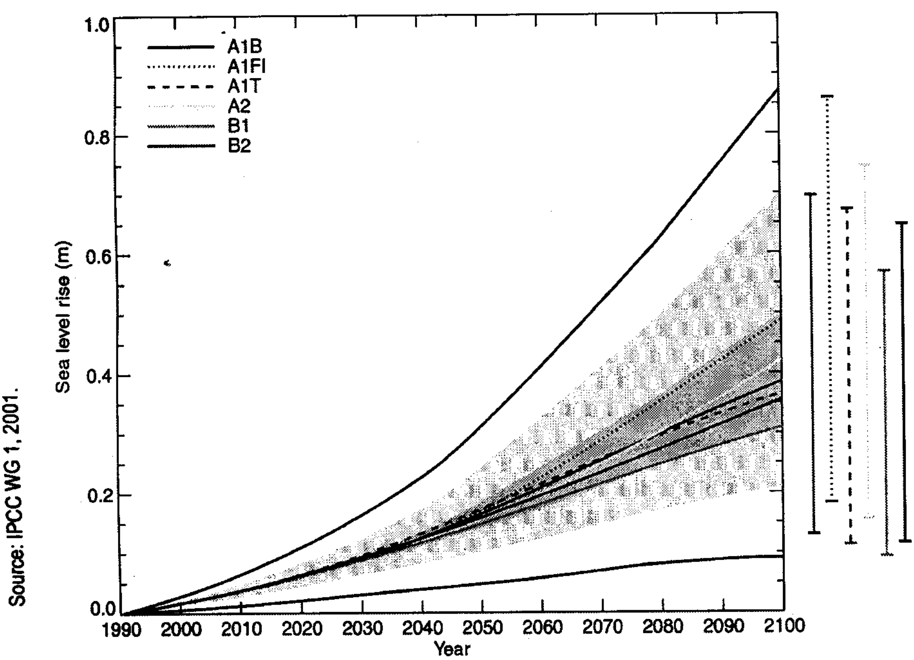


Fig. 4-5. Projected sea level rise in the 21st century

* Some units of measure commonly used in climate change literature: 1Gt = 1 billion metric tons or 10^9 tons; 1 Mg= 1 metric ton or 10^6g.

Table 4-1. Temperature change and rainfall ration by water resource region based on the Canadian climate center models (2xCO_2 scenario).

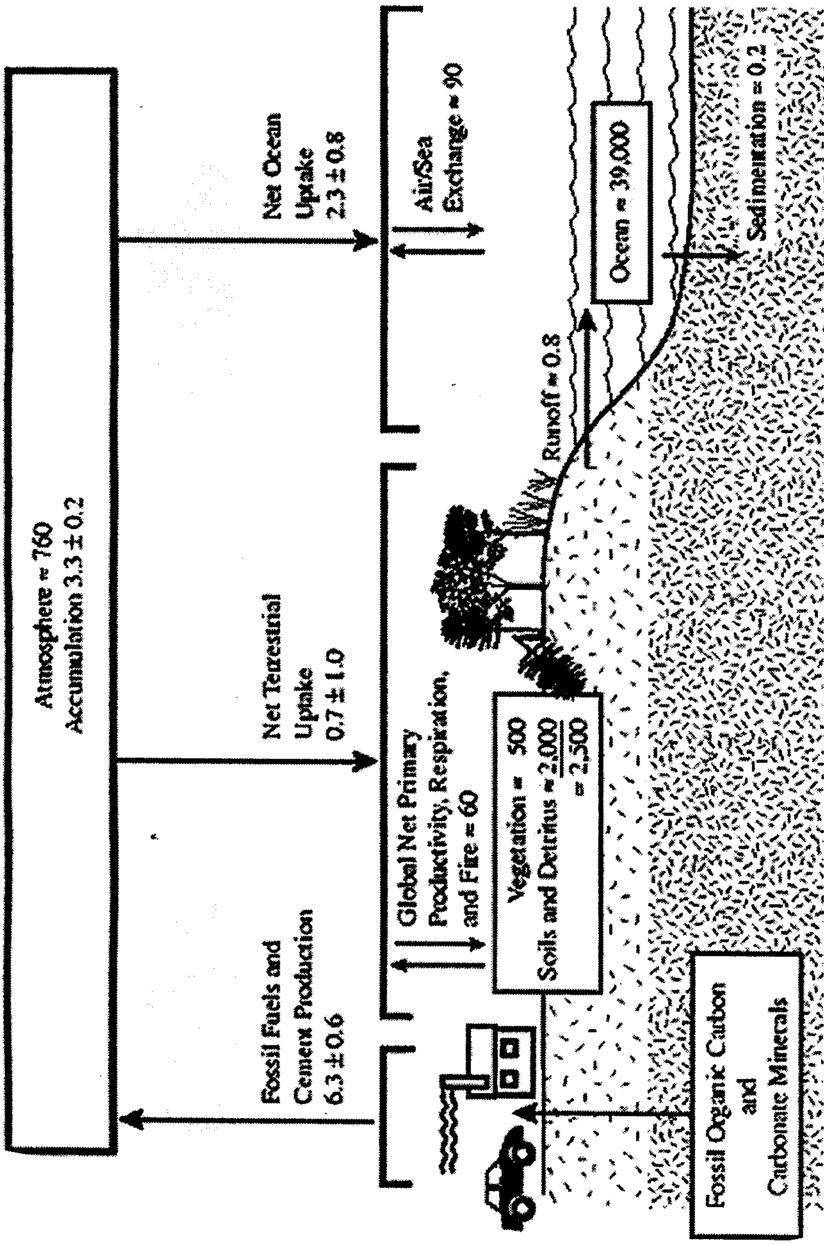
Name of Water Resource Regions		Temp. Change (°C)	Rainfall Ratio
I	Ilocos	<2	1.0-1.5
II	Cagayan Valley	<2	1.0-1.5
III	Central Luzon	2-3	1.0-2.0
IV	Southern Tagalog	2-3	1.6-2.0
V	Bicol	2-3	1.0-1.5
VI	Western Visayas	2-3	1.6-2.0
VII	Central Visayas	2-3	1.6-2.0
VIII	Eastern Visayas	2-3	1.0-2.0
IX	Western Mindanao	2-3	1.0-1.0
X	Northern Mindanao	2-3	<1.0-1.5
XI	Eastern Mindanao	>3	<1.0
XII	Southern Mindanao	2-3	1.0-1.5

Source: Philippines Initial National Communication, 1999.

is exchanged between terrestrial ecosystems and the atmosphere every year, with a net terrestrial uptake of 0.7±1.0 Gt C (Fig. 4-6). However, land use, land use change, and forestry (LULUCF) activities, mainly tropical deforestation, are also significant net sources of CO_2, accounting for 1.6 Gt C/yr of anthropogenic emissions (Houghton, et al., 1996; Watson, et al., 2000).

Mitigating carbon emission through forestry in tropical areas like the Philippines is one of the most feasible ways of reducing CO_2 in the atmosphere. In fact, drawing CO_2 out of the air and into the biomass is the only known practical way of removing large volumes of GHG (Trexler and Haugen, 1995). Among the different zones, forestry in the tropics has the greatest long-term potential for carbon conservation and sequestration by (in decreasing order of importance): protecting lands for natural and assisted regeneration; slowing deforestation; and forestation and agroforestry (Brown, et al., 1996).

Tropical forestry is also receiving much attention because of cost effectiveness (cheaper in the tropics), high potential rates of carbon uptake (because of fast growth), and associated environmental and social benefits (Moura-Costa, 1996).



Source: Bolin and Sukumar, 2000.

Fig. 4-6. Global carbon cycle.

Forests could serve as sinks of carbon through photosynthesis, which converts CO_2 from the atmosphere into carbohydrates. A large proportion of the carbon is released back to the atmosphere through respiration. However, a certain portion becomes "fixed" once it is incorporated in the biomass of trees. Thus, the higher the biomass accumulation the greater is the potential to sequester carbon. Aside from living biomass, forest soil also stores a substantial amount of carbon.

There are three general ways by which forest management practices can be employed to curb the rate of CO_2 increase in the atmosphere: conserving existing carbon pools, expanding the amount of carbon stored, and substituting wood products for fossil-fuel products.

Conservation of Existing Carbon Sinks

The goal of this approach is to maintain or improve existing carbon pools in the Philippine forests by protecting forest reserves use of appropriate silvicultural practices and controlling deforestation.

Protected (mainly old-growth and mossy) and second growth forests cover 6.1 million hectares in the Philippines (FMB, 1996). The National Integrated Protected Area System (NIPAS) Law provides the legal foundation for the conservation of protected forests. However, there are fears that a substantial portion of protected areas is still without adequate protection. Activities that promote the conservation of these forest areas will contribute positively by preventing the release of carbon to the atmosphere.

The deforestation rate in the Philippines is about 100,000 ha which translates to a loss of about 9 million tons carbon every year. Strategies that will reduce the rate of forest loss will contribute to the reduction of carbon emitted to the atmosphere. Globally, it is estimated that tropical deforestation contributed 1.7 billion tons of carbon in 1990 alone, about 30 percent of total net yearly emissions (Trexler and Haugen, 1995; Muoro-Costa, 1996).

Certain silvicultural practices such as timber stand improvement (TSI), improved harvesting and fertilization may lead to increased carbon sequestration since these practices are directed to increasing forest growth.

The exact contribution of these practices has not been quantified. As a rule, the higher the biomass produced the more carbon are fixed. However, this is not always true since different species and even age classes of trees affect the carbon density of the wood.

A good example of how silvicultural systems could be improved is the Reduced-Impact Logging Project in Sabah, Malaysia where the New England Electric System (NEES) provided funds to train personnel of the logging concession Innoprise Corporation Sendirian Berhad (ICSB) in improved harvesting techniques. By controlling logging damage, the project is able to sequester 25-45 tons carbon per hectare after 2 years of operation (Dixon, et al., 1993).

Another way of minimizing carbon emission from forestlands is by preventing fire. It is estimated that 68,636 hectares of Philippine forestlands were burned from 1992 to 1996 (Castillo, 1997). The exact amount of carbon emitted from these lands has not been quantified. In addition, other GHG such as methane and carbon monoxide (CO) are also released to the atmosphere. Programs aimed at fire prevention will result to conservation of carbon in plant biomass.

While much of the attention is focused on plant carbon storage, tropical forest soils are significant sinks of carbon. It is estimated that up to 30 percent (90 tons/hectare) of carbon in the forest ecosystem is tied up in the soil (Moura-Costa, 1996). Consequently, practices that help maintain or improve soil organic carbon will have positive benefits. Examples of these practices are (Dixon, et al., 1993):

- soil erosion control measures;
- soil fertility improvement;
- shifting agriculture reduction; and
- forest litter and debris retention after logging.

In sum, all the various programs and initiatives in the Philippines geared towards the preservation of remaining forest cover could contribute to the prevention in the increase of CO_2 concentration in the atmosphere.

Expansion of Carbon Stocks in Forestlands

The goal of this approach is to expand the amount of carbon stored in forest ecosystems by increasing the area and carbon density of natural and plantation forests as well as increasing storage in durable wood products.

Since carbon sequestration is a function of biomass accumulation, the simplest way to expand carbon stocks is to plant trees. In the Philippines, there is at least 1.18 million hectares of grassland areas that could be reforested. Aside from the many benefits associated with forests, these areas have the potential to sequester a substantial amount of carbon. Assuming a carbon fixation rate of 4.4 tons/hectare/year (Lasco, 1997) for Philippine plantations, a minimum of 5.2 million tons carbon can be sequestered every year if all these areas are reforested. This rate is already equal to 15 percent of the total current annual carbon emissions of the entire Philippines.

Aside from the grassland areas, brushland and agricultural areas could provide additional areas for rehabilitation (up to 8 million hectares). Most of these areas have low carbon densities because of less than optimum use of the land. In shifting cultivation areas, the use of agroforestry is usually recommended. The introduction of woody perennial species will expand the carbon storage capacity of cultivated areas. The great variety of agroforestry systems in the Philippines (Lasco and Lasco, 1989) in contrast to tree plantations makes it imperative that research be conducted on their potential to sequester carbon.

The choice of species to be planted will affect the potential to sequester carbon (Muora-Costa, 1996). In the Philippines, fast-growing species such as *Gmelina arborea*, *Acacia mangium* and *Eucalyptus* spp. are commonly used. They accumulate more biomass and carbon than slow-growing species for the same period. However, fast-growing species typically have lower wood density and thus contain less carbon than wood of slow-growing species.

A good example of this approach is the Forests Absorbing Carbon Dioxide Emissions (FACE) Foundation project with Innoprise in Sabah, Malaysia (Dixon, et al., 1993). Initially, 2000 ha of degraded forest stands will be rehabilitated. If successful, an additional 26,000 hectares will be rehabilitated over the next 25 years.

Substitution of Wood Products for Fossil Fuel-based Products

Substitution aims at increasing the transfer of forest biomass carbon into products (e.g., construction materials and biofuels) that can replace fossil-fuel-based energy and products, cement-based products and other building materials (Brown, et al., 1996). This approacn is considered to have the greatest mitigation potential in the long term (> 50 years). For instance, the substitution of wood grown in plantations for coal in power generation can avoid carbon emissions by an amount of up to four times that of carbon sequestered in the plantation (Brown, et al., 1996).

CONTRIBUTION OF THE PHILIPPINE UPLANDS TO CARBON EMISSIONS AND SEQUESTRATION

Historical Contribution of Philippine Forestlands to Carbon Emissions

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 million hectares out of a 30 million total land area) (Fig. 4-1). By the year 1900, there were still 70 percent or 21 million hectares of forest cover (Garrity, et al., 1993; Liu, et al., 1993). However, by 1996 there were only 6.1 million hectares (20 percent) of forest remaining (FMB, 1997). Thus, in this century alone, the Philippines lost 14.9 million hectares of tropical forests.

In terms of carbon lost due to forest destruction, we estimated that Philippine forests released about 4.1 gigaton (1 gigaton = 109 tons) of carbon into the atmosphere since the 1500s, assuming there are 199 tons C/ha in the original forests (Lasco and Pulhin, 2000). Of this amount, 70 percent (2.9 gigaton) were released this century. This is based on the premise that all the carbon in the forest biomass was released as CO_2 into the atmosphere. In reality, some portion of this carbon is still stored in long-lasting wood products such as in furniture and old houses. The above estimate of carbon loss does not include carbon in understorey vegetation, litter and soil. This unaccounted portion could amount to 25 percent of aboveground biomass (Brown, et al., 1996).

The global annual carbon emission from fossil fuel combustion and land use

change in the 1980s has been reported at 7.1 gigaton/year (Schimel, et al., 1995). Thus, the total carbon emitted by Philippine forests in more than 450 years is equal to 58 percent of global carbon emissions in one year alone. Another estimate from 1850 to 1986 placed the total carbon emitted from deforestation at 117 gigaton (Houghton, et al., 1997). Of this amount, 2.5 percent were contributed by Philippine forests since the year 1900.

Carbon Stocks of Current Land Uses in the Philippines

There are six major land cover categories of forestlands in the Philippines: 1) protection forests (old-growth forests and other protected forests); 2) second-growth forests; 3) brushlands; 4) grasslands; 5) tree plantations; and 6) agroforestry farms. We have previously attempted to quantify the potential of these categories to store and sequester carbon (Lasco, 1998; Lasco and Pulhin, 1998).

More recently, we have revised these estimates based on initial data from our field studies in the country. However, these estimates were mainly based on values generated from other tropical countries, default values, or expert's judgments.

Since then, a new set of data on biomass, biomass accumulation and carbon content of Philippine forests has been obtained. We use these new data, to make a new estimate of the potential of these land cover types to store and sequester carbon.

For carbon content, the UN Intergovernmental Panel on Climate Change (IPCC) set the default value at 50 percent, but actual analysis of Philippine biomass showed a range of 43-45 percent (including woody material, leaves and understorey vegetation). For total aboveground biomass, data are now available for old-growth forests, second-growth forests, brushlands, grasslands, tree plantations, and agroforestry farms that were collected from various parts of the country. Biomass accumulation rates are also available for old-growth forests, second-growth forests, brushlands, tree plantations and agroforestry farms.

Protection forests (2.7 million hectares) comprise the remaining natural forests

which include old-growth dipterocarp forests, mossy forests, pine forests, mangroves, and sub-marginal forests. Logging has been totally banned in these forest types since 1992 because of their biodiversity and cultural values. Total carbon stocks in these forests are estimated at 345 million tons while carbon sequestration is at 1.6 million tons per year.

There is an estimated 2.7 million hectares of second-growth forests in the Philippines as of 1997. The policy of the government since 1992 has been to rely on these forests as the main source of wood. Logging in natural forests are allowed only in second-growth dipterocarp forests. We calculated that the Philippine second-growth production forests store 318 million tons carbon. This new estimate is higher than the previous estimates of 253 million tons carbon (Lasco, 1998) and 298 million tons carbon (Lasco and Pulhin, 1998). In terms of carbon sequestration, second-growth forests are can sequester 7.6 million tons carbon per year excluding understorey vegetation, soil and litter. This new estimate is about the same as the previous estimate of 8 million tons per year (Lasco 1998; Lasco and Pulhin 2000).

In 1997, there were 2.2 million hectares of brushland areas in the Philippines with less than 20 percent canopy cover. These are essentially remnants of tropical forests that were progressively degraded by excessive tree cutting. The main vegetation cover in these areas is relic trees, shrubs, and grasses. Given adequate protection, these areas are expected to regenerate back to mature tropical forests. It is estimated that these brushlands store 66 million tons carbon, which is lower than the earlier estimates of Lasco and Pulhin (1998; 2000), and sequester 9.5 million tons carbon per year, which is higher than the previous estimate of 6.4 teragram per carbon per year (Lasco and Pulhin, 1998).

The Philippines has 1.2 million hectares of grasslands resulting from deforestation, land cultivation, and degradation. The vegetative cover present in most degraded sites is the grass *Imperata cylindrica*, which persists largely as a result of a grass-fire-grass cycle. Total carbon storage of grassland areas is estimated to be 16 million tons carbon. This estimate is higher than the previous estimate of Lasco and Pulhin (1998; 2000). The rate of carbon sequestration is conservatively assumed to be zero because grasslands are regularly burned. Experiences in the Philippines and in other countries in Southeast Asia show that if protected, these grasslands will likely regenerate

back to tropical forests since the latter is the native vegetation of the area (Friday, et al., 1999; Samson, 1986). Although at present, grasslands do not contribute much to carbon sequestration, they have the potential to do so. If protected from fire and allowed to regenerate or planted to trees, these areas would be a carbon sink since a forest cover has a higher carbon density than grasslands.

The main government strategy to rehabilitate these degraded areas is through reforestation and tree plantation establishment. Typically, fast-growing species such as *Gmelina arborea*, *Acacia* spp., and *Eucalyptus* spp. are used. There are several Philippine-specific data available for commonly grown species. We calculated that the existing tree plantations in the Philippines store 33 million tons carbon and sequester 2.4 million tons carbon per year. This estimate confirms the previous estimate given by Lasco (1998).

It is estimated that there are 6.5 million hectares of agroforestry farms in the Philippines. This area includes both forest tree-based farms as well as coconut plantations (which are typically intercropped) and fruit orchards. There are data now available on the carbon storage of various agroforestry systems in the Philippines but only one source for carbon sequestration. Total carbon storage for agroforestry farms is estimated at 327 million tons carbon, while carbon sequestration is 17.5 million tons carbon per year.

Based on the above calculations, the total carbon in the biomass of all Philippine forestland cover types is equal to 1,107 gigaton. This new estimate is similar to our previous estimate (Lasco and Pulhin, 2000). Not included in these calculations are carbon contained in understorey vegetation, litter, and soil. If these comprise 25 percent of the total aboveground biomass (Brown, et al., 1996), then the total carbon in the forest ecosystem could reach about 1,384 million tons.

Annual carbon sequestration amounted to 40 million tons carbon per year. However, it is estimated that Philippine forests release 0.3 million tons carbon per year and 11.1 million tons carbon per year because of wood harvest and deforestation, respectively (Lasco, 1998). Thus, the net carbon sequestration is 28.6 million tons carbon per year. This is similar to our earlier estimate of 27.2 million tons carbon per year (Lasco and Pulhin, 1998) but

higher than another estimate of 19.6 teragram per carbon per year (Lasco and Pulhin, 2000). The main reason for the latter is that the carbon sequestration rate of brushlands has been updated to reflect actual data from the Philippines. The uncertainty associated with these estimates will decline as more and more country data accumulates.

EFFECT OF LAND USE CHANGE IN CARBON BUDGETS OF PHILIPPINE FOREST ECOSYSTEMS

Effect of logging on carbon budgets

Our recent studies show that Philippine natural forests contain 86-507 megagram per carbon (MgC) per hectare (Table 4-2). The IPCC Revised GHG Inventory Guidelines (IPCC, 1996) estimates that old-growth forests in the Philippines contain 370-520 megagram per carbon per hectare of aboveground biomass equivalent to 185-260 megagram per carbon per hectare at 50 percent carbon content.

Logging operation is primarily responsible for the conversion of primary forests. Destructive logging and subsequentagricultural conversion has vastly depleted natural forests and left millions of hectares of degraded lands in the

Table 4-2. Biomass and carbon density of natural forests in the Philippines.

Forest type	Biomass Density (Mg/ha)	Carbon density (MgC/ha)*
Old-growth forest	446	201
Mossy forest	419	189
Mangrove forest	409	184
Pine forest	191	86

Source: Lasco, et al., 1999 and Lasco, et al., 2000a.

In general, logging leads to a reduction of carbon stocks in the forest as biomass is reduced by the extraction of wood. Carbon is released upon the decomposition or burning of slash-and-litter. However, regenerating trees sequester carbon back to biomass over time. In general, the biomass and

carbon of tropical forests in Asia declined by 22-67 percent after logging (Table 4-3).

In the Philippines, we studied the carbon density of logged-over forest plots with varying ages after logging (Lasco, et al., 2001c). Right after logging, carbon density decline by about 50 percent of the pre-logging forest (198 MgC/ha). In Indonesia, estimates of carbon density of logged-over forests range from 38-75 percent of the original forest (Lasco, 2001).

As can be gleaned from above, logging is typically a very destructive practice. In Malaysia, extracting 8-15 trees (80 m^3; ca. 22 MgC/ha) damaged as many as 50 percent of the remaining trees (Putz and Pinard, 1993). Out of the initial 348 megagram per carbon per hectare, 95 megagram per carbon per hectare are transformed to necromass which eventually releases its carbon via decomposition. In the Philippines, for every tree cut greater than 75 cm diameter breast height, 1.5 and 2.6 trees are damaged in favorable and unfavorable conditions, respectively (Weidelt and Banaag, 1982).

However, numerous studies have shown that logging damage can be significantly reduced by directional felling and well planned skid trails (Putz and Pinard, 1993). These practices are collectively known as reduced impact logging (RIL). The effect of RIL on carbon conservation has been thoroughly investigated in a study conducted in Sabah, Malaysia as reported by Pinard and Putz (1997, 1996).

Table 4-3. Biomass and carbon density of tropical forests in Asia.

	Closed- broadleaf	Closed-conifer	Open forest
Undisturbed-productive	196.3 (98.2)	144.9 (72.5)	79.0 (39.5)
Logged	93.2 (46.6)	112.5 (56.3)	26.32 (13.16)
% Decline	53	22	67

Source: Brown and Lugo, 1984; *carbon in parenthesis.

Carbon budgets following conversion from forest to non-forest cover

Impact of Deforestation to Carbon Budgets

While deforestation is a major land use change in the Philippines, there are no studies that directly track the change in carbon budget through the deforestation process. However, there are studies that have quantified the carbon stocks in deforested lands, typically covered with grasslands or annual crops. We estimate that grasslands and croplands contain 3.1 to 13.1 megagram per carbon per hectare (Table 4-4).

Conversion to Tree Plantations and Perennial Crops

Natural forest areas, usually after commercial logging, can be converted to plantations of forest tree or perennial crops. This land use change is expected to reduce carbon stocks. There are no studies that directly measure carbon stock change as a result of land use change through time. However, by comparing the carbon stocks of the resulting land use with the carbon stocks of a natural forest, we can

have an idea of the magnitude of change. This kind of comparison is of course preliminary as the carbon stocks vary with age of the plantation and the site characteristics.

Table 4-4. Aboveground biomass (AGB) density of grasslands and annual crops in the Philippines.

Land cover	AGB Carbon density (Mg/ha)
Imperata sp.	8.5*
Sacharum sp.	13.1
Rice	3.1
Sugarcane	12.5
Banana	5.7**
Imperata sp.	1.7

* Lasco, et al., 1999

** Biomass from Lachica-Lustica, 1997; C content = 45% (Lasco and Pulhin, 2000)

In the Philippines, we estimate that tree plantations in various parts of the country have carbon stocks that are 7-51 percent lower than natural forests (Table 4-5). This is consistent with estimates from Indonesia that showed agroforestry and plantation farms with carbon stocks that are 4-66 percent lower than an undisturbed forest (Lasco, 2001).

Table 4-5. Carbon density of tree and agricultural plantations in the Philippines.

Category	Carbon density (Mg/ha)	% of Natural forest
Mahogany	264	51
Legumes	240	46
Dipterocarp	221	43
Acacia sp.	81	16
Teak	35	7
Natural forest	518	

Source: Lasco, et al., 2000a.

In Mindanao, tree plantations of fast growing species contain 3-4.5 percent of the carbon of a natural dipterocarp forest (Table 4-6). On the other hand, a mature coconut plantation in Leyte province contains 86 megagram per carbon per hectare in aboveground biomass (Lasco, et al., 1999) which is about 43 percent (259 MgC/ha) of a natural forest in the same area.

Table 4- 6. Carbon density of tree plantations in Mindanao, Philippines.

Species	Age (yr)	AGB Mg/ha)	C density MgC/ha	Dipterocarp forest (%)
Albizzia falcataria 1	4	69.50	31.28	26
A. falcataria 2	5	75.60	34.02	28
A. falcataria 3	7	96.40	43.38	36
	7	8.10	3.65	3
A. falcataria 4	9	108.20	48.69	41
	9	28.70	12.92	11
Gmelina arborea 1	7	85.70	38.57	32
G. arborea 2	9	87.40	39.33	33
G. arborea 3	9	120.70	54.32	45
Dipterocarp*		265.40	119.43	

* Harvested 20 years ago; Biomass data from Kawahara (1981); C content assumed to be 45% (Lasco and Pulhin, 2000).

Agroforestry systems have been widely promoted as an alternative technology to slash-and-burn farming. They involve planting of trees and perennials in conjunction with agricultural crops. Various forms of agroforestry exist in the Philippines (Lasco and Lasco, 1989). A *Leucaena leucocephala* fallow field in Cebu, Philippines has a mean carbon density of 16 megagram per carbon per hectare during its six-year cycle (Table 4-7). This is very low compared to natural forests in the country. A coconut-based multistorey system in Mt. Makiling has a carbon density in AGB of 39 megagram per carbon per hectare (Zamora, 1999) which is only about 15 percent of the carbon of adjacent natural forest.

Means in a column with the same letter are not significantly different using DMRT at 0.05.

Table 4-7. Carbon density and MAI of a *Leucaena leucocephala* fallow field in Cebu, Philippines.

Years under Fallow.	Mean Dry Wt. of aboveground biomass (t/ha)	% Leaves	Carbon in Biomass (t/ha)	Annual rate of carbon accumulation (t/ha/yr)
1	4.3 d	36.5	2.2	2.2
2	16.1 cd	13.8	8.1	5.9
3	17.6 cd	8.9	8.8	0.7
4	36.4 bc	7.4	18.2	9.4
5	53.8 ab	5.3	26.9	8.7
6	63.6 a	6.1	31.8	4.9
7	17.6 cd	8.9	8.8	0.7
Mean	32.0		16.0	5.3

Source: Lasco and Suson, 1999.

However, once tree and perennial crop plantations have been established, they begin to accumulate carbon. Commercial tree plantations in the Philippines of fast growing species sequestered carbon at the rate of 0.50-7.82 megagram per carbon per hectare per year (Table 4-8). The next section (5.0) also presents estimates of carbon density and rate of sequestration of reforestation species.

A coconut plantation was found to have about half the soil organic matter/carbon (SOC) density of a natural forest (111 MgC/ha vs. 191 MgC/ha) (Lasco, et al., 1999). SOC is also affected by the change in land use. Carbon in the soil is a significant pool. It has the longest residence time among organic carbon pools in the forest (Lugo and Brown, 1993). However, the exact effect of land use change on SOC is largely unknown in tropical forests especially the rates and direction of change.

Table 4-8. Mean annual increment (MAI) of biomass and carbon of tree plantations in Mindanao, Philippines.

Species	Age (yr)	Biomass MAI Mg/ha/yr	C MAI MgC/ha/yr
Albizzia falcataria 1	4	20.20	7.82
A. falcataria 2	5	11.20	6.80
A falcataria 3	7	8.40	6.20
	7	2.20	0.52
A. falcataria 4	9	5.30	5.41
	9	3.70	1.44
Gmelina arborea 1	7	11.30	5.51
G. arborea 2	9	10.50	4.37
G. arborea 3	9	9.60	6.04
Sweitenia macrophylla	16	19.60	7.33
Natural forest*	100	4.90	1.19

* Harvested 20 years ago; assumed to be 100 years old; Biomass data obtained by destructive sampling (Kawahara, et al., 1981).

Carbon budgets following reforestation/afforestation of degraded and denuded lands

The rapid loss of forests in the Philippines has left millions of hectares of denuded and degraded land areas (FMB, 1998). As discussed earlier, deforested lands have much lower carbon density than the forests they replace. More importantly, they have greatly impaired ecological functions and provide little economic benefits.

In response, the Philippines has launched massive reforestation programs andhas reforested more than 500,000 hectares in the 1990s (FMB, 1998). In addition, tree plantations are also being established at a faster rate, not only

to rehabilitate degraded lands, but also to meet the wood demand of the country. The Philippines has about 500,000 hectares of tree plantations, mostly of fast growing species (Lasco and Pulhin, 2000).

There are very limited reports in literature on carbon density of reforestation and afforestation areas. However, there is a large body of literature on the performance of species planted in reforestation and afforestation areas. Typically, diameter breast height and height are the main variable measured and reported. Through allometric equations, primarily from the FAO Handbook by Brown (1997), we attempted to estimate the biomass and carbon stocks and their rate of accumulation.

We calculated that a reforestation project in very degraded soil conditions using fast-growing exotic species have carbon stocks of 3.47-48.52 megagram per carbon per hectare 6-13 years after planting (Table 4-9). On the other hand, mean annual increment (MAI) of carbon was 0.30-3.73 megagram per carbon per hectar per year. These values are very low compared to other Philippine forests and tree plantations. This is due to thepoor site conditions in the area which is predominantly covered with *Imperata* and

Table 4-9. Biomass and C density and MAI of reforestation species in Nueva Ecija, Philippines.

Species	Age* (yr)	Ave dbh* (cm)	Biomass** Mg/ha	MAI Mg/ha/yr	C density Mg/ha	MAI Mg/ha/yr
Acacia auriculiformis 1	6	5.68	7.39	1.23	3.33	0.55
A. auriculiformis 2	6	6.46	9.97	1.66	4.49	0.75
A. auriculiformis 3	9	9.62	42.51	4.72	19.13	2.13
A. auriculiformis 4	9	8.71	32.00	3.56	14.40	1.60
A. auriculiformis 5	9	10.47	46.11	5.12	20.75	2.31
A. auriculiformis 6	9	8.73	39.73	4.41	17.88	1.99
Tectona grandis 1	13	5.50	8.70	0.67	3.92	0.30
T. grandis 2	13	7.36	22.30	1.72	10.04	0.77
Gmelina arborea 1	6	7.33	17.22	2.87	7.75	1.29
G. arborea 2	6	6.80	7.71	1.29	3.47	0.58
Pinus kesiya	13	12.53	107.83	8.29	48.52	3.73
P. kesiya + broadleaf spp.	13	10.10	83.24	6.40	37.46	2.88

* source: Sakurai, et al., 1994;

** Biomass/tree in kg = 21.297-6.953*dbh+0.74dbh^2; for broadleaf species and Biomass/tree= EXP-1.17+ 2.119*LN(dbh); for conifers (from Brown, 1997); %C in biomass = 45% (Lasco and Pulhin, 2000).

Sacharum spp. grasses (Sakurai, et al., 1994).

In another part of the Philippines with similar vegetative cover but higher rainfall, carbon MAI was 6.4-7.9 megagram per carbon per hectare (Table 4-10). The carbon accumulation in this site was higher than the previous site most likely because of the more abundant water supply. This study is also unique in that the biomass was determined directly by destructive sampling (Buante, 1997). In the same island, three fast-growing species have a carbon density and MAI of 8-88 megagram per carbon per hectare and 0.7-8.0 megagram per carbon per hectare per year, respectively (Table 4-11).

Table 4-10. Biomass and carbon density and MAI in Leyte, Philippines.

Species	Biomass (Mg/ha)	MAI Biomass	C density	C MAI
Acacia mangium	56.90	14.23	25.61	6.40
Gmelina arborea	70.20	17.55	31.59	7.90
A. auriculiformis	63.50	15.88	28.58	7.14

Biomass data from Buante (1997); % C in biomass assumed to be 45%;
Age of trees= 4 years

Table 4-11. Carbon density and MAI of reforestation species in Leyte, Philippines.

Species	Biomass (Mg/ha)	MAI Biomass (Mg/ha/yr)	C density (MgC/ha)	C MAI (MgC/ha/yr)
S. macrophylla				
1	22.62	2.06	10.18	0.93
2	19.90	1.81	8.96	0.81
3	8.52	0.77	3.83	0.35
4	17.01	1.55	7.66	0.70
A. mangium				
1	220.93	20.08	99.42	9.04
2	162.93	14.81	73.32	6.67
3	203.64	18.51	91.64	8.33
Mean	195.84	17.80	88.13	8.01
G. arborea				
1	165.09	10.32	74.29	4.64
2	117.01	7.31	52.65	3.29
3	89.92	5.62	40.46	2.53
Mean	124.01	7.75	55.80	3.49

Source: Lasco, et al., 1999.

A planting trial of species not commonly growing in the Philippines but with potential for reforestation was conducted in Iloilo province where a similar grass cover as the above sites exists (Lachica-Lustica, 1997). After 4 years, carbon density ranged from 0.30 to 70.11 megagram per carbon per hectare while carbon MAI was generally less than 10 megagram per carbon per hectare per year (Table 4-12).

Table 4-12. Biomass and C density and MAI in Iloilo province, Philippines.

Species	Mean dbh* (cm)	Biomass Mg/ha	MAI Biomass	C density	C MAI
Acacia neriifolia	17.53	87.13	21.78	39.21	9.80
A. holosericea	11.92	34.40	8.60	15.48	3.87
A. crassicarpa	18.91	155.79	38.95	70.11	17.53
A. aulacocarpa	12.99	56.36	14.09	25.36	6.34
L. diversifolia	3.28	0.66	0.16	0.30	0.07
Casuarina cuminghiana	3.76	3.21	0.80	1.44	0.36
C. equisitifolia	7.77	15.55	3.89	7.00	1.75
E. citrodora	12.14	52.41	13.10	23.58	5.90
E. cloeziana	11.61	48.27	12.07	21.72	5.43
E. pellita	10.36	33.99	8.50	15.30	3.82
E. tereticornis	11.76	49.87	12.47	22.44	5.61

* Lachica-Lustica (1997); age of trees= 4 years; biomass computed using the equation Biomass/tree in kg= 21.297-6.953*dbh+0.74dbh² for broadleaf species and for conifers Biomass/t ree= EXP-1.17+2.119*LN(dbh) (from Brown, 1997); %C in biomass= 45% (based on Lasco and Pulhin, 2000).

In contrast, an adjacent grassland area has only 1.68 megagram per carbon per hectare. For long-term carbon stocks after reforestation, mahogany and dipterocarp trees planted about 80 years ago are estimated to contain 126-286 megagram per carbon per hectare with an MAI of 1.57-3.57 megagram per carbon per hectare per year (Table 4-13). These density and MAI are lower than the above results because mahogany and dipterocarp trees are relatively slow growing.

Silvicultural treatments such as fertilization, weeding, and mycorrhizal inoculation increase the growth of trees and enhance the rate of carbon sequestration. In degraded areas in Surigao del Sur, Philippines, the inoculation of mycorhizae increased carbon density by 32-237 percent compared to uninoculated treatments (Table 4-14). In another area of the country, mycorrhizal inoculation increased carbon density and MAI by 43-169 percent (Table 4-15).

Table 4-13. Carbon density and MAI of reforestation areas 80 years after planting in Mt. Makiling, Philippines.

Species	Age* (yrs)	No.	Biomass**	Annual Rate	C density Mg/ha	MAI Mg/ha/yr
Sweitenia macrophylla 1	80	802	564.92	7.06	254.21	3.18
S. macrophylla 2	80	405	634.99	7.94	285.75	3.57
Parashorea malaanonan + Anisoptera thurifera	80	569	536.12	6.70	241.25	3.02
Parashorea malaanonan + Dipterocarpus grandiflorus	80	701	279.14	3.49	1,25.61	1.57

* age and dbh data (Sakurai et al., 1994);
** biomass computed: Biomass/tree in kg= EXP{-2.134+(2.53*LNdbh)} (Brown, 1997);
%C in biomass= 45% (based on Lasco and Pulhin, 2000).

Table 4-14. Effect of mycorhizal inoculation C density and MAI of tree plantations in Surigao del Sur, Philippines.

Species/ Treatment	Age (yrs)	Diameter* (cm)	Biomass Mg/ha	MAI Biomass	C density	C MAI
Pinus caribaea						
Uninoc	2	6.11	15.97	7.98	7.18	3.59
Inoc	2	9.17	37.74	18.87	16.98	8.49
		% Difference	136			
Eucalyptus deglupta						
Uninoc	2	4.15	5.76	2.88	2.59	1.30
Inoc	2	6.30	7.63	3.81	3.43	1.72
		% Difference	32			
Eucalyptus deglupta						
Uninoc	3	9.44	23.96	7.99	10.78	3.59
Inoc	3	14.26	80.69	26.90	36.31	12.10
		% Difference	237			

* Diameter data from dela Cruz (1999); No. of trees= 1111/ha; Allometric equation for P. caribaea: Y (kg)= exp{-1.170+2.119*ln(D)} range 2-52cm; for E. Deglupta: Y (kg)= Y (kg)= 21.297-6.953(D)+0.740(D²) (Brown, 1997)

Table 4-15. Effect of mycorhizal inoculation carbon density and MAI of tree plantations in Tarlac, Philippines.

Species/ Treatment	Age (yr)	Diameter (cm)	Biomass Mg/ha	MAI Biomass	C density (MgC/ha)	C MAI (MgC/ha/yr)
Acacia auriculiformis						
Uninoc	2	6	6.91	3.45	3.11	1.55
Inoc	2	7	9.87	4.94	4.44	2.22
		% Difference	43			
Casuarina equisitifolia						
Uninoc	2	2.7	2.83	1.41	1.27	0.64
Inoc	2	4.3	7.58	3.79	3.41	1.71
		% Difference	169			

Allometric equation for C. *equisitifolia*: Y (kg)= exp{-1.170+2.119*ln(D)} range 2-52cm; adj r2=0.98 (Brown, 1997);
Allometric equation for *A, auriculiformis*: Y (kg)= 21.297-6.953(D)+0.740(D^2) range 4-112cm; adj r2=0.92 (Brown, 1997).

PHILIPPINE FORESTS AND ENVIRONMENTAL SERVICES: CARBON CONSERVATION AND SEQUESTRATION

Increasingly, scientists and policy makers are beginning to realize the value of environmental services that forests andsequestration is one of the most important. Ideally, countries and local communities who provide these services should be rewarded by society. For carbon services, there are now opportunities by which this can be done. An example of this is through the Clean Development Mechanism (CDM) under the Kyoto Protocol of the UNFCCC.

In 1997, the Kyoto Protocol was drafted. It was the first international agreement that placed legally binding limits on GHG emissions from developed countries (UNFCCC, 1997). The Protocol provides for flexible mechanisms to meet carbon reduction obligations by developed countries. The most relevant to developing countries is the Clean Development Mechanism (CDM) contained in Article 12.

Essentially, the CDM allows Annex 1 (developed) countries to meet their carbon reduction quota via activities in developing countries (non-Annex 1

countries). At the same time, such projects are expected to promote sustainabledevelopment of developing countries. Two forestry project activities are allowed under the first commitment period: reforestation and afforestation.

The Philippines, with its wide areas of lands needing reforestation and afforestation stand to benefit in the CDM, should it decide to participate. There are anywhere from 2 to 9 million hectares of denuded and degraded upland areas that need immediate rehabilitation (Lasco and Pulhin, 2000). These areas are former tropical forests but are now mainly grasslands, brushlands, and cultivated farms. With the present rate or reforestation (less than 100,000 hectares per year), it will take more than 100 years to fully rehabilitate these areas. In addition, up to 19 million people are living in the uplands half of whom rely on some form of shifting cultivation. This situation has spawned numerous ecological and socio-economic problems: soil erosion, siltation of water bodies, flooding, extreme poverty, and unrest.

CARBON STOCKS MEASUREMENT PROTOCOL

SAMPLING DESIGN[1]

This section deals with the following questions:

- How is a project area divided into more or less homogenous areas (or strata)?
- What is the appropriate number of sampling plots in each stratum?
- How are sampling plots established for the various carbon pools in the forest?

Stratification of the Project Area

Stratification involves the division of the project area into more or less homogenous units (strata) to improve precision,facilitate fieldwork, and reduce sampling costs. It should be carried out considering uniformity directly related to the variable being measured, in this case, carbon pool. Each stratum can be defined by vegetation type, soil type, topography, and age class.

[1] This section adapted from MacDicken, 1997.

The number of strata is determined largely by the expert's judgment considering the prevailing conditions in the project site. As a general rule, the strata should be large enough to allow for adequate sample size within each

Determining the Number of Sample Plots Required

Ideally, permanent monitoring plots should be established for carbon sequestration projects. The number of sample plots required for each stratum is a function of the variability of the carbon stocks in that stratum and the level of precision desired. The more variable the carbon stocks, the more sampling plots are needed. Similarly, the higher the precision desired the more plots are required.

From the foregoing, it is necessary to have an idea of the variance (a measure of variability) for each stratum of the carbon stocks to be measured. This information can be obtained either through (a) previous studies of the type of project to be implemented in the area or, in its absence, (b) by making measurements in areas with existing activities similar to the project. For example, if a reforestation project has a lifespan of 10 years, then measuring carbon stocks in 10-15 plots of an existing 10-year old trees will suffice. This should be done for each stratum.

a. *Determining the number of plots based on precision levels.* Project management can determine beforehand the level of precision desired. The precision levels are expressed as % of the mean (e.g., 5%, 10%, 20%, etc).

The total number of plots required can be calculated using the following formula (MacDicken, 1997):

$$n= (t/A)^2 (\Sigma W_h S_h sqrtC_h) (\Sigma W_h S_h/sqrtC_h)$$

Where: n = sample size (plots required)

t = tabular value of students t

h = stratum number

L = number of strata

$W_h = W_h = N_h/N$

N_h = number of sample units in h
N = total number of sample units
S = stratum standard deviation
A = allowable error exp as units of the mean
Ch = cost of selecting a sample plot in h

The total number of plots can then be allocated among the stratum using the following formula:

$$n_h = nP_h$$

Where: n_h = number of sample plots for stratum h
N = total number of sample plots
$P_h = (W_hS_h/\text{sqrt}C_h)/ (\Sigma W_hS_h/\text{sqrt}C_h)$

b. *Allocation of plots based on fixed costs.* At other times, the project is constrained by the level of funding available for sampling. In such cases, the following formula can be employed in conjunction with the previous formulas:

$$V_c = n\Sigma\, C_hP_h \text{ or } n = V_c/\Sigma\, C_hP_h$$

Where: V_c = variable cost of sampling

Once the number of permanent plots have been determined, it is wise to add 10-20 percent more as an allowance for plots that may be destroyed during the project.

c. *Sample problem.* The following tables and figures show how a sample problem can be worked out using the formulas given.

Table 4-16. Basic information about a hypothetical project site.

Site Name	Remexio
Measured parameter	Tree biomass
Unit of measure	Mg= ton
Number of strata	4
No. of plots measured per stratum	10 to 15
Desired level of p	0.01
Allowable error (% of mean)	5%
Sampling budget for inventory ($)	5,000
Sample plot size (m^2)	200 (5m x 40m)

Table 4-17. Variable cost of establishing each permanent plot per stratum.

Sampling costs per strata	S1	S2	S3	S4
Ave sample plot est. cost	40	40	50	26
Ave initial measurement cost	40	40	45	20
Ave relocation and measurement cost	0	0	0	0
Estimated remeasurement cost	0	0	0	0
Estimated variable cost per plot	80	80	95	46

Table 4-18. Sample biomass data per plot from the hypothetical project site.

Plot No.	Strata No.			
	S1	S2	S3	S4
1	2.31	5.99	4.23	10.21
2	2.99	1.57	2.44	15.13
3	4.33	5.36	5.66	12.35
4	3.49	2.07	9.11	6.76
5	3.41	5.97	3.55	13.83
6	3.62	2.71	9.83	5.65
7	2.57	0.66	5.67	4.66
8	2.64	5.95	5.70	5.62
9	2.48	2.13	8.99	12.30
10	2.33	3.31	4.67	11.10
11	2.87	3.85		
12	2.64	2.47		
13	3.92	1.58		
14	3.55	1.82		
15	2.44	3.25		
No. of plots	15.00	15.00	10.00	10.00
Mean	3.0	3.20	6.00	9.80
Variance	0.40	3.21	6.35	14.40
CV (%)	13.30	98.85	106.14	147.53
Sd	0.64	1.79	2.52	3.79
Wt mean	5.10		+/- 1.57	
Total	2,337,196		725,483	

Table 4-19. Number of permanent sample plots required.

Stratum	Area (ha)	Cost/ plot	Based on fixed cost	Fixed precision level			
				5	10	20	30
S1	10,000	80	6	37	9	2	1
S2	150,000	80	18	104	26	6	3
S3	300,000	95	16	89	22	6	2
S4	2,500	46	34	193	48	12	5
Total	462,500		74	423	106	26	12
Total Cost			5,000	28,637.05	7,159.26	1,789.82	795.47

Fixed cost est error, % 12

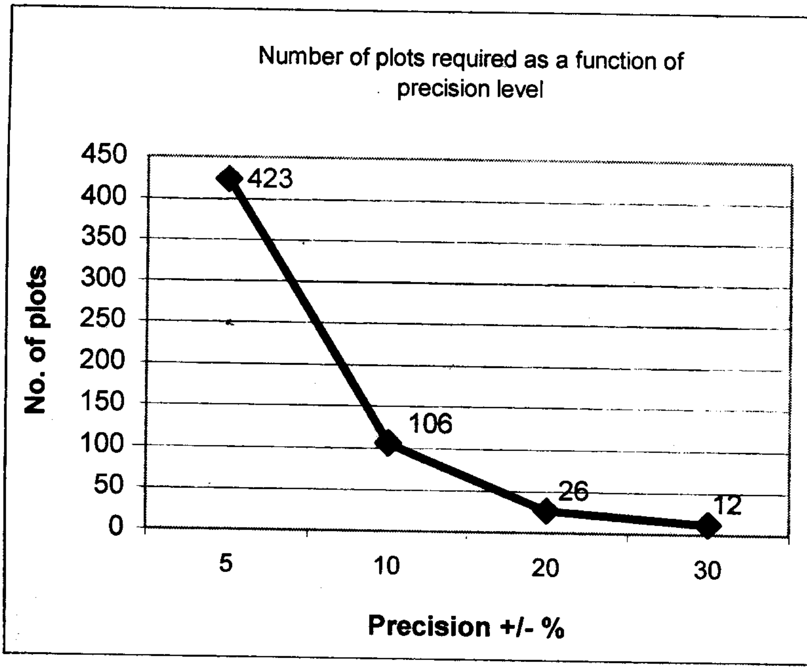


Fig. 4-7. Number of plots required based on sample problem.

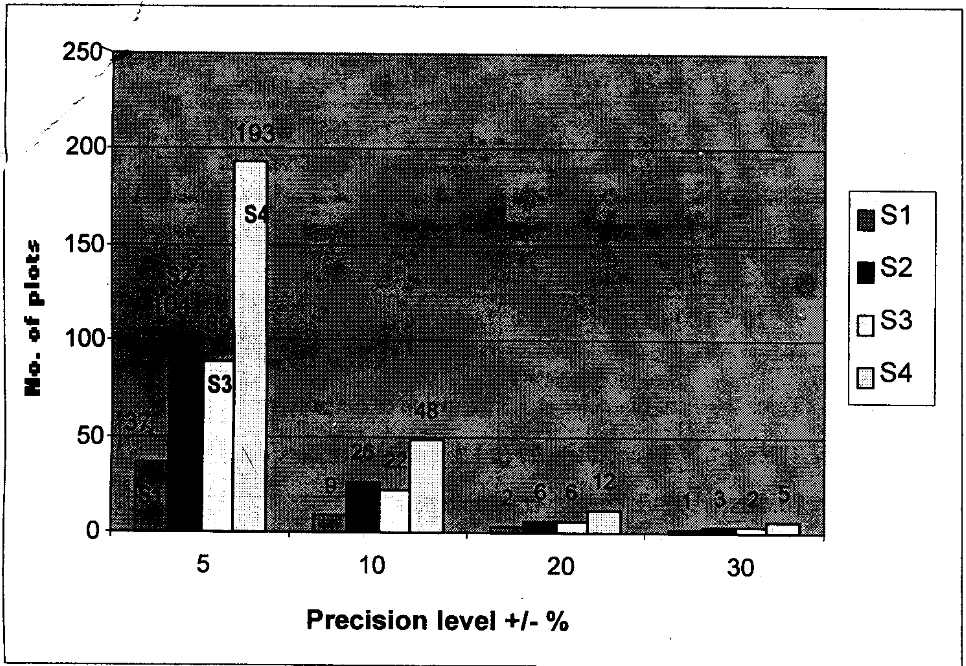


Fig. 4-8. Number of plots per stratum at different precision levels.

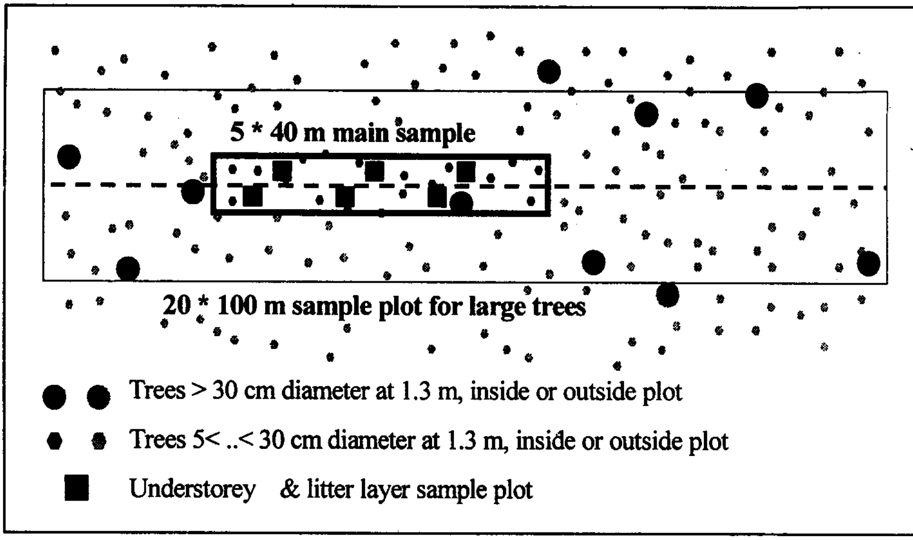
Sampling Plot Establishment

Following the Alternatives to Slash-and-Burn (ASB) protocol, a nested sampling design composed of rectangular plots will be used (Fig. 4-9):

- Trees with dbh >30cm: 20 x 100m ($2000m^2$)
- Trees with 5-30 cm dbh: 5 x 40m ($200m^2$)
- Understorey vegetation: 1 x 1m
- Litter: 0.5 x 0.5 m

Sample plots can be established randomly or systematically with a random start. It must be ensured that sample plots do not fall in areas with the densest or least vegetation.

A good map of the area is necessary to facilitate plot location and future monitoring and measurements. For field level use, a 1:10,000 scale is ideal



Source: Hairaih, et al., 2001.

Fig. 4-9. ASB nested sampling design.

while a 1:25,000 scale maybe more useful at the project management level. Plot locations must be clearly indicated in maps. It is recommended that handheld global positioning system (GPS) units be used for plot location in the field. The use of GIS software will facilitate mapping and subsequent spatial analysis of data.

FIELD MEASUREMENT OF CARBON STOCKS

This section addresses the question "How are carbon stocks measured in the following carbon pools: living trees and other woody perennials, understorey vegetation, necromass (litter, coarse woody debris), roots, and soils?" Table 4-20 summarizes the methods used in the assessment of aboveground carbon stocks in the project site.

Trees and other Woody Vegetation

Because of practical concerns, destructive sampling is not done on large trees. Instead, the biomass is estimated through the use of allometric equations typically relating tree diameter and/or height to biomass.

Table 4- 20. Aboveground carbon pool and methods used in carbon stock measurement.

Carbon Pool	Methods
1. Living trees with a stem diameter of • 30 cm in standard sample plot (20 x 100 m) • 5<...<30 cm in large area (5 x 40 m)	Non-destructive measurement of stem diameters, apply allometric equation on the basis of stem diameter
2. Understorey vegetation (including trees < 5 cm in diameter)	Destructive
3. Litter: • Coarse/standing litter • Fine litter • Surface roots	Destructive
4. Charcoal	Destructive
5. Ash	Destructive
6. Dead standing trees	Non-destructive, apply allometric or cylinder equation (for branched & unbranched remains, respectively)
7. Dead felled trees	Non-destructive, apply cylinder (or allometric) equation
8. Stump (trunk) remains in forest	Non-destructive, apply cylinder equation

Source: Hairiah, et al., 2001.

Field measurements

1. Tools, equipment, and materials needed:
   - Line or plastic straw;
   - Wooden sticks of 1.3 m length;
   - Measurement tape (for plots and for tree diamater);
   - Bolo and knife; and
   - Tree height measurement device (e.g. 'Hagameter' orclinometer).

2. In each 5 x 40m quadrat, sample all trees 5 to 30 cm dbh that are within 2.5 m of each side of the 40 m center line.

3. For each tree, the following information are obtained:
   - species name (local and preferably scientific name);
   - diameter at 1.3 m above the soil surface (dbh); and
   - height (optional in ASB).

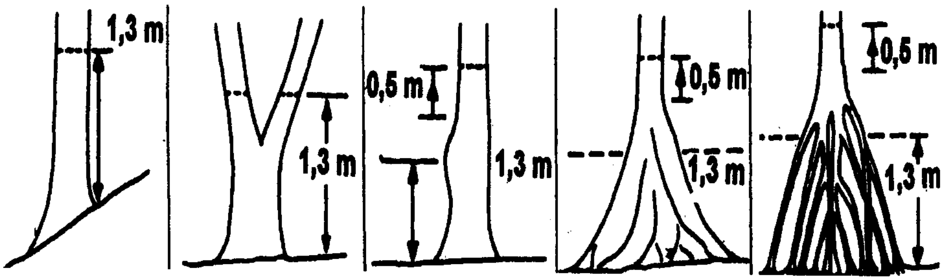


Fig. 4-10. Measurement of tree diameter at 1.3 m (breast height), or the equivalent on odd-shaped trees.

4. If trees branch below the measurement height, an equivalent diameter is defined as SQRT (ΣD^2) on the basis of all D values.

5. If trees > 30 cm diameter are present in the sampling plot, whether or not they are included in the transect, an additional larger sample of 20 m^2 x 100 m^2 is needed, where all trees with a diameter > 30 cm are sampled as above.

Use of allometric equations

The tree biomass (in kg/tree) should be calculated for each tree using an appropriate allometric equation (Table 4-21).Note that these equations were derived for natural forests, although they may also be applied for tree plantations in the absence of allometric equations for those species. Agroforestry species such as palms, bamboos, and lianas may need a different set of equations as enumerated in Table 4-22.

All tree biomass for each quadrat should be summed up to get the total biomass per sampling plot (expressed in megagrams per m^2; 1Mg= 1 metric ton).

Table 4-21. Allometric relations for estimating biomass from tree diameter (for D > 5 cm) and height.

Life zone (rainfall, mm/yr)	Equation*	Range, cm	No. of trees	R^2
Dry (<1500)	$W = 0.139\ D^{2.32}$ **	5-40	28	0.89
Moist (1500-4000)	$W = 0.118\ D^{2.53}$ ** $W = 0.049\ \rho\ D^2\ H$ *** $W = 0.11\ \rho\ D^{2+c}$ ^ $H = a\ D^c$ ^^	5-148	170	0.90
Wet (>4000)	$W = 0.037\ D^{1.89}\ H$ **	4-112	160	0.90

source: Hairiah, et al., 2001

* W = tree biomass, kg/tree; D = dbh, cm; H = height, m; ρ = wood density, g = cm^{-3}

** Brown, 1997; *** Brown et al., 1995; ^ with c (default 0.62) ; ^^ Ketterings et al., 2001

Table 4-22. Some special allometric relationships for components of agroforestry systems in Indonesia.

	D_range (cm)	Diameter – Dry Weight relationship		
		a, kg/tree	b,[ ]	r^2
Banana (Arifin, 2001)	7-27	0.03	2.13	0.99
Bamboo (Priyadarsini, 1998)	3-7	0.13	2.28	0.95
Coffee (pruned) (Arifin, 2001)	1-10	0.28	2.06	0.95
Paraserianthes falcataria (Sugiharto, 2001)	8-18	0.03	2.83	0.82
Pinus caribbea (Waterloo, 1995)	5-28	0.04	2.66	0.91

Source: Hairiah, et al., 2001.

Carbon content of biomass

In general, biomass consists of 50 percent carbon by dry weight (Houghton, et al., 1997) and in the absence of local data, this value can be used to convert biomass density to carbon density (in megagrams per carbon per ha). However, if project resources permit, carbon analysis of selected biomass parts could be done.

This will mean greater accuracy of results since the carbon content also varies as can be seen in wood carbon content in the Philippines (Fig. 4-11). A default value of 45 percent is recommended based on the data from neighboring countries such as the Philippines and Indonesia.

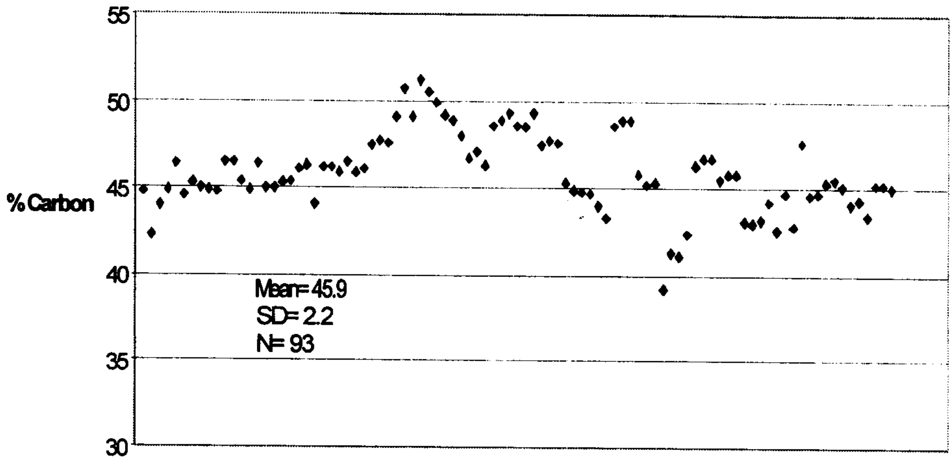


Fig. 4-11. Carbon content (%) of wood of tree species in the Philippines.

Understorey Vegetation

1. Tools and materials needed:

   - Quadrat of 1 x 1 m and 0.5 x 0.5 m (Fig. 4-7);
   - Knives and/or scissors;
   - Scales: one allowing weights up to 10 kg (with a precision of 10 g) for fresh samples and one with a 0.1 g precision for subsamples;
   - Marker pens, plastic, and paper bags;
   - Sieves with a 2 mm mesh size; and
   - Trays.

2. Locate sampling frames within the 40 x 5 m^2 transect, as shown in Fig. 4-12, placing it once (randomly) in each quarter of the length of the central rope.

3. Harvest all vegetation less than 5 cm dbh within the 1 x 1 m^2 quadrat. Weigh

the total fresh sample (g m^{-2}), mix well and immediately take and weigh a composite fresh sub sample (~300 g), for subsequent oven drying.

4. Dry the subsample at 80°C for conversion to dry weight and for analysis of C, N, and its quality (lignin and polyphenolic concentration which influence the decompo-sition rate of organic material); if oven capacity is limited, samples can be sun dried (in a ventilated plastic shelve system) and only sub-subsamples processed in the oven.

5. Calculate the total dry weight using the following formula:

$$\text{Total dry wt (kg m}^{-2}\text{)} = \frac{\text{Total fresh wt (kg) x Sub sample dry wt (g)}}{\text{Sub sample fresh wt (g) x Sample area (m}^2\text{)}}$$

6. Take the average of the four samples to record the biomass for the transect replicate.

Litter and Tree Necromass

Coarse litter

Coarse litter consists of any tree necromass < 5 cm diameter or < 50 cm length, undecomposed plant materials or crop residues, all unburned leaves and branches.

1. In the same quadrats for understorey vegetation (Fig. 4-12), collect all coarse litter in two randomly chosen and opposite 0.50 x 0.50 m quadrats (0.25 m^2). All undecomposed (green or brown) material is collected in a plastic bag.

2. To minimize contamination with mineral soil, the samples should be soaked and washed in water; the floating litter is collected, sun dried and weighed, the rest is sieved on a 2 mm mesh sieve and added to the fine litter fraction. Depending on the total amount, a sub sample can be taken at this stage for obtaining an 'oven-dry' correction (oven at 80°C). As alternative to the washing procedure, samples can also be ashed (at 650°C) to correct for mineral soil contamination.

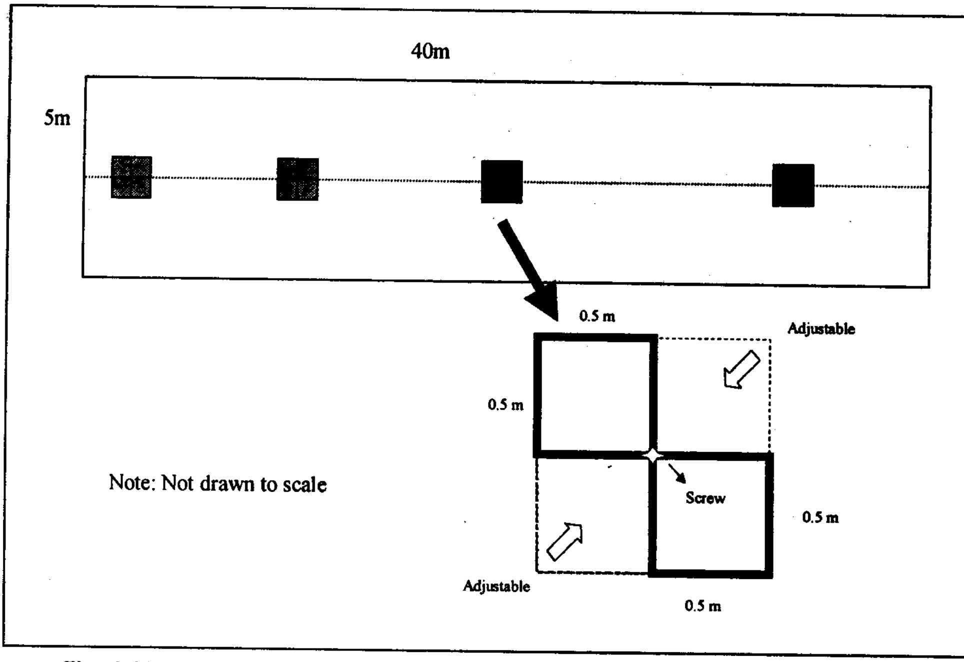


Fig. 4-12. Position of understorey sampling within a 40 x 5 m vegetation transect.

Fine litter and fine roots

1. After collecting the coarse litter, collect the 0-5 cm soil layer in the same quadrats (including all woody roots) and dry-sieve the roots and partly decomposed, dark litter. If time allows, the sieving can be done on-site, but it may be more convenient to collect bags of the topsoil and process elsewhere.

2. The litter (including dead roots) and (live) root material collected on the 2 mm sieve (by dry sieving) is washed and dried. The soil passing through this sieve is collected as 0-5 cm sample for soil organic carbon analysis (see below).

Tree necromass

1. Within the sampling plot, measure all trunks (unburned part), dead standing trees, dead trees on the ground and stumps that have a diameter of >5 cm and a length of >0.5 m.

2. Record their height (length) within the 5 m wide transect (Fig. 4-13) and diameter (halfway the length included), as well as the type of wood for estimating specific density.

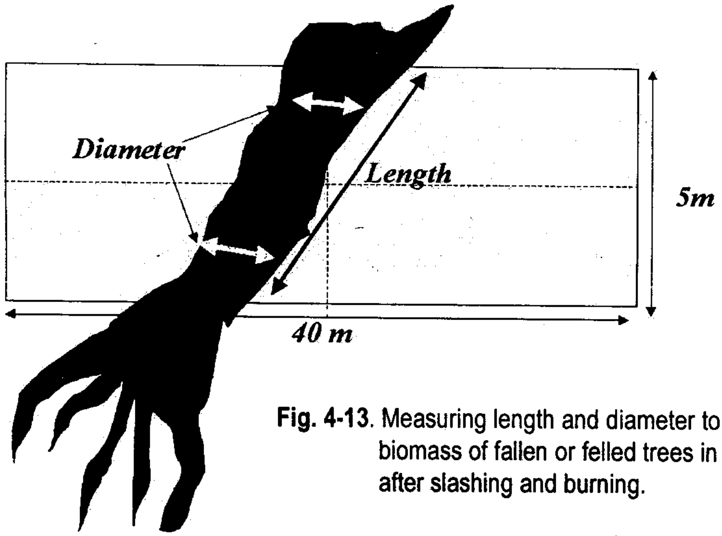


Fig. 4-13. Measuring length and diameter to estimate biomass of fallen or felled trees in a transect after slashing and burning.

3. For the **branched** structures an allometric equation is used just as for live trees. For **unbranched** cylindrical structures, an equation is based on cylinder volume:

$$\text{Biomass (kg)} = \pi D^2 h \rho / 40$$

Where: h = length (m),
D = tree diameter (cm)
ρ = specific gravity (g cm^{-3}) of wood.

The specific gravity (ρ) is estimated as 0.5 g cm^{-3} as default value, but can be around 0.8 g cm^{-3} for dense hardwoods, around 0.3 g cm^{-3} for very light species, and generally decreases during decomposition of dead wood lying onthe soil surface.

Roots

Measurement of total root biomass is both difficult, time consuming, and costly. In addition, methods have not been standardized. It is therefore

recommended that the following allometric equation based on aboveground biomass for tropical forests be used to estimate root biomass (Cairns, et al., 1997; n=151, r^2=0.84):

Root biomass = Exp[-1.0587+0.8836*LN(AGB)]

Where: Exp = e to the power of
LN = natural log
AGB= above ground biomass

Note that the resulting estimate includes the fine roots measured earlier. To avoid double counting, the fine roots estimate should not be included in the total carbon stocks for the whole quadrat.

Soils

Two types of soil samples can be distinguished:

- ***Disturbed soil*** samples for chemical analysis (where the results will be expressed per unit dry weight of soil); the samples are normally 'composites' obtained by mixing small amounts of soil from different sub samples.

- ***Undisturbed soil*** samples for physical analysis, especially the 'bulk density' (specific gravity) of the soil which is essential to convert the soil dry weights into soil volume.

Soils for chemical analysis

The same sampling quadrats used for fine litter sampling will be used for soil sampling.

1. After removing the 0-5 cm (usually organic) layer, take soil samples of the5-10 cm, 10-20 cm, and 20-30 cm soil depth. Approximately, 1 kg of fresh soil is sufficient, combining soil from three patches within the 0.5 x 0.5 m^2 sample grid. Twenty-four sub samples per 5 x 40 m transect per layer.

2. Soil samples from the same depth taken in the replicate sampling grids within a single transect can be combined directly in the field, or subsequently mixed in the sample processing site.

3. Mix the composite sample thoroughly, and divide into three bags: 0.5 kg for chemical analysis, 1 kg of fresh soil for SOM fractionation (if to be performed) and another 0.5 kg of soil for archiving; the remainder can be discarded.

4. Air dry the soil of all three sub samples by placing them in a shallow tray in a well ventilated, dust and wind free area. Break up any clay clods, and crush the soil lumps so that gravel, roots, and large organic residues can be removed.

5. Sieve the soil samples intended for chemical analysis through a 2 mm sieve, and grind them in a mortar in order to pass through a 60 mesh screen.

6. Write clear labels for each sample using a waterproof marker pen of each sample and wrap into a second plastic bag to prevent it from physical damage during transportation. Send it to laboratory for chemical analysis.

Soils samples for bulk density analysis

1. Equipment and materials needed:

   - Ring samples (stainless steel) with a sharp edge and of known volume and 100-200 cm^3, for example 5 cm diameter and height;
   - External ring to push ring samples gently into the soil;
   - Soil knife to remove the ring and any excess soil adhering to it; and
   - Plastic bags, rubber bands, and marker pens.

2. Choose a sampling spot close to the sample sites for destructive samples, butavoid any place with possible soil compaction due to other sampling activities.

3. Remove the coarse litter layer and insert the first ring gently directly from the soil surface, to sample the 0-5 cm depth layer; if the sample could not be inserted smoothly (e.g., due to woody roots or stones), try again nearby.

4. Excavate the soil from around the ring and cut the soil beneath the ring bottom.

5. Remove excess soil from above the ring using a knife: first remove excess soil on top of the sample, then place a cover on top of the ring and turn it upside down to remove soil adhering to the ring and cut a smooth surface at the bottom of the ring.

6. Either transport the cleaned ring to the laboratory, or remove all soil from the ring to a plastic bag and close it immediately.

7. On a nearby site, remove the top 5 cm of soil and insert a ring for sampling the 5-10 cm depth layer in a similar way. Repeat for the 10-20 cm and 20-30 cm depth layer, taking samples around 15 cm and 25 cm depth.

8. One set of ring samples per sample quadrant will give eight samples.

9. Weigh the samples fresh (W_1), dry at 105°C for 2 days, and weigh again (W_2).

10. Calculate the bulk density using the following formula:

    Bulk density = W_2/V (g cm^{-3})

    Volumetric soil water content (Theta) = $(W_1 - W_2)/V$ (cm^3 cm^{-3})

Forms for field data collection

Sheet 1

CARBON STOCK – <u>nondestructive</u> measurements
Site number ___________
Land Use Type: ___________
Location (GPS): _________ E, _________ S
Sample taken by: ___________
Farmer name: ____________________
Date: ___________
Sample area: .5 * 40 .m² ... 20 * 100 m²

Live tree (LT), Dead standing tree (DST), Dead, felled tree (DFT), Big tree (BT = tree diameter > 30 cm, in large sampling area), Estimated wood density: High, Medium, Low (0.8, 0.5, 0.3 g cm^{-3})

No	Type	Branched? Y_or_N	Tree diameter, cm	Tree height (h) or length (m)	Wood density ρ, e.g., H(igh), M(edium) or L(ow)	Estimated Biomass DW, kg/tree		
						Cylinder ($\pi/40$) $\rho h D^2$	For branched trees: 0.092$D^{2.60}$ (Brown, 1997)	0.11 $\rho D^{2.62}$ (Ketterings 2001)
1	LT	Y						
2	DST	N						
3								
4								
5								
6								
7								
8								
9								
10								
Total per category: kg / sample area LT DST DFT BG								

Sheet 2

CARBON STOCK – destructive samples
Site number ___________
Land Use Type: ___________
Location (GPS): _________ **E,** _________ **S**
Sample taken by: ___________
Farmer name: ____________________
Date: ___________
Sample area: ...1.... m²

W = Fresh weight; DW = Dry weight; S = Sub sample; Biom = Green biomass Leaf (L), Stem (S), Tuber (T); CLit = Coarse litter; FLit = Fine litter

No	Type	FW (kg)	SFW (g)	SDW (g)	Tot DW = FW * SDW/(SFW*area) (kg m^{-2})	Biomass DW = 10* TotDW (Mg ha^{-1})
1	Biom (L)	...				
1	Biom (S)					
1	CLit					
1	FLit					
2	Biom					
2	....	....	....			
..						

Sheet 3

ESTIMATION OF TOTAL C-STOCK, kg/sample area = destructive plant sampling + nondestructive sampling.
Two table calculation should be prepared as follows:

LUS	Tree* Mg ha^{-1}	DW Under-storey Mg ha^{-1}	DW Necromass Mg ha^{-1}	DW Root** Mg ha^{-1}	Total DW, Mg ha^{-1} 1+2+3+4	Total C, %	Total C-stock Tot DW * Tot C
	1	2	3	4	5	6	7
1						Est. 40-45	
2							
3							
4							
5							
etc							

*= estimated tree biomass using an allometric equation.
** = Root dry weight in soil layer 0-5 cm only.

Table (2)...

LUS	Soil weight 0-5 cm Mg ha-1	Tot. C, 0-5 cm %	Soil weight 5-15 cm Mg ha-1	Tot. C, 0-5 cm %	Total Soil C-stock 0-15 cm Mg ha-1	Total C stock Mg ha-1
	8	9	10	11	12	13 = 7 + 12
1					= (8x9) + (10+11)	
2						
3						
Etc						

ANNEX Table

Table A-1. IPCC default values for national GHG inventory.

Forest Type		Annual Increment in Biomass (Mg/ha/yr)	
Tropical tree plantations	*Acacia spp.*	15.0	
	Eucalyptus spp.	14.5	
	Tectona grandis	8.0	
	Pinus spp.	11.5	
	Pinus caribaea	10.0	
	Mixed hardwoods	6.8	
	Mixed fast-growing hardwoods	12.5	
	Mixed softwoods	14.5	
Natural regeneration of forests (Insular Asia)		≤ 20 yrs	≥ 20 yrs
	Wet	3.4	
	Moist with short dry season	11	3
	Moist with long dry season	No data	No data
	Dry	Little to none	Little to none
	Montane moist	12	3
	Montane dry	No data	No data
Natural forests (Insular Asia)		**Total aboveground biomass (Mg/ha)**	
	Wet	275	
	Moist with short dry season	175	
	Moist with long dry season	No data	
	Dry	Little to none exist	
	Montane moist	255	
	Montane dry	None exist	

SUMMARY AND CONCLUSION

This chapter is composed of three major parts. The first part provides an overview of climate change and its importance. The second part discusses the role of the Philippine uplands and forest ecosystems in climate change. The effect of various land uses on carbon budgets is also discussed. The third part presents a method for measuring carbon in forests and other ecosystems. This includes sampling designs and field measurements of above ground biomass, below ground biomass, necromass, and soil carbon.

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CHAPTER V

LAND USE CHOICES AND ENVIRONMENTAL SERVICES: TRADE-OFF AND POLICY ASPECTS

Virgilio T. Villancio

OBJECTIVES

After studying this chapter, the reader should be able to:

1. describe the land use situation in the country;
2. enumerate available land use choices and environmental services;
3. discuss the natural resources management system in the Philippines within the vantage point of land use and determine local benefits and impacts;
4. compare trade-off indicators for decision-making; and
5. describe policy implication at various levels – household, community, landscape, national, and global.

INTRODUCTION

The pressure on land to produce for the benefit of man has steadily increased with the population despite efforts to minimize both. Correspondingly, consumption demand has increased both in quantity and quality, thus the need for higher production putting pressure on natural resources to the extent of degrading it and reducing its productive capacity.

The quality and management of our land resources may be an increasing concern, but the prevailing poverty and social problems, particularly in the uplands are of equal importance.

The sustainability of agriculture in the lowlands is heavily dependent on the management of the uplands. Unsustainable practices in the uplands may result

in reduction of forest cover, soil erosion, and loss of biodiversity thus undermining its watershed functions and other environmental services. Water, being a major productivity determinant in agriculture, is becoming scarce. The degradation of watersheds has reduced water storage and flow potentials while soil erosion from unprotected uplands has silted irrigation dams. Even fully irrigated areas experience drought during the dry season.

Migration is no longer just an urban phenomenon. It has increased at alarming rates in the uplands. The influx of migrants to the uplands threatens the remaining natural virgin forest (only about 800,000 hectares remaining as of 2003). Illegal logging is still rampant among forest residuals and regeneration even with the existing log ban. The common reason for defying the log ban and other natural resources protection policies is poverty. People in the uplands have no other means of earning a living.

Recognizing this dilemma, man has devised ways to survive. There are available land use management practices that can be used to provide for the needs of the people without jeopardizing its ability to provide for its ecological function and environmental services. Man is given an option to choose given its trade-off and various considerations. Scott (1979) emphasized the role of the *kaingineros* (swidden farmers) in soil conservation,

> "... the Philippine kainginero has his own culture, socio-economic constraints, and will power. He is, or strives to be, his own master and barring compulsory resettlement, it is he who will eventually decide if erosion is to continue unabated or be controlled."

Scott argued that vital to soil erosion abatement is the development of cropping systems and agroforestry techniques that are not only socially and economically acceptable but would reduce the loss of valuable top soil. These views were given when the loss of biodiversity and climate change was not yet in the mainstream of development discourse. However, the observation echoes the important role man has to play in his land use decision and how it would affect the sustainability of society.

The analysis of land use choices and trade-offs would need to look not just at the direct effects to farm households but at the environmental services as well. This paper will briefly look at the natural resources management system in the Philippines within the vantagepoint of land use (Fig. 5-1) and then

focus on determining local benefits and impacts. The benefits and impacts are classified into those related to the socioeconomic, productivity, watershed, biodiversity, and carbon stock function of various land uses. Productivity would include the satisfaction of farm households and society's need for food security, profit, and income. These benefits are not necessarily exclusive but are interrelated, thus emphasis on one may have an impact on the attainment of the other. These trade-off indicators are then compared for decision-makings which are done at various levels – household, community, landscape, national, and global. Policy implications of various land use decisions are then digested from the presentation of these various decision determinants.

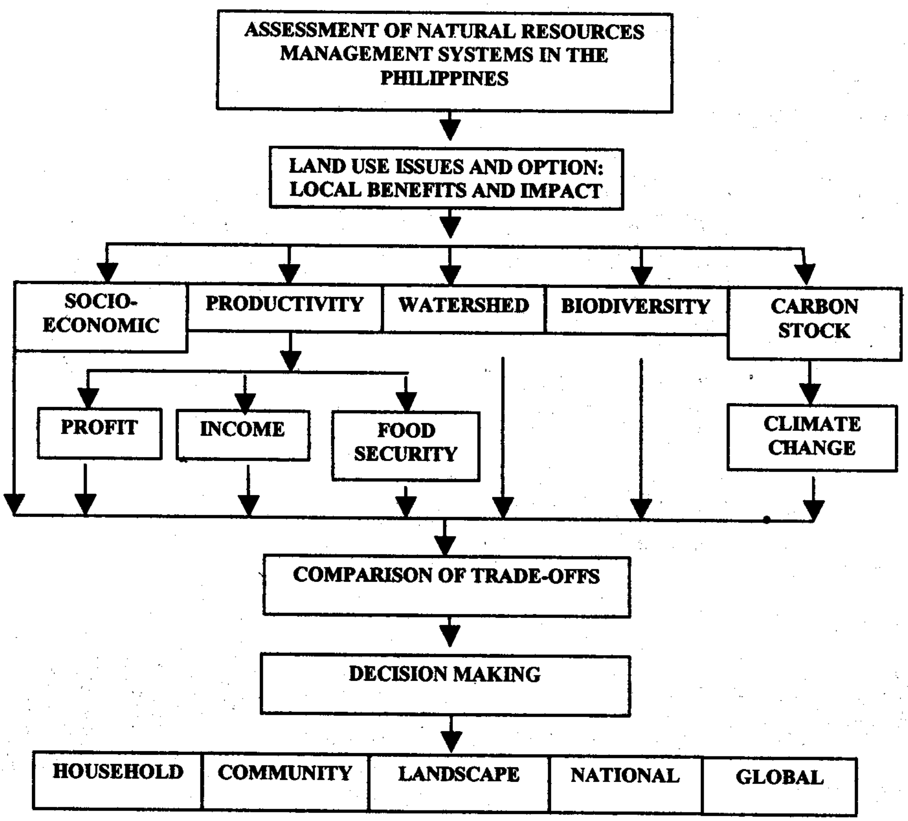

Fig. 5-1. Structural framework for the analysis of land use change benefits and trade-offs.

LAND USE CHANGE AND CURRENT ISSUES

Land use options are situated within an environment where men continually put pressure on the natural ecosystem to provide for their needs. Men modify the ecosystem to produce goods and services (to include amenities) either for their own use or for the use of others. The market economy, where consumptive behavior prevails, puts more pressure on producing those goods and services for the market at the right price. Because there are more demands to satisfy, more areas covered by natural ecosystems are converted to agriculture. Besides interventions in the ecosystem, mas has established institutions and set rules comprising a social system that further dictates into how the natural system will be explored (or exploited) and managed. With this, various land uses arose as the needs of man changed from hunting and gathering to sedentary and commercial agriculture. In the pursuit for satisfaction of human wants, the following issues and concerns has emerged:

a. *Deforestation.* A total of 11.5 million hectares in the Philippines are considered forestlands (Vergara, 1995). However, recent estimates (2003) show that there are only about 800,000 hectares of natural forests and 5.7 million hectares of residual forests. About 9 million hectares is now occupied by almost 20 million upland farmers. Deforestation has been attributed to commercial logging, shifting cultivation, and commercial agriculture.

b. *Soil erosion.* Soil erosion remains to be a major concern in land use. Cabrido (1984) cited that about 9 of the 13 million hectares of alienable and disposable lands are eroded with 13 provinces having more than half of their areas as such. This includes Batangas, Cebu, Ilocos Sur, La Union, Batanes, Bohol, Masbate, Abra, Iloilo, Cavite, Rizal, Capiz, and Marinduque. With the increasing rate of soil erosion, it would be valid to assume that this condition has now affected even wider areas.

   The causes of soil erosion are usually viewed in the technical and ecological context. However, it also has political and socioeconomic aspects (Cabrido, 1984).

   Among the ecological factors contributing to soil erosion are loss of

vegetative cover, heavy rainfall intensities, steep slopes, and structural soil characteristics. Soil erosion results to loss of topsoil leading to loss of fertility, sedimentation of water bodies, alteration of landforms and terrain, and even changes in microclimate.

The extent of soil loss varies with land use. Citing various literature, Nelson (1994) argued that the undisturbed forest is estimated to have as low as one-half ton per hectare while newly cleared area for shifting cultivation may have as high as 400 metric tons/hectare/year.

Barbier and Bishop (1995) noted that the economic factors influencing farmers' decisions on whether to conserve or degrade the soil are:

1. the value the farmers attach to future income than to the present income, which may reflect the farmer's attitude to risk and uncertainty, access to credit, and off-farm income;
2. the cost of current soil conservation to the farmer, which may reflect the availability of labor, purchased inputs, and credit for conservation efforts;
3. the relative input and output prices which determine the current profitability of erosive vs. less erosive cropping systems; and
4. the future return of the farming systems, as affected by technological improvements, and by the impact of current cultivation techniques and crops on soil fertility and future yields.

c. *Poverty.* The migration of farmers to the uplands is motivated by the need to survive. Farmers have no more land to till in the lowlands. Hence, they have to look for other areas to till which can only be found in less productive sloping lands. However, the use of lowland technologies without due regard to soil conservation, will result in land degradation and low soil fertility causing low productivity. This then results in low income and poverty of upland farmers.

d. *Population pressure*. There are available policies restricting the exploitation of our natural resources particularly in forestlands. However, people continued to migrate to the uplands. Mining activities at any scale were not regulated, mangroves became overexploited,

pasturelands leased cheaply, and logging concessions harvested timber without replanting trees. Limiting access to these areas will be difficult to implement without political will and participation by the stakeholders themselves.

Furthermore, the lack of land motivated lowland families to migrate to the uplands in search for land to till. The open-access nature of the uplands made it difficult to regulate the intrusion of lowland agriculture. Thus more forest areas were opened and cultivated.

Source: Godilano, 2004

characterized by steep slopes, less land cover, loss soil texture, and high rainfall.

Fig. 5-2. Aftermath of landslides in critical areas.

LAND USE DECISION-MAKING

Decisions on land use choices are made at various levels - household, community, landscape, local, and global. At the farm household level, every member participates in resource allocation decisions. In the same manner, different involved in decision-making.

No matter which level, decisions have to be made and there are general factors that need to be considered. These factors include the biophysical,

institutional, socioeconomic, cultural, and policy circumstances (Fig. 5-1). Biophysical factors include landforms, soil characteristics, rainfall, climate, elevation, access to roads, physical facilities available as well as other infrastructure. Socioeconomic circumstances may include demographic profiles, land tenure, education, health, and nutrition. Cultural circumstances may include religion, beliefs, traditions, and other parts of culture which may have positive or negative effects on land use. Institutional and policy circumstances may be related to administration, credit, market, control, and other regulatory provisions.

These circumstances are then matched with whatever resources are available or can be made available which can be allocated to particular land use option to satisfy the objective of the farm household (or whatever level). Resources are classified as natural, human, financial, and economic resources. Natural resources may be non-renewable like land or renewable resources like forest, fisheries, and wildlife. Economic resources include land, labor, capital, and management. Social capital may be included as a resource in the same manner that human resources are given importance. Objectives may include food security, income, asset accumulation, resource conservation, social security, poverty alleviation, etc.

Land use decisions are not just the responsibility of the farmers but policy makers and other stakeholders as well. The process of decision-making has to be made as an integral part of reconciling private gains and societal welfare and will involve the harmonization of the conflict of subsistence, economics, and the environment. These decisions also involve spatial, temporal, and intergenerational dimensions interwoven with complex social, cultural, economic, political, and environmental issues.

The spatial dimension looks at the appropriate balance among the land uses to satisfy the objectives of allocating available resources — food security, income, asset accumulation, resource conservation, social security, or ecological balance. Although it is very difficult to determine the optimum mix of land uses for forest, agriculture, industries, and other land uses, decision has to be made that will estimate the desired outcome. There were arguments that at least 45% of our land area must be kept under forests. What type of forest would that be? Where will those forests be? How are those determined?

This would also reflect the hierarchy where land use decisions have to be made — plot, farm, community, municipality, province, landscape, regional and national level.

The temporal aspect of land use decision also has some bearing on the intergenerational dimension. Anything you do today will have impact on the future. Thus, the decision to plant trees today will not alleviate poverty in the near future except for the direct payments that will be made on those who may be hired to plant trees. The economic yield of the tree has to come after 3 years if used for fuel wood, 5 years if for fruits, and 10-15 years if for timber. Nonetheless, during its growing period, it serves some ecological functions, which unfortunately are difficult to give financial and economic value.

Citing Haughton and Hunter (1994), Alcantara and Ilao (1999) enumerated the following principles and guidelines in land use decisions especially for the sloping lands:

1. Principles of intergenerational equity – must consider the the effects of current land use decisions on the ability of future generations to meet their needs and aspirations.

2. Principles of social justice – where land use affects the distribution of resources, there should be wider participation among various stakeholders. Decisions are made without taking the opportunities of others to meet their basic needs and aspirations e.g., food, shelter, energy, security, and clean environment.

3. Principles of transboundary responsibility – where land use decisions has effects on the landscape of the global environment, effort is made to protect, conserve, or minimize disruption in the natural processes and ecosystems functions.

Sustainable land use is not synonymous to sustainable agriculture as this would involve a wide range of spatial and temporal aspect in the whole landscape. Among other things, these include watershed, forest, streams, and biodiversity, which have its own sustainability features. Such features are not necessarily

exclusive but interlinked and inclusive since the sustainability of one depends on the sustainability of the other. Sustainable agriculture greatly depends on how watersheds are sustainably managed. In the same manner, the sustainability of the watersheds greatly depends on how agriculture is able to buffer the intrusion of protected areas. The different determinants of sustainability (Table 5-1) at various levels maybe different but it could be shown that the lower level of the hierarchy is nested to the next higher level.

Table 5-1. Typical determinants and characteristics of sustainability by levels of assessment.

LEVELS OF ANALYSIS	TYPICAL CHARACTERSISTICS OF SUSTAINABILITY	TYPICAL DETERMINANTS
Field/ production unit	Productive crops and animals; conservation of soil and water; low levels of crop pests and diseases	Soil and water management; biological control of pests; use of organic manure, fertilizers, pesticides, crop varieties and animal breeds.
Farm	Awareness of farmers; economic and social needs satisfied; viable production systems	Access to knowledge, external inputs, and markets.
Country	Public awareness; sound development of agroecological potential; conservation of resources	Policies for agricultural development; population pressure; agricultural education, research and extension
Region/ continent/ world	Quality of natural environment; human welfare and equity mechanisms; international agricultural research and development	Control of pollution; climatic stability; terms of trade; distribution

Source: Dumanski, et al. (1991) as cited by Maglinao, 1999.

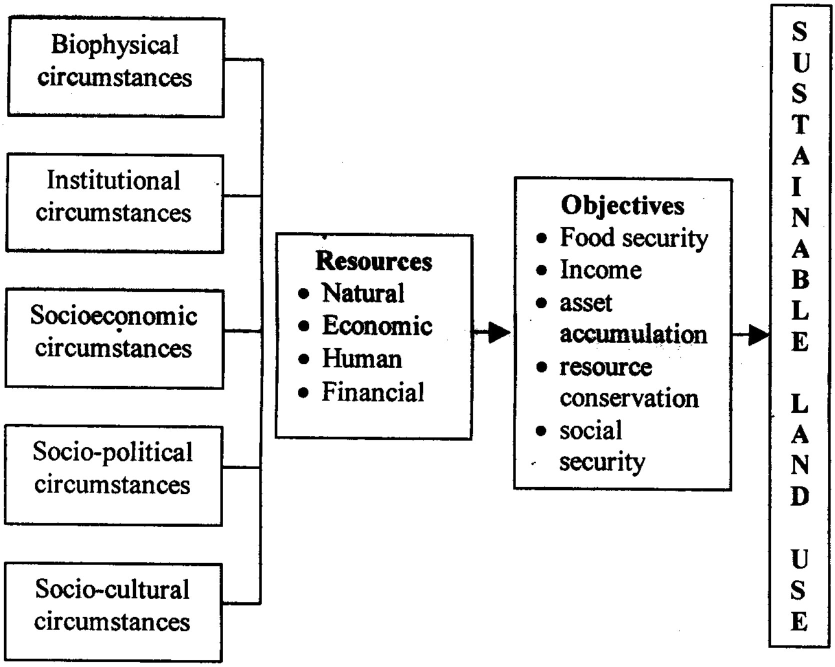

Fig. 5-3. Conceptual framework of land use decision-making.

LAND USE CHANGE TRADE-OFF

The process of analyzing trade-off in land use change can be done with the following series of steps - from the inventory of land use alternatives to deciding appropriate option.

Inventory of Land Use Alternatives. This will involve the identification of existing and alternative land uses. Each of these land uses is then described as to its basic characteristics. These characteristics may include its biophysical components,productivity, profitability, environmental aspect, and other information associated with the cost, benefits, and services being provided. Among the land use system considered include the following:

- Forestry which include both the natural forest and man-made forest or plantation forest;

- Agriculture to include monocropping, multiple cropping, animal production, and other domestication enterprise;
- Agroforestry that combines trees, crops, and animals which include among others pasture (grasslands), shifting cultivation, agri-silviculture, silvipasture, agri-silvipasture, alley cropping, multistorey cropping, and other systems;
- Perennial and semi-perennial plantation crops production, which include among others monocropping of coconut, palm oil, rubber, fruit orchard, sugarcane, pineapple, and banana.
- Annual crop production which include among others the monocropping of rice, corn, legumes, and vegetables.

Stakeholder Analysis. Stakeholder analysis is the identification of key stakeholders in the management of natural resources. It is an assessment of their interests and motives, and how these would affect land use viability and sustainability. This answer the basic questions who are the stakeholders and how do they influence land use decisions, its effect and impact. Stakeholder analysis is conducted to improve the effectiveness of decisions (policies, projects, programs or for this case, land use) by considering stakeholders' interests, identifying and dealing with conflicts, and considering the potential for consensus. In case of land use decisions, assessment of the interests of various stakeholders and impacts of actions has to be done considering the trade-offs between varying goals and objectives.

Stakeholder analysis is particularly relevant to land use problems for a number of reasons:

- Land use impacts cut across social, economic, and political units involving different stakeholders, and frequently associated with externalities wherein costs are borne by stakeholders other than the decision-maker.
- In areas where there is open access, due to its common property attributes, there are multiple users with different motives that need to be reconciled and conflicting uses that need to be prioritized; and
- The spatial, temporal, and sectoral trade-offs with respect to land uses need to be determined.

There are several concepts and procedures followed when doingstakeholder analysis. At the project level, several steps identified were (ODA, 1995):

- draw up a "stakeholders table";
- assess each stakeholders' importance and relative power/influence to the success of the project; and
- identify risks and assumptions which will affect project design and success.

On the other hand, proponents of the stakeholders power analysis recommended a six-step process:

1. Develop purpose and procedures of analysis as well as initial understanding of the system;
2. Identify key stakeholders;
3. Investigate stakeholders' interests, characteristics, and circumstances;
4. Identify patterns and contexts of interaction between stakeholders;
5. Assess stakeholders' power and potential roles; and
6. Assess options and use the findings to make progress.

Stakeholder or stakeholder power analysis, is particularly useful to assist in decision-making situations where there are competing interests, limited resources, and needs must be appropriately balanced among stakeholders. This can also be used in evaluating existing policies and institutions, as well as possible land use scenarios. This determines whose problems are addressed, who gains and loses, who have the power and influence in making the decisions and making the gains, and how to make the relationships among and between stakeholders to be more beneficial. The analysis should be able to identify strategies to avoid negative outcomes and enhance positive ones.

Who are the stakeholders? Stakeholders refer to individuals, organizations, and institutions that depend or have claims onthe benefits derived from the resources. In case of land use planning and management, they may include farmers, households, consumers, development/extension agents, researchers, educators, policy makers, peoples' organizations, and even donors. Each of the stakeholders has their own motives, objectives, interests and strategies related to the use of the resource (Table 5-1).

Primary stakeholders are those ultimately affected, either positively (beneficiaries) or negatively (for example, those involuntarily resettled) while

secondary stakeholders are the intermediaries in the aid delivery process (ODA,1995). Stakeholder in this case includes both winners and losers, and those involved or excluded from decision-making processes.

These stakeholders, among others are as follows (ICRAF, 1990 as cited by Avila, 1992):

- *Farmers/households* - They manage production systems to earn their livelihoods. They have experiences in some land use options. They are interested in improving land use if the alternatives are more attractive than the present and can easily fit with their farming system.
- *Development/extension agent* – They are professionals employed by the government agencies or are with the private voluntary and non-government organizations (NGOs). They are keen of land use options that are technically feasible, socially acceptable, and environmentally sound.
- *Researcher/scientist* – Their interests are mainly for the development of the science and technology (S&T) of improving land use from basic to more applied researches. They are from the national and international research institutions or from agricultural and forestry schools/universities.
- *Policy makers* – They can be classified as national, regional and local policy makers. National legislations related to land use and resource allocation affects the achievement of national and regional development goals that relate to agricultural productivity, food security, poverty alleviation, employment generation, and sustainable development. With the devolution of some policy initiatives in the Philippines, local government at the municipal and provincial levels can also formulate local laws and regulations that may affect land use decisions.
- *Donors* – They include local and international agencies, private foundations and corporations supporting various research and development projects. Their intent may have been varied, ranging from the need to contribute to basic science to the promotion of human welfare.

Identification and clarification of trade-off. The analysis of trade-off can be done at various dimensions. Trade-off can be due to the conflict in policy

objectives which could be at the local and national levels, between the farm families and those who suffer from the impact of land use due to externalities, or between competing uses. The analysis should start with a clear understanding of the objectives and priorities of various stakeholders. Trade-off can be clarified if the stakeholders are cleared about the land use objectives.

The objective of sustainable land use can be described using the definition cited by Maglinao (1999) which considers "sustainable land management (SLM) as a package of technologies applied at all levels of land use, which individually or in aggregate contributes to sustainable agriculture. It aims to maximize the efficiency of use of inputs in relation to the amounts and quality of the outputs, while incorporating long term environmental and social concerns associated with the outputs. It evaluates management not only in terms of production efficiency but also in terms of its impact on the environment and its ability to insure intergenerational equity." This is given definitive substance by International Board for Soil Research and Management or IBSRAM (1997) which looked at SLM as "combining technologies, policies, and activities aimed at integrating socioeconomic principles with environmental concerns and be able to address the five pillars of sustainability – productivity, security, protection, viability, and acceptability. This would mean simultaneously maintaining or enhancing production services (productivity), reducing the level of production risk (security), protecting the potential of natural resources and preventing degradation of soil and water quality (protection), be economically viable (viability), and be socially acceptable (acceptability).

While this definition did not specifically mentioned biodiversity, watershed functions, and carbon sequestration, these could be included in the protection aspect. Productivity, on the other hand, could be extended not only to mean farm product related but could also mean land use productivity in terms of water yield, carbon sequestered, and biodiversity promoted.

However, those important to the society may not necessarily be the important objective as far as the farmers are concern. We will need to clarify the trade-off as perceived by various stakeholders. Various stakeholders may have different perceptions as to the cost and benefits associated with the particular land uses. For example, in a multistorey agroforestry system, the presence of

nurse trees for coffee are considered important for the production system, thus the tree should not be harvested to provide benefits. To other farmers, the benefits from the tree could only be realized if the tree is cut for timber. A matrix describing and comparing those conflicting and complementary

Identification and measurement of trade-off indicators. Indicators refer to the qualitative and quantitative descriptors of a set of conditions and objectives are described in Table 5-1.

Identification and measurement of trade-off indicators. Indicators refer to the qualitative and quantitative descriptors of a set of conditions and information about a change or trend in those conditions. In this chapter, trade-off indicators have to be identified and measured to describe changes or trends in soil fertility, productivity, profitability, carbon sequestration, biodiversity, food security, labor utilization, and other resource use measures.

Maglinao (1999) presented some principles of SLM and how these could be evaluated. The identified indicators can be used to provide a rational basis for the monitoring and evaluation of SLM systems and could serve as a guide in decision making at various levels- plot, farm, watershed, region, and country. Citing various studies, Maglinao (1999) presented a workable framework in identifying and measuring variables and indicators for evaluating SLM initiatives. He also cited Dumanski, et al. (1991b) who described an example of the levels of assessment and the typical characteristics of and determinants of sustainability (Table 5-1). At the plot level, important characteristics of sustainability include the production of basic commodities such as crops and animals as well as the component technologies in soil, water, and pests and diseases management. There are also various characteristics and determinants that can be identified at the farm – community - and country level.

Dumanski and Pierre (1997 as cited by Maglinao, 1999) applied the pressure-state-response (P-S-R) framework in identifying land quality indicators. The framework describes the linkages among the pressures (P) exerted by human activities on the land resulting on the changes in the quality of the resource (state, S), and the response (R) of the individuals (community and society) to address the P and improve the current S.

Pieri, et al. (1995 cited by Maglinao, 1999) gave the following examples of the P-S-R framework application for sloping lands where soil erosion causes land degradation:

• Pressure indicator	Extent of sloping lands without adequate conservation measures
• State indicator	Rates of soil erosion (t/ha/year) obtained by field measurement or modeling; loss of top soil; amount of soil organic matter (OM) and nutrients; truncated soil profiles; extent and severity of visible signs of erosion, e.g., thin or rocky soils, soil slips, gullies, areas of abandoned land.
• Response indicators	Extent of adoption of soil conservation practices by area or farm; number of farmer associations active in soil conservation; and abandonment of formerly cultivated land.

Indicators can then be identified depending on the objectives and frameworks where evaluation will be based. Using the five pillars of sustainability, various indicators can be identified (Table 5-2). Noticeably, these indicators are not mutually exclusive but relate with each other. For example, in the case of *productivity aspect*, this could be broken down to those related to soil fertility such as soil OM, N, P, and K and production of basic farm products or biomass. The amount of biomass leakage and its plow to the land use system determines the *security aspect* as this indicates soil fertility renewal. On the other hand, the amount of soil erosion, which is related to loss in soil fertility, can be measured to indicate the degree of *soil protection* being instituted. The *viability* of the land use systems are then evaluated based on costs, benefits, and other resource efficiency parameters.

Some characteristics to be considered in choosing indicators are the following (Oakley, 1991 as cited by Santoso, et al., 1999 from Lal, 1994):

1. simple and easy to measure under field conditions;
2. applicable across temporal, systematic, and spatial scales (e.g., soil erosion processes); and
3. extrapolatable and predictable to similar soils and ecoregions.

Table 5-2. Example of measurement and indicators identified in each pillars of sustainability.

PILLAR	INDICATOR	MEASUREMENT
Productivity		
Soil fertility	Soil organic matter	% OM
	Available N	
	Available P	
	Available K	
Production	Product yield	Kg/ha, Kcal/ha
	Biomass yield	Kg/ha, Kcal/ ha
Security	Average annual rainfall	
	Biomass plowed back	
	Drought frequency	
Protection	Erosion	
	Cropping system	
	Extent of protection	
Viability	Benefit: cost ratio	
	Percent of off-farm income	
	Difference between farm gate price and market price	
	Availability of farm labor	
	Size of farm holdings	
	Availability of farm credit	
	Percentage of farm produce sold in the market	
Acceptability	Land tenure	
	Support for extension services	
	Health and educational facilities in villages	
	SWC Training of farmers	
	Availability of agricultural inputs within 5-10 km radius	
	Village road access to main road	

Maglinao (1999) cited several studies in the Philippines and Australia that used a simplified selection of indicators for sustainability (Gomez, 1997a, 1997b: Swete-kelly and Gomez, 1988). These studies used two categories of indicators -- for resource conservation and for farmer satisfaction. The indicators for resource conservation identified were:

1. organic matter (OM) content;
2. cation exchange capacity (CEC);
3. moisture content at 1/3 bar;
4. water dispersible solids;
5. permanent ground cover, and
6. soil depth.

For farmer's satisfaction, indicators included were:

1. gross return;
2. material cost;
3. diversity index;
4. farm size;
5. membership in organization; and
6. number of large animals.

Santoso, et al. (1999) cited Smyth and Dumanski (1993) in defining indicators, criteria, and thresholds as follows:

- Indicators refer to environmental statistics that measure measure or reflect environmental status or change in condition (e.g., t/ha of erosion);
- Criteria are standards or rules (models, tests, or measures) that govern judgments on environmental conditions (e.g., impact assessment of the level of erosion on yield, water quality, etc.);
- Thresholds are levels beyond which a system undergoes significant change. They are points at which stimuli provoke response (e.g., a level beyond which erosion is no longer tolerable).

Indicators can be measured and quantified. There are qualitative indicators that can be assigned numerical values (rating) for standardization. However, there are indicators which are yet to be standardized or critical values yet to be identified. Nevertheless, identified indicator should be important enough

to be useful as basis for decision. Santoso, et al. (1999) enumerated the indicators of land sustainability as used by FAO and IIRR (1995) (Table 5-3).

Table 5-3. Sources, ratings, and indicators of sustainability.

Indicator	Rating	Source of Information, Means of Collection, and Verification
Soil loss	1. Serious erosion (gully) 2. Moderate erosion (rill sheet erosion) 3. Less erosion	Sediment in stream, top soil thinning, data base information from records/ reports, field observation
Soil productivity	1. Low productivity 2. Somewhat reduced average production 3. High productivity	Records/reports on annual yield and production of selected crops from agricultural extension offices
Problem soils	1. High occurrence 2. Medium 3. Rare	Records/reports on the area and effects of problem soils
Stream flow	1. Overflow after rainfall 2. dry in summer 3. regular flow	Records/reports on stream flow from irrigation and meteorological stations
Occurrence of floods and drought	1. often 2. moderate 3. rare	Records/reports from irrigation agency, community and key informant
Quality of water	1. Poor (turbidity, polluted) 2. somewhat moderate 3. good (clean, no pollution)	Records/reports on physical and biological aspects of water flow and its quality from irrigation and land development agencies
Water sources for agriculture	1. mainly rainfall 2. partial irrigation 3. full irrigation	Records/statistics/information on agriculture from agricultural extension offices, NGOs, research institutions, development agencies, key informants and field observations
Weed and pest control	1. with chemicals 2. biological/mechanized 3. biological, cultural, alternative pest management	

Kragten, et al. (no date) discussed the indicators that could be considered at the level of the farm households and the policy makers. For the small-scale farmers, the important indicators are:

Household food security indicators incorporate both direct consumption of home-produced food as well as those coming from the market. This is especially important for land-use systems that do not involve food crops, but applies to food-producing systems as well.

Private profitability use the expected Net Present Value (NPV) of revenues less costs of purchased inputs and of domestic factors of production, all valued at market prices.

Labor requirements (person-days per year) which will be averaged over the land-use cycle. The periods of peak labor demand in the system, availability, and deficit should be taken into account. Division of labor by gender and age among the farm household and within the community for agricultural activities may have to be measured and differentiated.

Cash flow which include the time to reach positive cash flow at a level sufficient to make a substantial contribution to sustaining a farm household. Cash flow is also important to compensate for the cost opportunity of family labor or to meet hired labor needs should family labor be insufficient.

Table 5-4. Livelihood options for an average farmer in Salinas, Bambang, Nueva Viscaya.

Income source	Average Annual net earning (P)	Man-day labor	Time engagement	Cash regularity
Rice production	32,000	100	seasonal	low
Vegetable sales	30,000	120	seasonal	low
Off-farm labor	15,000	Varied	intermittent	high
On-farm labor	10,000	144	seasonal	high
Reforestation	22,376	240	full time	very low

Source: Pasicolan, 2007.

Table 5-5. Average yearly gross production of 1-ha kaingin at Lacab Reforestation site.

Source	Average gross income/annum	Remark
1. Banana	2,000	Year-round production for market
2. Upland rice	1,800	One season; mainly for home use
3. Corn	3,500	One season; for market & home use
4. Vegetable & coffee	1,000	Year round production for home use
Total	18,300	

Source: Pasicolan, 2007.

VALUATION

While there are some problems associated with measurements, more problems are confronted when these trade-offs are valued. Valuation is the process of converting the costs and benefits associated with land use decisions into monetary units to have a common unit of measure and that would merit comparison among land uses in analyzing trade-off. The problem, however, arises from various aspects of land uses that do not merit quantification so much as valuation.

There are several concepts in environmental valuation that can also be applied to land use valuation i.e., monetary and non-monetary valuation.

Monetary or direct valuation directly determines the monetary values placed by the individual on the benefits (i.e., product, services and environmental amenities or avoiding costs). These include the use-values and non-use values categories. The use values refer to those given to goods and services actually consumed such as direct payments to timber, user fees for irrigation water, park entrance fees, and the like.

Non-use values are given for those goods and services that are not actually consumed. Among its type is the existence value place on a product or services that are unrelated to its consumption. An example is the support given by corporations for the preservation of an endangered animal like Philippine eagle or tarsier. These could be given in the form of bequest, gift or donations. Another type is option value for possible use of the goods and services though it is not currently used. Farmers may be willing to have some part of the land

to remain fallow even though it will not provide them products for use. Vicarious value, which is placed on goods and services although it is not yet seen, may also be applied in land use decisions particularly in land uses that would reap benefits in the future. The farmer may plant lanzones now thinking that the future generation would reap the fruit. Quasi-option values are given into a decision that will keep the option open over resources whose future benefits are uncertain.

Non-monetary, indirect, or physical valuation measures the physical impact without directly giving monetary value on those impacts e.g., tons of soil eroded or deposited into the streams. Take note that a ton of soil deposited in an irrigation dam reduces the water storage capacity equivalent to the volume of the soil.

These concepts of monetary and non-monetary valuation are used in various valuation techniques used. Direct damage cost method determines the direct cost of damages to crops, animals, or to the resource. However, this technique applies only to those products which are marketed and have market prices. Another method is the hedonic pricing approach which measures the willingness to pay for the amenities. On the other hand, the travel cost method measures the cost of availing the amenities, such the cost of going to an agroforestry demonstration site in order to learn the practice. The contingent valuation method determines the individual's preference and willingness to pay for a good or service or what they are wiling to accept to tolerate inconvenience or damage. Conjoint analysis uses statistical techniques to establish a relationship between characteristics of the products and the preference of individuals. Each characteristic is priced in order to derive the willingness to pay for changes in the level of other characteristics. These techniques have their strengths and limitations. Practical considerations have to be made as to its appropriateness, accurateness, and cost-effectiveness.

Environmental valuation is necessary but there are some conceptual and operational problems associated with it. The conceptual problem arises due to the public good nature of the environment which is also being carried out in the management of resources like the land. In economics, public good is any item characterized by non-rival consumption or non-excludability. Everyone can have a free ride and enjoy public good even without paying for

it. This also happens because of the open-access characteristics of the public goods, as in the forest where anybody could come and harvest timber. Another problem arising from the public good and open access nature of the resource is externalities where the action of a firm or individual affects another but is not compensated. This happens when the upland farms are not properly cultivated, eroded, and degraded thus affecting the lowland farmers with less water, and silted rivers. Externalities may not always be negative. Positive externalities also exist when upland farmers have appropriate land use practices. Will the lowland farmers be willing to pay for the upland farmers if they do provide watershed management services? The externalities may also be a one-time consequence of destruction as in the damage caused by landslide. Continued flow of eternality also occurs such as in the inability of the watershed to provide for irrigation water to the lowland.

The problem of monetization limits the operationalization of environmental valuation. There is a danger in trying to put monetary value on the environment as if individuals can damage it if they can pay for it. There are irreversible actions which would not merit monetization as the streams of values of benefits forgone would be large enough to value at all.

There are various attempts to make use of available approaches, methods, and tools to analyze the economics of agroforestry but problems arose not much on theory and methods but its operationalization. There are problems as to the inadequate data on environmental effects and valuing environmental benefits. Nevertheless, those attempts do contribute to more understanding and appreciation of the trade-offs in making land use decisions.

LAND USE DECISIONS: LOCAL ACTIONS AND CONSEQUENCES

Of Farm Household Decisions. As mentioned in the previous sections, the basis of farm households' decision as to land use is different from the community, landscape, regional, national, and global level. The Matrix used by Kragten, et al. (2001) was adapted in Table 5-6 to illustrate the basic indicators that each level of decision makers may consider. In the same manner, Reiche, et al. (1982) lists of data needs for such decisions is provided in Table 5-7. Farm household are primarily preoccupied with satisfying subsistence

Table 5-6. Matrix for evaluating land-use systems as potential best bet alternative systems to slash-and-burn at forest margins at the small-scale farm level.

Land-use systems	Small-scale farmers' concerns				
	Productivity	Household Food Security	Private profitability	Return to labor	Institutional & Policy Issues

and other necessities. Farm household may be contented in having enough production for homeconsumption and marketable surplus to have cash to pay for external inputs, clothes, education and other amenities. Farmers may put importance on the total cash income than return to cash as they may have less cash investment anyway. In here, the analysis of trade-off is what the farm household may receive as incremental gain in production, food security, cash availability, labor productivity, and institutional/policy support to the land use system. Net present value (NPV) may not be applicable for small-scale farm households since their planning period may be limited on what can be produce at the present rather the present value of what they could gain in the future.

Of institutions and governance. Although farm households decide based on household and plot level consideration, their linkage to the local market provides some level of dependence on the local institutions and governance. The recent hype about the utilization of *Jatropha curcas* (Physic nut) for biodiesel is an example. Farmers are cautioned not to plant Jatropha curcas in food and feed crop areas so that it will not affect food and feed availability. The profitability of *Jatropha curcas* planted as monocrop in agricultural areas is lower considering that the opportunity value of using them to food and feed crops are higher. However, *Jatropha curcas* may be more viable if planted in idle lands which has lower opportunity value, thus *Jatropha curcas* is being promoted to be planted in marginal uplands and degraded lands (e.g., lahar affected and mine silted areas). The common question asked by farmers, however, are where to get the planting materials and where to market the produce? The absence of sources of planting materials and processing plants

nurse trees for coffee are considered important for the production system, thus the tree should not be harvested to provide benefits. To other farmers, the benefits from the tree could only be realized if the tree is cut for timber. A matrix describing and comparing those conflicting and complementary

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• Pressure indicator	Extent of sloping lands without adequate conservation measures
• State indicator	Rates of soil erosion (t/ha/year) obtained by field measurement or modeling; loss of top soil; amount of soil organic matter (OM) and nutrients; truncated soil profiles; extent and severity of visible signs of erosion, e.g., thin or rocky soils, soil slips, gullies, areas of abandoned land.
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Indicators can then be identified depending on the objectives and frameworks where evaluation will be based. Using the five pillars of sustainability, various indicators can be identified (Table 5-2). Noticeably, these indicators are not mutually exclusive but relate with each other. For example, in the case of *productivity aspect*, this could be broken down to those related to soil fertility such as soil OM, N, P, and K and production of basic farm products or biomass. The amount of biomass leakage and its plow to the land use system determines the *security aspect* as this indicates soil fertility renewal. On the other hand, the amount of soil erosion, which is related to loss in soil fertility, can be measured to indicate the degree of *soil protection* being instituted. The *viability* of the land use systems are then evaluated based on costs, benefits, and other resource efficiency parameters.

Some characteristics to be considered in choosing indicators are the following (Oakley, 1991 as cited by Santoso, et al., 1999 from Lal, 1994):

1. simple and easy to measure under field conditions;
2. applicable across temporal, systematic, and spatial scales (e.g., soil erosion processes); and
3. extrapolatable and predictable to similar soils and ecoregions.

Table 5-8. Strategic action of specific land use systems and approaches.

LAND USE SYSTEM	APPROACH	STRATEGIC ACTION
Agroforestry	Convert land under annual crops or pasture to multi-species agroforests.	Provide training, technical and marketing assistance; finance livelihood projects; develop local capacity to manage and implement agroforestry and forest plantation projects.
Forest gardens, secondary forest fallows; community forest plantation	Promote tree growing in forest lands and farms or associated fallowed lands to supply tree products and provide ecosystems services	subsidize tree plantation establishment; training, technical, marketing and credit assistance.
Rehabilitated and regenerated forest	Rehabilitate and regenerate severely degraded areas to supply products and ecosystems services; once regenerated, develop sustainable forest management systems with local communities	Provide training, local organization and planning; pay cost of forest protection and management to be used in financing livelihood projects; compensate users excluded from regenerating forests.
Strictly protected forest areas	Remove potential threats of deforestation, and manage area to minimize human impacts.	Compensate sources of deforestation threats; pay costs of forest protection; financing livelihood projects; develop income sources outside protected forests; reduce leakage

may have to provide incentive on the expansion of *Jatropha curcas* in the country. However, there are still some questions that need to be answered as to how the expansion of *Jatropha* plantation in the landscape may affect the aboveground and underground biodiversity, carbon sequestration, nutrient

dynamics, and watershed function particularly as to water quality. The smallholder farmers will be involved and may benefit from the production of feed stocks but may not receive the benefits of processing and industrial application of the finished products.

Appropriate incentives should be given to farms practicing appropriate land uses particularly those that promote soil, water, agrobiodiversity, and resources conservation (Villancio and Sales, 2005). Those incentives is primarily directed to enhance private profitability, food availability, labor employment, and institutional and policy support to stallholders. These incentives may include among others, discounts in real property taxes, exemption in paying forestry charges and other fees as well as facilitation of permit to harvest and transport timber and wood-based products produced on-farm. On the other hand, tax should be imposed on sloping lands that are idle and do not have adequate vegetation cover to promote soil and water conservation and agrobiodiversity.

Pasture lease agreements and similar timberland lease agreements that are not adequately improved and maintained according to the conditions stipulated in respective lease agreements should also be cancelled. The same applies for the reversion and cancellation of land titles, special patents or any other tenurial instruments of alienable and disposable (A&D) lands and forestlands (to include Certificate of Land Ownership Allocation or CLOA, Community-based Forest Management Agreements or CBFMA, Protected Area Community-based Resources Management Agreements or PACBRMA and the like) if the holder of such title, patents or any other tenurial instruments failed to undertake soil, water, and biodiversity resources conservation.

Another option could be to provide alternative tenurial instruments to convert idle A&D lands which are in grasslands, shrubs, marginal pasturelands to encourage partnership among landowners and agroforestry contractors/ developers without fears of being subjected to land reform. Extensive real state development that promotes ecology, conservation farming, and environmental features with soil, water, and biodiversity resources conservation component may be encouraged subject to appropriate environmental impact assessment.

Financing mechanism should be developed to provide credit to medium and

long-term projects by individuals, private corporations, organizations who will venture into agroforestry, forest plantations, ecotourism, and other soil, water, and biodiversity conservation related enterprises.

Overall, landscape approach focusing on critical sustainable development unit (SDU) within the watershed should be adopted as a planning and development unit transcending boundaries and will involve various stakeholders beyond administrative subdivision (municipality, province, and region).

SUMMARY AND CONCLUSION

Land use choices at the local level have global effect. Intensive agriculture in the upland without due regards to soil and water conservation will have negative effect to those land uses in the lowland. In the same manner, the expanding and conflicting demands for water in the lowland for agriculture, domestic uses, power generation and industry may provide pressure for the capability of the watershed to provide water. Analysis of trade-offs as to various land uses involved various stakeholders (e.g., farm households, business, researchers, policy makers, and development workers) and levels–household, community, landscape, local, and at the global level.

The process of land use decision-making reconciles private gains with societal welfare harmonizing the need for subsistence and profit with the sustainability of environmental services. The process involves the inventory of alternative land uses, stakeholder analysis, and identification, clarification, and measurement of land use trade off indicators. There are some difficulties on the valuation of trade off particularly on land use externalities but there are available tools that can be used to help in making decisions without necessarily quantifying cost and benefits. The analysis of trade off considers the consequences of local actions by farm households to the upper level of the hierarchy – community, watershed, landscape, and country. In the same manner, the impact of national development policy has significant impact on local decisions. The recent approval of the Biofuel Bill is an example of how the conflict of the need for food, feed, fibers, and fuels will have to be resolved to balance private benefits with the national goal of poverty alleviation, employment generation, energy efficiency and sustainable environment. Policy

initiatives that need to be done include structural, fiscal and financial interventions such as providing incentives to farm households practicing appropriate land uses, tenurial security, taxation of idle lands, and financial mechanism that would enhance profitability and encourage investment and partnerships to venture on agroforestry, forest plantation, agroecotourism and other enterprises that promotes soil, water, and biodiversity conservation.

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