AGROBIODIVERSITY ENHANCEMENT FOR THE SUSTAINABILITY OF THE TROPICAL UPLANDS:

An Evaluation of Agricultural Land Use
in Liliw, Laguna, Philippines

A Thesis Submitted in Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

The International Global Change Institute
. I. G. C. I.

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

AMPARO M.WAGAN

2008

ABSTRACT

Agrobiodiversity Enhancement (ABDE) is a strategy that has been advanced for preventing environmental degradation without losing agricultural productivity. However, there is not yet sufficient evidence to support the important role that ABDE might have for managing agricultural land use in the tropical uplands. This research is an attempt to help fill this knowledge gap. The general aim of the thesis was to explore the potential of ABDE as a management alternative for agricultural land use in the uplands in terms of environmental protection, productivity and farmer acceptability. To achieve the aim, a methodological framework for evaluating agricultural land use in the uplands was developed. The methodology aimed at allowing one to understand the influence of agricultural land use on natural resources and farm productivity and the social factors that will most likely influence land users to enhance agrobiodiversity of their production. The methodological framework provided a minimum set of criteria and indicators that can be used for assessing agricultural land uses in the uplands. Main criteria for the evaluation included protection, productivity, viability security and acceptability. The following indicators were included: Shannon Diversity Index, Depth of Topsoil, Soil Organic Matter, Soil Nitrate, Crop Yields, Net Income, Trend in Income and Harvest Loss, Farmer Traits, Farm Characteristics and Farmer perceptions on the influence of farming on the health of natural resources and of the farm workers. The methodological framework also includes a range of methods and techniques for gathering environmental, economic and social data in the uplands and indicates circumstances under which each might best be utilized.

Using the methodological framework, agricultural land use in an upland area in Liliw, Laguna Philippines was evaluated for protection of natural resources, specifically of the soil quality and for farm productivity and for the social factors that influence the way agricultural lands are managed. Results showed integration of horticultural trees and crops have potential for protecting thickness of the topsoil, reducing nutrient wastage and is more economically profitable than monocropping systems. Specifically, coconut exhibited importance in maintaining thickness of topsoil while lanzones played major role in augmenting farm income and as buffer to income losses from annual crops. Older farmers and women were found associated with agricultural land use with diversified production in the case study area. The Logit model analysis further showed that leadership quality and land ownership are the social factors that will likely influence integration of horticultural trees and crops in the uplands. Other personal characteristics like years of experience in farming, access to other sources of livelihood, land size, awareness of land degradation and effect of agrochemicals on heath of the farm workers have no likely influence on agricultural lands with integration of horticultural trees and crops. SWOT analysis of agricultural land use in the case study site showed that despite the environmental and economic advantages of agricultural lands with diversified production, there are weaknesses and barriers to its further development and implementation. From this assessment, implications for developing and implementing an ABDE intervention program for the tropical uplands were drawn.

ACKNOWLEDGEMENT

I would like to praise and thank God for all the resources and the people He provided without whose help this piece of work would not have been done.

My deepest gratitude first and foremost to Professor Neil Ericksen, my chief supervisor, for his guidance and supervision from the beginning until the end of the thesis. Without Professor Ericksen’s professional supervision during the entire conduct of this study, I would not have been encouraged to keep on working.

To Dr. Gavin Kenny, Dr. Richard Warrick, Dr. Percival Sajise and Dr. Peter Urich, for their significant suggestions and corrections on the thesis.

To the University of the Philippines Los Banos for allowing me to go on study leave. To the NZODA for the Scholarship. Again, to Dr. Gavin Kenny for his assistance during my application for the scholarship.

To a Christian brother, for his kindness that made possible for me to continue my studies. Again, to Professor Neil Ericksen, for his generosity in providing accommodation and willingness to provide even more during my extended stay in Hamilton. Such gestures of kindness are so highly appreciated and will forever be remembered.

For my Christian brothers and sisters in the Hamilton (Shirley, Meredith & Jonathan, Rick&Helen, Hoii Yen, Andre, Tina; Jojo&Rey, Elizabeth, Preetha) and in the Philippines (Edna, Jean & Bro Bing, Nestor, Richelle, Jay , Wally and all others in LBBC), especially to Shirley, Bro Bing and Jean, for their passion in prayer and for their huge faith in God and in His Goodness that inspired me to keep on going despite the difficult circumstance and uncertainty of completion.

For the wonderful people who became my friends while in New Zealand and who gave me assistance of all sorts--Claire, Wanda, Heru&Fitri, Iman, John, Katie, Annabelle, Nerma&Joseph, Amor and Josie

To Nestor, for all kinds of assistance (from field work to taking over my work responsibilities); To Myrna and Ricky for their assistance in using STATA.

To my supportive family back home, especially my sisters who have attended to all my personal responsibilities I left behind and for the encouragement to finish this thesis. To all other members of my family, especially the young ones, simply for their presence that added joy into my life.

To all others who have contributed but whose names I fail to mention here, Thank you very much.

TABLE OF CONTENTS

CHAPTER 6 Environmental Protection and Agricultural Land Use in an Upland Area: the Case of Liliw, Laguna

CHAPTER 7 Economic Productivity and Agricultural Land Use in an Upland Area: the Case of Liliw, Laguna

CHAPTER 9 Towards Agrobiodiversity Enhancement

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

GLOSSARY AND ABBREVIATIONS

AAD	Agroecosystems Development and Analysis
ABDE	Agrobiodiversity Enhancement
Agc’l LU	Agricultural Land Use
ANOVA	Analysis of Variance
ASM	Agrarian Systems Modelling
BAR	Bureau of Agricultural Research
BAS	Bureau of Agricultural Statistics
BSWM	Bureau of Soil and Water Management
“BUNDOK’	Local Land Classification referring to the Forest Mountain Reserve
CENRO-LB	Center for Environment and Natural Resources Office-Los Banos
C+L+T	Intercropping of Coconut, Lanzones and Tomato
C+T	Intercropping of Coconut and Tomato
CSR	Cropping Systems Research
DA	Department of Agriculture
DENR	Department of Environment and Natural Resources
EDU	Education
ENVT	Environment
FAO	Food and Agriculture Organization
FARMYR	Number of Years in Farming
FESLM	Framework for Establishing Sustainable Land Management
FSR/D	Farming Systems Research and Development
IA	Integrated Assessment
IAM	Integrated Agrarian Modelling
IBSRAM	International Board for Soil Research and Management
“ILAYA”	Local Landscape Classification referring to farmlands in Steep Slopes
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
KI	Key Informant
KIP	Key Informant Panel
KCL Extraction	Potassium Chloride Extraction
Lsize	Land Size
L+T	Intercropping of Lanzones and Tomato
NAMRIA	National Mapping and Resource Information Authority
NAS-LB	National Agrometreology Station –Los Banos
“NAYON’	Local Land Classification Referring to Farmlands in Rolling and Gently Sloping Areas
NFI	Net Farm Income
NFInc	Non-farm Income
N03	Nitrate
OFInc	Off-farm Income

PCA	Philippine Coconut Authority
PCARRD	Philippine Council for Agricultural Resources Research and Development
"POBLACION"	Local Terminology for Center of the Town
"PALAYAN"	Local Land Classification referring to Rice Production Area
PhP	Philippine Pesos
RCA	Rapid Community Appraisal
TNFI	Total Net Farm Income
SCUAF	Soil Condition under Agroforestry
SDI	Shannon Diversity Index
SLM	Sustainable Land Management
SOM	Soil Organic Matter
STARRDEC	Southern Tagalog Agricultural Resources Research and Development Center
SWOT	Strength-Weakness-Opportunity-Threat
T-alone	Tomato Monocropping
T-F	Tomato Monocropping followed by a Fallow Period
T-R	Tomato Monocropping followed by Radish
UNEP	United Nations Environment Program
UPLB	University of the Philippines Los Banos
Vposi	Position in the Village
WaNulCAS	Water Nutrient Light Capture in an Agroforestry System
WRI	World Resources Institute

CHAPTER 1

Enhancing Agrobiodiversity in the Uplands

One of the most important concerns in global environmental change is land use and land use cover change (Walker and Steffen, 1997). Change in land use from natural forest ecosystems to intensive agricultural production is among the causes of environmental degradation, especially in tropical regions, which in turn threatens agricultural productivity and food security (Scherr, 1999; Wood et al., 2000). In some developed countries, where there is food surplus, some areas have been retired from agricultural production and cleared areas have been reforested (GEO, 3, 2003). In developing countries where the food requirement exceeds food supply, the approach of retiring agricultural lands is a remote possibility. Efforts to reforest cleared areas are in most cases not successfully carried out. In many developing countries, agricultural production has extended to sloping marginal areas. Typical of the agricultural production in the marginal sloping areas is smallholder farming, where cash cropping is an important source of livelihood for a significant portion of the population.

In tropical countries, like the Philippines, environmental and socioeconomic concerns are of utmost significance in the marginal uplands where agricultural production has intensified and extensified. There, rapid degradation of natural resources is evident and alarming. Populations have markedly increased in these areas and are highly dependent on agriculture for their livelihood. Receptivity to agricultural innovations in the uplands either for enhanced production or for resource conservation is low due to difficult biophysical and socioeconomic conditions. The natural or biophysical conditions in the uplands are highly variable requiring a continuous search for, and adaptation to, site-specific production alternatives. The social and economic circumstances of the upland communities likewise vary, thus necessitating production alternatives that suit the socioeconomic circumstances.

1.1. The Research Problem

Up to this time, there has been a lack of management alternatives that might best suit agricultural land use in the uplands so that environmental degradation, including loss of biodiversity is minimized. And more important, there has been little research into how an integrated system for enhancing agrobiodiversity might be achieved

Enhancing biological diversity of farm production systems or agrobiodiversity enhancement (ABDE) is one strategy that has been advanced for preventing environmental degradation without losing agricultural productivity (FAO, 1999; Thrupp, 1998; Wood and Lenne, 1999). Agrobiodiversity enhancement emphasizes restoration of biodiversity in the production system using agricultural resources. It is considered as key to sustainable agriculture as it restores important ecological functions, which are necessary for agricultural productivity (Altieri, 1987). ABDE may involve manipulation of the structure (i.e. species composition) and management (i.e. water, soil, and nutrient management) of any given production setting (Thrupp, 1998; FAO, 1999; Pimbert, 1991). An example that might have a potential role in improving land cover is the integration of permanent crops in the production system. Farmer-initiated practices of integration of perennial crops that serve as source of cash income like plantation and fruit trees, with annual cash crop production are not evaluated for their ecological and socioeconomic importance for upland agricultural land use. That is the research problem that this thesis seeks to address.

1.2 Research Questions

While agrobiodiversity enhancement is a promising strategy for managing agricultural land use, there is not sufficient evidence to support the important role that ABDE might have for managing agricultural land use in the uplands of the humid tropics. This research attempts to help fill this gap in knowledge. Given the condition in the uplands where both environmental and socioeconomic concerns need to be addressed, this research poses the main question:

> *Would enhancing agrobiodiversity, through integration of perennial crops and annul crops, be an appropriate management alternative in the uplands?*

An appropriate management alternative for the uplands would be one that is environmentally protective of the natural resources, enhances economic productivity and is acceptable to the land users. Thus, corollary research questions are:

> *What would be the influence of agrobiodiversity enhancement on environmental protection and productivity in the uplands?*
>
> *What social factors might influence enhancement of agrobiodiversity of the production systems in the uplands?*

1.3 Research Aim and Objectives

The general aim of the thesis is to explore the potential of agrobiodiversity enhancement as a management alternative for agricultural land use in tropical uplands, especially that of the Philippines, in terms of environmental protection, productivity and farmer acceptability. The objectives are:

Objective 1: to describe the characteristics and properties of agrobiodiversity and agrobiodiversity enhancement (ABDE) as a concept and as a practice, in order to provide an understanding of its potential as a management alternative for agricultural land use in tropical uplands such as in the Philippines;

Objective 2**:** to develop an integrated methodology (incorporating environmental, economic and social indicators) that could be used for evaluating agricultural land uses in tropical uplands, in order to evaluate the potential of agrobiodiversity enhancement as a management alternative in the tropical uplands such as in the Philippines;

Objective 3: To apply the integrated methodology developed in objective 2 , by evaluating the spectrum of agricultural land uses in the uplands and its influence on environmental protection and economic productivity in order to explore the potential benefits of enhancing agrobiodiversity ;

Objective 4: to identify the social factors that influence management of agricultural land use in the uplands, in order to explain the potential for wider acceptability of agrobiodiversity enhancement as a management alternative for the uplands.

1.4 Research Design

The research design as presented in Figure 1.1 has two important points. First, the research seeks to determine the role that agrobiodiversity enhancement might have on the sustainability of agricultural land use in the Philippine uplands. Second, the research strives to evaluate agricultural land uses in the uplands in a holistic, integrated manner where environmental, economic and social aspects of the upland agroecosystem are included. This form of evaluation extends conventional research that focuses on only one or two aspects.

First in Figure 1.1 is an understanding of agrobiodiversity enhancement (top box) and design of an integrated methodology that will determine environmental economic and social conditions in the uplands. This necessitates identification of criteria, indicators and techniques for data gathering and measurement which are important in the uplands (central box with three interrelated boxes within). Proposed criteria for evaluation (in asterisks) will include protection of natural resource base; productivity, and security of production; and farmer acceptability of agrobiodiversity enhancement. Field evaluation of agricultural land uses will be done in terms of the influence of agricultural land use on the natural resources and economic productivity and the social factors that influence agricultural land use in the uplands.

The evaluation of will be done in a case study area in the Philippines. From the integration and synthesis of the results of the research can be drawn new knowledge about enhancing agrobiodiversity of the uplands, which could be useful for further development of production systems appropriate in the tropical uplands, specifically for the Philippine uplands.

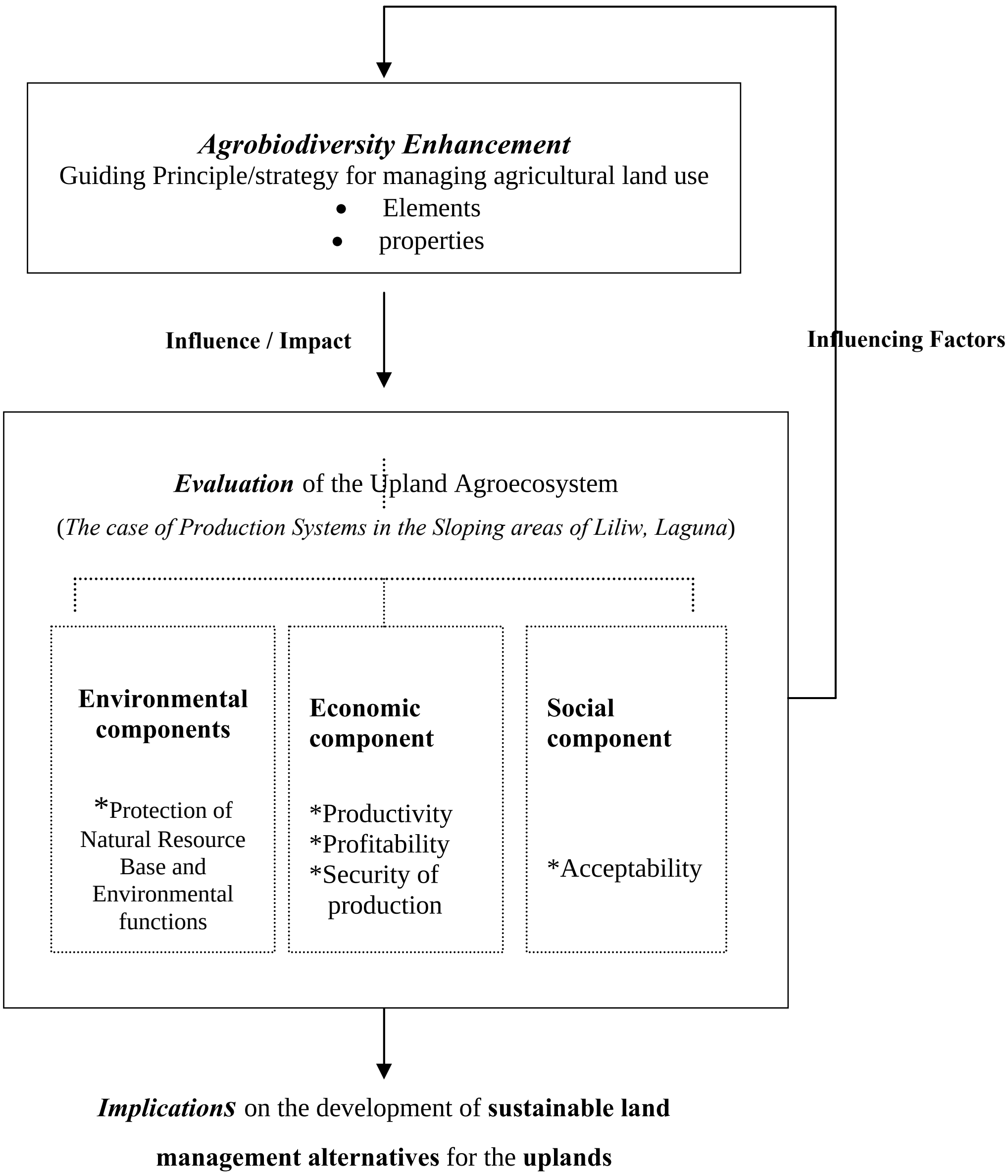


Figure 1.1 Schematic Presentation of the Research Design

1.5 Thesis Structure

The thesis is organized into 10 chapters.

The first chapter ***(Chapter 1)*** introduces the research problem and highlights its importance. It then, poses the research questions, and outlines the research objectives. ***Chapter 2*** addresses the first objective, which is to detail the environmental disturbances associated with modern agriculture and the potentials of overcoming these disturbances through agrobiodiversity enhancement (ABDE). This situation being most significant and evident in the tropical uplands, the case of the Philippine uplands in general and the Province of Laguna in particular are described in this chapter.

Chapter 3 addresses in part the second research objective, which is to discuss integration of varying disciplines (ecological, economic and social) in agricultural research. Different integrated methodologies used in agricultural research are reviewed and their strengths and weaknesses analyzed. This is used as a basis for designing a methodology for evaluating management alternatives for agricultural land use in the uplands.

The methodology is designed in ***Chapter 4*****,** as promised in the second research objective. There, a framework of criteria, indicators, and methods for measuring the indicators is developed. The subsequent chapters deal with the influence of agricultural land use on the natural resources and economic productivity and the social factors that influence agricultural land use in an upland area specifically the case study site which is described in detail in ***Chapter 5***. The methodology devised in Chapter 4 -- the framework of indicators and method for measuring them -- are applied in this chapter.

The third research objective is pursued in Chapters 6 and 7. ***Chapter 6*** evaluates a spectrum of agricultural land use and their influence on the most important natural resource in the uplands, the soil and its quality. In ***Chapter 7*****,** the influence of agrobiodiversity on farm productivity is determined and analyzed.

The fourth and last research objective is addressed in ***Chapter 8***. The social factors that influence agricultural land use were assessed by investigating on farm and farmer characteristics and their association with agricultural land use.

An integration and synthesis of the results obtained in evaluating agricultural land use in the case study area with respect to environmental protection, economic productivity and farmer acceptability and their implications for wider implementation of ABDE practices in the uplands is provided in ***Chapter 9***.

Chapter 10 provides a summary of the research, its main conclusions, and recommendations for future research.

CHAPTER 2

Environmental Issues in Agricultural Production, Agrobiodiversity Enhancement and their Importance in the Tropical Uplands

This chapter provides the context within which the methodological and field research is conducted. It discusses three important concerns. First, environmental degradation typically associated with modern agricultural production. Second, recent interest on agrobiodiversity enhancement as a strategy for overcoming environmental degradation associated with modern agricultural production. Third, conditions in the Philippine uplands, one of the most threatened ecosystems in the country where agrobiodiversity enhancement might have a significant role in its conservation. Conservation of the uplands also necessitates consideration of the socioeconomic conditions that influence land use and this complicates attempts to improve agricultural land use in the uplands. By way of exemplification, an overview of the biophysical, demographic conditions and the problems in an upland area in Liliw Laguna, Philippines, the case study site, is also presented in this chapter. This chapter therefore addresses the first research objective: *to describe the characteristics and properties of agrobiodiversity and agrobiodiversity enhancement (ABDE) as a concept and as a practice, in order to provide an understanding of its potential as a management alternative for agricultural land use in tropical uplands such as in the Philippines*

2.1 Environmental Changes with Agricultural Production

The continuing and growing concern over undesirable changes in the environment associated with modern agricultural production systems is a result of the changes observed over the last 30 to 60 years. Food and fiber production all over the world has intensified in different ways: *temporally*, as the land is more frequently and repeatedly used, usually for the same crop; and *technologically* as the level of external and chemical inputs applied have increased (Trenbath *et al*., 1990). In Southeast Asian countries, agriculture has not only intensified, but also *extensified* resulting in cultivation even of the sloping, marginal areas. These changes have caused great loss in biodiversity and significant disturbances to the condition of the natural environment (Wood et al, 2000). This is particularly evident where in recent decades agriculture has extended beyond traditionally formed lowlands and into upland areas. There, forests are being quickly replaced by a variety of crops for subsistence and commercial purposes.

There are at least three major environmental concerns that are associated with agricultural production in general: land degradation, pollution, and biodiversity loss.

2.1.1 Land Degradation

Land degradation or the reduction of the production potential of the land (Kessler et al., 1995) has occurred for a variety of reasons, like over-exploitation of the land, excessive and continuous use of agricultural chemicals, and the deforestation of highlands and sloping areas. In Asia, degradation of the land is of concern because a very significant portion of cultivated areas is in the uplands. In Southeast Asia, upland cultivation is rapidly expanding and is moving towards commercialization or permanent annual cropping (Garrity, 1993). This is not surprising because of the geographical dominance of the upland areas in the entire continent. It is estimated that 60% to 90% of the total land area of the Southeast Asian countries is upland (Garrity, 1993). Furthermore, the upland area has served as a home to a large portion, usually the poorest sector, of the population in several countries in Asia.

As land degrades, agricultural productivity declines because of soil loss and hence reduced soil quality and fertility. There is a steady decline in crop yield in the upland/sloping areas in Asia by 5-30%. In Southeast Asia, annual soil loss is estimated to be over 3.2 billion metric tons annually, (in terms of sediment discharge from Southeast Asian rivers), a loss greater than in any other part of the world (Garrity, 1993).

2.1.2 Pollution

Pollution from agriculture affects the terrestrial, aquatic, and/or atmospheric environments. One of the forms of pollution due to agricultural production involves contamination of food, feed, land and water resources with chemical residues, which are directly harmful to human life and destructive to wildlife and the natural environment. In Southeast Asia, there are instances of contaminated crop harvests, aquatic/terrestrial animal meats and even milk from lactating mothers with toxic pesticide residues (Tejada et al., 1990; 1992). There are also cases of unsafe levels of nitrates in food and water from nitrogen fertilizers. Several water bodies have been found to be highly eutrophic due to the accumulation of nitrates and phosphates from chemical fertilizers or improper disposal of farm wastes and by-products thus, rendering them unhealthy for human use, destructive to marine resources, and reduced aesthetic value. Pollution and contamination through the agricultural production system is an important concern to international/national research and policy support in agriculture because of their direct impacts on human health.

Pollution due to heavy use of agrochemicals likewise disturbs the food web and destroys biological assets including pollinators and microbial decomposers as well as the biological checks and balances that could prevent pest and disease outbreaks. Efficient agriculture (i.e with minimal dependence on agrochemical and energy inputs) could develop agroecosystems where ecological interactions and synergy among biological components provide the mechanisms for the system to sponsor their own soil fertility and crop production functions (UNEP, 2001).

Change in atmospheric composition is another environmental concern associated with agricultural production. The expansion of food production areas causes a change in land cover resulting in loss of gases, otherwise stored in permanent vegetation cover as well as in the soil, into the atmosphere contributing to the increasing concentration of greenhouse gases due to human activities. Agriculture occupies a larger portion (35%) of the total land area in the world than any other human activity. This scale and intensity is reported to account for about 25% of carbon dioxide, 50% of methane and 70% of nitrogenous oxide released via human activity, globally. This also accounts for 50% of the ammonia released into the air (Jansen et al., 1999).

While atmospheric health is a primary concern in studies related to global environmental change, the potential of alternative agricultural practices for reducing carbon emission has not yet gained much attention in agricultural research. This may be attributed to the indirect effect of declining atmospheric health of agricultural productivity compared to the more evident and easily felt impact of land degradation. In the same way, however, the effect of poor atmospheric environment, like climate change and its anticipated consequences, like increase in temperature and precipitation, will eventually render food production most vulnerable. This will be most critical in tropical countries where rainfed farming systems predominate. While land users/farmers are unaware and might give least attention to the state of the atmospheric environment, they will eventually have to bear the consequences of such environmental disturbance.

2.1.3 Biodiversity Loss

The declining variety of living organisms in all its forms, levels and combinations (i.e. genetic, species and ecosystem diversity) is another undesirable change in the environment to which the current agricultural production system has contributed significantly. Continuous attempts to select and propagate crop and animal species, though useful and desirable for human food and fiber needs, have resulted in the loss of genetic resources, species and natural habitats. With modern agriculture, loss of biodiversity has reached an extreme form in agricultural monocultures (Altieri, 1987). For example, it was reported that there are several thousands of plant and animal species that have served as human food. Currently, however, 90% of the world food supply comes from only 15 plants and eight animal species. Sixty percent of the world food supply comes mainly from three plant species namely rice, wheat and corn (Giampetro, 1997). Furthermore, highly diverse traditional crop varieties have been displaced by fewer high-yielding varieties. In rice production, widespread and continuous planting of high yielding varieties requires high applications of chemical fertilizers and pesticides. This practice has resulted in insect-pest outbreaks and emergence of new strains of pests and diseases (Winarto, 1997). With further advancement in the development of high yielding crop varieties, FAO has predicted a very high chance for main crops like rice, sorghum, wheat and corn to further lose 90% of the existing genetic diversity (Giampetro, 1997).

Expansion of agriculture to the frontier areas has likewise contributed much to biodiversity loss worldwide, particularly to the destruction of natural habitats. With the deforestation of the tropical moist forests alone, the haven of more than half of the world’s plant and animal species was destroyed. The estimated species loss in the early 1990s was at least 4000 each year (National Research Council, 1993). The conversion of forestlands into agricultural production areas has entailed further loss of forest cover in steep lands. This resulted to further destruction of the natural resources, land degradation and pollution.

There is an increasing realization that conservation and restoration of biodiversity is a very promising way to counteract the externalities of the current agricultural production system on the natural environment, and thus a means to a more sustainable agriculture (UNEP,1997; FAO et al.,1999). Such restoration of biodiversity however does not mean simply restoration of any biodiversity (i.e natural ecosystem) but of functional diversity where each biological specie would have specific role to play for the productivity of the system or of an agroecosystem. A way to achieve this is by using agricultural resources to enhance diversity of the ecosystem or through agrobiodiversity (Thrupp, 1998; Heywood, 1999; Pimbert, 1999). An example of doing this would be crop diversification through multiple cropping systems (intercropping, relay and sequential cropping) especially involving the integration of long-term if not permanent tree crops, farming practices that encourage recycling and ecologically-based pest and disease management, genetic and germplasm conservation especially at the farm level and even conservation of the flora and fauna of the surrounding landscape outside the farming system. However, in spite of this awareness on the importance of agrobiodiversity, research and development efforts on reconciling biodiversity conservation/restoration in agriculture are mostly directed towards genetic conservation and/or protection of endangered species rather than addressing the problem at the ecosystem level (Srivastava et al., 1998).

The alarming changes in the environment reveal the need to restore functional diversity. While agriculture is seen as a culprit in this loss in biodiversity, mere restoration of any biodiversity for the sake of the environment per se is not possible because agriculture will always have have purpose to fulfill and that is to supply food and provide livelihood. Yet, agricultural production can be managed where both functional and structural diversity can be restored without necessarily sacrificing agricultural productivity. This is through diversification using agricultural resources or agrobiodiversity enhancement.

2.2 Agrobiodiversity Enhancement: Response to Environmental Degradation Due to Agricultural Production

The environmental disturbances associated with modern agriculture can be attributed to loss of biodiversity as land use is transformed from natural ecosystems to agroecosystems. For this reason, there is today very little regard shown to the role agriculture might have on biodiversity and, thus, on environmental conservation and management.

In the international biodiversity agenda, there is no positive reference for agriculture's role in restoring biodiversity and conservationists do not consider agroecosystems as biodiverse ecosystems (Wood and Lenne, 1999). Or, if biodiversity conservation and management is discussed within the agricultural context, they are only referring to genetic diversity (Cox and Wood, 1999). As such, concerns on biodiversity, conservation and management are typically focused on attempts to save endangered species or to protect particular habitats (wetlands, coral reefs or mangroves) (Srivastava et al., 1998). This focus eclipses an important dimension of biodiversity -- the connection between raising the productivity of the crops and livestock and safeguarding the biological richness of the environment (Srivastava et al., 1998).

There is, however, a way by which agricultural production could be managed in a manner wherein functional and structural diversity would be restored without necessarily sacrificing agricultural productivity. This involves diversification using agricultural resources or agrobiodiversity enhancement.

2.2.1 Agroecosystem Definition and Concept

To have a clear understanding of the positive role of biodiversity in agriculture, it is helpful to show here the difference between an agroecosystem and a natural ecosystem.

An agroecosystems is defined as an ecological system transformed and managed by humans specifically for food and fiber production (Odum, 1983; Hart, 1984; Conway, 1987; Altieri, 1989; Soemarwoto and Conway, 1992 and Ikerd, 1990, Wood et al., 2000). First, it differs from a natural ecosystem in terms of energy source, energy flow, biological composition and control of the system. Like the natural ecosystem, an agroecosystem is solar powered, but uses additional forms of processed fuels along with human and animal labor in order to enhance productivity. Second, an agroecosystem is managed to increase the yield of specific food products, thus its biological diversity is reduced. Third, as an agroecosystem is managed for a particular purpose, the selection of the dominant animal and crop species is artificial rather than natural. Fourth, the control of an agroecosystem is external and goal–oriented rather than internal and through the natural feedback mechanisms of a natural ecosystem (Odum, 1984).

It is clear that the difference between a natural and an agroecosystem lies in the degree of human control. While the basic, renewable and ecological processes are contained in an agroecosystem, they are overlain and regulated by cultivation processes. Such processes in turn, are regulated by economic and social decisions. As such, an agroecosystem is as much a socioeconomic system as a natural ecosystem (Soemarwoto and Conway, 1992)

2.2.2 Definition of Biodiversity in Agroecosystems

Biodiversity broadly covers all living things and the interactions between them, which are characterized as infinite and complex (Wood et al.,1999). Agricultural biodiversity is a subset of biodiversity (Thrupp,1998, Wood et al.1999;).

Agricultural biodiversity or agrobiodiversity refers to all agricultural resources (plants, animals and microorganisms) with functional roles in maintaining the structure and processes of an agroecosystem and contribute to food production and security (Aarnink et al., 1999; Thrupp, 1998; Tisdell, 1999; Heywood, 1999; Pimbert, 1999; Cromwell, 1999).

Agrobiodiversity draws support from the Redundancy Theory in ecology which considers that the interaction of the species rather than the number of species determines the stability of the system or the ability of the system to function after a disturbance (Johnson et al., 1996). This further suggests that species may be segregated into functional groups and that certain species in the community are able to expand their role in the ecosystems in order to compensate for other species that go extinct (Johnson et al, 1996). This provides a basis for planning diversity or selecting composition of an ecosystem just like how it is done in an agroecosystem. It is not always necessary to maintain the natural ecosystem.

From the definition of agrobiodiversity, it can be noted that biodiversity in an agroecosystem is limited to biodiversity with function and not broadly covering biodiversity present in the system. Thus, agrobiodiversity enhancement is the increase in agricultural biodiversity. Agricultural biodiversity consists of three levels: genetic diversity, species diversity and ecosystem diversity. *Genetic diversity* is the variability of genetic resources within plant and/or animal species. *Species diversity* is the variability in kind and number of plants, animals, aquatic species as well as soil organisms that are vital to the maintenance of soil condition and naturally occurring insects, bacteria and fungi that are important in pest and disease management of crops and animals (Thrupp, 1998). *Ecosystem diversity* is the combination or the different mix of crops, trees, livestock, soils and topographies, which are important to the productivity of an agricultural landscape which may be at the farm, community, watershed or regional level. Natural habitats and species outside the farming systems, like forests resources (including wild flora and fauna that benefit agriculture, provide food sources, or enhance ecosystem functions), are also considered as part of ecosystem diversity.

Agrobiodiversity enhancement also includes cultural and local knowledge for managing biological resources (Thrupp, 1998).

Diversity at all levels as mentioned above (i.e. genetic, species and ecosystem) may not be achievable at the same time in the same area/location but diversity could be managed such that diversity at one level would be high even if diversity at one level is narrow. In small farming systems for example, high levels of diversity (genetic and species diversity) may not be achieved at the farm level as development of markets may favor planting of the same crop variety and species (monocropping). Communal effort to maintain high levels of diversity in the surrounding landscape outside the farming system could still be a way of enhancing agrobiodiversity (Thrupp, 1998; Heywood 1999, Pimbert, 1999). Another form of diversity in an agroecosystem may be that species diversity at farm level is low (single crop specie planted) but the genetic diversity of the crop vary. An example is provided by PLEC in their banana-based agricultural system project where over 25 varieties of bananas are grown for different purposes. In the surrounding landscape are ornamental species and grass planted to trap water and sediments within the groves and planted on the upper slopes are cereals and root crops (cassava) (NAO, 2006).

In a natural ecosystem, diversity is always high at all levels. With agrobiodiversity, diversity may vary at different levels, depending on the functions of the species within the system.

2.2.3 Ways of Enhancing Biodiversity in Agroecosystems

There are several ways by which agrobiodiversity may be enhanced. It may involve either management of agricultural resources or conservation and regeneration of important, beneficial, and threatened agricultural resources (Thrupp,1998). The management of various agricultural resources for agrobiodivesity enhancement involves agroecological and organic approaches to agricultural production. These include: 1) crop diversification and enhancement either spatially, temporally, genetically or based on ecological zones; 2) recycling and conservation of soil nutrients and organic matter using plant or animal biomass, reuse of nutrients and resources that are internal or external to the farm and integration of plant or animal microorganisms; and 3) ecologically-based integrated pest and disease management using biological controls, diversifying crop and soil management to enhance natural fauna, and use of habitat and species in habitat. Conservation and regeneration of resources include: 1) conservation of germplasm, more importantly, in situ germplasm conservation like local management of seed banks, indigenous plant and seed conservation and farmer breeding methods; 2) conservation of beneficial flora and fauna; 3) conservation of soil health through control of soil erosion and maintenance of good soil quality; and 4) water conservation.

Enhancement of biodiversity in agroecosystems may also be achieved through its promotion. Education and information campaign on the importance of agrobiodiversity supported by training manuals and packets for human resource development is one way of promoting agrobiodiversity. Carefully planned and well-implemented agricultural development programs would be viable venues for showcasing the importance of enhanced agrobiodiversity and a way to encourage farmers to increase their commitment to incorporate greater diversity in their farming systems. Local ordinances restricting destruction of biological diversity of the surrounding landscape outside the farming system backed-up by government commitment to mainstream biodiversity in agriculture and rural development should be an effective way of, not only promoting, but of conserving agrobiodiversity (Srivastava et al., 1998).

2.2.4. Forms of Biodiversity in Agroecosystems

Diversity in an agroecosystem is described in different ways. First, it is classified into two categories namely planned diversity and associated diversity (Vandermeer et al., 1998; Altieri, 1999). Planned diversity refers to the biological species, like plants and animals, which are deliberately incorporated into the system by the land users, i.e., farmers. Associated diversity on the other hand includes all other living organisms above and below the ground, as well as those within and outside the farm boundaries whose function and/or role in the agroecosystem is mediated by the planned diversity. Their presence in the system is a result of the management and structure of the planned diversity (Altieri, 1999).

Second, diversity in agroecosystem is described in terms of classifying the biological components into productive, destructive and resource biota (Altieri, 1999; Swift and Anderson, 1994). The productive biota includes all those organisms that are involved in the production of food and fiber, like plants and animals. The destructive biota are those which do not contribute to the production of food or fiber, like weeds, animal pests, and microbial pathogens, and are thus reduced through management practices. The resource biota includes all organisms that contribute to the productivity of the system, but does not generate products that are directly useful to the land users. These biota contribute to the system through processes like pollination, biological control, and decomposition.

The degree of diversity in agroecosystem is influenced by several factors. These are the diversity of vegetation within and around the agroecosystem, the permanence of the different crops within the agroecosystem, the intensity of the management, and the extent of isolation of the agroecosystem from the natural vegetation (Altieri, 1999). It is important to distinguish the type of biodiversity so that the best agricultural practices may be applied for the maintenance and enhancement of the desirable biodiversity components or those that carry out the desired ecological services (Altieri, 1999).

Third, diversity in agroecosysetm may be described according to its hierarchical, genetic, species and ecosystem level. This research focuses on plant species diversity. Species diversity is described by its richness or the number and kind of species in the system (Brower et al., 1990). The importance of species diversity is

dependent on the role, rather than the number, of species in carrying out natural processes that enable the system to accomplish its function (Bengtson , 1998).
Based on the definition of sustainability in this study, a sustainable agoecosystem has a two-pronged function of continuous production and environmental protection.

2.2.5 Importance of Biodiversity in Agroecosystems

Agrobiodiversity enhancement is a way to reconcile and build complementarities between agriculture and biodiversity. There is much promise on the positive influence of agrobiodiversity enhancement on nutrient cycling. Studies conducted by ecologists on biodiversity and ecosystem function, explain that the influence of agrobiodiversity enhancement on ecosystem functions is more significant in below-ground functions than the above-ground functions. Above-ground functions are more related to the gaseous exchanges that influence atmospheric changes. Below-ground functions, like organic matter decomposition, are positively influenced by enhancing agricultural diversity, specifically that of plant diversity (Swift et al.,1994; Vitousek et al.,1994).

Restoration and/or maintenance of ecological functions (like nutrient recycling) basically determine the important role of agrobiodiversity enhancement on the overall productivity and sustainability of agricultural systems. Other ecological functions that are positively influenced by agrobiodiversity enhancement are control of microclimate, regulation of local hydrological processes, regulation of the abundance of undesirable organisms, and detoxification of noxious chemicals (Altieri, 1987). With these ecological functions, land productivity is restored resulting in increased biomass production and crop yields, more stable farming systems, sound pest and disease management, soil conservation and natural fertility, and soil health (Thrupp, 1998; Pimbert, 1999). Consequently, this leads to increased farm productivity through diversified products and income opportunities, additional income and increased net returns to farms, reduced risks of crop failure, increased efficiency in resource use, reduced dependency on external inputs, reduced agricultural pressure in fragile areas, forests, and endangered species (Thrupp, 1998; Pimbert, 1999).

Having outlined problems of biodiversity loss through agricultural production and the role of ABDE as potential strategy to reverse the trend, the following discussion focuses on the Philippine uplands, and in particular the case of the province of Laguna.

2.3 The Philippine Uplands

Nowhere are environmental problems associated with modern agricultural production more disturbing than in the uplands of the humid tropics. Thus, agrobiodiversity enhancement will be most beneficial in these areas. As an agroecosystem, the need for environmental conservation in the uplands is complicated by socio-economic factors. The uplands in the humid tropics have not only undergone transformation from natural ecosystems to agroecosystems, but also became a dwelling place for farming communities that are heavily dependent on agricultural production for livelihoods. To help exemplify this situation, a picture of the upland agroecosystem in the Philippines will now be drawn.

2.3.1 Importance of the Uplands in the Philippines

Physical Geography

The Philippines is an archipelago that lies in Southeast Asia. It sprawls between the Asia mainland and Australia between latitude 21°25’ N and 4°23’N and longitude 116°E and 127°E (Figure 2.1). It has an approximate land area of 300,000 square kilometers (or 30 million hectares), encompassing 7,107 islands. However, ninety-four percent of the total land mass is made up of eleven islands, two of these, Luzon and Mindanao, are the largest measuring 105,000 and 95,000

Figure 2.1 Map of the Philippines

square kilometers, respectively. Together with the cluster of Visayan Islands (57,000 square kilometers) that separate Luzon and Mindanao, these islands comprise the three major regions of the archipelago. The Philippines is physically fragmented because of the several bodies of water within and around it. With its island nature, it has a very long coastline relative to its size and no inland area is far from the coast.

Being a humid tropical country, its climate is characterized by a normal average annual temperature of 27°C and two pronounced seasons, wet and dry (National Statistics Coodination Board,2000). Annual rainfall measures as much as 5000ml in the mountainous areas, but less than 1000ml in sheltered valleys. It is beset by typhoons from July to October. These are especially hazardous in the northern and eastern Luzon, Bicol and Visayas regions.

The Philippines is characterized by high relief. Its terrain is diverse consisting of numerous high mountains, extensive valleys and plateaus interspersed with many rivers and lakes. Based on Philippine laws, all lands with slope of 18% and more are classified as uplands (Department of Environment and Natural Resources, 1996). These are rolling and steep areas where agriculture and forestry are both practiced. Based on this definition, the upland areas in the Philippines measures about 55% of the total land area or 165,000 square kilometers (Garrity, 1993).

Uses of the Uplands

The uplands are an important resource in the Philippines in terms of not only the extent of area they occupy, but also the number of people living in them. There are two groups of people in the uplands: the tribal ethnic groups and the lowland migrants. The latter contribute more to the population growth in the uplands (Cruz, 1986; Fujisaka, 1986; DENR, 1996; Robotham, 1998). The Philippine Department of Environment and Natural Resources (1996) estimated that about one third (25.1 million) of the total population of the Philippines are uplands settlers. With a current total Philippine population of 75.3 million and a 2% annual growth rate, by the year 2030, there will be about 40 million Filipinos in the upland areas alone (Philippine National Statistics Office, 2000).

The Philippine uplands are also devoted to production of semi-temperate vegetables (considered as high-value vegetables), tropical fruits and plantation crops, corn, rootcrops, medicinal plants, forage grasses for livestock, bamboo and timber materials for wood and charcoal (Robotham, 1998).These uplands also render important environmental roles. First, is the protection of Philippine watersheds. Upland catchment areas serve as important sources of drinking and irrigation water for most of the major Philippine cities and agricultural areas as well as water for generating electricity. Destruction of the forest resources in the uplands causes flashfloods, damaging other resources in the lowlands as well as water bodies due to sedimentation (Robotham, 1998).

Second is the prevention of undesirable gases in the atmosphere. Changes in the atmospheric composition revealed that the loss of vegetation cover in the Philippine uplands, estimated at the rate of 100,000 hectares every year in the 1990's, is equivalent to 8.8. million tons of carbon released into the atmosphere (Lasco, 1998). Restoration of vegetation cover in the uplands through reforestation is estimated to be able to sequester 22% of the annual carbon emission (104 million tons) in the country (Lasco, 1998).

Third, the uplands serve as a nature reserve. Almost 80% of the land classified as upland areas in the Philippines are forest lands (Sajise et al., 1990). The Philippine forest has one of the world's richest plant and animal species. At least 3000 plant species were identified as endemic to the Philippines (IBON, 1997). Based on an inventory made by the Philippine government in 1991 and 1996 (Department of Environment and Natural Resources, 2001), there are nearly 1000 wildlife species (including mammals, birds and reptiles) in the country. However, 20% of these are endangered.

2.3.2 Biophysical and Socioeconomic Pressures on Land Uses

Land Uses in the Uplands

There are two broad land categories in the Philippines, namely: 1) alienable/disposable lands, which maybe privately owned; and 2) forestland or lands intended for forestry purposes (whether or not covered with forest vegetation) (Garrity, 1993). The proportion of forestland in the Philippines declined from 65% to 53% of the total land area from 1955 to 1995 (National Statistics Coordination Board, 1997). The total forestland measures 15,882,756 hectares, but less than half (5,590,179 hectares) has forest cover (Department of Environment and Natural Resources, 2001).

What the Philippine government has defined as uplands, based on 18% slope, is almost 80% forestland (Sajise and Ganapin, 1990). There are three broad land use zones in the Philippine uplands: permanent agricultural lands, grasslands and forested lands. The permanent agricultural lands are located on the lower slopes closest to the lowlands and the roads. The grasslands are in the more remote and higher elevations. These are the logged-over forestlands. The forested lands are in the highest elevations and on the steepest slopes (Cramb, 2000; Garrity, 1993).

Land Degradation in the Uplands

Two of the most important environmental and developmental concerns confronting the uplands are forest destruction and soil erosion. It was recorded that in 1903 over half of the Philippines (70%) had forest cover. It declined to 54% of the total land area by the late 1960s then to 39% by the early 1980s and to less than 20% of the total land area by 1994 (CEC, 2002). Of the current forest cover, less than 15% (804,900 hectares) is old growth forest (or the original forest). The forest flora and fauna are diverse and each species is important. The Philippine forests also support the indigenous peoples.

The main forest types are Dipterocarp, Mossy and Sub-marginal, Pine and Mangrove. The Dipterocarp forest, which consist of the old growth (the virgin forest or tropical rainforest) and residual forest (with traces of commercial logging), are the most important and the most prevalent in the country. There is however, more of the residual than the old growth forest today (IBON, 1997)

The mossy and the sub-marginal forests are those that serve to protect the Philippine watersheds to supply water for the country. These are not commercially exploitable forests, yet are also reported as degraded (IBON, 1997). There are different reports on the annual forest denudation. World Development Indicators (2000) shows that, during the period 1990-1995, the Philippines had an annual average change in forest cover of 3.5%-- the highest in Southeast Asia. However, the latest report from DENR (2001) showed an annual forest denudation rate of only 1.49% of the current forest cover in 1996. Still this amounts to 87,556 hectares/year of loss in forest cover in the Philippines.

Soil erosion is the other main environmental disturbance associated with the Philippine uplands (PCARRD, 1999). The steep slopes covering half of the country, abundant rainfall, and frequent typhoons combine to make erosion a severe problem in the country. It is reported that around 5.2 million hectares of the country is severely eroded (IBON, 1997). The gross erosion rate for the country is computed at 2,046 million metric tons per year with grasslands contributing 76.34%, agriculture, 22.34% and woodlands, 1.32% (IBON, 1997). For this reason, soil erosion was declared a national problem requiring necessary attention (PCARRD et al.,1999). There is no absolute measure of the amount of soil eroded in the country.

Causes of Land Degradation

Degradation of the Philippine uplands (including forest cover loss and soil erosion) can not be attributed to a single factor, but rather to the interlocking of several factors ranging from the micro to macro-economic level (Garrity, 1993;

Cramb, 1999; Kummer, 1992; Sajise et al., 1992). These factors include logging (legal and illegal), agricultural expansion in the uplands, increasing upland population, the agrarian structure and the economic condition of the Philippines. Logging and agricultural expansion in the uplands are so interrelated that one cannot be separated from the other (Kummer, 1992; Garrity, 1993). Expansion of agriculture in the uplands is driven by increases in population, landlessness, and widespread poverty in the country (Garrity, 1993).

Upland areas given over to small-scale or subsistence farming are logged-over areas (secondary forest or grasslands) abandoned by the loggers. Deforestation in the Philippines was for a very long period of time (1500s to mid-1970s) done without forest protection, i.e., no replanting or reforestation (Garrity, 1993; IBON, 1997). Loggers exploited one primary forest after another. Logging roads were constructed in the process thus rendering the logged over areas in the uplands open to landless and jobless lowlanders. As the forested lands decreased, agricultural lands increased as more and more of the grassland and logged-over areas were converted into subsistence agricultural production.

Today, upland farming plays a key role both in forest destruction and land degradation making upland farming a central issue in Philippine upland development.

2.3.3 Interventions in Upland Agriculture

Both government and non-government organizations conduct numerous upland development programs throughout the country. These programs include reforestation with community development activities (DENR, 1996). These community development activities, in most cases use agriculture as the entry point. While there could be a number of agricultural production technologies for the uplands, holistic analysis of their characteristics are still lacking.

The lack of management alternatives for the uplands is attributed to the following reasons: 1) absence of baseline information for the upland areas making development of agricultural production systems difficult; 2) farmer-initiated and indigenous practices and knowledge that could serve as basis for developing suitable production systems in the uplands are not documented, and 3) the biophysical condition of the upland areas is highly heterogeneous and thus requires site–specific production systems. Agricultural production practices in the lowlands are not suitable to the upland ecosystem (Cramb et al., 1994).

So far, researcher-introduced agricultural production practices in the uplands are limited to hedgerow intercropping using fast-growing leguminous trees or grasses. Such practices were found effective in controlling soil erosion. Farmer adoption of such practices has, however, remained low and slow. This could be attributed to the lack of economic incentives for the farming household to adopt the practice and limited applicability of these practices to specific conditions and/or areas (Gerritts, et al., 1996). The above situation shows that it is important to consider not only the suitability of the agricultural management practice, but also their acceptability to the land users. Often, introducing an agricultural production practice in the uplands is difficult because land-users do not readily adopt them.

Described below is the case study site for this research. It exemplifies in more detail management of an agricultural land use in an upland area in the Philippines. An overview of the biophysical and socioeconomic condition as well as the farming problems in this research site will be provided. Information for this overview was gathered through rapid community appraisal of the area involving transect walks, ocular observation, key informant interviews, with early settlers in the village, and a review of municipal records and other reports about the area. This field work was carried out in a preliminary field visit ahead of the research proper reported on later in the thesis.

2.4 The Sloping Areas of Liliw Laguna: The Case Study Site

2.4.1 General Description

Liliw is one of the agricultural municipalities in the province of Laguna, which is approximately 110 kilometers away from Manila, the capital of the Philippines (Figure 2.2). Laguna is characterized by alluvial plains, high relief and mountain areas. The Alluvial plains or the low-lying areas (<300m asl), are those along the lakeshore, occupying about 25% of the entire province. The high relief or hilly (300–700m asl) and mountain areas (>700m asl) combined account for about 34% of the total land area. In between the alluvial plains and the high relief and mountain areas are the foot slopes that occupy about 41% of the land area of the province. Liliw is situated in these footslopes with elevations ranging from 400m to >700m asl and is characterized by undulating topography. It lies at the foot of Mt. Banahaw, one of the tallest (1,470m asl) and active volcanoes in the Luzon Island. Liliw has a total land area of 5,680.65 hectares. Almost 60% of the total land area (2,593.15 has) has a slope of 0-3%. About 19% (1,100 has) has a slope of over 3% to 8% slope and almost 35% of the total land area (1,987.50 has) has slopes over 8 to 15%.

Today, agricultural lands dominate Liliw, occupying about 76.4% of the total land area or 4,339.52 hectares. Forested land occupies only 19.5% of the total land area or 1,107.72 hectares. The built-up area occupies about 3.1% of the total land area or 176.10 hectares. Liliw is also a watershed protecting the natural springs that abound in the area. These natural springs are the main source of potable water. Water bodies (natural springs and rivers) abound occupying 50.56 hectares (0.89% of the total land area).

2.4.2 Agricultural Land Use in Liliw

The favorable climate and soil condition encouraged people to use the sloping lands for crop production. The farmers produce semi-temperate climate vegetables

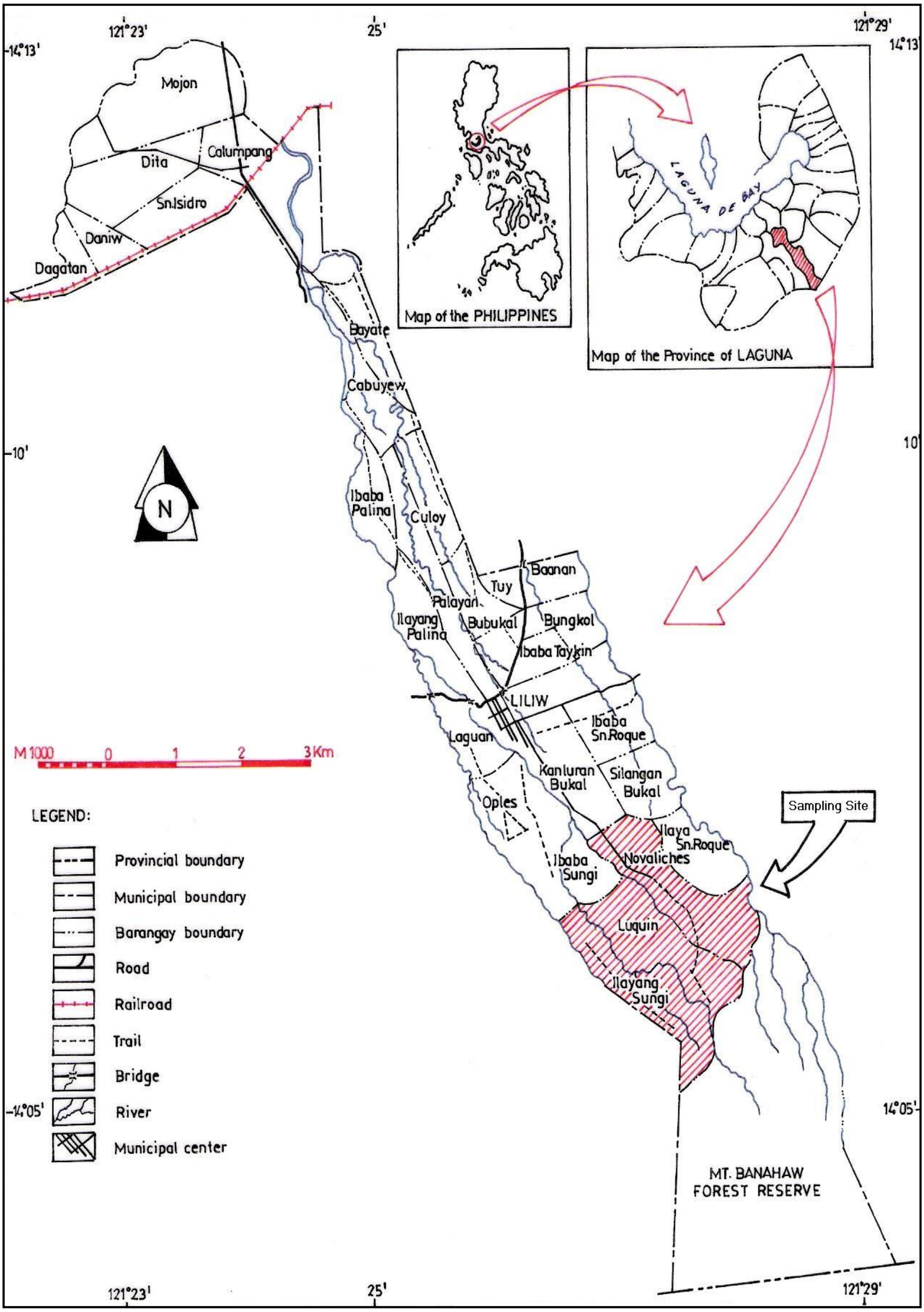


Figure 2.2. Location Map of Liliw Laguna

that command higher market value than the local tropical vegetables. Because crop production in the sloping areas of Liliw is successful, more farmers are encouraged to plant similar crops in the area. For this reason, Liliw is envisioned to become the "vegetable bowl" of the province (Provincial Development Plan, year, 1995). The local government supports the practice. Cemented farm roads were constructed as well as cemented foot trails leading to and within farms. This development has further opened upland areas for agricultural production in the past 5 years.

Today, vegetable monoculture dominates even in areas with steeper slopes. It has even extended into the Mt Banahaw Forest Reserve Area. JICA (1995) assessment for a possible irrigation development project in the research site and contiguous municipalities noted that vegetable production in Liliw is mostly located in areas with elevations from 500 to 800m elevation. Making the situation worse is the land preparation being practiced in the area. Land preparation for the growing of vegetables, particularly for tomato, involves complete clearing of the land of any vegetation, frequent application of chemical pesticides and application of chemical fertilizers and chicken manure.

The historical account of the development of agricultural production in the area shows that there was a complete change in the landscape from purely forest vegetation to agricultural production areas. This influenced biodiversity of what otherwise was a natural ecosystem, now an upland agroecosystem.

Historical Account of Agricultural Land Use in Liliw

A dialogue with older women farmers and farmers' wives (ages ranging from 75 85 years old), revealed changes in agricultural production in the area. The change in the kind of crops and the agronomic practices employed resulted in a shift from the natural landscape, which was basically forested lands to the current cultivated lands, particularly in the areas located at high elevations

Information gathered from the key informants provided insights into, and implications for, the influence of agriculture on the biodiversity trends in the area. The area has become a permanent settlement for the people for more than three centuries. The conversion from natural ecosystems into permanent agroecosystems, however, mostly occurred in the last 50 to 60 years (1940's-1950's).

Permanent cultivation marks the start of decline in species diversity because it involves clearing of the land and planting of choice crops. Further decline in crop species diversity and crop varietal diversity occurred when agriculture production became an income generating activity. For vegetable production, specifically tomatoes, this started in the 1950's, which consequently intensified during the 1960s, and its area further extended during the last 20 years (1980's). The advent of the green revolution technology (during the 1960's), which started with rice and was later applied to vegetable production, further limited varietal diversity as farmers' preference for non-traditional, high yielding varieties increased. Today, the ill-effects of such trends in the production has become more evident and most felt by the land users.

Problems in Liliw, Laguna

Problems cited by the residents and farmers in the Liliw area include: a) declining soil fertility, which was manifested by the increasing amounts inorganic and organic fertilizers they have to apply to their crops, specifically for tomato crop, to get good yield; b) increased pest population and pest resistance to chemicals as well as emergence of new strains of diseases in tomato and other vegetable crops; c) declining tree population due to pest damage, old age of trees and lack of initiative for replacing old trees; e) possible pollution of sources of water from the agrochemicals used in the area; f) in the farm production areas, loss of birds that prey on the insect pest of fruit tree crops, due to the increase in the use of agrochemicals poisoning/death of the birds.

Other reported problems in the area include; a) soil erosion manifested by deep gully formation in areas between elevations 650 to 900m (JICA,1995); b) that vegetables sold in the market containing a residue level higher than the maximum tolerable level and c) contamination of the Liliw River catchment for all the natural springs that abound in the upper portion of the area, with wastes from backyard hog farms; d) in the Mts Banahaw-San Cristobal National Parks (measuring 11,133 ha) there is illegal land clearing for cash crop production by about 100 people (CENRO-LB census,1991); and e) extinction of wild deer, which used to widely inhabit the area.

2.5 Summary and Conclusion

The chapter highlighted the environmental changes resulting from agricultural production in tropical uplands, especially those of the Philippines where the uplands are both geographically and demographically important. These changes have created environmental issues that are critical in the tropical uplands because of the growing trend towards cash monocropping in the sloping areas. Thus, these environmental issues can not be separated from the socioeconomic concerns in the uplands. The chapter also showed how in principle, enhancing biodiversity of agricultural areas play important role in addressing both the environmental concerns and socio-economic needs in the uplands.

To illustrate in more detail management of agricultural land use in an upland area, the case of Liliw Laguna in the Philippines was described. There, farms are mostly located in elevations of more than 500m asl and are adjacent to the protected forest areas. The trend in agricultural production, like in many Philippine uplands, is towards monoculture of annual cash crops, especially tomato.

Based on the information gathered and presented in this chapter, the research site is one of those agroecosystem that developed in areas that are otherwise covered by forest vegetation. The current production system in the area causes complete loss of vegetation cover in certain times of the year as the trend moves more into monocropping of annual cash crops. High relief, steep slopes, heavy rainfall during the typhoon season, and frequent cultivation of the land are considered as primary causes of soil erosion and, therefore, the significant decline in soil quality and productivity. This in turn tends to increase the use of chemical fertilizers, further affecting soil quality.

Integration of perennial trees, like plantation and fruit trees, with the production of annual cash crops is a way of enhancing diversity of the upland agroecosystem. This system has not been investigated by researchers in terms of its protective functions, specifically protection of the soil quality and its productivity, as well as of its acceptability by the land users in the uplands. Evaluation of this issue will contribute to the development of management alternatives for sustainable agricultural land use in the Philippine uplands.

The evaluation of management alternatives for agricultural production in the uplands requires integration of ecological, economic and social concerns. The following chapter reviews and analyzes the commonly used integrated approaches in agricultural research and attempts to find out their appropriateness and usefulness in evaluating agrobiodiversity enhancement as a management alternative for the uplands.

CHAPTER 3

Review of Integrated Research Methodologies: In Search for a Methodology for Evaluating Agricultural Land Use in the Uplands

Enhancement of agrobiodiversity intends to serve not only the protective function, but also the productive and social functions in the upland agroecosystem. This suggests that an integrated methodology is needed for evaluating its veracity as a management system; one that covers the ecological, economic and social concerns of the upland farmers. There are commonly-used integrated methodologies in agricultural research. However, in most of these approaches the protective, economic, and social aspects of an agroecosystem are not altogether considered. Nevertheless, some of these commonly-used methodologies are reviewed and analyzed, in this chapter, in terms of their underlying principles, concepts, data requirements and gathering methods to find out how these could be useful in designing an *integrated* methodology for assessing agrobiodiversity enhancement practices for the uplands. This chapter addresses in part the second research objective, i.e. *to evaluate performance of agricultural production in the uplands, in order to determine the performance of ABDE as a management alternative in terms of sustainability.*

3.1 General Approaches to Problem Solving in Agriculture

The integration of varying disciplines in agricultural research came about because of the recognition of agriculture as a system. Thus, the application of systems thinking in problem solving in agriculture can be found in various methods. There are two approaches in problem solving in agriculture. First, is the reductionist approach where the problem is considered as an irreducible whole, hence a study of its parts will not lead to the understanding of the whole. Second, is the holistic approach where a production setting is considered as a system with components and the examination of how these components interact, interconnect, interrelate and control each other is encouraged (Wilson and Morren, 1990). Bawden, et al., (1984) further classified these approaches into four: the scientific reductionist, reductionist technological, hard systems, and the soft systems approaches.

The scientific reductionist approach is used in basic research involving a scientific procedure that aims to explain reasons behind, or the cause and effect of, a particular agricultural process or phenomenon by means of understanding the behavior of specific variables involved in the process. The procedure used in this kind of investigation is based on a systematic collection of facts from which a relevant hypothesis is formulated and tested experimentally, several times, in order to explain or suggest solutions to the problem (Bawden, et.al, 1984; Wilson et.al., 1990). Information gathered in this type of investigation plays a very important role in the world of agricultural science research. Information from this kind of research does not relate to the different sectors in the society (Teague, 1996). As such, the information is not all that helpful for policy makers, land managers, and the general public.

The *reductionist technological approach* is common in applied research especially in situations where technical or technological interventions are used to respond to identified agricultural problems. It is similar to the scientific approach in terms of reductionism, repeatability and refutation of alternative hypothesis. This approach provides a technical/technological solution to a problem (Bawden, et al., 1984; Wilson et al., 1990). This approach is used for component technology research or technology development, which is very much disciplinary–biased. As such, the scope of its inquiry is limited and compartmentalized. This kind of approach may involve several disciplines in addressing the problem without much interrelation between disciplines involved.

The hard systems approach involves formulation and development of models, usually quantitative or computer-aided models. The models are used to predict or assess the efficiency of the different alternative technologies, policies and/or strategies that will solve the problem. System thinking is applied here as early as problem identification. Similarly, in the soft systems approach, systems' thinking is applied during problem identification. This approach, however, highlights more the human dimension of agricultural production. Perceived solutions to identified problems will require changes or recommendations for actions (Bawden et al, .1984).

While the reductionist approaches deal with specific agricultural problems, the holistic approach deals with broad and complex problems. For complex issues confronting food production, agriculture, and natural resource management, systems approaches are relevant. Within the hard systems and the soft systems approaches, there are a number of integrated approaches in agricultural research. It is important to understand how the integration of the various disciplines in agricultural research evolved through time.

3.2. Trend in the Development of Integrated Methodologies in Agricultural Research

As hard and soft systems approaches developed, more disciplines were integrated into agricultural research. Now, in addition to the natural sciences, economics, engineering, social sciences and other disciplines are involved in agricultural research. This is due to the emerging needs and concerns that are related to food and fiber production. Through time, more sectors in the society are affected by agricultural production. In the same way that more sectors influence agricultural production. This trend for over 30 years now fostered a pattern in development of integrated approaches in agricultural research (Jansen et al., 1996).

In Figure 3.1, for example, the rise of industrialization in developing countries, which drew away human labor from agriculture, led to the concern for optimization in the use of farm resources. This made farm management as the integration domain for approaching agricultural research and development in the early 1960's. As such, research became focused on fields of disciplines like agricultural engineering, farm planning and economics.

During the late 1960's, the concern over the need for increasing food production due to increasing world population led to the green revolution era where modern technologies and high yielding crop varieties were promoted. The integration domain was crop ecology. This involved the disciplines of genetics and plant breeding, physiology, pathology, entomology and agronomy.

By the early 1970's, there was a realization that green revolution technologies were beyond the farmers' economic capability to sustain the recommended management practices. For this reason, the green revolution did not necessarily benefit small farm holders in developing countries. Farming systems increasingly became the integration domain involving disciplines like agronomy, soil science, economics and anthropology.

In the early 1980's, there were increasing manifestations of the ill-effects of modern agriculture threatening both human and environmental health. During this period more ecological farming system practices, like integrated farming, natural farming, and organic farming became the focus of concern (Altieri, 1989; Conway, 1985).

By the 1990's, there was global consciousness on the effect of food and fiber production on human and environmental health and vice versa. Sustainability became the integration domain. This domain has so far involved the most number of disciplines in research that seeks solutions to problems stemming from agricultural production. There was global consciousness over fragile ecosystems and food security. There was greater participation and involvement of the different stakeholders and sectors of society at local and global level. Integrated assessment in general may be described as vertical integration of the different stakeholders/actors and horizontal integration of disciplines and knowledge sources (Gough, 1998). With increasing global consciousness of the interaction of agriculture and the environment, horizontal integration transcends more and more disciplinary boundaries. In a similar manner, vertical integration transcends the concerns of different sectors of the society and the global community. This is shown diagrammatically in Figure 3.1. There, the horizontal integration of more disciplines in agricultural research through time is summarized along with the inclusion of the concerns and interest of an increasing number of stakeholders or sectors of the society (vertical integration). This transcends the hierarchical scale of agricultural systems.

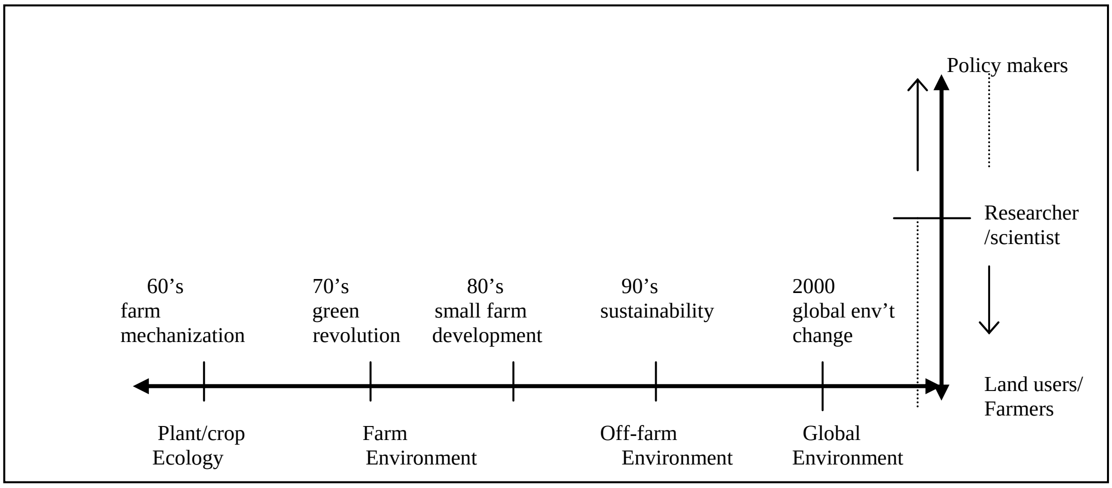


Figure 3.1. Integration of Various Disciplines and Stakeholders in Agricultural Research Methodologies.

In summary, approaches differ according to the purpose for which each is developed, the extent of concern for the different components of an agricultural system, the unit of analysis used (which is indicative of the level of hierarchy it is addressing), and the methods employed for data gathering (which determines the extent of involvement of the different stakeholders).

3.3 Integrated Methodologies in Agriculture Research

There are a number of integrated research methodologies for studying agricultural systems. Examples of the hard systems approach include the bioeconomic modeling and agrarian systems modeling. Agroecosystems analysis and development, cropping system research, farming system research and development, and, most recently, sustainability assessment are the soft systems approaches.

Along with the development of these integrated methodologies is an increasing understanding of interactions between problems, and the ability to deal with interactions. More and more tools and techniques had been developed to support investigations. These tools and techniques include both quantitative and qualitative tools. The quantitative tools are mostly those derived from the hard systems approach, like linear programming, mathematical models, and geographic information systems. Linear programming is a useful support for decisions in farm resource allocation. Mathematical models can stimulate growth processes in different environmental conditions. Geographic information systems allow not only the handling and storage of large amount of data but also the ability to relate layers of information for specific areas and at varying scales. Qualitative methods from the soft systems approaches include interaction between researchers and farmers during data gathering, experimentation like rapid rural appraisal; on-farm trials; and farmer surveys and interviews.

The seven methodologies commonly used in current agricultural research today are discussed below. The following discussions will describe these approaches in detail to show their important features some of which might serve useful in designing an integrated methodology for agrobiodiversity enhancement as management alternative for the uplands.

3.3.1 Agroecology

Agroecology employs scientific research to diagnose problems and propose strategies for alternative low-input management of agroecosystems (Altieri, 1989). It is a synthesis of two disciplines: agriculture and ecology. It aims to provide direction for technological development towards environmental soundness on the assumption that agricultural technologies must ultimately enhance nature rather than replace nature; to work with nature rather than attempt to conquer it (Ikerd, 1993). It recognizes, however, that confronting the environmental crisis resulting from modern agriculture is beyond a mere technological issue. It is an economic, social and political issue as well. From a more philosophical perspective, it advocates *socially equitable technologies*, meaning: 1) socially-activating by empowering farmers with their own development agenda; 2) culturally-compatible by making use of local/traditional knowledge in combination with modern knowledge in improving farming systems; 3) ecologically-sound by making farming and nature complementary yet being able to satisfy food requirements and not merely producing food for profit; and 4) economically-viable by reducing the cost of production through the use of locally-available resources and less use of external inputs (Altieri, 1989).

The focus of agroecology in agricultural development is on the technology generation process. Some of the technologies identified within agroecology include: integrated pest management, integrated nutrient recycling, integrated farming, agroforestry, multiple cropping, and organic farming. It considers agrobiodiversity enhancement or restoring diversity using agricultural resources as a key for operationalizing a sustainable agriculture (Altieri, 1987). The use of agroecological technologies is, however, dependent on how well these are promoted and extended in actual farmers' conditions.

3.3.2 Cropping Systems Research (CSR)

Cropping systems research primarily aims to improve crop productivity in farmers' fields located in specific recommendation domains, like rainfed or irrigated areas in lowland or upland areas. This approach recognizes the following as important for the successful use of alternative agricultural technologies: 1) the *technical feasibility* of the technology or its suitability to the biophysical condition of the area; 2) *economic viability* or its superiority over existing farmers' practices in terms of farm economic profit; 3) *social acceptability* in accordance with farm household goals, needs and wants, as well as within the farm household's resource capability; and 4) *Environmental soundness* on the sloping or hilly areas that are susceptible to soil erosion.

Technologies in cropping systems research may be new crop cultivars, cultural management that either involves crop intensification, crop rotation, crop diversification, land cultivation or management of fertilizer inputs. The core of its activity is the actual testing of these recommended technologies in farmers' fields. The design and implementation of these trials involves thorough investigation of the farm conditions, which includes: 1) identification of a crop productivity problem, description of the biophysical condition that causes the problem, as well as its potential influence on the alternative technology; 2) identification and description of the socio-economic, personal/cultural and political factors affecting the problem and their likely influence on the use of the alternative technology; and 3) the presence of support services for the actual use of the alternative technology (Zandstra et al., 1981; Bureau of Agricultural Research, 1990).

This research is a response to, and improvement of, the weaknesses of the conventional "technology-push" approach in agriculture. This approach integrates technical with economic and social concerns in actual farming conditions. Its scope, however, is limited to crop production. Furthermore, improvement in cropping systems is measured by economic productivity hence many of the technologies recommended are modern rather than the agroecological ones.

3.3.3 Farming Systems Research and Development (FSR/D)

This is an approach to improving existing agricultural systems by means of strengthening linkages between technology generation and extension services. It is a process that attempts to put together research and extension as a continuing and complementary process aiming to make the delivery of agricultural interventions responsive to the needs of farming communities and thus effective for wide implementation. This approach was developed as a response to, and improvement of, the conventional approach to technology generation and extension where modern technologies are massively promoted for the mere purpose of increasing food production. Unlike the conventional approach of "technology–push", the FSRD considers both the bio-physical capability of the farms to sustain productivity and the socioeconomic capability of the farming communities to sustain the recommended farming practices (Shaner, 1982).

The theoretical root of this approach lies on ecology and systems thinking (Schiere et.al, 1999). It is based on the following concepts and principles: 1) *holistic and systems perspective,* which means that any agricultural setting is a system with interacting components and that any attempt to improve it requires an understanding of the system and its components; 2) *multi-disciplinary,* which means that to be able to understand and improve an agricultural system, several interacting disciplines must be involved*; 3) farmer-centeredness,* which means that planning and implementation of any improvement to the agricultural system must conform with the goals and aspirations of the farming community. It should be built upon farmer knowledge and involve their participation (BAR, 1990). This approach started mainly in the tropical agriculture areas and thus has a very strong developing world orientation, and hence its concern with indigenous knowledge and farmer centeredness where decisions on managing the farms must be based on allocation of limited resources. Development of productivity-enhancing technologies must be applicable to farms in similar conditions or in the same recommendation domain (Okey, 1996).

Using a systems framework for its procedure, this approach has the following activities: 1) *characterization and understanding of an agricultural system,* which is considered to have biophysical and socioeconomic components; 2) *identification and diagnosis of problem*s/*constraints* to farm productivity; and 3) *design and testing* of recommended technologies/actions, in order to overcome the problem/constraints and *extension or implementation* (Shaner, 1982). Given the concepts and principles on which it was based, the procedure is further characterized as iterative and interactive making use of a “bottom-up” strategy for its research design. In this process, it is important to understand existing farmers’ practices/expertise and household goals and constraints to production, in order to come up with compatible technologies after a series of tests and evaluations. This process makes use of several tools and techniques for data gathering, usually a combination of methods for technical, economic and social research. This approach was initiated and promoted by international research agencies like Food and Agriculture Organization (FAO) and Consultative Group for International Agricultural Research (CGIAR) in the mid-seventies and is popularly used in several tropical countries up to this time.

While the FSR/D has been in use for more than two decades, it has always drawn strongly from production agriculture (Flora, 1992). As such, the importance of characterizing and understanding the biophysical component is for the purpose of its optimum utilization for increased production. In terms of sustainability, specifically in sustainable resource management, its role is seen to be for the enhancement of the use of alternative practices (Ison et al., 1997; Harrington, 1995).

3.3.4 Agroecosystems Analysis and Development (AAD)

This is a procedure proposed and developed during the mid-1980s, for evaluating agricultural systems and identifying appropriate research and development interventions, drawing from theories and principles of agricultural ecology and human ecology (Conway, 1986). There are at least four concepts that AAD is based on. First, the *agroecosystem concept,* which defines an agricultural system in terms of its biophysical and socio-economic components and so fosters a genuine interdisciplinary approach to the agricultural systems analysis. Second, it uses the *systems concept* as its framework for analysis. Third, *agroecosystem properties* serve as the basic criteria for evaluating the performance of agricultural systems, including: productivity, stability, sustainability, and equitability. Productivity is usually measured in terms of income or yield per unit of area or energy invested. Stability is defined as the degree to which productivity remains constant in spite of normal, small-scale disturbance from the environment, like climate and market conditions. Sustainability is defined as maintenance of productivity in times of stress, which means regular or continuous, relatively small, predictable disturbances, or, larger perturbations which means irregular infrequent unpredictable disturbances. Equitability is defined as the even distribution of the benefits of productivity among a population in a farm, village, region or nation (Conway, 1986). The higher the level in the hierarchy, the greater the dominance of socioeconomic processes, but the ecological processes remain important and crucial in terms of achieving sustainability goals. Fourth, AAD recognizes *trade-offs* between agroecosystem properties, which can be either within the agroecosystem or between the agroecosystem in different hierarchies.

AAD has provided a stepwise procedure for the evaluation and analysis of agricultural systems. The procedure is drawn largely from the analysis of natural ecosystems (Conway, 1990). It relies heavily on the use of different descriptive diagrams prepared in the field from direct observation and through interviews with farmers. The diagrams are used to facilitate communication between researchers and/or development workers for identifying critical problems or opportunities for improving the agricultural system under study. The result of the AAD process is a series of key questions and hypotheses which may lead to either research or development action (Conway, 1986, 1990).

With AAD, the criteria for evaluation, while clearly defined, are not easy to measure and may be subject to bias of the one doing the evaluation, thereby influencing the analysis and recommendations for intervention either in the form of research or development.

3.3.5 Bioeconomic Modeling

The current trend in integrating the different concerns in agriculture is by using quantitative models, which can simulate the performance of an agroecosystem and alternative management options without going through lengthy field trials or experiments. The useful models include: 1) *crop growth/suitability models,* which can predict the interaction between biological species, like crops in their environment (such as soil, temperature, solar radiation and climate) and thus simulate crop performance in varying environmental conditions in the field; and 2) *Bioeconomic models,* which make use of crop growth, ecological, and soil erosion models as sub-models and link these sub-models with economic analysis. Bioeconomic models simulate the effect of different management options, not only on growth performance of crops, but also on the economic returns or profit. This is well illustrated in multi-species agroecosystems like the Soil Condition under Agroforestry Systems (SCUAF). SCUAF predicts the effect on soil of specific land use systems, under given environmental conditions. It can be used to compare agroforestry systems, provides annual simulation of changes in soil conditions and effects of soil changes on growth and harvest. It can also be used for economic analysis of soil conservation to show the consequences of land use with and without conservation (Young, et al., 1998). Water, Light, Nutrient and Resource Capture under Agroforestry Systems (WaNuLCAS) is a model of tree-soil-crop interaction and its efficiency in the use of resources like water, nutrient and sunlight in varying temporal and spatial arrangements (Noordwijk et al., 1999). This model can also be used to provide economic values necessary for cost-benefit analysis of different land use systems. It enables simulation of resource use of different land uses over a period of time and a corresponding economic benefit from each land use. Stocking et al. (1999) developed an integrated model combining a soil erosion sub-model with farm economic analysis. The model aimed to predict the impact of changing soil properties on soil productivity and economic profitability under different land management options.

In bioeconomic modeling, however, economic productivity is often used and assumed as the only factor that influences acceptability of these alternative practices. While it is true that economics is often cited as a primary factor that determines acceptability of alternative practices, there are other equally influential factors in the use of alternative practices (Pannell, 1999; Guo, 1999; Sajise et al., 1996; Fujisaka, 1994). These are usually socio-behavioral factors which are not easily quantifiable and thus may not easily fit into quantitative procedures, like bioeconomic models.

3.3.6 Agrarian Systems Modeling

Agrarian Systems Modeling (ASM) is a recently proposed procedure for evaluating agricultural systems (Bland, 1999). It suggests a “high-order approach” to the evaluation of the food and fiber production system and reconciling this with nature conservation on a wider spatial scale. This model is drawn from Integrated Assessment (IA), a methodological approach for making policy decisions on matters related to global environmental changes (such as acid rain, climate change, land use, gas emissions). An important feature of IA is the use of knowledge from scientific investigation as well as knowledge from different sources within society for policy making with environmental motivation (Gough et al., 1998; Bland, 1999).

Combining technical or scientific knowledge and information from different stakeholders in policy-making in IA is made possible through the development of integrated assessment models (IAM). Like bioeconomic models, IAM are effective for providing scenarios on managing natural resources and their effects on global, regional or national scales over long time frames.

Agrarian System Modeling is a way of applying the concepts of IA to food and fiber production systems (Bland, 1999). IAM have a broad range of concerns from fundamental issues (resource degradation; off-site environmental quality impacts, environmental services of the land) to economic issues (contribution of the system to the regional economy, demands on public infrastructure, return on investment to maintain reinvestment). IAM are also concerned with social issues such as the influence of the workforce on the social structure, and individual farmer attitudes to public concerns regarding adoption of improved practices. IAM also have a wide-system boundary, based on geographical characteristics (such as climate, soil type and land forms) or based on the nature of the enterprise (resource inputs, products sold, ownership management structure). The use of IAM, however, is up to this time limited two cases: the rising water table and salinization in the Murray-Darling basin of Australia, a major irrigated region; and the problem with nitrate contaminated water in the irrigated potato farming industry in Central Wisconsin (Bland, 1999). This shows that IAM is appropriate for large-scale commercial farming in developed countries. Further study and refinement of the model for application to small farm systems in developing countries are needed.

While the creation of IA is viewed as an essential and powerful means for broad participation and understanding between scientist and community (policy makers and citizens), its limitation is in the imbalance in the study of the IA process where emphasis is placed on IAM itself rather than the participatory or political aspects (Gough, 1998). It is also similar to bioeconomic models, as IAM is basically a quantitative procedure and it is inherently biased to quantifiable information (Rothman, et al., 1997). Exclusion of non-quantifiable information can result in inaccurate presentation of actual situations. If IAM are developed for providing objective information (i.e., based on scientific information) for policy making purposes (Gough, 1998; Rothman et al., 1997; Schneider, 1997) then it is particularly important to be aware of the inherent bias in the procedure. IAM, when specifically used for global climate change can be a matter of being an "opaque screen hiding value-laden assumptions rather than a transparent rational tool for policy making" (Schneider, 1997).

3.3.7 Sustainability Assessment

Sustainability assessment emerged as a procedure for evaluating the performance of agricultural systems beginning in the early 1990's following the international endorsement of sustainability as a paradigm for development, by the World Commission on Environment and Development in 1987 (Smith and McDonald, 1998; Smit et al., 1999). Sustainability encompasses the ecological/environmental, economic and social aspects of development making it a multifaceted, multiscalar and multidimensional concept that is difficult to define in operational terms (Smit, 1999; Manyong and Degand, 1995; Zinck and Farshad, 1995; Senanayake, 1991).

Similarly, in sustainable agriculture, it is generally accepted that it has environmental, economic and social dimensions, yet gets interpreted and expressed in different ways as either dominantly-ecology oriented, dominantly economy-oriented or dominantly socially-oriented (Farshad and Zinck, 1993). Because of these varying perspectives, sustainability assessment studies are able to provide pointers on identifying/selecting descriptors of sustainability in agriculture that can be measured (Cornforth, 1999) through useful indicators. Ecology-oriented perspectives provide biophysical indicators that describe the conditions of the natural environment as influenced by agricultural production (Lewandowsky, 1999; Kleinman et al., 1995; Yunlong and Smit, 1994;;Neher, 1992; Budelman et al, 1992; Caporalli et al., 1989). Economy-oriented perspectives provide ways of incorporating economic values of the natural resources used in agricultural production (Tellarini et al.,2000). Socially-oriented perspectives provide indicators that consider the impact of agricultural production on the community or society in general, like health, food security/sufficiency, and unemployment/poverty, aesthetic value of the agricultural landscape and other human dimensions of sustainability (Ikerd, 1998; Gowda et al., 1998; Yunlong et al., 1994).

Other sustainability assessment procedures attempt to provide common descriptors by means of formulating a sustainability index (Gomez et al., 1996; Manyong and Degand, 1995; Senanayake, 1991). Others have provided a general framework for measuring sustainability, like a framework for evaluating sustainable land management (FESLM) (Smyth and Dumaski, 1995; Syers et al., 1995; Gameda et al., 1995) or a matrix for analysis where the ecological, economic, and social aspects can be put together when evaluating sustainability (Smith and Donald, 1998; Stockle et al., 1994). Each method is however different from the other having: their own set of indicators; with different purposes for assessing sustainability; different methods for data collection and analysis ranging from simple to complex, qualitative to quantitative and short or long term; and each varying in scale or level of analysis (i.e., field, farm, community/watershed or national scale). Of all these suggested procedures, not one is accepted as standard and sustainability assessment remains a methodological issue up to this time. Nevertheless, the information, methods and data generated by sustainability studies are useful for evaluating the performance of agricultural systems and alternative management options.

The seven integrated methodologies discussed above maybe different in their step-by-step process yet similar in several aspects like in having holistic perspective, in their attempt to integrate various disciplines in their analysis (particularly the environmental, economic and social aspects) which is leading towards the broader concept of sustainability and in terms of their applicability in different hierarchical levels of an agricultural system. The following subsection, further discuss these similarities and differences, including their strengths and weaknesses in order to highlight the usefulness of these methodologies for evaluating agricultural land uses in the uplands.

3.4 Strengths and Limitations of the Seven Integrated Methodologies: Discussion

Presented in Table 3.1 is a summary of the seven integrated approaches discussed above and analyzed according to the following attributes: the unit of analysis used, which reflects the level of hierarchy addressed; the nature of data gathering methods employed; the extent of concern for the three main components of an agricultural system (ecological, economic and social); and the strengths and weaknesses of each approach in terms of its usefulness as a methodology for evaluating agricultural land use in the uplands.

Agriculture as a system has three main components that reflect the main areas of concern: ecological, economic and social. The ecological aspect emphasizes the relationship between the physical environment and/or the biological components of an agricultural system (specifically the utilization of the natural resources). The economic aspect deals with the performance of an agricultural system in terms of resource allocation and returns from the use of resources. The social aspect includes both personal and institutional factors that influence the structure and management of agricultural systems. Further, agriculture as a system is also subject to a hierarchical organization involving different sectors of the society at various spatial scales. Given this characteristic of agriculture, an approach that is based on systems thinking and uses a systems framework for its analysis is appropriate.

In approaches like Cropping Systems Research (CSR) and Farming Systems Research/Development (FSR/D), as they are drawn mostly from production agriculture, the biophysical aspect of an agricultural system is focused more on the efficient utilization of the natural resources for enhanced production, rather than on a more complementary interaction between the natural resources and the biological species in the system. Hence in Table 3.1 these approaches are considered as having weak (w) ecological concerns, in contrast to other approaches like Agroecology, Agroecosystesm Analysis, Bioeconomic Modeling as well as Agrarian Systems Modeling. This can be attributed to the purpose for which CSR and FSR/D were developed. They were intended to increase economic farm productivity by means of introducing alternative production systems. These two approaches do, however, have strong concerns for the social components of the agricultural system (Table 3.1), and they have integrated into their methodology social factors that will influence adaptation and adoption of alternative production system. As such, the methodological procedure of CSR andFSR/D is both diagnostic (which means that characterization and understanding of production as biophysical and socio-economic is done prior to any experimentation or recommendation) and interactive (which means that the entire procedure entails a side-by-side activity between researchers, extension workers, and land managers/ farmers. These two approaches, especially FSR/D, have been considered as ideal approaches for small farm development. They are widely implemented in developing tropical countries, but lack of concern for the environmental conditions beyond the farm level means they are now viewed as somewhat limited. Nevertheless, methodological procedures in these approaches are appropriate for extending alternative management options that may lead to sustainable production systems.

Fully short of addressing wider environmental concerns, it is not impossible to incorporate them. While their methodological procedure is interactive, their shortcomings are more attributed to their weak interaction with public decision-makers (Figure 3.1.) Vertical integration is from the scientists/researchers down to the land users and/or farmers. As such, institutional factors that may influence wide use of alternative management options, which could only be rectified by top level/public decisions-makers, are not addressed in the CSR and FSR/D approaches In contrasts, the recently developed/proposed procedures for assessing performance of agricultural systems, like bioeconomic modeling (BEM) and agrarian systems modeling (ASM), already have very strong ecological components (Table 3.1). They are focused more on presenting the benefits from resource conservation practices or the extent of environmental impacts of agricultural production practices for decision-making on the farm or policy level.

Table 3.1 Strengths and Limitations of Different Integrated Methodologies in Agricultural Research

Approach	Hierarchical Level	Purpose	Data-Gathering method	Disciplinary Concern			Strengths	Limitations
				Eco	Econ	Soc		
Agroecology	Field, Farm	Offer alternative management options (technology generation)	Scientific	s	s	s	Well-focused on developing alternative mgt practices which are ecologically sound, based on scientific study	Current efforts focus on technology generation hence success in implementation on a wide scale is highly dependent on the delivery system of its research result
Cropping Systems Research (CSR)	Field ;Farm	Improve Farm Productivity through Improved Cropping Systems (Adaptive Research)	Interactive-Diagnostic	w	s	s	Strongly considers socioeconomic circumstances of the farmers in order to enhance adoption of alternative practices; Utilizes interactive methods of adapt gathering	Heavily drawn form production agriculture hence priority is efficient utilization of natural resources for maximum crop yields and farm productivity
Farming Systems Research and Development (FSR/D)	Farm; Community	Improve Farm Productivity through Agricultural Interventions (Research-Extension)	Interactive-Diagnostic	w	s	s	Emphasize Systems Framework for its Procedure and Analysis; Considers both the biophysical and socioeconomic circumstance of the farmers; make use of interactive data gathering methods	Long-term Process; Promise of impact on Adoption of Improved Practices and Increased Farm productivity becomes Evident after Long Period of Implementation;

Approach	Hierarchi-cal Level	Purpose	Data-Gathering method	Disciplinary Concern			Strengths	Limitations
				Eco	Econ	Soc		
Agroecosystems Analysis and Development (AAD)	All Levels	Identify Research and Development Interventions (Exploratory)	Interactive; diagnostic	s	w	s	Provides Systems Framework For Analysis and Implementation; Strongly based on Ecological principles and concept; Uses Interactive Data Gathering Methods	More Often Used For Farm to Community Level Planning; Criteria for Performance Assessment are Difficult to Measure
Bioeconomic Modeling	Field; Farm	Predict Performance of Conservation Practices both Ecologically and Economically (Farmer Decision-making)	Predictive; Simulation	s	s	w	Combines Ecological Models that Show and Predict the Efficiency of Alternative Management Options for Resource Conservation and Integrate with Economic Analysis	Main Consideration of Acceptability is Economic Profitability
Agrarian Systems Modeling (ASM)	Global; Regional; National	Use technical Information for Public Decision-making through Land Use Scenarios (Policy decision-making)	Predictive; Simulation	s	s	w	Utilizes Technical Information for Policy- Making	Top Level; Does not Provide Understanding of the Local Conditions
Sustainability Assessment	Field; Farm; Watershed; Community; National	Varies for Comparison of Individual farms or Practices; For monitoring Impact; Search for Better Alternative	Varies; Quantitative or Qualitative	s/w	s/w	s/w	Able to Provide Guidelines for Selecting and Identifying Ecological, Economic and Social Indicators and Methods for Measuring Sustainability and Methods	Varying Perspectives on Sustainability; No Standard Methodology

In these approaches, as in CSR and FSR, economic aspects of agricultural production are well integrated. These approaches are able to utilize computer-based procedures that test different land use scenarios over long time-frames, in order to simulate and predict changes. However, these quantitative evaluative approaches make it difficult to integrate non-quantifiable, usually socio-behavioral, factors that influence the structure and management of agroecosystems. As such, the determinants of acceptability of alternative options considered are usually limited to economic productivity. Contrary to this, several studies on socio-economic factors influencing the adoption of conservation practices revealed that while economic productivity might be a major factor, farm characteristics, personal attributes, and institutional factors do highly influence the use of conservation practices.

Agroecology, on the other hand, is an approach that is strong on dealing not only ecological concerns, but also social and economic concerns. It aims to provide options that are not only environmentally sound, but also socially equitable and economically viable as well (Altieri, 1987). However, its role is limited to the generation of technologies and thus depends on effective delivery system for the wide implementation of alternative practices.

Agrosystems Analysis and Development (AAD) is likewise among those approaches that deal strongly with ecological concerns. Similar to FSR and CSR, it uses a systems framework for its analysis. Unlike all other approaches though, it is intended to address all levels of the agricultural systems hierarchy (Conway, 1986), yet it is more often used for farm-level evaluation as its means because evaluating performance of agricultural systems are not easy to measure.

3.5 Relevance to the Evaluation of Agrobiodiversity and Land Use in the Uplands

The seven integrated methodologies discussed above are variously relevant to the development of management alternatives for agricultural land uses in the uplands. The integrated procedures coming from the soft systems approach have features that appear more useful for the purpose of this thesis research. While the integrated approaches coming from the hard systems approach, like bioeconomic modeling (BEM) and Agrarian Systems modeling (ASM) are the more popular procedures today, and would indeed be very useful for the development of the uplands in so many ways, their use in this thesis research will be constrained by the lack of baseline and long-term data about the uplands, especially that in the Philippines. Below is outlined the important features of the reviewed integrated approaches that are useful in developing an evaluation procedure for management alternatives in the uplands, as proposed for this thesis research.

As explained in the previous chapter, land use in the uplands has become a central issue in the management and thus, development of the uplands. As such, today, there is a need for more technological options for agricultural land use in the uplands. ***Agroecology***, the thrust of which (Table 3.2) is to generate technologies that are ecologically/environmentally-sound, is very timely for the uplands which, in the case of the Philippines, are the most ecologically-threatened agroecosystems because of the expansion of agricultural production in the frontiers and the use of modern agricultural production techniques. More importantly, agroecology promotes the idea that the best technological options are those that allow the agroecosystem to operate as closely as possible to natural ecosystems. In other words, it promotes ABDE. Given the thrust of Agroeclogy, it serves best as a basis for selecting management alternatives that will be evaluated for appropriateness in the uplands.

Agroecosystems Analysis and Development (AAD) on the other, has devised a stepwise procedure that is useful for a preliminary assessment of an upland area that is targeted for development (Table 3.2). ***Cropping Systems Research*** (CSR) and ***Farming Systems Research and Development*** (FSR/D) are two of the more useful procedure among the seven examined for adapting or verifying the field performance of generated technologies that are introduced in the field. They provide a practical yet scientific procedure for evaluating the performance of agricultural production practices in comparison with existing farmers' practices. The core activity of CSR and FSR (called on-farm trials) serve both as a demonstration of technologies while at the same time verification of the performance of on-station generated research in actual farmers' field condition.

Table 3.2.Different Integrated Methodologies and their Relevant Features for Evaluating Agrobiodiversity Enhancement in the Uplands

Methodology	Important Feature
Agroecology	Technology generation of ecologically-sound production alternatives; Promotes agrobiodiversity
Agroecosystems Analysis and Development	Site assessment and flow or resources within the system
Cropping Systems Research (CSR)	Integration of the socioeconomic aspect of crop production;
Farming Systems Research and Development (FSR/D)	Understanding of the biophysical and socioeconomic conditions in smallholder farming systems;
Sustainability Assessment	Evaluates performance in terms of environmental protection, productivity, and social acceptability

CSR and FSR provide a guide for the description and appraisal of the research site where a given technology will be tested or introduced. Critically, the socio-economic/cultural factors that may affect the performance of the technology on-farm are determined prior to wide-scale promotion/implementation of a new technology. In the case of the uplands, there is at present not enough technologies that are both environmentally enhancing and at the same time in accordance with the socioeconomic needs in the upland communities. The integration of the socioeconomic aspect into the production systems is very strong in CSR and FSR, especially in FSR. These procedures thus have generated methods and techniques for gathering information that enables thorough understanding of the socioeconomic aspect into the production system. These methods are useful for evaluating management alternatives in the uplands.

Sustainability Assessment evolved from the sustainability concept, which gives equal emphasis to the ecological, economic and social aspects of the agroecosystem and served as the foundation for sustainable agriculture. It sets the twin goal of environmental protection/enhancement and agricultural productivity, which is what is needed today in the uplands.

From among the seven integrated approaches discussed above, Sustainability Assessment suits best as basic framework for the procedure for evaluating existing management alternatives for agricultural land use in the uplands

3.6 Summary and Conclusion

The study of food and fiber production as a system requires the integration of various disciplines in dealing with agricultural problems. Evidence of this is the evolution of approaches in agricultural research from single-discipline-oriented research to multidisciplinary, integrated approaches. The integration of various disciplines in these approaches is responsive to the needs of the time. Earlier integrated approaches were concerned with increasing productivity and thus with the biophysical aspects of agricultural production is to maximize its utility to enhance land productivity. In more recent approaches the socioeconomic aspect of production is given importance, especially in developing countries, hence the emphasis on small farming systems.

Today, sustained food supply and hence food security is of prime concern. Protection and conservation of the natural resources necessary in food production is another aspect that has to be added in these integrated approaches. This need is most evident in situations like the upland agroecosystem especially in the humid tropics, where there is a need for environmental protection as well as enhanced production for the well being of the of the upland communities.

Among the seven integrated research methodologies reviewed in this chapter, five have characteristics and properties that are useful for evaluating agrobiodiversity as a management alternative in the uplands. These are: agroecology; agroecosystems analysis and development; cropping systems research; farming systems research and sustainability assessment. This selection is based on their strengths and weaknesses, appropriateness for the conditions in the uplands, data requirements and level of analysis, other resource requirements, and time or duration of investigation. Approaches that involve modeling, which require long-term data apparently, are the least favored options because of the lack of baseline information about the uplands especially about enhancing agrobiodiversity in the uplands. Agroecology justifies the need for agrobiodiversity in the uplands. Agroecosystems analysis and development provides a guide for preliminary assessment and analysis of the conditions in the uplands. Cropping systems Research and Farming Systems Research provides tools and techniques for integrating socioeconomic aspect in agricultural production. Sustainability assessment provides an overall guide for developing framework of indicators for evaluating management alternatives in the uplands.

Agrobiodiversity enhancement is a relatively new concept. It requires different sets of measures and combinations of data gathering techniques to fully understand its appropriateness in complex situations like the Philippine uplands. The reviewed integrated approaches have nevertheless underlying principles, tools, and techniques for investigation that are relevant for the enhancement of agrobiodiversity in the uplands. The next chapter attempts to put these findings together into an alternative methodology useful for evaluating agrobiodiversity enhancement as a management alternative for the uplands.

CHAPTER 4

Developing a Methodological Framework for Evaluating Agricultural Land Use in the Uplands

This chapter addresses, the second research objective, to develop an integrated methodology (incorporating environmental, economic and social indicators) that could be used for assessing agricultural land uses in tropical uplands, in order to evaluate the potential of agrobiodiversity enhancement as a management alternative in the tropical uplands such as in the Philippines;

There are three important considerations that need to be taken into account when developing an evaluative methodology. First, the criteria for evaluating agricultural land uses in the uplands need to be identified, and must encompass environmental, economic and social components of the upland agroecosystem. Second, indicators need to be identified for determining, through use of relevant methods, the environmental, economic and social conditions in the uplands and how these conditions change in response to different agricultural production systems. Third, the level of evaluation needs to be carefully considered so that the application of criteria and indicators provides useful results that can be used for assessing the potential for enhancing agrobiodiversity in the uplands.

In this chapter, a methodological framework is developed that contains a set of environmental, economic, and social criteria, indicators, and data gathering methods for conditions under differing agricultural production systems in tropical uplands, especially those in the Philippines. First discussed are the broad concepts that guided development of the methodology. They provided a basis for selecting the criteria, indicators, and data-gathering techniques. Discussion of these concepts is followed by a framework of criteria, indicators and techniques, which highlights the data and information that need to be gathered, in order to evaluate agricultural productions systems in upland areas. More particularly, the methodology is aimed at determining the influence of agrobiodiversity on not only the protection of natural resources, but also productivity. As well, the methodology aims to highlight social factors that influence farmers’ choice of production systems. This information can then be used to assess the potential for agrobiodiversity enhancement practices in tropical uplands.

4.1 Conceptual Basis

The evaluation of seven approaches to agricultural research in Chapter 3 suggests that understanding agricultural land use in the uplands and evaluating management alternatives for upland agriculture will be more appropriately achieved through use of an holistic integrated procedure that covers the environmental, economic and social aspects of the production systems. For these reasons, three interrelated concepts will be used as basis for developing the methodology for evaluating agrobiodiversity enhancement as a management alternative for upland agriculture. These concepts are sustainable land management (Smyth and Dumanski, 1995), the agricultural systems hierarchy (Spedding, 1996; Lowrance et al.,1986), and the six areas of concern in agricultural production outlined by Cornforth (1999).

The concepts of sustainable land management and the areas of concern in agricultural production are a more focused means of dealing with the broad concept of sustainability. Sustainability as a concept is multi-faceted, multi-dimensional, and multi-scalar and subject to time variability. Each scientific discipline contributes to the definition of sustainability and each user group adds a different dimension to the concept. Dimensions, in turn, are scale-dependent and vary with time and space (Zinck and Farshad, 1995). This is the reason why sustainability in agriculture is referred to and assessed in different ways. This is also the reason why sustainability assessment, in agriculture, up to this time, is a continuing exploration process.

The concept of sustainable land management provides a common perspective by focusing on the management of the land for food and fiber production through the five evaluative criteria in section 4.2.1: productivity, security, viability, protection and acceptability.

On the other hand, the six areas of concern concept in agricultural production attempts to improve clarity over the application of the sustainability concept in agriculture, particularly on assessing sustainability. It provides a guide for selecting indicators for assessing sustainable land use, including inputs for production, influences on production, and influences of outputs from production, influence on product value and product value. These are elaborated on in section 4.2.3.

The agricultural systems hierarchy concept stems from the ecological theory of organizational hierarchy (Odum, 1983; Lowrance et al., 1986; Lowrance, 1992; Ikerd, 1993;, Conway, 1990;1997). It is applied in economics, natural and social sciences, and is viewed as a scientific way of assessing a phenomenon or an activity from the same perspective in terms of space (hierarchical level) and time (long-term and short-term) (Giampetro, 1994). Its application in agriculture research goes hand-in-hand with the recognition of systems perspective/approach in dealing with agricultural problems. Its application in tropical agriculture was at its peak when farming systems research and development was introduced in the 1980's. Today, its application in sustainability assessment is also recognized as crucial. Either sustainability assessment must be done in wide range of scales (Izac and Swift, 1994) or at one particular level (Lewandowsky et al., 1999; Guo, 1999; Manyong and Degand, 1995; Dalsgaard and Official, 1997; Kirkwood and Dumanski, 1999; Neher 1992). Its relevance for developing a method for evaluating agrobiodiversity enhancement is outlined in sub-section 4.4.2.

The following sub-sections further describe the above three concepts (sustainable land management, agricultural systems hierarchy, and areas of concern) and their value in developing a methodology for evaluating agrobiodiversity enhancement in the uplands.

4.1.1 Sustainable Land Management Concept

The concept of Sustainable Land Management (SLM) proposes performance over a period of time rather than suitability as the basis for evaluating land use (Smyth and Dumanski, 1995). SLM is defined as technologies, policies and activities aimed at integrating socioeconomic principles, with environmental concerns, in order to achieve the following goals simultaneously: to maintain and enhance productivity; to decrease risks to production; to protect the potential of natural resources and prevent degradation of soil and water quality and; to be economically viable and be socially acceptable (Smyth and Dumanski, 1995). SLM reflects holism and integration of the different components of a given system. It is concerned with the output, as well as the long-term preservation of the natural resources for continued production in a way that is acceptable, economically viable and environmentally sounds (Lefroy, et al., 2000).

The definition of SLM (sustainable land management) provides five criteria for evaluating the performance of a given system. The criteria include: productivity, security, protection, viability and social acceptability.

Productivity

The primary concern and purpose of any production system is productivity. As one of the sustainability goals, this refers to the capability of the system to continuously produce outputs of desirable quantity and quality to both the producers and consumers. In most cases this is measured by agronomic and farm economic yield. The most crucial factors that affect productivity are the biophysical conditions of the farm units and the management techniques used by the farmers.

Security

This refers to the capability of the farming system to remain productive in spite of biophysical and socioeconomic disturbances. Biophysical factors that are crucial to security may include occurrence of natural calamities. Socioeconomic stress may include market failure or a glut in the market.

Viability

This refers to the capability of the farming system to produce at the level that is economically satisfying to the land users. This is usually measured by the short-term and long-term economic profitability of the production system.

Protection

This refers to the capability of the system to produce without degrading the natural environment. This is a major concern especially in sustainable agriculture after realizing the adverse effects of specializing agricultural production on the terrestrial, atmospheric and aquatic resources.

Acceptability

This is the desirability of the production system to different stakeholders, from the farm through to community, national and global level. Land use methods are expected to fail in time if their social impact is unacceptable. Populations most directly affected by social and economic impact are not necessarily the same.

The five evaluation criteria under the SLM concept correspond to the environmental, economic and social issues that need to be included for comparing different agricultural land uses in a sloping area. The protection criterion will help to determine the influence of agrobiodiversity on the natural environment, particularly soil condition, which is critical for the tropical uplands. The productivity, security and viability criteria help to determine the influence of agrobiodiversity on the economic aspect of agricultural production in a given sloping area. Further, the acceptability criterion corresponds to the social factors, including characteristics, perceptions and choices, that most likely influence the way production systems are managed in the tropical uplands.

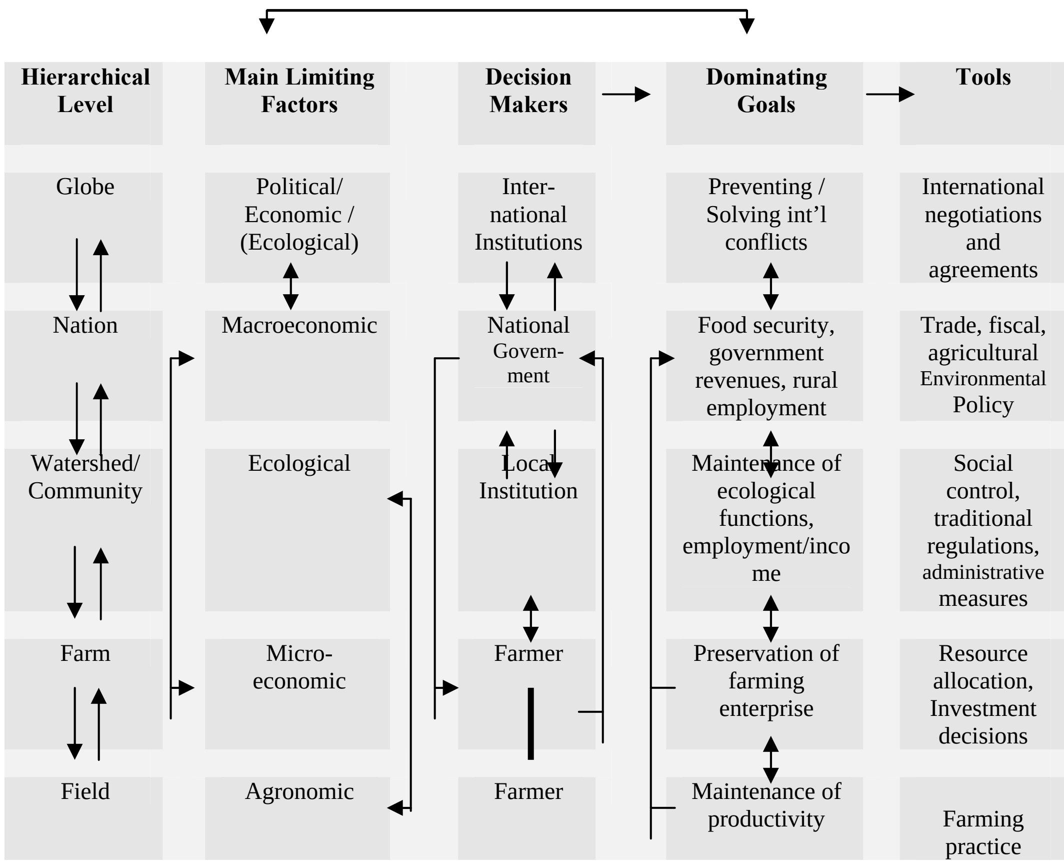
These five criteria, however, provide only the general basis for an evaluation. The specific parameters needed to measure each criterion and the methods for measuring them are the more important points that must be included in the development of a generic evaluation methodology. It is also necessary to determine the spatial level at which the entire evaluation may be conducted. These matters are discussed in section 4.3 and in its subsections.

Below are discussions and further elaborations of the other two concepts that serve as a general basis for determining the spatial level of the evaluation and analysis, and for the identification of indicators for each of the five SLM criteria. These are the agricultural systems hierarchy and the areas of concern in agricultural production, respectively.

4.1.2 Agricultural Systems Hierarchy Concept

Food and fiber production can be organized in a hierarchical and spatial way. It ranges in level from the field-plot, farm, watershed or community, national, regional to global (Hess et al., 2000; Herzog et al., 1998; Spedding, 1976; Lowrance et al, 1986; Smith and Donald; 1998; Conway,1990). The hierarchy concept sets the spatial boundary in agricultural systems. It thus provides a clearer picture of the main concerns and goals and major actors involved in decision-making on land use and management. In spite of the spatial boundaries, there is interaction among the different levels. Understanding agricultural systems in a hierarchical context also illustrates the degree of integration and involvement of the economic and social aspects of the production system that vary at each level (Lowrance et al., 1986; Izac, et al., 1994).

Figure 4.1 suggests that the basic unit of the food and fiber production system is at the field level (bottom left corner of the chart). At this level, concern is focused on land productivity. Constraints to sustainable production at this level are, therefore, agronomic in nature. This would include soil condition or microclimate that directly affects plant or animal growth. The biological, chemical and physical processes that affect the growth and performance of the crops (or animals) are, however, the most important constraints. Sustainability at this level refers to the ability of the piece of land to maintain acceptable levels of production over a long period of time (Lowrance et al., 1986; Smith and McDonald, 1998). At the field level, integration of the economic and social aspects of the agroecosystem is nil as human involvement is exogenous or external to the system (Izac, 1994).



Source: Herzog and Gotsch, 1998.

Figure 4.1 Hierarchical Levels in Agricultural Systems.

The next level, the farm system, consists of several fields/plots. The ability to maintain productivity of each of the field/plots determines its sustainability (Lowrance et al., 1986). The farm is the basic economic unit in the hierarchy of the agricultural systems. The predominant concern is the socioeconomic viability of the production system. This is the smallest unit where the ecological, economic and the social aspects of the agroecosystem are integrated. Smith and Donald (1998) suggest the following as sustainability indicators at this scale: farmer management skills, access to information, attitudes and perspectives on conservation, and conservation incentives.

Figure 4.2 illustrates the decision-making process on land use management at the farm level. It shows how the process affects or is affected by environmental, economic and social factors beyond the farm boundaries or other levels of the hierarchy. In the uplands of the humid tropics particularly in the Philippines, smallholder-farming systems dominate. As such, management of natural resource is in the hands of the small farmers. Thus, decisions at the farm level are as important and as critical as decisions at the higher levels of the hierarchy, i.e., community or national level.

The aggregate of farms and other land uses in an area comprise the community or watershed level (Figure 4.1). This is also referred to as the agricultural landscape level (Lowrance et al., 1986). Sustainability at this level is determined by the ability to maintain life support to a larger spatial scale over a longer period of time. It is at this level that the agricultural carrying capacity of an area may be determined.

Hence, the relationship between populations, farm productivity, and diet may be quantified. Farms acquire goods and services from using the environment, like the forests, rivers, and streams. Sustainability at this environment level is needed for sustainability at the field and plot level (Lowrance et al., 1986). It is at this level where the social, economic and cultural factors interact very powerfully with biological and physical processes. Smith and Donald (1998) suggest further that at the watershed level, management of natural resources (e.g. drainage, ground water or surface water quantity and quality, habitat biodiversity and connectivity as well as flora and fauna conservation needs) are the most important concerns.

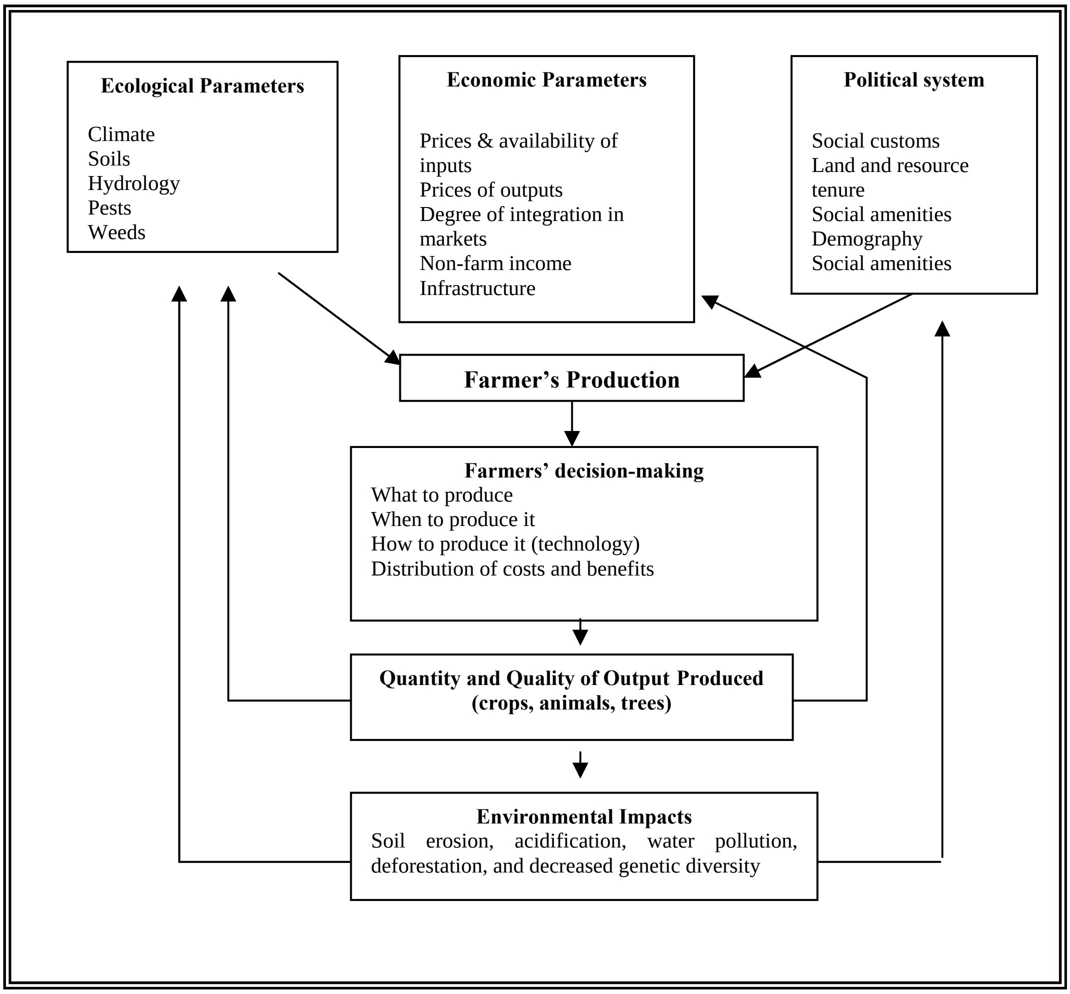


Figure 4.2. Integration of Factors from Higher and Lower levels at the Farming System Scale by the Process of Decision-making (Izac et al., 1994).

At the national level, governance, institutional arrangements, legislative frameworks and policies are important considerations (Figure 4.1). Fiscal and monetary policies of the government determine the focus and structure of the national economy, and thus, the ability of the national agricultural system to feed its population. At this level, wider socioeconomic concerns predominate, where national food sufficiency ranks as an important concern. Sustainability indicators, therefore, need to include measures of employment, social equity, technology base, land use control, and population pressure (Smith and Donald, 1998).

In spite of the varying levels of hierarchy in an agricultural system, the spatial boundaries are collapsible (Lowrance et al., 1986) or decomposable (Giampetro, 1994). This is due to interaction of the systems at different levels and the fact that while a system at one level is a whole in itself, that system under study is still part of a bigger system (Lowrance et al., 1986; Giampetro, 1994).

The hierarchy concept provides a way of understanding how agricultural systems operate and highlights the factors that constrain or facilitate sustainability of the production system. The concept provides a basis for scoping and focusing the assessment to, and on the level that will be of most relevance to the part of the system being investigated.

Ideally, sustainability assessment would transcend all the levels in the hierarchy, but such an assessment would be very complex. Focusing on one level may enable a feasible assessment to be undertaken. It is, therefore, necessary to clarify the spatial scale or the hierarchical level in doing an evaluation for sustainability assessment.

In developing a framework and methodology of use in evaluating production systems in the upland areas of tropical countries, the complexity of the task is reduced by focusing at the farm level. This is justified because in general, smallholder farming systems dominate in upland areas and decision-making on agricultural land use primarily depends on small farmers.

4.1.3 The Concept of the Six Areas of Concern in Agricultural Production

If the general criteria and the spatial scale of the evaluation procedure were drawn from the concepts of sustainable land management and agricultural systems hierarchy, respectively, then the indicators for measuring protection, productivity, security, viability and acceptability will need to be selected from the range of possible indicators of the kind categorized by Cornforth (1999) in his six areas of concern of agricultural production.

Indicators are qualitative and quantitative variables that can be used to describe the physical, economic and social environment within which the land management system operates (Neave et al., 1995). Indicators not only measure the system's condition (Hess et al., 2000), but also the status or change in sustainability (Syers et al., 1995; Smyth et al., 1995).

Cornforth (1999) proposed the area of concern concept to help facilitate the selection of indicators for assessing sustainable land management. The term "area of concern" is defined as any factor able to influence the ability of a production system to achieve sustainable land management (Cornforth, 1999). These factors are summarized below and their relationships schematized in Figure 4.3.

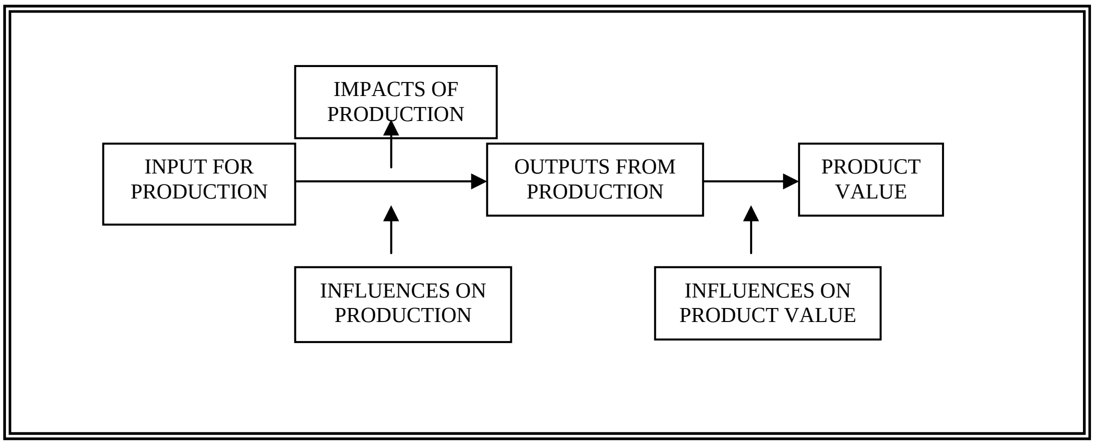


Figure 4.3. Areas of Concern in Agricultural Production (Cornforth, 1999).

Inputs for Production

Inputs for production include all biological and physical resources required in farm production. These are land, labor capital/material inputs as well as skills required in production.

Influence on Production

These are biophysical and social conditions or circumstances that determine the continuous productivity of the system. Included here are climate, weather, soil quality, water quality, pests and diseases, attitudes and legislation.

Influence of Production

This refers to the impact of production on the ecological, economic and social aspects of the system. These include impacts of production on the quality of the soil, water, air, landscape, local and international economy or livelihood.

Outputs from Production

These include the product, by-product, waste products and the nutrients provided by the products.

Influence on the Product Value

These are factors that are economic, social and market-oriented. This may include quantity and quality of the produce, demand and acceptance for the produce, ability of the consumers to pay for the produce, transport and marketing facilities that facilitate delivery of the products to the consumers.

Product Value

This refers to the economic value of the product in the system.

Classifying sustainability indicators into these areas of concern provides a systematic way of grouping the numerous indicators that can possibly be used for measuring sustainability. All factors that may fall under each category could influence sustainability, but only a few would seriously affect the system at any one time (Cornforth, 1999). The concept allows consideration of all the identified factors and selection of the most critical ones.

While Cornforth (1999) originally intended to provide the area of concern concept to facilitate selection of sustainability indicators, the definition of the term “area of concern” implies a broader use in sustainability assessment. In developing the generic evaluative methodology, Cornforth’s “area of concern concept” is used for not only selection of sustainability indicators at the specified spatial level, but also further identifying factors beyond the level being evaluated that influence agrobiodiversity of land use. This is further elaborated on in the discussion of the evaluation methodology in the following section.

4.2 Drawing on the Concepts for Developing the Evaluation Methodology

Understanding of agricultural land use and thus, appropriate evaluation of management alternatives in the uplands is best achieved through a holistic integrated methodology. Figure 4.4 illustrates the important components of a methodology for evaluating management alternatives in the uplands.

This methodology is an integration of the three broad, but interrelated, concepts presented earlier. The SLM concept will set the goal for the evaluation so that the ecological, economic and social aspects of the upland agroecosystem are equally considered. The hierarchy concept will show the varying levels or spatial scales at which the assessment can be made, and at which varying perspectives on sustainability apply. There will be five criteria suggested by the SLM concept namely protection, productivity, security, viability and acceptability. Indicators for each of these criteria will be selected from the range of indicators classified under the six areas of concern in agricultural production.

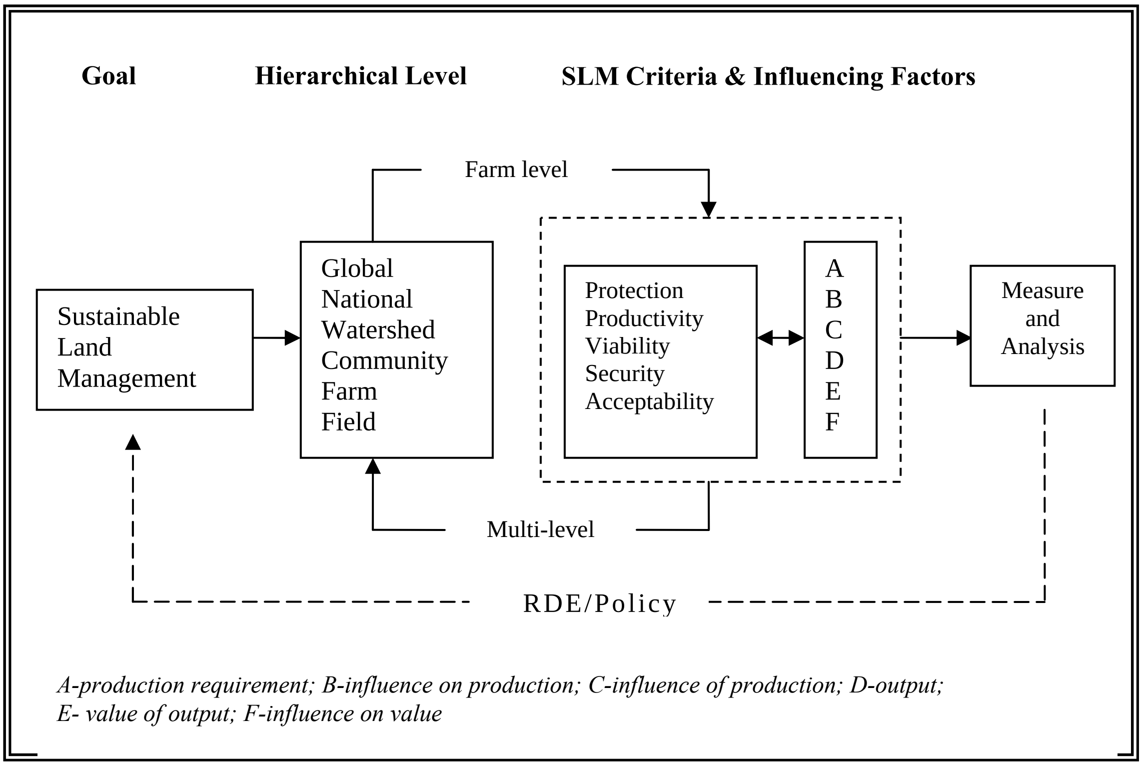


Figure 4.4 Important Components of the Methodology for Evaluating Agricultural Land Uses in the Tropical Uplands

As already noted, the farm level is the point in the agricultural systems hierarchy at which development of the generic methodology is being focused. The farm level is the first stage in the spatial hierarchy where there is clear integration of the ecological, economic and social aspects of the system. In the case of the Philippine uplands, the ultimate decision-makers on agricultural land use are small farmers. A detailed assessment at this level will likewise show how management alternatives influence and are influenced by other factors outside the farm boundary.

4.3 Criteria and Indicators

The aim of the evaluation is to determine if enhancing the diversity of agricultural land use in the uplands (specifically through the integration of perennial cash crops with annual cash crops) is: protective of the soil (the natural resource base for agricultural production), economically productive, and acceptable to the land users. The five criteria suggested by SLM can be used to achieve this aim. Each criterion can be measured using the suggested indicators. The suggested indicators in the study that a preliminary field study and documentary search might suggest are most relevant to smallholder farming systems. Drawing on experience in the Philippines, an exemplar is provided in Table 4.1. The selected indicators are discussed under each of the five criteria in turn below.

4.3.1 Protection

A sustainable land management is one that contributes to, or enhances, environmental protection while at the same time maintaining or improving agricultural production. The measure of environmental protection in this methodology will be limited to protection of the soil, the natural resource base for agricultural production, and soil quality. Soil quality is complex because of its physical chemical and biological properties. Soil quality indicators are therefore limited to the following:

Thickness of Topsoil

Loss of topsoil is an important concern in sloping areas. Sloping areas are naturally susceptible to the downward movement of the soil surface. This is even more aggravated when soil is subjected to frequent disturbances such as cultivation, without the necessary soil conservation practices.

Loss of topsoil has undesirable consequences both for agricultural productivity and the environment. Its immediate effect is on plant growth. Soil loss can adversely affect plant growth because it reduces the availability of water and nutrients. It also restricts rooting depth as the soil surface thins out. Soil loss also has a long-term effect on agricultural productivity because it can result to the loss of organic matter thereby reducing soil quality (Lal, 1998; Pimentel et al., 1993). Soil loss can also have off-site impacts such as those that occur when run-off and sediments from one field, watershed or waterway enter another (Lal, 1998). These pollute and destroy other natural resources, usually water bodies, thereby reducing their usefulness and disturbing/adversely affecting the productivity of aquatic systems (Pimentel et al., 1993).

Soil Organic Matter Content

The most important measure of soil quality and, thus, the condition of an agroecosystem is soil organic matter (Wood et al., 2000). It is an indicator not only of the current productive state of an agroecosystem, but also of future productive capacity. Organic matter highly influences the physical, chemical and biological properties of the soil (Lal, 1998; Pimentel,et al., 1993). Other than the productive capacity of the agroecosystem, organic matter has an equally important role in serving as either a sink or source of carbon and nitrogen that influences the gaseous composition of the atmosphere (Keeney, 1997).

Table 4.1 Selected Indicators for SLM and their Importance in Upland Agricultural Land Use as Exemplified in the Philippines.

Category	SLM Criteria	Indicators	Rationale/Importance
Environmental	Protection	Soil Organic Matter	Soil Organic Matter is the most important indicator of soil quality. It has an important role not only in productivity but also in soil conservation.
		Depth of Topsoil	Sloping areas are most susceptible to soil loss especially with frequent cultivation.
		Soil Nitrate	Nitrate accumulation in the soil is a potential pollutant to water resources, trend in cash crop production in the uplands involves heavy use of nitrogen fertilizers.
Economic	Productivity	Crop Yields	Crop species diversity is a way to enhance biodiversity of the upland agroecosystem. The total amount of crops produced per unit of land per unit of time is a basic measure of land productivity at the farm level.
	Security	Occurrence of Crop Failure	A management alternative that is able to keep the land productive is advantageous over production areas that are likely beset by uncertain biophysical (natural calamities) and market (unstable price conditions

Category	SLM Criteria	Indicators	Rationale/Importance
	Viability	Farm Economic Profitability	Another basic measure of land productivity at the farm level is the economic returns obtained from the capital, labor and materials invested. A management alternative that provides long-term profit is required of an agroecosystem where productivity is threatened by land degradation due to agricultural production.
Social	Farmer Acceptability	Farm Attributes Farmer characteristics Farmer Perceptions and Choices	Ultimate decision-makers in agricultural land use in the tropical uplands are the farmers. Management Farmers choose alternatives that meet their goals, aspirations, attitudes, perceptions/beliefs; practitioners and/or adopters of management practice may differ from the non-practitioners and/or adopters in terms of characteristics, circumstances, attitudes and perceptions.

The primary cause of decline in soil organic matter is land conversion into agricultural production. This is due to the decline in litter formation and oxidation of organic matter due to tillage and soil erosion (Wood et al., 2000). However, studies also reveal several ways in which the amount of organic matter in the soil can be rehabilitated or maintained. The loss of organic matter in the soil is a form of chemical degradation that is reversible, but entails significant cost (Scherr, 1999).

Different agricultural management practices cited by various authors can enhance or maintain organic matter content in the soil. These include application of green and animal manure, reduced tillage and reduced application of inorganic fertilizers, maintenance of soil cover and diversifying crop production (Doran et al., 1996, Fernandes et al., 1997, Gruhn et al., 2000).

Soil Nitrate

One of the most important uses of the uplands is that it serves as a watershed. Watersheds protect the natural sources of water in the uplands. The trend towards production of cash crops in the uplands has led to the use of agrochemicals, especially nitrogen fertilizers that can potentially pollute these natural sources of water. A management alternative that contributes, rather than prevents this from happening is unsustainable.

Nitrate is an essential nutrient requirement for plant growth. It is the source of nitrogen to form plant protein that becomes protein sources for humans and animals. Adequate amounts of nitrogen are needed for plant growth. When there are excessive amounts, nitrogen, leaches into the groundwater or run-off into surface waters. Balance of nutrients in the soil is a key feature of soil quality. To ensure efficient crop production and minimize environmental contamination soil nutrient balance is necessary (Cihacek, et al., 1996).

Agricultural management practices have proven able to serve as effective mechanisms for reducing, if not totally preventing, accumulation of nitrates in the soil (Sainju et al., 1999; Guo et al., 2001; Diez et al., 2000; Puckett, et al., 1999). A relevant finding showed that integration of fast growing and deep-rooted trees into the agricultural system reduced the amount of nitrate accumulation in the soil. The advantage of integrating trees into the production system is attributed to the rooting system of the trees which is able to absorb nutrients beyond the rooting zones of the food crops to which added fertilizers are intended (Jama et al., 1998; Hartemink et al., 1996).

4.3.2 Productivity

Agricultural systems are used for food and fiber production, thus the basic measure for productivity is quantity and quality of agricultural output at a given time. An indicator for this criterion is:

Agronomic Yield

Agricultural land use in the uplands often involves crop production thus crop-yield will be used as the basic indicator of productivity. This criterion refers to the quality and total quantity of crop harvested during the last cropping season during the year. Total quantity of crop yield will include harvests from the primary crops and secondary crops. Quality includes the harvested product, which could be sold in the market or the marketable yields.

4.3.3 Security

This criterion is related to productivity. Agricultural systems are beset by several disturbances, which are biophysical/environmental and socioeconomic in nature. As defined earlier, security is the capability of the system to remain productive in times of biophysical or socioeconomic disturbances. Examples are drought, excessive rainfall and typhoons, which can cause loss in harvest and market glut, which can cause unstable market price for the produce. These factors most adversely affect the small farmers. Security of production can be measured by determining the occurrence of crop failure due to these factors.

Occurrence of Crop Failure

This refers to frequency of harvests and farm income losses due to the abovementioned natural and human-induced disturbances.

4.3.4 Viability

Another criterion related to productivity is viability. This criterion refers to economic viability and, thus, will be determined in terms of farm economic profitability. A sustainable land management is one that is not only currently productive, but also promises future productivity.

Farm Profit

Indicators for economic viability will be estimated by current profitability at the farm level. This is estimated by the value of the land through gains/benefits obtained from the production system.

4.3.5 Acceptability

The acceptability criterion corresponds to the social component of the upland agroecosystem. There could be different ways to view and analyze acceptability. One is by looking at the social impact of the land use system on the farm householders and to the farming community (Guo, 1999; Smyth and Dumanski, 1993; Neave et al., 1995). Another way, which is often used, is by determining factors that influence adoption of agricultural innovations (Lefroy et al., 2000; Craswell et al., 1998).

As such there are a number of suggested acceptability indicators. Some of the suggested measures of farmer acceptability are: profitability to the farmers, farm workers and farming community (Gerritts et al., 1996; Cary, 1997; Nelson, 1998; Guo, 1999; Panel, 1999; Scherr, 2000). Beedel et al. (2000) and Makokha et al. (1999) argued farmer characteristics influence farmer adoption of agricultural innovations because of the association of some personal characteristics with exposure to conservation practices and their benefits. Similarly, Ervin et al.,(1982) and Ayuk (1997) found that personal characteristics influence adoption because of its association with farmers' receptivity to wider ranges of agricultural production practices. Farmer characteristics also are associated with their perceptions and awareness on environmental degradation leading to their adoption of innovations particularly conservation practices (Taore, 1998; Sinder et al., 1990).

Other recommended indicators are those that reflect the quality of life, food security, and nutrient requirement (Manyong et al.,1995) and standard of living over time (Ellis and Wang, 1997). Neher (1992) suggested that acceptability indicator must reflect the well being of the environment

Based on these previous works, indicators of acceptability should reflect: 1) the well-being of the farmers and their households; 2) the well-being of the environment; and 3) factors that will likely influence adoption of innovations. At the farm level, acceptability indicators should be specific to farmer acceptability, and thus would include the following:

Farmer Characteristics

Age, gender, educational attainment, experience in farming and leadership or position in the village are among the indicators that could be included. Previous studies used farmer' attributes of the farmers as determinants of adoption of soil conservation innovations in the Philippine uplands. For example, gender and age become important factors to adoption if the innovation being introduced requires strenuous work (Cramb et al., 1999).

Farm Attributes

Land Tenure status or Land ownership is important. Studies on improvement of upland agriculture showed that farmers are less likely to adopt an innovation if they do not have secure land tenure (Fujisaka, 1994; Sajise and Briones, 1996). Commonly, the landowners and not the tenants benefit from the long-term effects of innovations in the uplands. Also, construction and use of conservation practices also depend on the landowners' approval. This is the reason why land tenure or tenancy agreement is an important indicator of acceptability of agrobiodiversity in the uplands (Cramb, 1999). This is especially true if agrobiodiversity enhancement involves planting of permanent crops.

Size and location of the farms will also serve as important indicators of acceptability. Cramb (1999) realized that farmers with larger farm size are more receptive to soil conservation practices. Furthermore, farmers, whose farms are far from the roads and houses, are less likely to adopt soil conservation practices. Choice of crops to be planted is also dependent on distance between farms to roads and market. Farmers tend to plant more permanent crops if farms are far from the market roads and tend to plant more annual crops if close to market roads (Sajise and Briones, 1996).

Farmers' Perceptions about Farming in the Uplands

This refers to the farmers' perceptions of the influence of their farming practices on the health of the environment and health of the farm workers. Measure of farmers' health will be limited to incidence of agrochemical poisoning among farm workers. Encroachment of modern agricultural production in the uplands entailed intensive use of agrochemicals. There is no evidence showing a direct relationship between chronic diseases and the use of agrochemicals. However, one of the more direct effects of the use of agrochemicals is poisoning. This could be manifested by nausea, vomiting or fainting immediately or hours after application to the crops. Incidence of poisoning could thus be verified from the farmer respondents.

Farmer perception of the influence of farming on the environmental degradation in the area is also determined by their awareness of environmental problems in their area and probable cause of these problems. Perceptions on environmental problems and the benefits from soil conservation practices are considered as important factors that determine adoption of these practices in the Philippine uplands (Cramb et al., 1999).

It would therefore be helpful to probe further farmers' reasons for managing their productions systems. This can provide insights on factors other than farm-level factors that influence or constrain agrobiodiversity in the area. Information can be directly elicited from the selected farmer respondents or key informants.

4.4 Data Gathering Methods

Having presented the theoretical basis, the criteria and indicators necessary for evaluating production systems in the uplands, in the previous sections, (sections 4.3 and 4.4), it is now necessary to identify the methods that can be used for gathering information about the ecological, economic and social aspects of agricultural land use in tropical uplands to complete the methodological framework that is being developed in this chapter. A framework that encompasses the range of methods and techniques appropriate for this purpose is provided in this section and encapsulated in Table 4.2. Which method or technique is chosen for a particular task depends on resources available and skills of the user. There will be situations where multiple methods and multiple means can be applied providing a richer understanding of the phenomena in question.

4.4.1 Initial Assessment of the Research Site

Rapid Community Appraisal (RCA)

A rapid assessment of the site should be conducted to provide: a general picture of the biophysical and socioeconomic condition of the selected study area; a general description of the different agricultural land uses in the area; and an initial description of the management practices in agricultural production. There is now a number of sources and information that explains RCA methods and techniques (Chambers 1994;Selener et al., 1999; Shaner, 1982). In summary, the RCA may involve a transect walk with a local agricultural officer or with a farmer guide, ocular observation of the area, non-formal interviews with key informant farmers (e.g. farmer leaders) regarding their production practices (including cropping pattern, cropping calendar, production management practices, marketing system) and a group discussion with the older members of the community to account for the historical background of the production systems. Secondary data about the site and the production systems could also be collected from government offices, such as the provincial, municipal and village level. A thorough ocular inspection of the area would be helpful to validate information during the key informant interviews. It is always best to select key informants who are active in farming in the area.

4.4.2 Biodiversity Measurement in an Agroecosystem

Measuring biodiversity in agroecosystems is not usually done in agriculture research although a range of indicators can be used like microorganisms, plants and animal species, depending on the level of investigation, i.e., at the genetic, species and ecosystem level. Since farm-level evaluation is the focus of the generic methodology under development, plant species as the indicator of biodiversity could be used, specifically plant species diversity, as the interest of the assessment is on agricultural production the uplands.

Plant species diversity can be measured by obtaining plant species, number and type of plants in a given area. These can be identified and counted using standard procedures used in plant ecology like the belt transect technique or the quadrat technique (Brower et al., 1990). From these data can be derived a quantitative measure of the diversity of the agroecosystem using the Shannon Diversity Index or the SDI (Brower et al., 1990).

An alternative way of plant species diversity of the production system is by simple ocular inspection and identification of multiple-species agroeocosystem. While this method is very practical as it will also identify the planned (purposely planted like crops) and the unplanned (like the weeds) plant species in the system, this will not provide as much detailed information when one needs a quantified measure of plant species diversity in the area.

4.4.3 Measuring Environmental Protection

The major interest here is protection from land degradation with soil fertility, soil loss and soil nitrate as the major indicators. These may be measured using standard procedures and field techniques for characterizing soil properties that involves soil sampling and laboratory analyses for each soil characteristic (Brown, 1999; de Vries et al., 1998; Doran et al., 1996; Haverson et al., 1996)). An alternative method for determining soil characteristics is the use of rapid test kits (University of the Philippines Los Baños,, 1980). Another is the descriptive method which makes use of the physical appearance of the soil (e.g. color of the soil, taste, stoniness) or presence of organisms (e.g. earthworms; nematodes) to determine fertility, acidity and other characteristics (Lal, 1994). The use of any of these methods though depends on ones expertise and availability of resources.

Measuring Productivity

The main interest here will be land productivity which will be indicated by crop yields. Crop yields could be measured through experimentations, where cropping systems trials would be established in experiment stations or in farmers' fields. In farmers' fields, crop-cut techniques (BAR, 1990; IRRI, 1983; Gomez, 1984) could be done which might entail destruction of farmers' crops. An estimation of harvest (crop yields) could also be obtained through formal and non-formal surveys, use of secondary information and long-term records may also

Table 4.2 Methods and Techniques for Gathering Environmental, Economic and Social Data for Evaluating Agricultural Land Use in the Tropical Uplands.

Research Phase	Data Gathering Methods	Remarks
Initial Site Assessment • Rapid Community Appraisal (RCA)	1.Collection and Review Secondary Data; and 2. Key informant (KI) and Key Informant Panel Interview (KIP); and 3. Ocular inspection of existing agroecosystems	An understanding of the biophysical and socioeconomic conditions in the area and initial understanding of the production systems in the area is necessary and could be obtained through these methods;
Assessment of Plant Species Diversity of the Agroecosystem	1. Simple Identification of Multi-Species Agroecosystems (by ocular inspection); and/or 2. Measure Pant Species Diversity and Estimate Plant Diversity using Shannon Index (using Standard Field Measurement for Species Diversity like Quadrat Technique; Belt Transect Technique and others)	Mere inspection and identification of the agroecosystems in terms of its species composition will provide information enough to describe agrobiodiversity of the production system but using a quantified measure of agrobiodiversity i.e plant species diversity might be useful not only in describing the agroeocsystem but will also be useful for further analysis especially if statistical procedures might be sued to determine interaction between species diversity and other properties/characteristics of the production systems.
Assessment of Natural Resource Protection • Soil Fertility	1. Field Techniques for Measuring Soil Characteristics (through Random/Composite Soil sampling and Laboratory Analysis); Or 2. Measure Basic Soil characteristics using the Rapid Test Kit (e.g. UPLB rapid soil test kit for	A number of methods for determining soil quality may be used depending on expertise, time and resources available. Standard procedures that involve soil sampling and laboratory analysis are more expensive and

Research Phase	Data Gathering Methods	Remarks
	N,P,K, OM and pH); Or 3. Descriptive Method where rating scale is used to rate soil characteristics (e.g. stoniness to indicate eroded topsoil; soil color for organic matter content; soil taste for acidity);	time-consuming but provides more accurate results that could also be used for further analysis where statistical procedures will be used; The use of rapid test kits as the name implies require less time, easy to use but most often recommended for routine examination of soil condition; descriptive methods for assessing soil quality would be useful and interesting, would be more participatory but there are no standards yet nor guidelines for this method yet.
Assessment of Land Productivity	1. Cropping Systems Trials ; or 2. Crop-Cut Techniques; or 3. Estimated Crop Yields; or 4. Farm Records and other secondary Data	A number of standard methods may be used to determine land productivity using crops yields. Cropping systems trials would involve actual establishment of the crops thus would be long-term; crop-cut techniques may involve getting samples from existing production systems, usually referring to farmers' fields thus would require farmer cooperators; Estimated Crops Yields may be obtained through farmer interviews hence may not provide very accurate results; other sources of information maybe used like farm records or municipal records, which often are not available in the rural uplands.
Assessment of Economic Viability	1 Preparation of Net Income Statement for each farm with detailed costs and returns through individual farmer interviews;	More accurate data can be contained through close monitoring of productions monitoring especially those incurring material and labor

Research Phase	Data Gathering Methods	Remarks
	2. Preparation of Net Income Statement for each farm with detailed costs and returns obtained through daily monitoring of activities; 3. Preparation of Net Income Statement for each farm with detailed costs and returns estimated based on municipal records;	cost however this will require farmer cooperators or hiring of staff to do the monitoring hence will entail cost on the part of the researcher; Individual farmer interviews on the costs and returns of the most recent harvest is also a tedious task but will provide reliable results; if interested on a more general estimate of farm profitability in the area, secondary information about the costs and returns of the production system would serve the purpose.
Assessment of Security of Production	Occurrence of Crop Losses may be obtained through a record of loss of harvest or loss in income in a span of at least 10 years. Data could be obtained through key informant interviews along with verification of local records of natural or human-induced disturbances to production in the area.	This is not very easy to measure and the best method would be a long-term record of the production system in the area which most often is not available especially in the rural area; Getting information about this through farmer interview would not be easy either but could be done .
Assessment of Farmer Acceptability	Social indicators associated with the way production systems are managed in the tropical uplands may be obtained through formal and non-formal surveys, use of secondary information and long-term records or combinations of all these	A simple and direct way , if could be done in the area, is by simply counting /identifying practitioners and their reasons; For a mor in-depth analysis of the social factors associated with the way production systems are managed , detailed information will have to be obtained .

be obtained through information elicited from the farmers or combination of these sources. Farm records of crop yields would also be a way of getting information about crops yields, if records are available. While in the experimentations and crop-cut techniques, one would have more control over the collected data, farmer interviews will require a one-on-one interaction with selected respondents. While there are a number of ways by which a survey could be accomplished (Moser, 1971) in rural situations, like the uplands, it is likely best to conduct formal interviews with the respondents at the time that is most convenient to them, i.e., during off-peak hours for farming activities, using prepared questionnaires (BAR, 1990; Dooley, 1995; Morris et al., 1993).

4.4.5 Measuring Economic Viability

The basic measure of economic viability in this methodology is farm profitability, often referred to in agricultural economics literature as Net Farm Income. This could be obtained through the use of a typical Net Farm Income Statement where gross income and costs are all recorded (Chudleigh, 1987). As farm records are often not kept in tropical uplands, the net income statement for each farm will have to be prepared. Details on material costs and benefits could be obtained through farmer interviews or through daily monitoring of farm activities and record keeping described in cropping systems manuals (IRRI,1983; BAR 1990) or in farm management economics manuals (Chudleigh, 1987).

4.4.6 Assessing Security of Production

Among all the five criteria in the methodological framework being developed in this chapter, this criterion can be considered as a new addition to the criteria often used in sustainability assessment studies (Tellarini, 2000; Crabtree, 1998; Robotham, 1998; Smith et al., 1998; Gomez et al., 1995; Neher, 1992). Hence, there is no reference on to how best the data could be gathered for this criterion. Though, as defined by Smyth and Dumansky (1995), this could be indicated by the occurrence of crop failure. By its significance and application in the tropical uplands, occurrence of crop failure could mean either loss in harvest or income due to natural or human-induced disturbances to production. As such, it is suggested here that data on this be gathered through information directly elicited from the upland land users or the farmers which can then be verified using local records as well as national records on natural calamities and market failure due to glut, if available. Further, it is suggested that information on the occurrence of crop failure be done for a span of time, period of 10 years or more, so the frequency of its occurrence could be estimated. This method of data gathering would provide descriptive discussions about the occurrence of crops loss. Econometric tools used in risk analysis (Pannell, 1999) may also be explored for use depending on ones' expertise to come up with a more quantitative estimate of occurrence of crop losses.

4.4.7 Determining Farmer Acceptability

Determining farmer acceptability of a production system is not easy to measure as it involves a degree of subjectivity (i.e. what might be desirable to one person may not necessarily be desirable to another person) and maybe subject to time scale (i.e. what may be acceptable now may no longer be acceptable in the future or vice versa). Nevertheless, a range of methods have proven useful for determining farmer acceptability (Iqbal et al., 2006; Beedel, 2000; Makokha et al., 1999; Traore, 1998; Cary, 1997; Ayuk 1997; SEARCA, 1995; Fujisaka, 1994; Ervin et al., 1982)). These methods could be descriptive (SEARCA, 1995) where the number of farmers doing a given practice is identified and the social benefits associated with the practices are described or the farmers' reasons for their production systems are simply asked or identified (Sajise et al, 1996; Fujisaka, 1994). Quantitative methods are, however, becoming more commonly used (Iqbal et al., 2006; Beedel, 2000; Cary, 1997; Ayuk 1997; Taore, 1998; Makokha et al., 1999; Ervin et al., 1982). With quantitative methods, the association of variables about personal traits and characteristics, perceptions and economic factors with choices and decisions on land management are measured. Common to the descriptive and quantitative methods though are implications that could be drawn from the information obtained on the likelihood that a given practice will be widely used or practiced by the target users.

Either the descriptive or quantitative methods could be used in trying to understand farmer acceptability of ABDE practices. Combination of the descriptive and quantitative methods will likely prove more useful in drawing implications for enhancing agrobiodiversity in the uplands.

A number of indicators for measuring farmer acceptability are discussed in section 4.4.5. Data about these indicators could be obtained through formal and non-formal surveys, use secondary information and long-term records, or combinations of all these (Iqbal et al., 2006; Beedel, 2000; Maglinao et al, 1999; Makokha et al., 1999; Traore, 1998; Ayuk 1997; Cary, 1997; SEARCA, 1995; Fujisaka, 1994 Ervin et al., 1982).

4.5 Integration and Analysis

In this section, methods for integrating the results for deeper analysis are provided. The evaluation methodology presented in this chapter included criteria, and indicators to measure the ecological, economic and the social components of the upland agroecosystem. The evaluations will normally be done more or less sequentially. Once results for each component are to hand, it is necessary to integrate or synthesize them so as to highlight the important role that agrobiodiversity enhancement in the uplands might have were it to be introduced as a management alternative for agricultural land use.

One way of doing the integration of the results is by the use of the SWOT (i.e. STRENGHT-WEAKNESS-OPPORTUNITY-THREAT) Matrix (Table 4.3). **S**trengths will include factors that currently make the system protective, productive, economically viable, secure and acceptable. **W**eaknesses will include factors that currently make the system unable to meet the sustainability criteria. **O**pportunities are those factors that can be more readily fostered when considering the introduction of ABDE as a management alternative for the

Table 4.3. SWOT Matrix for Evaluating Agricultural Land Use in the Uplands.

Agroeosystem Component	Criteria & Indicators	Strength	Weakness	Opportunity	Threat
Environmental	*Protection* Soil Organic Matter Topsoil Soil Nitrate				
Economic	*Productivity* Crop Yields Total Net Farm Income Income and Harvest Loss				
Social	*Acceptability* Personal Traits Farm Characteristics Perception on effect of farming on environment and health				

uplands and **T**hreats are constraints that need to be overcome or barriers that need to be lifted if ABDE will be used as a management alternative for the uplands.

Another way of doing the integration and analysis of the results is to make use of the devised tool below (Table 4.4) where all criteria and indicators were presented as key questions. The first column shows the three important components for evaluating agricultural production systems in the uplands. The second column contains the environmental, economic and social indicators that need to be measured. The last column could be filled-up with yes or no replies depending on the results of the data gathering or one may devise a rating scale if needed.

Either or both tools for integration and analysis of the results of the evaluation could be used to compare various production systems or for monitoring existing systems to determine if they are appropriate for the uplands. A practice that have protective and productive functions at the same time would be acceptable to the land users is appropriate for the uplands.

Table 4. 4. Alternative Tool for Evaluating Agricultural Land Use in the Uplands.

Key Questions		Rating Scale/ Remarks (Yes or No)
Main Criteria	**Indicators**	
Environmental component Is it protective of the Natural Resources?	Does it have diverse species composition?	
	Does it enhance soil fertility?	
	Does it protect topsoil?	
	Does it prevent nutrient wastage?	
Economic Component Is it Productive?	Are there main crops and secondary crops?	
	How much yields are obtained form each crop?	
	How much income are obtained form each crop?	
	Is the production of each crop profitable?	
	Has there been increasing or declining trend in harvest from each crop?	
	Has there been increasing or declining trend in income from each crop?	
	Are there natural or human-induced disturbances to production that would account for long-term trends in yields and income?	

Key Questions		Rating Scale/ Remarks (Yes or No)
Main Criteria	**Indicators**	
Social Component Is it Acceptable to the Land Users?	Are the land users in the area young farmers?	
	Are the land users in the area old farmers?	
	Are the land users experienced farmers?	
	Are the land users in the area new farmers?	
	Do the land users have formal education?	
	Are the land users involved in the community as leaders?	
	Are the target users land owners, tenants or farm workers?	
	What is the size of the average land size in the area?	
	Are the land users aware of the consequences of farming the area on the health of the environment?	
	Are the land users aware of the effect of intensive farming on the health of the farmworkers?	

4.6 Interventions

The results of the evaluation using the above framework will provide information and insights that might serve as basis for developing interventions, which could either be research, extension and development interventions or policy recommendations for enhancing agrobiodiversity in the uplands. In the development of such interventions, the hierarchical level at which the interventions will be implemented is an important consideration. Each hierarchical level will vary in terms of scope of concern, particularly with policy recommendations, the components and activities specifically for research, extension/development, the constraints and potentials as well as support requirements for effective implementation.

4.7 Summary and Conclusion

In this chapter, a methodology for assessing agrobiodiversity enhancement practices in the uplands was developed. The integrated methodology was designed to address the environmental, economic and social concerns in the uplands. It has provided the important criteria and indicators to use in order to assess if a production system is appropriate for the uplands. It has also provided a range of possible data gathering techniques. Likewise shown in the chapter is the way by which results maybe synthesized and analyzed. Tools for synthesis and analysis were also provided. Results obtained may be utilized as basis for developing interventions including research, extension or development activities and policy recommendations for enhancing agrobiodiversity enhancement in the uplands.

This methodological framework will be useful for comparing or monitoring agricultural land uses in the uplands. It will provide combined technical and social information useful for the further improvement/implementation of management alternatives that encourages agrobiodiversity enhancement.

How well this generic methodological framework for evaluating agricultural production systems, leading to a better understanding of enhancing agrobiodiversity in the uplands, works well in practice, is shown in the succeeding chapters. In applying the methodology, the tropical uplands in the Philippines will be used, more particularly the area of Liliw, Laguna.

CHAPTER 5

Case Study Site and Methods: Evaluating Agricultural Land Use in Liliw Laguna and its Implications for Agrobiodiversity Enhancement in the Uplands

---

This chapter in effect links Objective 2 (which is to develop an integrated methodology for evaluating agricultural land use in tropical uplands) and Objectives 3 and 4 (which are concerned with applying the methodology to the spectrum of agricultural land uses in a case study area, in order to evaluate on the environment and on economic productivity (Objective 3) along with identifying social factors affecting choice of agricultural land use (Objective 4). It does this first by expanding on the summary description of the case study area, Liliw, Laguna, Philippines, provided in Chapter 2, and then indicating how the generic methodology for evaluating agricultural land use developed in Chapter 4 will be applied to the case study area. This chapter therefore sets the geographical and methodological scene for testing the methodology in Liliw, Laguna.

The chapter is in two main parts: the first focusing on the geography of the Liliw area, with particular reference to agricultural land uses and problems facing farmers; and the second on the methods for evaluating the spectrum of agricultural land uses in the uplands and their influence on natural resources and economic productivity and for social acceptability.

5.1. Part I. Geography of the Study Site

This section of the chapter explains the study site selection, the initial appraisal used for building some understanding of the study site, and the framework used for sampling farms and farmers for the evaluation of agricultural land uses in the area. The general vegetation of the upland area of Liliw is shown in Figure 5.3A with more specific land uses in Figure 5.3B on pages 5-9 and 5-10, respectively. The topography and slopes of the sampling sites at Liliw are shown in Figures 5.4A and 5.4B on pages 5-15 and 5-16, respectively.

5.1.1 Selection of the Case Study Site

Liliw, the research site was selected for the following reasons : 1) different vegetation types exist in the area, like natural forests, single-species vegetation (monoculture of cash crops) and multi-species vegetation (intercropping); 2) agricultural production in the area is characterized by small-holder farming systems (not large plantations or commercial farms) where trend in agricultural production is towards monocropping of cash crops; and 3) the area is accessible using public transport to make regular trips possible.

5.1.2 Initial Assessment of the Case Study Site

In this section, the initial assessment of the case study area is presented. It therefore extends information about Liliw, Laguna, introduced in Chapter 2, pp. 19-23. This initial assessment was done by conducting a rapid community appraisal, which made use of multiple methods and means to build up a picture of Liliw of relevance to later evaluations. Included are the transect walk in the area, ocular inspection of the crop production areas and of other natural resources, non-formal and panel interviews with key informants, including local government officials, farmer leaders, elders in the community, staff of the Department of Agriculture (DA), Department of Environment and Natural Resources (DENR), and review of secondary data available at the Local Government of Liliw. These methods provided information that served as a basis for gathering environmental, economic and social data relevant to the way farmers manage agricultural land use, as well as for later considering of the potential for agrobiodiversity enhancement in this tropical uplands.

The sub-sections below describe the biophysical conditions and general landscape of the case study site, existing land use and changes overtime on land use, and the farming community and their agricultural problems.

Biophysical Condition and General Landscape

A transect was done by going through the area by transport from the boundary line between the adjacent municipality up to Liliw residential area and a trek to the production areas in higher elevations and steep areas as indicated by the map in Figure 5.1. The insert shows the transect line from the built-up to the production areas. The shaded portion on the insert map indicates the location of the production areas and the sampling sites for the environmental economic and social data. The transect walk was done with a farmer guide and an extension worker in the area who also served as key informants.

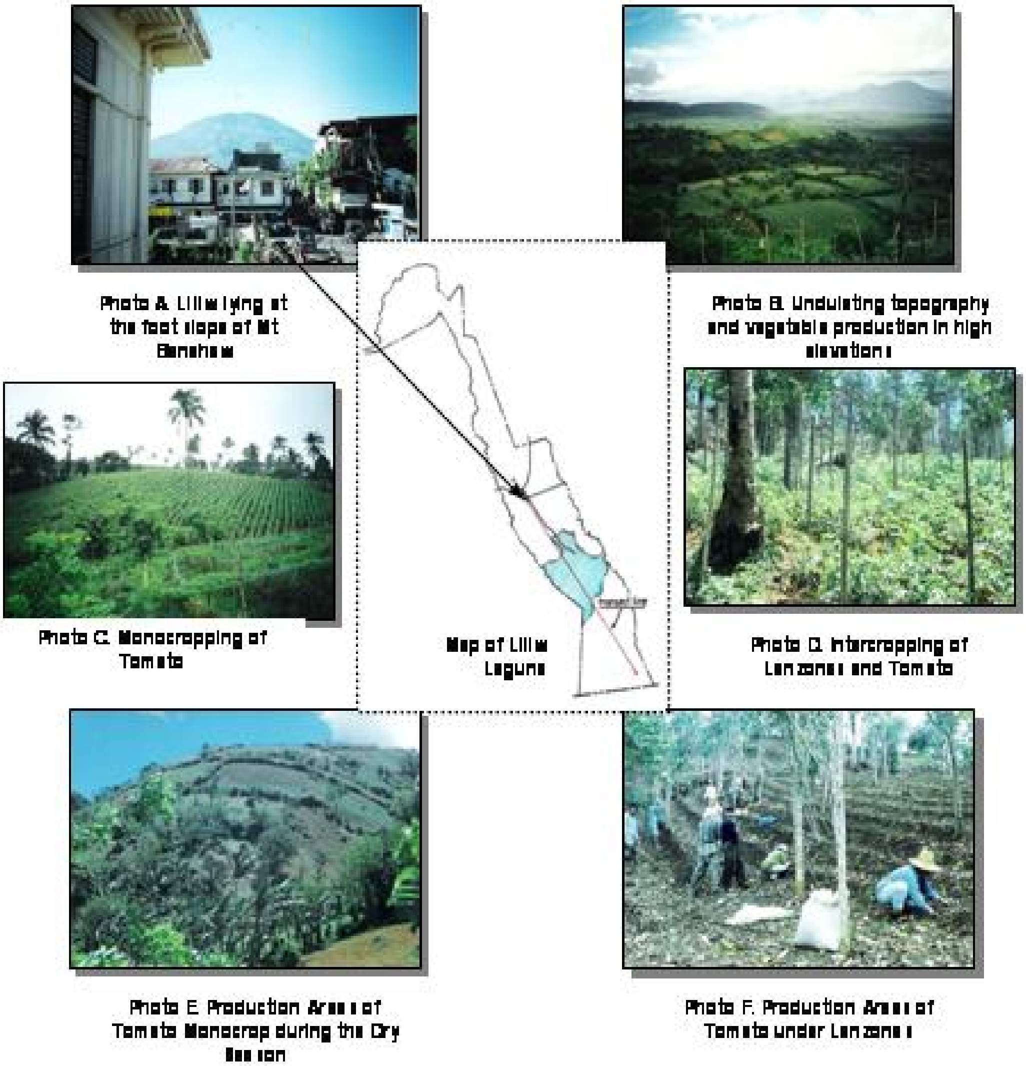
It can be seen in Photo A of Figure 5.1 that Liliw, Laguna, is lying on the footslopes of Mt Banahaw, one of the tallest volcanoes in the country. As such, Liliw is situated in elevations ranging from 400 to 800m above sea level with undulating topography, as indicated in Photo B in Figure 5.1. There slopes range from 0 to over 15%. About 45.6% (2,593.15 hectares) of its total land area has a slope from 0-3%, 19.4% of the entire area (1100 hectares) has a slope of 3-8% and 34.9% (1987.5 hectares) has 8 to >15% slope. Basically an agricultural area, about 76.4% of its total land area (4,339.52 hectares) is devoted to agricultural production (Liliw Municipal Record, 1999).

As illustrated in Figure 5.2 (transect diagram), agricultural production areas are located in low-lying areas up to the slopes, even encroaching some portions of the forest reserve. Locally, the entire landscape is classified according to its land use, vegetation and elevation. The residential/built-up area (or the ‘poblacion’) is located in the low lying areas, as shown in Photo A in Figure 5.1. Vegetable production is located in the gently sloping areas (or the ‘nayon’) up to the steeper slopes and higher elevations (or ‘ilaya’). It was noted, however, that vegetable production, especially tomato production, becomes more intensive in higher elevations (also shown in Photo B and C Figures 5.1). This is basically due to the cooler temperature that is favorable to semi-temperate crops, particularly tomatoes.

Situated at the western side of the Laguna basin, Liliw has mean monthly temperatures ranging from 22.7 to 27.2˚ C. The coolest months are from December to February, while the warmest months are in April to September. It is is also characterized by two pronounced seasons: a rainy season from May to December and dry season from January to April. The mean monthly rainfall ranges from 24.2 to 283.7 mm and the annual rainfall averages 1983.9 mm (National Agromet Station, Los Banos (1950-2005).

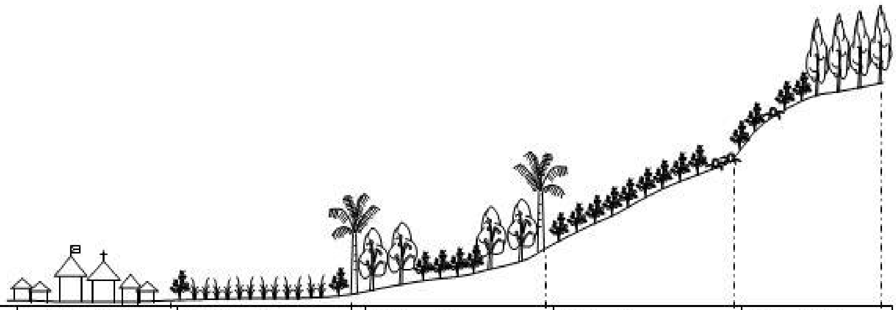
Liliw is also endowed with good soil and water resources. It is dominated by the Alipit Soil Series, which is of volcanic origin (i.e. developed from volcanic turf), and moderate-to-deep well-drained soils with a moderate to rapid infiltration rate.
It is also a watershed protecting the natural springs that abound in the area. These natural springs serve as the source of potable water. A few farms close to the springs are able to use them for irrigating their crops. These natural springs all drain towards the main river, the Lilio River, which is used for domestic purposes as well as for leisure.

With bountiful natural resources, these high elevation areas are green and teeming with crops (see Photos C and D in Figure 5.1) during the rainy season and are fallowed during the dry season (see Photo E and F in Figure 5.1).



(*Shaded portion in the map indicates the location of the production areas and the sampling sites for the ecological, economic and social data*).

Figure 5.1. Photo Documentation during the Transect Walk to the Case Study Site showing the Residential Areas and Crop Production in the Sloping Areas.



Local landscape Classification (Land Use)	" *Poblacion*" (built-up area)	"*Palayan*" (Irrigated lowland rice farms)	" *Nayon* " (gently-sloping farming areas)	" *Ilaya* " (farming areas in steep slopes)	" Bundok " (forest reserve)
Slope Erodobility	0-3% no apparent erosion	0 – 3% no apparent erosion	3-8% no apparent erosion	8-13% less susceptible to erosion	15% and above highly susceptible to erosion
Current Vegetation	None	Rice-rice Vegetables in few and small plots	Coconut + lanzones + banana + tomato/ tomato or eggplant or radish or other vegetables	Tomato – sweet potato or fallow	Forest trees
Important characteristics	Houses are closely built; Concrete one way roads; Water supply from natural springs;	Few farmers plant vegetables in small plots ; River and streams serve as source of water for irrigation	Perennial crops are declining in number; no replanting of damaged and old trees ; no cultural management practice for the perennial crops ; In few farms, there are bananas other than coconut and lanzones; Streams serve as source of water for nearby farms; Natural Springs and rivers are famous picnic sites for local tourist in summer time; Concrete one way road constructed to facilitate transport of produce; Site of trading ;	Few perennial crops on the borders; Open field favors growth of tomatoes thus farmers are not willing to plant trees here; Streams serve as source of water for nearby farms; Concrete foot trails encouraged production of vegetables in high and steep slopes; Farm houses are built here because of long distance from town proper;	Natural Springs abound; At the lower portion, few farmers cultivate tomatoes and other vegetables; Others cultivate fruit trees; Agricultural production is completely restricted here;
Problems (farmers' perspective)			Pest and disease problems in tomatoes; Low profit in tomato due to the marketing system ("booking");	Pest and disease problems in tomatoes; High cost of production for additional cost on labor for transport of water, materials and produce;	

Figure 5.2. Transect Diagram for Liliw Laguna, Philippines, showing the General Landscape, Local Land Classification and Important Observations during the Rapid Community appraisal and Key Informant Interviews.

(Source: Field Work,1999)

Existing Land Use and Changes in Land Use

Before explaining in more detail the current land use in Liliw, changes in land use over time in relation to declining biodiversity are traced through the panel interviews with older members of the community. The resulting historical changes in land use and declining biodiversity in the area are encapsulated in Table 5.1.The key points to emerge from this historical analysis of land use change is that subsistence or slash-and-burn communal farming was still dominant in the 1940s.

Table 5.1 Timeline Showing Significant Changes in Agricultural Production in Liliw, Laguna, Philippines

Year	Characteristic/Description	Implications on Biodiversity
1571	Establishment of the area as a settlement community	Start of the cultivation of the lands in the area;
1935	Upland rice and vegetable production is already a common household activity; Local upland rice varieties planted are called "Balam" and "Pinursigi"; these are characterized by reddish colored grains; aromatic and tastier than the current planted rice varieties; Sweet potato and /or other tropical vegetables are planted after upland rice, for home consumption;	Presence of land races or traditional varieties of rice; High varietal or genetic diversity of rice (these varieties no longer exist in the area); High crop species diversity (production is intended for home consumption) and production must have been in small plots in the homestead (not yet in higher areas);
1940s	Communal farming; "kaingin" or "slash and burn" was still a common practice by the farmers;	
1950s	Settled farming; Began planting of Local varieties of tomato for sale; Start of cropping pattern: tomato-sweet potato; No external inputs applied; Burned grasses were used as fertilizer;	Specialized farming systems is indicative of declining varietal and species diversity in crop production;
1960s and 1970s	Began the use of inorganic fertilizers for crops; high yielding varieties for rice and use of agricultural chemicals against pests and diseases in rice;	
1980s	Started using of high yielding varieties for tomatoes; Beginning of increase in cost of production due to material and labor inputs like trellis; chemical	

Year	Characteristic/Description	Implications on Biodiversity
	fertilizers and pesticides; Observed increasing number of pests and diseases in tomatoes as well as increasing resistance of insect pests to agricultural chemicals; Observed declining population of birds that feed on insect pests of fruit tree crops; Combined application of inorganic fertilizers with organic (chicken manure) in tomatoes;	Impact of loss of species diversity in crops on insect diversity is already evident; Destruction of habitat for wildlife;
1990s	Observed pest damages in tomatoes in earliest stage (at seedling stage); Mid 90's some farmers tested lowering chemical inputs by reverting to the use of burned grasses as fertilizer, application of chicken manure only (in small plots) ;	

Source: Key Informant Panel Interview, Liliw Laguna, February 1999.

It was in the 1950s that commercial cash cropping, including tomato, began to take hold, but not until the 1980s that high yielding varieties and use of chemical fertilizers and pesticides became common practice.

The maps in Figures 5.3A and 5.3B, which have been developed from the field work carried out in 1999, show the change in agricultural land use in Liliw between the 1960s and 1999. It is clear from the two maps that over the 40 years, most of the coconut/fruit trees crop-type, which occupied about 60% of the area, had been replaced by either monocropping of tomato or intercropping of coconut, lanzones and tomato by 1999. Indeed, the latter land use type had even encroached on the steeper slopes under Mt Banahaw Forest Reserve (Figure 5.3B).

From the key informant interviews, the sloping and high elevation areas are purely devoted to vegetable production. Actual observation during the transect walk of the area, however, proved that while the area where pure vegetable production is wider, there is diversity of agricultural land uses ranging from purely monocropping of annual vegetable crops to integration of agricultural trees and annual vegetable crops. The latter can be divided into two-species and three-

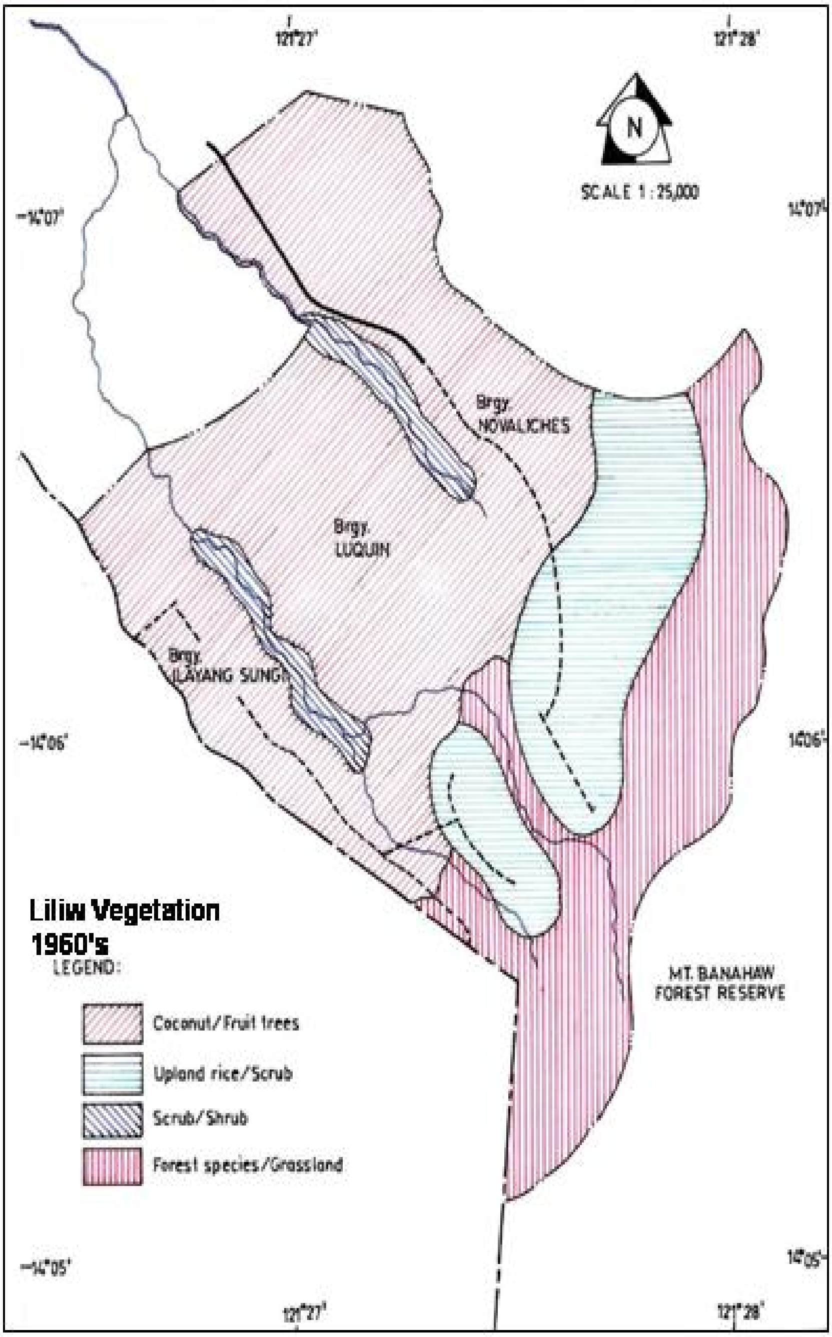


Figure 5.3A. Vegetation in the Upland Areas of Liliw, Laguna, Philippines in 1960s.

(*Source: based on Topography Map for Laguna, National Mapping and Resource Information Authority, 1990*)

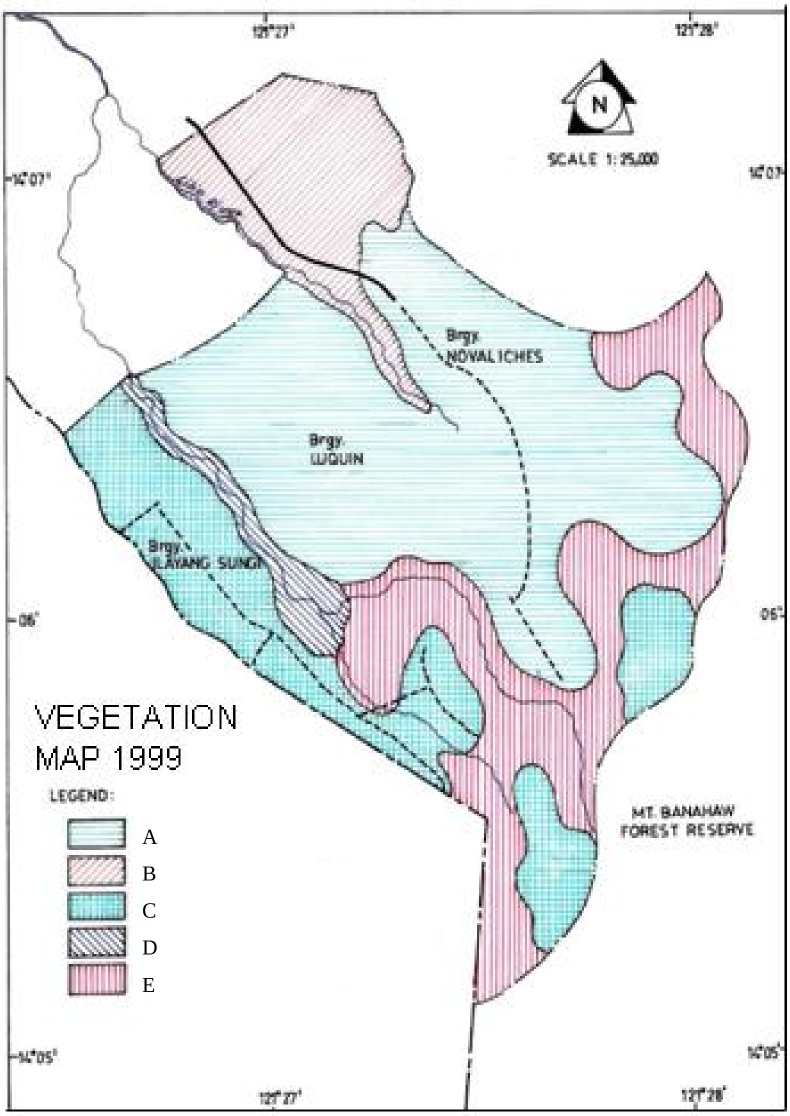


Figure 5.3B. Vegetation in the Sloping Areas of Liliw, Laguna Philippines in 1999.

(Source: Based on topography Map for Laguna, NAMRIA 1990)

Note: Illustration of vegetation was generated during the field work in June 1999;

A-Dominantly tomato monocropping and few (few coconut + tomato) intercropping;
B- Dominantly (coconut + tomato) intercropping and few (coconut + lanzones + tomato) intercropping
C- Dominantly (lanzones + tomato) intercropping and some (coconut + lanzones + tomato) intercropping
D- Coconut and Shrub; **E**-Forest Species and grass

species systems i.e.: 1) intercropping of plantation tree and fruit tree crops and vegetables; 2) intercropping of plantation tree crops and vegetables and 3) intercropping of fruit tree crops and vegetables. It was also noted that many trees are old and require replacing.

These production areas are apparently where the farming community is most active because vegetable production has become a major source of livelihood in the area. It is also in these areas where problems in agricultural production are now most felt by the farmers.

5.1.3 The Farming Community

Based on the municipal record, there are 33 villages in the municipality of Liliw, five of which comprise the town proper and the rest (28 villages) scattered throughout the agricultural areas. The population (as of the last census survey in 1999), is 21,910 consisting of 4,469 households with an average household size of 4.9. Records also showed that the workforce (aged 15-64), which is almost half of the total population (49.2%) consists of nearly the same number of males (52.7%) and females (47.3% of the total population).

Farming is a major source of livelihood, although off-farm and non-farm sources of income are available within the municipality. The reported household average annual income is PhP24, 000 (US $600).

While farming is a major source of livelihood, not all farmers in the area own the land they work on. There are tenants and merely hired farm workers. Ownership of farmland is based only on rights to cultivate the lands granted by the local government. The farmlands are as yet untitled up to the time of the study. The local government, has, nevertheless, already identified the patent applicants and these are the elders or the original settlers in the area, many of whom are too old to farm, whose children have continued farming or have rented out their farms to other farmers. The usual size of a farm is 0.5ha to 1.0ha.

There are no reported illegal settlers from neighboring provinces or towns. Thus, all dwellers in Liliw are all registered members of the community. Migrants in the area are usually from nearby provinces that originally worked as hired farm workers. Children from Liliw who have earned university degrees usually migrate to the cities for employment. A recent trend shows, however, that more of them are returning to farming due to the difficulty of getting employment in the towns and cities.

5.1.4 Problems Facing Farmers in the Liliw Uplands

Key informants provided information about problems facing farming in the uplands. This information is summarized below and is important for providing insights for later evaluating farmer views on agricultural land use alternatives and the potential for agrobiodiversity enhancement in the area.

Declining Soil Fertility

There is no record of the current or past soil fertility status in the area. However, informants say that during the last 30 years, increasing amounts of both organic and inorganic fertilizers have been applied to the tomato crop in order to achieve marketable yields. Based on farmer experience, the application of organic fertilizer in the form of chicken manure has increased six-fold per hectare, while the amount of inorganic fertilizer applied to the tomato crop has increased 3.5 times per hectare. Attempts to reduce the amounts of fertilizers applied to the tomato crop, in order to save on production costs resulted in stunted growth, yellowing of leaves, and low yields.

Crop Diseases, Pests, and Pesticides

Farmers are confronted with problems of crop damage due to insects and diseases in tomato and other vegetables. At the time of the case study, there were no official records of identified pests and diseases for the area. However, farmers reported not only an increasing number of different insect pests causing damage to their crops, but also their increasing resistance to chemical pesticides. What is more alarming is that they highlighted the emergence of plant diseases which otherwise have not been observed in earlier cropping seasons. As a result, farmers resort to more frequent and increased dosages of pesticide applications. To save on labor cost for spraying, a cocktail of pesticides and fungicides are applied 2–3 times weekly beginning at 3 weeks after planting up to the 2-3 days before the last day of harvesting the tomatoes.

Tree Diseases, Pests and Pesticides

Tomato and other semi-temperate vegetables are now grown in areas that were previously predominantly covered with trees. With the increasing economic importance of tomato and other semi-temperate vegetables, less attention is given to coconut and other fruit trees in the agricultural production areas. Most of the coconut trees are more than 30 years old and there is no replanting to replace old or dead trees. Fruit trees like Lanzones are considered by many as second to tomatoes in terms of economic importance. Thus, in spite of observed insect pest damage on the trunks that is causing trees to die, this is being ignored. No replanting to replace old or dead lanzones trees is being done. No investigation has been conducted into the pests and their possible control. It is interesting to note that farmers attributed the presence of the insect pests to the loss of the wild birds that feed on these insects. The loss of the wild birds was observed to have started when the amount and frequency of agrochemical spraying on the vegetables increased. In the uppermost part of the agricultural landscape, there are fewer coconut and lanzones trees. Instead there only tomato crops in February to May, other short-term vegetables or are fallowed during the rest of the year. After having observed better crop yields, specifically of the tomato crops in higher elevations and unshaded condition, farmers are even more encouraged to continuously use lands in high elevations for vegetable monocropping.

5.1.5 Sampling Sites and Sampling

Random selection procedure was employed in which names of individual farmers were selected from the master list of vegetable growers in the production area. Production areas are located in elevations ranging from 500 to 700 meters above sea level (Figure 5.4A) and with slopes ranging between 8 to 25% (Figures 5.4B). This covered three villages having agricultural land uses with vegetable moncropping and agricultural land uses with integration of horticultural trees and vegetables. The villages are Barangay Novaliches, Barangay Ilayang Sungi and Barangay Luquin.

The sample size was determined to be 10% of the total population of vegetable growers (383). Each farmer/household served as the sampling unit from where the environmental, economic and social data were obtained. For presentation of analysis of results, only samples with a complete set of data (environmental. economic and social data) were included, i.e., 24 sample (Appendix 5.1). Data for soil quality was not obtained in too distant farms and from farms of those who were unwilling to have soil digging. Economic data from respondents who were unwilling to provide information on income or whose responses were unreliable were also not included. Not all of the selected farmers were willing to be interviewed or were unavailable (doing off-farm jobs in another province) for interviews during the time of thesis field work.

In order to assess environmental protection and economic productivity of the agricultural land uses in the area, each farm sample was assessed for: plant species composition, plant species richness and abundance: soil quality, including depth of topsoil, soil organic matter and soil nitrate; and farm economic productivity, including estimated crop yields, production costs and income. In order to assess security of production in different land uses and determine the social factors that influence the way agricultural land uses are managed, information was obtained through interviews on the farmers, their years of experience in farming, trends in harvest and income losses, income sources, reasons for their production systems,

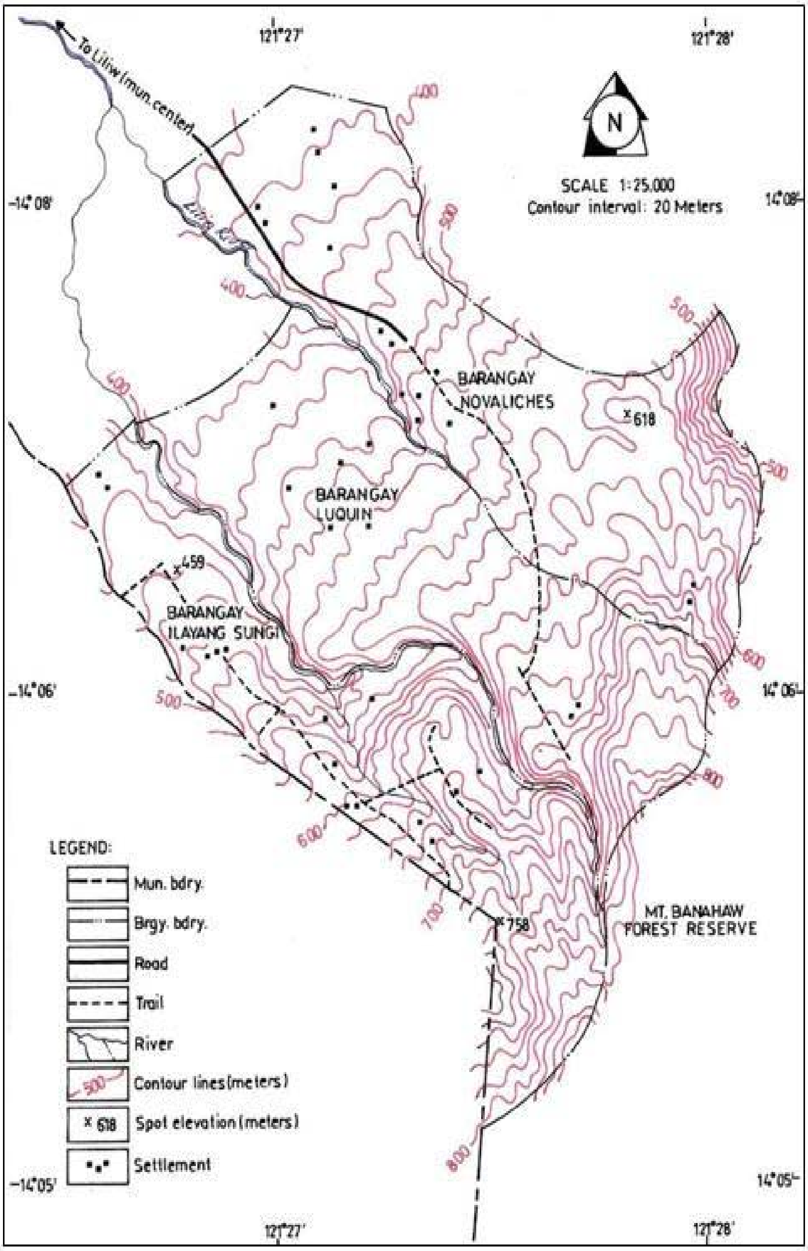


Figure 5.4A. Topography of the Sampling Sites (Barangay Novaliches, Ilayang Sungi and Luquin) in Liliw Laguna, Philippines

(Based on Topography Map for Laguna, NAMRIA,1990)

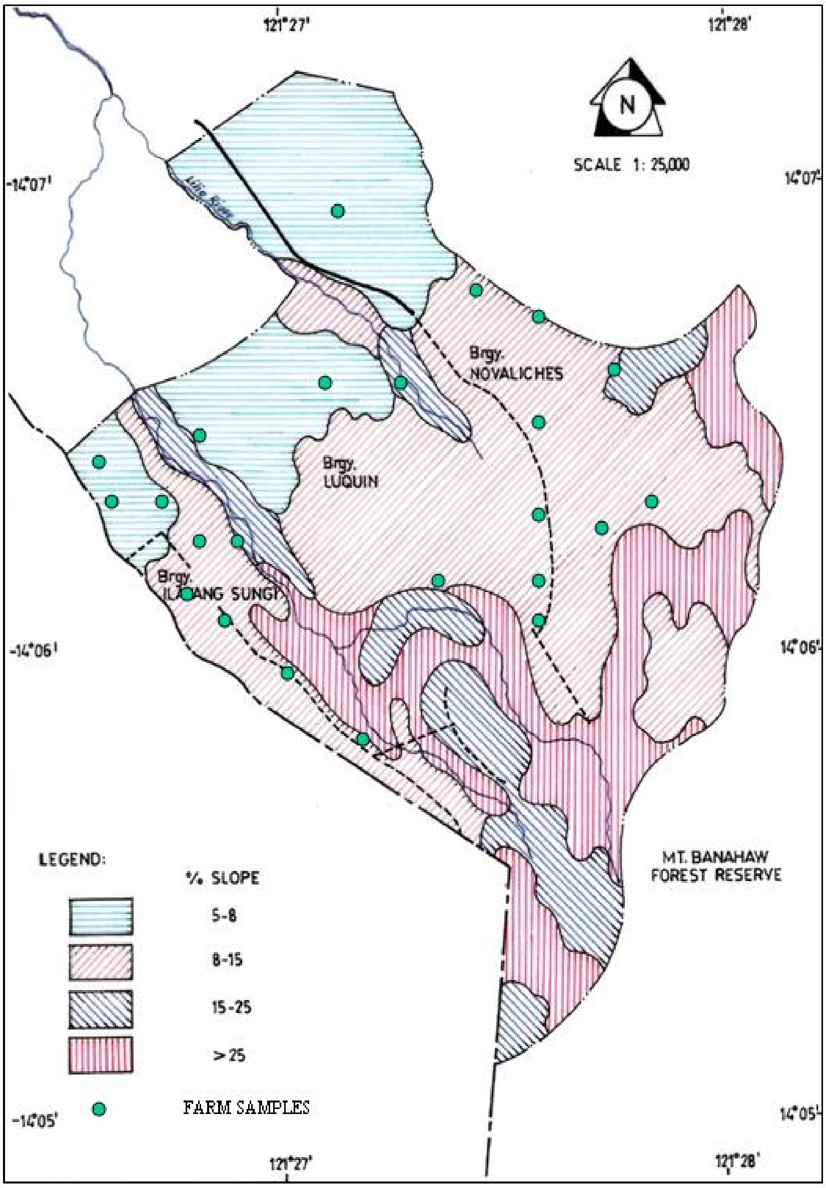


Figure 5.4B. Slope AND Sampling Sites (Barangay Novaliches, ilayang sungi and Luquin) in Liliw Laguna.

(Source: based on Topography Map for Laguna, NAMRIA,1990)

awareness of environmental degradation in the area, and incidence of poisoning due to agrochemicals were also gathered through individual farmer interviews (Appendix 1).

5.2 Part II: Applying the Method to Liliw

In the next six sections of this chapter, the various methods for evaluating agricultural land uses in an upland area that were outlined in Chapter 4 are revisited with respect to the Liliw case study. The aim is to explain what was done to gain data for evaluating agricultural land uses in the uplands and their influence on protection of the natural resources, specifically soil quality, farm economic productivity and for identifying the factors that influence choice of agricultural land use in the uplands. The results from the data analysis appear in later chapters. The sections below are organized according to the framework of criteria, indicators and data gathering techniques presented in Chapter 4.

5.2.1. Measuring Plant Species Diversity

As defined in Chapter 2, agrobiodiversity refers to all biological organisms that contribute to the functioning of an agricultural system, directly or indirectly, at the various levels (at the field, farm, landscape or community level). The study, being focused at the farm level, made use of plant species as the basic measure of biodiversity and the Shannon Diversity Index was used to compare biodiversity of different agricultural land uses in the case study site.

Shannon Diversity Index (SDI)

Plant species diversity was measured using the belt transect technique. In every farm, a 20 m string with stakes on both ends was laid on the soil in a diagonal position at the center of the farm where the crops are planted. All plant species within the line in each farm, including the destructive and productive biota or those which were purposely or not purposely planted by the farmers, were identified counted and recorded. From this data, plant species composition, species richness and plant species density were calculated for each farm. Using this data, the Shannon Diversity Index for each farm sample was calculated. Mean SDI was used to indicate biodiversity of each agricultural land use in the case study site. SDI of different agricultural land uses was compared and analyzed.

The Shannon Diversity Index was calculated using the formula provided in Field and Laboratory methods for General Ecology (Brower et al., 1990). An index value of 1 indicates highest diversity.

$$H' = -\Sigma P_i \log P_i$$

H' is the diversity index and

P_i is the proportion of the total number of individuals occurring in species i.

Where

$P_i = n_i / N_i$

n=*plant species ith*

N = *total number of plant species in the system*

5.2.2 Assessing Environmental Protection Using Soil Characteristics

As discussed in the previous chapter, soil resources in the uplands and its protection is very important, it being most susceptible to degradation. During the initial assessment of the case study site, the importance of investigating soil characteristics was even more realized as declining soil fertility is the farmers' most cited problem in the area. Likewise, the observed excessive use of agrochemicals by the farmers in the case study site also served to indicate the importance of investigating the effect of such practice on the quality of the soil. As such, the three soil characteristics that were included in the framework of indicators developed in the previous chapter were all used for evaluating the influence of different agricultural land uses on soil quality.

Having realized this from the initial site assessment, the main interest of the investigation in the area then is protection from loss of soil fertility. In this study, soil organic matter was used as the main indicator with thickness of the topsoil and nitrate in the soil to further explain the influence of the different agricultural land uses on soil fertility.

Collection of Soil Samples in the Field

Soil samples were collected in individual farms using composite soil sampling technique. Soil samples were also collected at varying depths; at 20 and 40 cm soil depth for determining soil organic matter content and at 20, 40 and 100 cm soil depth for determining soil nitrate. The soil samples were processed (air-dried and pulverized) and submitted for laboratory analysis for soil organic matter and nitrate content using the KCL Extraction Method as described in Standard Methods of Analysis for Soil, Plant tissue, Water and Fertilizer (PCARRD, 1980).

Measuring Thickness of the Topsoil

The topsoil is investigated here because of its significance to maintenance of soil fertility. Measuring thickness of the topsoil involved the following: examination of the soil type and characteristics of the research site using soil maps, examination of the soil profile in the field, and soil sampling in individual farms.
With the use of the soil map of the province of Laguna, soil type in the case study sites was identified. Description of the soil type was reviewed particularly the thickness of A-horizon or the topsoil. In the field, the soil profile of the undisturbed soil was also examined. The A-horizon was identified using the Color chart. The A-horizon was measured identified and measured in centimeters.

In relation to depth of topsoil, the slope of each farm was also measured using a clinometer.

Statistical Analysis

To determine significant differences on the soil quality of the different agricultural land uses, analysis of variance and correlation analysis between Shannon Diversity Index (SDI) and the soil characteristics was done.

5.2.3 Evaluating Economic Productivity

The following sections show the methods used for measuring farm economic productivity of the different agricultural land uses in the area. Productivity was evaluated in three ways: a) crop productivity as indicated by estimated crop yields; b) current farm profitability as measured by net income from individual crops and total net farm income; and c) long-term productivity as indicated and described by the trends in losses in income and harvests. Data were obtained through farmer interviews.

Crop Yields

Crop yield for each farm was estimated based on the reported quantity of produce harvested and sold by the farmers during the last cropping season. Local measures of the products harvested and sold and the size of the land from which the crop was harvested was converted and expressed in metric tons per hectare (mt/ha) for the fruits and vegetables and number of nuts per hectare for the plantation crop.

$$\textbf{Crop Yield } (Y_i) = \left\langle Quantity(kg) \div area(m^2) \right\rangle \div 1000kg \div 10000m^2$$

Average crop yield was used to indicate crop productivity for each agricultural land use. This was estimated by:

$$\textbf{Average Crop Yield} \text{ (Mt /Ha)} = \sum_{f=1} Y_{if} / n$$

where:

Yi = yield of ith crop

f = farm 1…n

n = total number of farms with the ith crop

Estimating Net Income

Net Income for each crop was obtained through a cost and return analysis for each crop in each sample farm. Detailed information about all costs incurred and returns obtained for each crop was obtained through farmer interview. These included expenditures in all activities and inputs from land clearing to cultivation and from maintenance to harvesting (e.g. details about labor and material inputs) including quantity and price of the products sold. Net income per crop was calculated by subtracting total costs from gross income. This value was expressed in Philippine Peso per Hectare.

Net Farm Income (PhP) = Gross Return – Total Cost

Average Net Farm Income (NFI) was used to indicate net income per crop in each agricultural land use.

$$\textbf{Average NFI} = \sum_{f=1} NFI_{if} / n$$

Where NFIi is net income from crop ith

f is farm 1…n

n is the total number of farms

Total Net Farm Income

Total Net farm Income (TNFI) was obtained from the sum of the net income from all crops within a farm.

$$\textbf{Total Net Farm Income} = \sum (NFI)_{i\,jk}$$

Where i = ith crop

J = jth crop

K= kth crop

Security of Production

Security of production was determined by long-trends in quantity of harvest and trend in income using secondary data. Farmer insights were also solicited through individual farmer interviews regarding their observations on the trends in production and profitability of production and the factors that are likely to affect the trends.

5.2.4 Determining Farmer Acceptability

Determining the social factors that influence farmers' choice of agricultural land use was done first by: determining farmers' own reasons for having monocrop (annual crops only) or by maintaining an integrated crop production (where agricultural trees and annual crops are intercropped). Through an open-ended question (Appendix 5.2), information was provided on all possible factors (environmental, economic or social) that influenced farmers' choice of agricultural land use in the area.

Second, personal traits, farm characteristics, perceptions on the effect of upland farming on the health of the farm workers and on the environment are analyzed for their association with farmers' choice of agricultural land use through the Logit model analysis.

Farmer Traits

Information on personal traits and characteristics of farmers who were involved in different agricultural land uses were gathered, including: age, number of years of experience in farming, gender, educational attainment, leadership quality and access to other sources of livelihood. The fundamental interest was in seeing if there were differences in these characteristics across various agricultural land use types.

Farm Characteristics

From the initial assessment, two farm characteristics were considered important in the case study site, land tenure and size of the farm. During the initial assessment, records showed that land tenure status of those involved in farming in the sloping areas have varying land tenure status (i.e. land owners or tenants). Also, integration of perennial crops, especially tree crops, requires wider spaces and hence land size is hypothesized as influential to farmers choice of agricultural land use.

Farmers' Perceptions of the Influence of Upland Farming on the Health of the Farm Workers and Health of the Environment

Influence on Health of the Farm Workers. During the initial assessment of the case study site, it was noted that farmers in the area have developed their own system of using agrochemicals, i.e., increased frequency and dosage of chemical spray on their crops, specifically for the annual crops and mixing different chemicals (i.e., fungicides, insecticide) to save on labor cost for spraying. It is now common knowledge that agrochemicals pose hazards to the health of producers and consumers if precautionary measures are not observed. In spite of this, however, it is reported that it is not easy to establish direct connection between farmers' or farm workers' health and the farming practices, particularly, the use of agrochemicals. Hence, this evaluation was limited only to the most immediate effect of agrochemicals on human health, which is incidence of poisoning. This portion of the study is an attempt to find out if multi-species agroecosystem (specifically where agricultural trees and vegetable crops are integrated) would in a way encourage farmers to reduce the use of agrochemicals, thus making it more beneficial for the farm workers. This was determined by farmers' awareness of the incidence of poisoning due the application of agrochemicals and how it is manifested and the ways to avoid such effects.

Influence on the Health of the Environment. Key informants during the initial assessment mentioned that degradation of some natural resources in the area (including soil, water resources, flora and fauna) was among their problems. This was also reflected in a written report about the area. Based on these sources of information, it was considered necessary to include farmers' awareness of environmental degradation as a factor that might influence farmers' choice of agricultural land use.

Farmer awareness on environmental degradation in agricultural production areas of Liliw was determined by asking the farmers if they are aware of any environmental degradation occurring in the area and by identifying their observed environmental degradation. Responses of farmers from different agricultural land uses were noted separately.

Logit Model Analysis

Farmer traits (age, gender, years of experience in farming, level of education and access to sources of income other than faming their own lands), farm characteristics (land size and land tenure) and farmers' perceptions on the influence of farming and on the natural resources in the area were all hypothesized to influence choice of agricultural land use in the case study area. This was analyzed using the Logit Model Analysis.

Logit model analysis has been widely used to investigate participation in agricultural land use activities and to assess the impact of extension programs (Synden, 1990). It is a tool often used in explaining farmers' decisions in technology adoption (Ervin et al., 1992; Ayuk, 1997; Cary et al., 1997; Synden et al., 1990) The Logit model analysis is used for estimating binary choices. The objective of the model is to determine the probability of an individual making one choice rather than the alternative (Ayuk, 1997).

The logit model is usually specified as:

$$E(Yi)=P(Yi)= e^{\alpha+\beta\chi i} / 1+e^{\alpha+\beta\chi i}$$

where:

Pi *is the probability of the ith individual with Xi attributes falling on to one of the dependent variable classes;*

E(Yi)=P(Yi)=1, Yi = 1 *if the individual adopts; Yi = 0 if the individual does not adopt;*

X = represents a vector of characteristics or attributes associated with the individual I;

B *is the vector of estimated coefficients*

In the thesis, farmer decision to diversify agricultural land use (through multiple - crop species production) or not is considered as a binary choice. If the farmer decided to maintain a diverse agricultural land use (through multiple-crop species): $P(Yi) = 1$ and if the farmer decided not to diversify then $P(Yi)= 0$. The main assumptions are that: a) the farmer is faced with a choice between two alternatives, i.e., to diversify agricultural land use (where agricultural trees and annual crops are integrated) or not to diversify his production system (monocrop of annuals); b) the choice the farmer makes depends on farm characteristics, his personal traits and perceptions on the influence of upland farming on the health of the environment and of the farm workers. It is hypothesized here that farm characteristics, farmer traits and perceptions are positively related to farmers' decision to diversify agricultural land use (i.e. by integrating agricultural trees and annual crops).

On this basis, the model estimated in this study is;

$$E(Yi) = \alpha + \beta_1\, age + \beta_2\, gender + \beta_3 edu + \beta_4 farmyr + \beta_5\, vposi + \beta_6\, Lsze + \beta_7\, tenure + \beta_8\, OFInc + \beta_9\, NFInc + \beta_{10}\, Envt + \beta_{11}\, Health$$

where:
EYi = 1 if the farmer maintained a diversified production system
EYi = 0 if the farmer did not diversify

The variables contained in the model are further defined in the subsection below.

Variables used in the Logit Model Analysis. The symbols and definitions of the variables used for the logit model analysis are provided in Table 5.2 below. The dependent variable is the farmers' management system (croppat) where 1 refers to a diversified agricultural land use where agricultural trees and annual are integrated and 0 refers to the monocropping of annual crops. Farmer personal traits include age (*age*), gender (*gender*), farming experience (*farmyr*), educational attainment (*edu*), leadership quality (*vposi*), income sources other than farming like *OFInc* meaning off-farm Income and *NFInc* meaning non-farm income.

Farmer perceptions of the influence of upland farming on health of the environment (*Envt*) and of the farm workers (*Health*) were indicated by farmers' awareness of these factors.

Farm characteristics include size of the land (*Lsze*) and land tenure *(tenure)*.

Table 5. 2. Definition of the Variables used in the Logit Model

Symbol	Name and Description
Croppat	Agricultural Land Use; 1 if the farmer diversified; 0 otherwise
Age	Age (in years) of farmer or head of household;
Gender	Gender ; 0 if male; 1 if female
Edu	Highest Educational Attainment of the farmer; 1-primary ;2-secondary level; 3- vocational course university undergraduate or graduate;
Farmyr	Farming Experience or number of years of experience in farming
Vposi	Leadership Ability as exemplified by position in local or community government and in farmer organization; 0 no position, 1 if with position.
Lsze	Size of Landholding; 1 if </=1 hectare, 2 if >1.0 hectare
Tenure	Land tenure status; 0if tenant, 1 if landowner.
OFInc	Access to off-farm income or other source of income outside their own farm; 0 if none, 1 have off-farm income.
NFInc	Access to non-farm income or other source of income coming form non-agricultural activities; 0 if none, 1 have non-farm income.
Envt	Farmer perception on influence of farming on the natural resources; 0 perceives no effect; 1 otherwise.
Health	Farmer perception on effect of farming on farm workers' health; 0 perceives no effect; 1 otherwise.

5.2.5 The Farmer Interview Schedule

A survey instrument was developed for collecting socioeconomic data. While data for soil quality was directly measured using field techniques, productivity data including crops yields and income were indirectly measured through farmer interviews. Furthermore, information related to farm and farmer characteristics, farmers' reasons for integrating trees or not into their productions systems, and their perceptions and awareness of environmental degradation in the uplands were also collected through farmer interviews.

There were nine sections in the questionnaire. These are: 1) general information about the farmer and his farm; 2) detailed information about the current production system; 3) cost of production; 4) trend in production for the last 10 years; 5) indebtedness; 6) incidence of poisoning; 7) perceptions on land use management; 8) perceptions on environmental degradation; 9) additional information/comments.

The English version of the survey instrument is provided in Appendix. 5.4.

5.2.6 Integration and Analysis

After having assessed natural resource protection though soil quality, evaluated productivity in the different agricultural land uses in the study area, and determined the social factors the influence choice of agricultural land use, the results were integrated in terms of their implications for enhancing agrobiodiversity in the uplands and its potential for contributing towards the sustainable land management of tropical uplands, the Philippines in particular. The Integration of all results was done qualitatively using the Strength-Weakness-Opportunity-Threat technique.

5.3 Summary and Conclusion

Liliw is an example of an upland area where its agricultural land use has become intensive through time. Different agricultural land uses existed in the area including monocropping of annual crops and integration of annual crops, plantation and fruit crops. What otherwise was a forested land is today mostly in agricultural production, which serves as source of livelihood for the village communities. Being an upland area that has lost most of its permanent vegetation cover, problems related to agricultural productivity and environmental degradation are now apparent.

The framework of criteria and indicators devised in Chapter 4 was used for developing the method to be applied in the case study site. This is aimed to evaluate the influence of agricultural land use on soil fertility and farm economic productivity, as well as to determine the social factors that influence the way farmers' manage agricultural land use.

Species composition of different production systems was determined through the belt transect technique; soil fertility was determined through actual soil sampling and laboratory analysis for soil organic matter and soil nitrate; thickness of the topsoil was measured in the field as support information to soil fertility. Productivity of the different production system was measured in three ways: existing farm productivity with farm profit as the basic measure, land productivity with crop yields from previous cropping season as basic measure and long term productivity as indicated by the trends in income and harvest losses for the last 10 years. These were all obtained through farmer interviews.

Finally, social factors influencing the way farmers' manage agricultural land use was to be determined by hypothesizing that farm characteristics, farmer characteristics and farmer perceptions on the influence of upland farming on the natural environment and health of the farm workers influence choice of agricultural land use.

Results of the evaluation are discussed in the following chapters (Chapters 6, 7 and 8). Integration of the results and implications for enhancing agrobiodiversity in the uplands are drawn out and discussed in Chapter 9.

CHAPTER 6

Environmental Protection and Agricultural Land Use in an Upland Area: the Case of Liliw, Laguna

This chapter is the first of the three chapters (Chapters 6, 7 and 8) that evaluates agricultural land use in Liliw, Laguna, Philippines using the methodological framework developed in Chapter 4 and adapted for the case study in Chapter 5. This chapter addresses in part the third objective of the thesis: to apply the integrated methodology developed in objective 2, by evaluating the spectrum of agricultural land uses in the uplands and its influence on the environment and economic productivity, in order to explore the potential benefits of enhancing agrobiodiversity in tropical uplands.

Environmental protection, one of the criteria for evaluating agricultural land use discussed in Chapter 4, which could have a very broad concern, is limited here to protection of the soil, it being one of the most important natural resource in the uplands. The soil condition in the uplands which could be subject to various kinds of degradation due to loss of permanent vegetation (as discussed in Chapter 2) is given importance in this chapter by looking at the extent by which agricultural land uses influenced soil fertility. Agricultural land uses in the area (as introduced in Chapter 5) involved vegetable monocropping and integration of horticultural trees and vegetables.

First, discussed in the chapter is the plant species diversity in different agricultural land uses followed by description of the soil fertility in different agricultural land uses. Interaction between plant species diversity and soil fertility is also discussed in later part of the chapter.

This part of the research is based on field work that involves actual measurement of plant species composition and soil characteristics in the area.

6.1. Plant Species Diversity in Different Agricultural Land Uses

Plant species diversity of agricultural land uses with vegetable monocrop and with multiple crops was measured, and is compared and discussed in this subsection, using species richness, species abundance and Shannon Diversity Index (Table 6.1).

6.1.1 Species Richness

Species Richness or the number of plant species range from 5.4 to 10 in the different agricultural land uses in Liliw, Laguna (Table 6.1). These plant species are composed of the planned and the unplanned plant biota. The planned biota are the crops that have been deliberately selected or planted by the land users for production. This is further classified into the permanent plant biota referring to the permanent tree crops and the annual productive biota referring to the annual cash crops. In the area, the planned plant biota consists of vegetables (specifically tomato and radish as sequential crop after tomato, denoted T-F/T-R in Table 6.1), plantation tree crops (specifically coconut, denoted C in Table 6.1) and tropical fruit tree crops (specifically lanzones, denoted L in Table 6.1). The unplanned biota are the weeds that are associated with each of the productive plant biota.

Expectedly, there are more plant species in land use types that involve the integration of annual cash crops and perennial cash crops than in the monoculture of vegetables. This is due not only to the integration of the planned plant biota, but also the presence of weed species associated with the crops. On the other hand, agricultural land use with vegetable monocrop was also made complex, in terms of plant species diversity, by the unplanned biota or the weed species associated with vegetables, specifically with tomato. Nevertheless, Table 6.1 shows that agricultural land uses with multiple crops are still more complex as indicated by the higher number of plant species.

Table 6.1. Plant Species Diversity of the Differing Agricultural Land Uses in Liliw, Laguna, Philippines (Crop Year, 2001).

Characteristics	Agricultural Land Uses (n=24)			
	With Monocrop (T-R/T-F)	**With Annual crops + Plantation + Fruit Tree Crops (C+L+T)**	**With Annual crops + Fruit Tree Crops (L+T)**	**Annual Crops + Plantation Tree Crops (C+T)**
Species Richness	5.4	9.5	8.50	10.00
Total Abundance	86.30	103.33	12.75	156.25
Relative abundance planned (annual) biota (%)	18.20	11.79	11.95	11.54
Relative abundance planned (perennial) biota (%)	0	3.82	3.10	2.49
Relative abundance unplanned biota (%)	81.80	84.39	84.96	85.97
Shannon Diversity Index	0.622[a]	0.769[b]	0.749[b]	0.815[b]

Plant species are collected using 20m transect line sampling; ANOVA shows SDI values are significantly different at 5% level; Shannon Diversity Index values followed by same letter are not significantly; Standard Deviation in brackets.
C = coconut; T = tomato; L = lanzones.

6.1.2 Species Abundance

In terms of the number of individual plants per plant species present in the system, results revealed a similar trend. Total species abundance is relatively higher in land use types where annual and perennial cash crops are integrated. This indicates that there are more individual plant species in these land use types as compared to the monocropping of annual cash crops.At the time of observation, though, the most abundant plant species in all land use types evaluated was the unplanned plant biota (Appendix Table 6.1). Relative abundance values for the unplanned plant biota is more than 80% of the total number of plant species in all land use types (Table 6.1).

6.1.3 Shannon Diversity Index (SDI)

The index provides the number and abundance of planned and unplanned plant biota in the system. High species diversity indicates a complex community and thus greater variety of species interacting with each other. A community has high species diversity if many equally or nearly equally abundant species are present (Brower et al., 1990). SDI is calculated based on the *species richness* and *species abundance*.

Figure 6.1 compares plant species diversity of agricultural land uses with vegetable monocrop and agricultural land uses that integrated horticultural trees and vegetables. Agricultural land use with vegetable monocrop exhibited the lowest SDI. This was seen to be significantly different from the SDI of agricultural land uses where horticultural trees and vegetables are intercropped. SDI among the agricultural land uses with multiple crops is not significantly different from each other.

Having known plant species diversity in each agricultural land use, the role of these land uses in protection of the natural resources from degradation, specifically of the soil, the most important resource for upland agricultural land use, is elaborated in the following subsections.

6.2 Soil Characteristics in Different Agricultural Land Uses

Soil condition in the research site is assessed for its fertility, using soil organic matter as the main indicator. The topsoil or the rooting zone, which is very important to plant growth and which could be subject to degradation in high elevations and sloping areas, was also measured for different agricultural land uses. Concentration of Nitrate in the soil was also measured to assess the role that agricultural land uses might have in preventing wastage of nutrients applied into the crops.

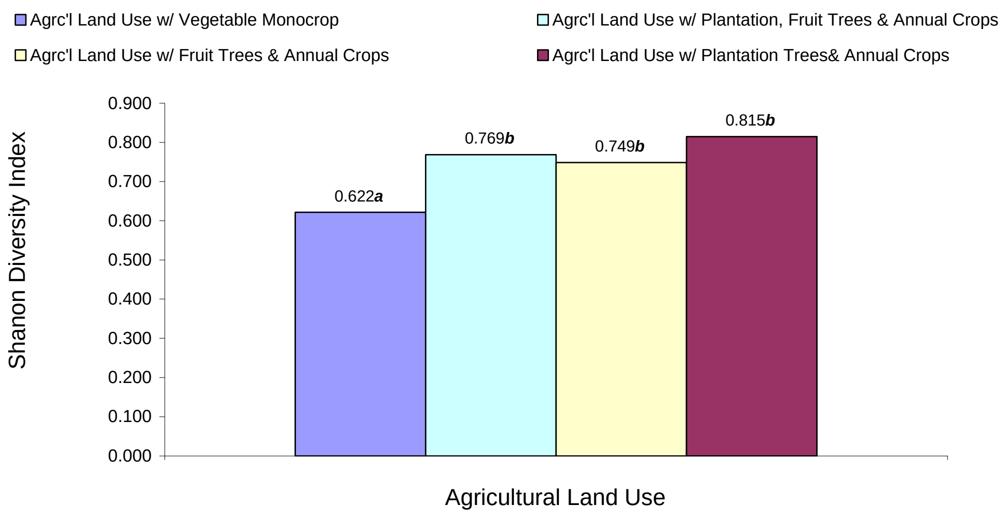


Figure 6.1. PLant Species Diversity in Different Agricultural Land Uses in Liliw,Laguna,Philippines (Crop Year, 2001).

**Means followed by the same letter are not statististically different at 5% level of significance*

6.2.1 Thickness of the Top Soil

Based on land classification for the Province of Laguna, Alipit Soil Series, the soil type in the study area, has a solum thickness of 80 to 150 cm and its A-horizon or the uppermost part of the soil profile may range from 20 to 35 cm thick. A representative soil pedon of Alipit Soil Series for Laguna Province showed an A-horizon of 22 cm (Bureau of Soil and Water Management, 1987).

Actual measurement of the soil in the study area showed thicker A-horizon (29.78 cm) in agricultural land uses with multiple crops (Table 6.2). On the other hand, agricultural land uses with vegetable monocrop exhibited thinner topsoil (14.57cm). Agricultural land uses with multiple crops have A-horizon thickness, which is within the reported range of the depth of topsoil for Alipit Soil in Laguna Province.

Table 6.2. Average Thickness of Topsoil in Agricultural Land Uses with Vegetable Monocrop and with Multiple Crops in Liliw, Laguna, Philippines (Crop Year, 2001).

Agricultural Land Use (n=24)	A-Horizon Thickness (cm)
Agricultural Land Use with Vegetable Monocrop	14.57
Agricultural Land Use with Multiple Crops	29.78

Among the agricultural land uses with multiple crops, those that involved intercropping of plantation trees, fruit trees and vegetables have best conserved the topsoil thus the rooting zone (Figure 6.2). This is followed by land use types with intercropping of plantation and vegetables. In agricultural land use types with multiple crops, intercropping of fruit trees and vegetables have least conserved the topsoil. Over all, the worst soil condition in terms of thickness of topsoil is in agricultural land use type with vegetable monocrop. Soil depth in these different land uses are found statistically different from each other.

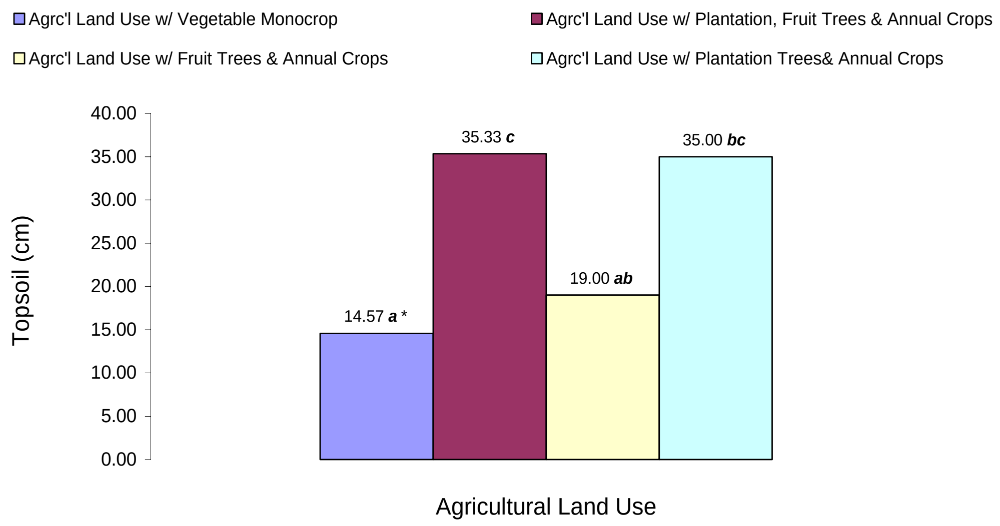


Figure 6.2. Thickness of Topsoil in Different Agricultural Land Uses in Liliw, Laguna, Philippines (Crop Year 2001).
**Means followed by the same letter are not signicantly different at 5% level using T-Test*

6.2.2 Soil Organic Matter

Organic matter content in the topsoil and in the subsoil of land uses with either monocropping of annuals or integration of perennials and annual crops is relatively high. Figure 6.3 shows that on average, agricultural land use with the monocropping of vegetables has 4.85% organic matter content in the topsoil (20 cm soil depth) and 4.90% in the subsoil (40 cm soil depth). In agricultural land uses with intercropping of horticultural trees and crops, organic matter ranges from 3.45% to 4.207% in the topsoil and from 2.91% to 3.4% in the subsoil. Based on the land classification for the Province of Laguna (BSWM, 1987), soil organic matter in the topsoil of Alipit Soil Series generally is about 1.78 % to 2.78 % in the topsoil and about 0.81% to 0.83% in the subsoil. This unexpected result is discussed later in section 6.5.2.

Table 6.3. Percent Organic Matter Content at 20cm and 40cm Soil Depth in Different Agricultural Land Uses in Liliw, Laguna, Philippines (Crop Year 2001).

Soil Depth (cm)	Agricultural Land Use (n=24)	
	With Monocrop	With Multiple Crops
20	4.85	3.87
40	4.91	3.23

Organic Matter at 20 cm Soil Depth

Comparing the soil organic matter content of agricultural land uses with vegetable monocrop and with intercropping of horticultural trees and crops, the former had the highest organic matter at 20 cm soil depth (Figure 6.3). Among the agricultural land uses with intercropping of trees and crops, highest soil organic matter content at 20 cm depth (4.2%) was observed in the intercropping of fruit trees (lanzones) and vegetable crops (Tomato). This is followed by intercropping of plantation, fruit trees and annual crops (3.97%) then intercropping of plantation and annual crops (3.45%). Observations for agricultural land uses with multiple crops are not significantly different. Organic matter content in topsoil of agricultural land uses with monocropping is significantly higher than the rest.

Organic Matter at 40 cm Soil Depth

At 40 cm depth, agricultural land uses with vegetable monocropping also have higher amount of organic matter (4.90%) and this observation is significantly higher than organic matter of agricultural land uses with multiple crops.

Where there is integration plantation, fruit and vegetables, organic matter declined with soil depth (40 cm). Organic matter content of intercropping of plantation, fruit and annual crops (3.39%) was almost the same as the organic matter content of intercropping of fruit trees and annual crops (3.40%). Least organic matter content in the subsoil was exhibited by farms with intercropping of plantation and annual crops (2.91%). Soil Organic Matter Content in agricultural land uses where trees and vegetables are integrated is not significantly different from each other.

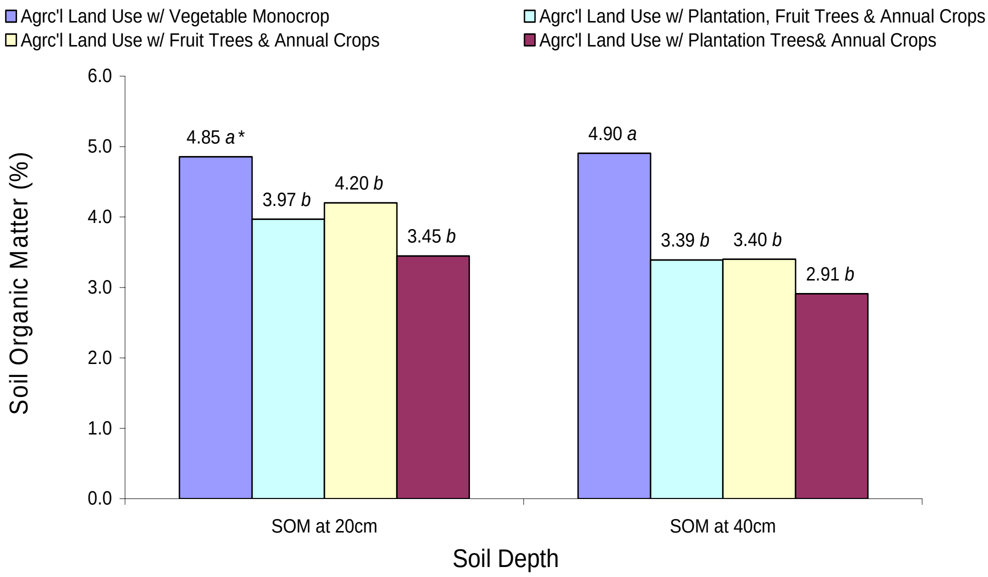


Figure 6.3. Soil Organic Matter at 20 and 40 cm Soil Depth in Different Agricultural Land Uses in Liliw, Laguna, Philippines (Crop Year 2001).

***** *Means followed by the same letters are not significantly different at 5% level using independent t-test*

6.2.3 Nitrate Concentration at Varying Soil Depths

Higher concentration of soil nitrate was found in agricultural land use with monocropping of the annual crops than in agricultural land use with intercropping of perennials and annual crops. In both land uses, highest nitrate concentration was observed at 40 cm soil depth (Table 6.4). In agricultural land use with vegetable monocrop, concentration of nitrate at 40 cm soil depth is higher by about almost 40% than the concentration on nitrate at 20 cm soil depth. In agricultural land use with intercrops on the other hand, nitrate concentration at 40 cm soil depth is higher by about 42% than the nitrate concentration at 20 cm soil depth. At 100cm soil depth, nitrate concentration was reduced by almost 50% in agricultural land use with monocrop. In agricultural land use with multiple crops, nitrate concentration was reduced by about 42% at 100cm soil depth.

Table 6.4. Soil Nitrate in Different Agricultural Land Uses in Liliw, Laguna, Philippines (Crop Year 2001)

Nitrate Accumulation (ppm)	Agricultural Land Use (n=24)	
	With Monocrop	With Multiple Crops
At 20 cm soil depth	10.35	6.86
At 40 cm Soil Depth	16.83	11.91
At 100 cm soil Depth	8.5	6.90

Nitrate Concentration at 20 cm Soil Depth

At 20 cm soil depth, highest concentration of soil nitrate (10.35ppm) was observed in agricultural land use with monocropping of annual crops. This is about 33.7% more than the nitrate concentration in the soil with diverse system. Least nitrate concentration of 5.48 ppm was observed in agricultural land use with intercropping of fruit tree and vegetable crops. Agricultural land use with intercropping of plantation, fruit tree and vegetable crops had the second highest nitrate concentration (8.53 ppm) followed by agricultural land use with intercropping of plantation tree and vegetable crops (6.57 ppm).

Nitrate Concentration at 40 cm Soil Depth

It can be noted that at 40cm soil depth, nitrate concentrations across all land uses is at its highest (Figure 6.4). At 40 cm soil depth, the highest concentration of nitrate (16.83ppm) was also observed in agricultural land use with monocropping of annual crops. This is about 29.2% more than the average nitrate concentration in agricultural land uses with intercropping of horticultural trees and crops. The least nitrate concentration (11.06 ppm) was observed in the intercropping of plantation, fruit and annual crops. Intercropping of plantation and annual crops exhibited the next highest nitrate concentration (13.32 ppm). This was followed intercropping of fruit trees and annual crops at 11.35 ppm.

Observations for nitrate at 40 cm soil depth in agricultural land uses with monocrop is significantly different from that of nitrate observed in agricultural land use with plantation, fruit and vegetables and agricultural land use with fruit trees and vegetables.

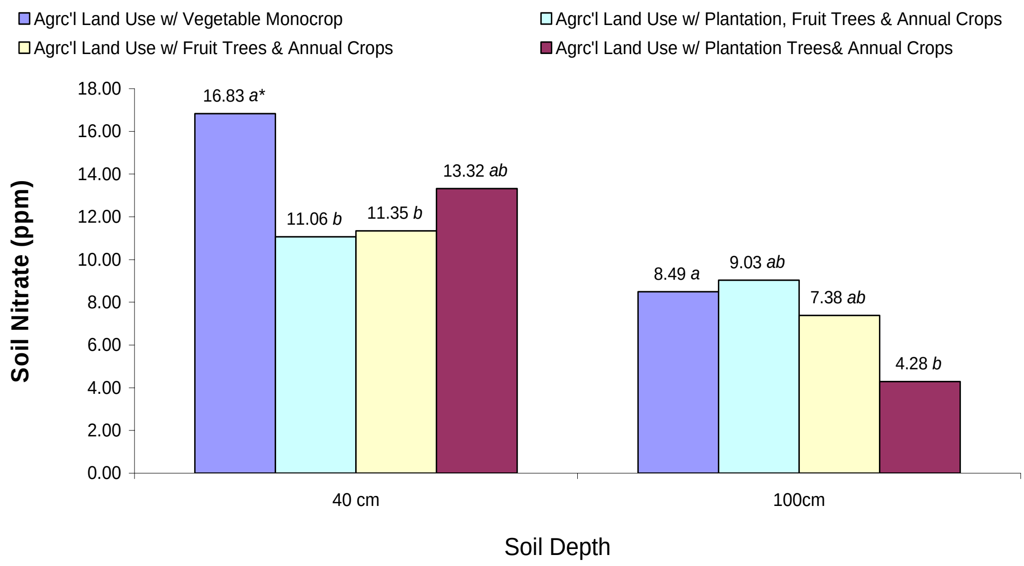


Figure 6.4. Nitrate Concentration at Varying Soil Depths in Different Agricultural Land Uses in Liliw,Laguna,Philippines (Crop Year 2001).

**Means followed by the same letters are not significantly different at 5% level using Independent t-test*

Nitrate Concentration at 100 cm Soil Depth

At 100 cm soil depth, nitrate concentration in agricultural land use plantation, fruit and vegetable is highest (9.03ppm). This is just slightly higher and not significantly different from nitrate in agricultural land uses with vegetable monocrop. The least nitrate concentration, 4.28 ppm, was observed in agricultural land use with intercropping of the plantation and annual crops. This was followed by that of the soil with intercropping of fruit trees and annual crops, 7.38 ppm.

6.3 Plant Species Diversity and Soil Characteristics

Correlation analysis of the Shannon Diversity Index (SDI) and the soil characteristics (thickness of the topsoil, soil organic matter, and soil nitrate) shows that among the variables used, thickness of the topsoil is a very important measure for determining the influence of Plant Species Diversity on soil quality in the uplands (Appendix 6.2). This also shows thicker topsoil in agricultural land uses where horticultural trees and annual crops are integrated, an indication of better protection of the topsoil with increasing plant diversity.

Organic Matter in the topsoil is positively related with SDI, indicating good soil condition in terms of soil fertility even with high plant species diversity. In deeper soil layer (at 40 cm), the rooting zone for the perennial crops, decline in organic matter with increasing plant species diversity where tree crops are integrated could be expected.

Declining soil nitrate with increasing plant species diversity on the other hand, implies the advantage of integration of horticultural trees and annual vegetables in terms of preventing nutrient wastage or nutrient loss in the system.

These observations on soil quality could be explained by a number of factors which are discussed in the following subsections.

6.4 Discussion

In this section, the results from the previous sections are discussed in light of findings in the relevant literature. In turn, this discussion includes thickness of topsoil, soil organic matter, soil nitrates and their relevance on soil fertility in the case study site. As cited in the previous chapter (in the initial assessment of the case study site), loss of soil fertility is the most important cited problem in the area. In general, the upper soil horizon is most critical for agricultural productivity (Wood, et al., 2000). Reduction of the topsoil means reduction of root zone as well as the water holding capacity of the soil (Young et al., 1998). A soil depth of at least 50 cm is considered ecologically sustainable (Gomez et al., 1995).

6.4.1 Depth of Topsoil

Farms with a diversified system, or where there is integration of trees and annual crops, exhibited thicker topsoil than in the monocropping of annuals. This observation could be an indication of lesser incidence of soil loss and hence more favorable rooting zone for crop growth.

In general, permanent vegetation like trees is known to improve soil conditions and properties (Young, 1989; Cooper et al., 1996). Their role as protective physical barriers to soil loss in sloping areas is supported by several research findings. Craswell (1998) for example, cited the works of IBSRAM in the Asia and Pacific regions, on the effect of hedgerow intercrops on soil loss in sloping areas planted to cash crops. In some countries in Southeast Asia, fast growing leguminous tree species like Leucaena leucocephala and pigeon pea planted along with upland rice resulted to a reduction in soil erosion by 50%. Other leguminous trees like Fleminga as well as plantation crops, specifically bush coffee, was found effective in reducing soil erosion from over 50% to 100% in island countries including Fiji, PNG, Vanuatu, and West Samoa. Long-term studies (4-10 years) in the sloping areas (slopes ranging from 7-44%%) of Southeast Asia, including the Philippines, Indonesia, and Africa (Nigeria, Malawi, Kenya and Rwanda) and Peru, showed that crop hedges reduced soil loss and run-off by more than 100%, as compared with land without barrier hedges (Cooper, 1996).

The cited studies are researcher-designed systems where fast growing trees and grasses are introduced into the food production system and tested as barriers to soil loss. The agricultural land uses evaluated in the study are multi-strata/multi-species agroecsosytems, the diversity of which are deliberately planned and implemented by the land users. The crops in the land uses studied in the thesis have not been investigated for their role in soil protection in the literatures. Yet similar to the other tree crops, the presence of horticultural trees in land use in Liliw, Laguna, indicated the potential of perennial crops, like coconut and lanzones, in minimizing loss of topsoil. This was exhibited by thicker topsoil of agricultural land use types where these horticultural trees were integrated.

The potential of the trees to prevent loss of topsoil is attributed to their leaf and root characteristics. The trees are able to provide permanent canopy that cushions the impact of rainfall. Similarly, the roots provide permanent support to the soil surface. This is explained further below.

Crop Roots and Soil Loss

Based on the results obtained in this case study in Liliw, Laguna, coconut roots played an important role in minimizing loss of topsoil. This is shown by the thicker A horizon in soils where there are coconut trees in the system. The roots of coconut in general are dense and plentiful (Philippine Recommends for coconut, 1992). It spreads up to 2 meters from the base of the stem. This may even extend further in sandy soils, like in coastal areas (FSSRI-PCA, 1984). Eighty percent of the roots are concentrated at 30-120 cm below the soil surface (Magat, 1999). The shallow and spreading nature of the roots of coconut explains its potential to minimize loss of topsoil.

Cultivation Practices and Soil Loss

Cultivation management is also a factor that enhances or reduces the crops' capability to protect the soil from erosion. Annual crops require intensive land preparation. In contrast, there is less soil disturbance with permanent crops. Lanzones roots for one are very sensitive to disturbance. In intercropping systems, like in the study area, farmers prepare the soil for the annual intercrops differently from areas with the monocropping systems. Very minimal land cultivation is done for planting tomatoes in between the trees because, according to the farmers in the area, disturbance to the roots of the lanzones trees cause the trees not to bear fruits.

Results of the study showed the advantage of integrating plantation and fruit tree crops in the food production system over the monocropping of the annual cash crops in terms of maintaining a favorable root zone for crop growth, i.e., thicker topsoil.

6.4.2 Soil Organic Matter

Soil organic matter in the Liliw study site either agricultural land uses with vegetable monocrop and with multiple crops where horticultural trees and vegetables are integrated, is high as compared to the recorded soil organic matter content in the Province of Laguna in general. In agricultural land use with vegetable monocrop, soil organic matter is highest in spite of evidence of loss of topsoil. Furthermore, in agricultural land use with vegetable monocrop, soil organic matter in the subsoil (at 40 cm soil depth) remained higher than for the other land uses. This result does not fit with the general rule in soil science that soil organic matter declines with depth of soil (Haverson, 1996). This observation can be explained by the influence of several factors on soil organic matter. Among the most important are the application of organic inputs (Lal,1998; Fernandez et al., 1997; Sisworo,1990; Sidhu et al., 1993), cultivation practices (Doran, 1996), and integration of permanent crops (Neupane, 2001) in the system, discussed below.

Organic Inputs and Soil Organic Matter

With respect to soil loss and organic matter, observation in this study revealed a trend opposite to that expected. The greatest impact of soil loss is on soil fertility (Lal, 1998). In this study, however, farms with monocropping of annual cash crops, which appeared to be the most eroded among all the land use types observed, exhibited higher fertility as indicated by the organic matter content.

Research findings reveal that the drastic effects of soil erosion can be masked by different management practices, more so with the so called “improved technologies” like a high amount of fertilizer input, irrigation, tillage/residue management, high yielding varieties, and pest control. Application of high amounts of chemical fertilizer inputs tops the list of these technologies in terms of masking the effect of soil loss on soil productivity (Lal, 1998). As such, high yields may still be harvested from highly eroded soils. However, while these high external-input technologies may replenish loss of soil nutrients, they do not have long-term soil enhancing properties (Doran et al., 1996).

Several studies in the literature note that the addition of organic inputs into the soil is most effective in enhancing soil properties in the long-term. Organic inputs are believed to have lignin content that increases the size of the slow and passive soil organic matter pools thereby promoting long-term soil productivity (Fernandes et al., 1997). There are several sources of organic inputs that can be used in agricultural production. These include animal and human refuse, crop residues, green manure and agroindustrial wastes. Nitrogen content of these organic materials may range from 0.25 to 7.8% (wet weight basis). Except for the agroindustrial wastes, poultry manure is reported to contain the highest nitrogen content of 3% (Fernandes, 1997). The effect of organic inputs is reported to accumulate in the soil over repeated applications. Studies by Sisworo (1990) and Sidhu et al. (1993) observed residual effects of applied organic inputs on crop uptake can be up to the sixth crop after application.

Application of poultry manure is a dominant practice in the Liliw study site. This in part explains the relatively high soil organic matter in the four land use types observed in the study, but especially that of the monoculture of annual cash crops as compared to the reported organic matter content of Alipit soil in the Province of Laguna in general.

Cultivation Practices and Soil Organic Matter

Minimum tillage is yet another management practice that can prevent the decline in organic matter content of the soil. Excessive tillage causes physical disruption in the soil aggregates. This physical disturbance increases aeration and warming in the soil resulting to rapid decomposition of the organic matter in the soil. This process causes the decline in soil organic matter (Doran et al., 1996). In the Liliw study area minimum tillage is actually applied. Given the high elevation, rolling to step slopes, and too much rain during the wet season, there is minimal land cultivation. The lands are kept fallow for almost half the year. This practice could be contributory to the relatively high organic matter in the soil, especially under monocropping, as compared to normal level of organic matter in the province.

Integration of Perennials into the System and Soil Organic Matter

As regards to the presence of the perennials into the system and its influence on soil organic matter in the soil, observation in Liliw showed that organic matter is lower than organic mater in agricultural land use with the vegetable monocrop. There are two points of view about the influence of integrating perennials crops into the system on soil characteristics.

Forestry and agroforestry studies tell of the important role of integrating trees into food crop production in terms of enhancing soil quality. Several studies have shown how trees are able to improve the physical, chemical and biological activities in the soil thereby improving soil productivity through time.

Fernandes et al. (1997) cited studies that reported a rapid recovery in soil organic matter content in deforested areas when planted with shade, timber trees, perennial crops and alley cropping of legumes trees and fruit crops. Carg (1998) on the other hand observed the capability of trees to rehabilitate environmentally degraded soils like sodic soils or soils with high sodium contents impairing productivity, infertile, no microbial activity, with low infiltration and with hard soil. These improvements in the soil condition are attributed to the high amounts of leaf litter produced by the trees that eventually covered the soil and are further decayed in the soil surface. Enhanced cropping intensity is also believed to harbor below-ground diversity because of the tree rooting system, which activates soil microbial and faunal activities (Carg, 1998). Soil organisms are the ones responsible for the preservation and build up of organic matter (Doran et. al, 1996)

On the other hand, there are also studies showing that integration of perennial crops with food crop production does not always result to beneficial effects on soil quality. Neupane et al. (2001), in a study on integration of fodder trees into the food crop production in the hill lands of Nepal, found that soil fertility (measured by organic matter, pH, N, P, K, sand silt and clay) was not significantly different from those of the monoculture of food crops. This was attributed to the nutrient uptake of the fodder crops, which could possibly mask the effect of the fodder trees on soil fertility. This was supported by a similar observation in the Philippines on hedgerow intercropping which exhibited limited contribution of leguminous tree species on soil fertility when these tree species are trimmed four times in a year (Garcia et al, 1995). Furthermore, Neupane et al., (2001) supported his observation by citing studies showing that build–up of soil organic matter resulting from crop diversification is a long-time process and thus may not be immediately observed.

In the Liliw study the observed organic matter content in the soil could have been influenced more by the organic inputs and other cultivation practices in the study area than by the plant species diversity of the agricultural land uses observed.

6.4.3 Soil Nitrate

In the Liliw case study, there is more accumulation of nitrate in agricultural land use with vegetable monocrop than in agricultural land use with multiple crops where horticultural trees and vegetables are intercropped. This is made evident by the higher nitrate concentrations at different soil depth. At 20 cm soil depth, the rooting zone of the annual crops and uptake of available soil nutrients by them is expected to be most active. This explains the lower concentrations of nitrate in the upper layer of the soil (20 cm soil depth).

The high concentrations of nitrate exhibited by agricultural land use with vegetable at 40 cm depth of soil, suggests poor plant uptake of nitrogen by the annual crops. This poor uptake results in accumulation of nitrates in the soil. Sainju (1999) in his study on the effects of different management practices on the nitrate-N movement and content in the soil under tomato observed a considerable amount of nitrate accumulation in the soil and attributed this to poor nitrogen recovery by the crop.

The lower nitrate concentrations in the topsoil and subsoil of agricultural land uses with multiple crops (where tree crops and annual crops are integrated) as compared with vegetable monocrop, specifically at 40 cm soil depth, suggest that at that level in the soil profile, the presence of tree crops in the system in Liliw, Laguna aided in prevention of nitrate accumulation in the soil. As previous research findings suggest, the rooting system of trees are able to absorb nutrients beyond the rooting zone of annual crops for which added fertilizers are intended.

Reported results from other studies also indicate that nitrate can be leached further into the deeper layer of the soil, way below the rooting zone of most of the crops. The lower concentration of nitrate in the Liliw diverse system at 100cm soil depth, though, indicated the advantage of the presence of the trees into the system.

Reported results in the literature show that by increased diversity of the production systems through integration of agricultural tree crops and annual crops, there is better utilization of nutrients applied into the system due to deep nutrient capture by the trees. The fewer the nutrient losses from the system, the fewer inputs needed from outside the system (Sanchez, et al., 2006).

6.5 Summary and Conclusions

Measures of soil quality in the study include thickness of topsoil, soil organic matter, and soil Nitrate-N accumulation. The topsoil is an important repository of nutrients immediately needed for crop growth. Organic matter determines long-term productivity of the soil and serves as source or sinks for nutrient gases. Accumulation of Nitrate-N in the soil is a measure of nutrient loss hence a waste on the inputs intended for the crops. These are all-important indicators of how plant species diversity in an agroecosystem is able to perform protection from land degradation specifically loss in soil fertility.

There is an apparent advantage of diversifying land use through integration of perennial cash crops with annual cash crops in terms of conserving topsoil. But this is not as evident in terms of the organic matter content in the soil in the Liliw case. There is even an observed higher organic matter content on the soil surface of land use types with the monocropping of annuals and no difference in the organic matter content in the subsoil of land use types used for either monocropping of annual cash crops or for the integration of perennial cash and annual cash crops. This can be attributed to the amount of external inputs, organic or inorganic fertilizer, applied to the annual crops. This is also indicative of higher nutrient uptake in land use where there is integration of perennial and annual cash crops.

In terms of reducing nutrient wastage into the soil, diversifying land use by integration of horticultural trees and vegetables has an apparent advantage over the monocropping of annual cash crops. Nitrate being a mobile element, when accumulated in the soil, would result to leaching causing nutrient wastage than be utilized by the crops. Integration of trees and annual crops effect a more efficient nutrient utilization in the system through deep nutrient capture.

Evaluation of the different land use types was based on observations of actual farm conditions and is thus not subject to uniform/controlled conditions as in a field trial and/or experiments. The effect thus of farmers' practices cannot be disregarded. Combined effects of the type, amount, frequency and timing of application of external inputs, cropping pattern, length of fallow period, irrigation and others management practices by the land users and plant species diversity in a production system, will best be revealed by in–depth research in soil science and ideally under controlled conditions.

Based on the results of the observations at Liliw, agricultural land use where horticultural trees and vegetable crops are integrated, exhibited the potential to maintain soil quality in terms of protection from loss of topsoil. In terms of maintaining soil organic matter, the influence of crop species diversity is not very explicit. In terms of nitrate accumulation in the soil, agricultural land use with intercropping of horticultural trees and annual crops performed better than that with vegetable monocrop.

CHAPTER 7

Economic Productivity and Agricultural Land Use in an Upland Area: the Case of Liliw, Laguna

In this chapter, agricultural land uses in the case study area are evaluated for three criteria (discussed in Chapters 4 and 5), namely: productivity, viability and security of production. Being all interrelated and concerning economic performance, these three criteria are altogether presented in this chapter and referred to as economic productivity. In part, this chapter addresses thesis objective 3, which is *to apply the integrated methodology developed in objective 2, by evaluating the spectrum of agricultural land uses in the uplands and its influence on the environment and economic productivity in order to explore the potential benefits of enhancing agrobiodiversity* in the uplands.

First discussed in the chapter is the financial benefit from different agricultural land uses in the case study area. Crop productivity is then discussed in relation with their contribution to the financial benefits gained in different agricultural land uses. Long-term trends in production and profitability of different agricultural land uses as well as market-related and natural factors that contribute to or deter the stability are also discussed to describe security of production.

This part of the evaluation draws on information on economic productivity of agricultural land uses in the uplands to explain the implications for enhancing agrobiodiversity in the uplands, especially where agricultural trees and vegetable crops are integrated.

Discussion in this chapter is based on data obtained during the field survey, secondary data, and insights from interviews with the land users in the case study site.

7.1 Financial Benefits from Different Agricultural Land Uses

As described in the previous chapters, agricultural land uses in Liliw ranged from lands with vegetable monocrop to lands with multiple crops. Agricultural lands with vegetable monocrop follow two systems: tomato production alone after which the land is kept fallowed (T-F) and tomato production followed by radish (T-R). Agricultural lands with multiple crops vary from intercropping of agricultural trees and vegetable crops, specifically intercropping of plantation trees, fruit trees and vegetables (C+L+T), intercropping of plantation trees and vegetables (C+T) and intercropping of fruit trees and vegetables (L+T).

7.1.1 Profitability

Agricultural production is a profitable venture in the uplands of Liliw, Laguna, as shown by the average annual net income per hectare for 12 years of the different agricultural land uses in the area (Figure 7.1). Among all the land uses in the area,

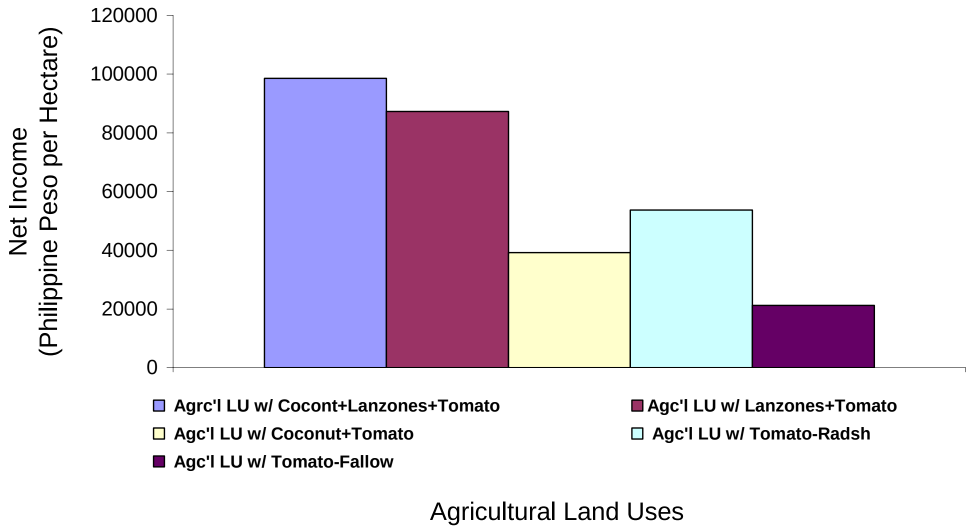


Figure 7.1 Average Annual Net Income for Different Agricultural Land Uses in Liliw, Laguna, Philippines (1994-2005).
Source:Field Survey, 2003 ; BAS,2006

those with the integration of trees and vegetables are the most profitable. Annual average income from different agricultural land uses shows highest net income is from agricultural land use with plantation, fruit trees and vegetables followed by agricultural land use with fruit trees and vegetables.

In the case of a bad year for economic productivity, like the cropping year of 2002, the land use with the most number of agricultural crops (agricultural land use with plantation trees, fruit trees and vegetables) was still the most profitable (Figure 7.2). This was followed by agricultural land use with intercropping of fruit trees and vegetables. The least profitable was the agricultural land use with monocropping of vegetable (T-F) and agricultural land use where plantation trees and vegetables are intercropped (C+T).

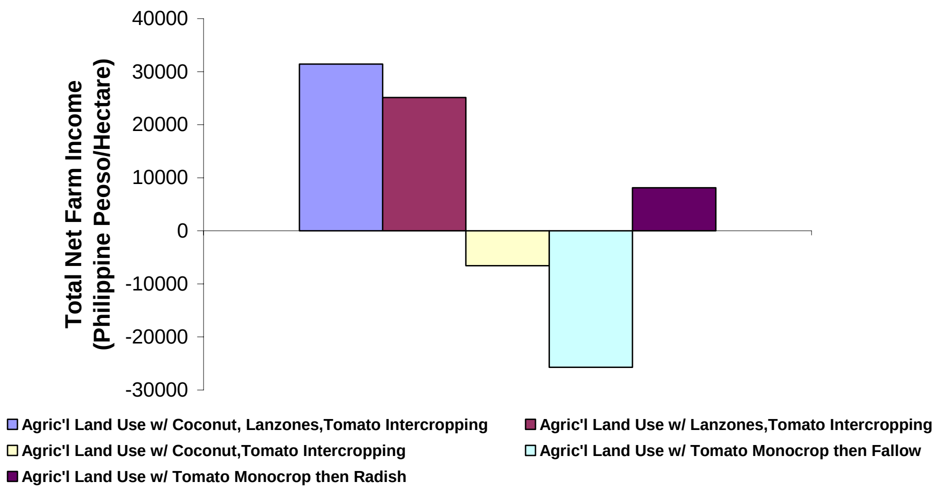


Figure 7.2. Total Net Income from Different Agricultural Land Uses in Liliw, Laguna, Philippines,Crop Year 2002.

Despite this pattern of profitability across agricultural land uses where integration of horticultural trees and vegetables has been more profitable (Figures 7.1 and 7.2), there is continuous use of agricultural lands in Liliw, as in other tropical uplands, for vegetable monocropping. Later in Chapter 8, farmers' reasons for continuing with vegetable monocropping in spite of poor returns are explained.

7.1.2 Income Share per Crop

There are at least four crops that contributed to the profitability of the different agricultural land uses. These are: the annual crops of tomato (*Lycopersicum esculantum*) and radish (*Raphanus sativus*); fruit tree crops, namely lanzones (*Lansium domesticum*); and plantation crops, namely coconut (*Coco nucifera*). Tomato, a highly-valued crop in the area at the time of the study, is a common crop in all agricultural land uses in the area.

Figures 7.3 shows the income share of each crop component in the total net income obtained from different agricultural land uses in Liliw.

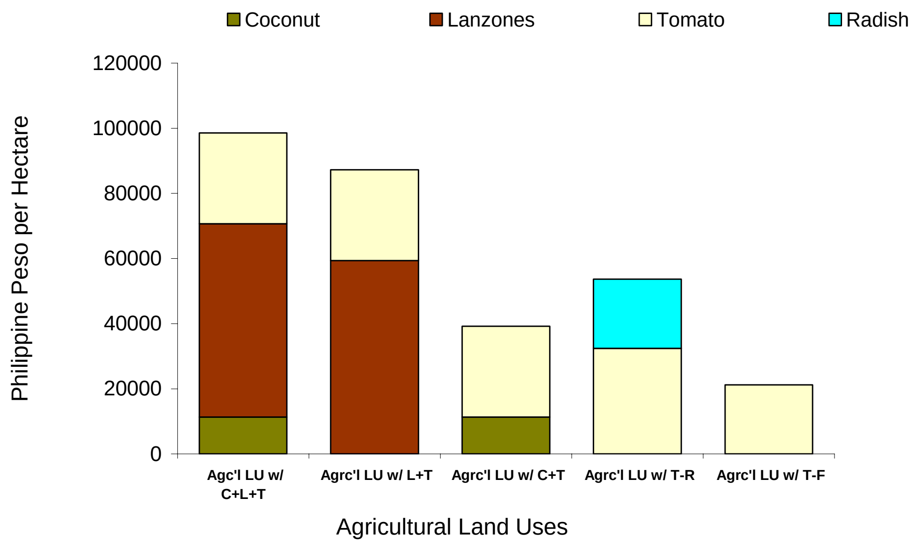


Figure 7.3. Income Contribution per Crop on the Profitability of Different Agricultural Land Uses in Liliw Laguna Philippines,1994-2005.
Source: Field Survey, 2003 ;BAS 2006

In agricultural land uses where there are fruit trees, the highest income share is obtained from this crop followed by tomato and least from coconut. In agricultural land use where fruit crops (lanzones) and vegetables (tomato) are intercropped, the share of fruit crops is over 50%. In agricultural land use with coconut and tomato intercrop, the bigger share of income is from tomato with coconut being generally less than 50%.

In a bad year for tomato production (cropping year, 2002), Figure 7.4 shows a significant contribution, particularly of the fruit trees (lanzones), on the profitability of agricultural land uses with multiple crops and of radish as a sequential crop (after tomato) in agricultural land use with vegetable monocrop. It is worth noting that coconut, which plays an important role in soil protection (as discussed in previous chapter), makes little contribution to the financial benefits obtained from agricultural land uses with multiple crops.

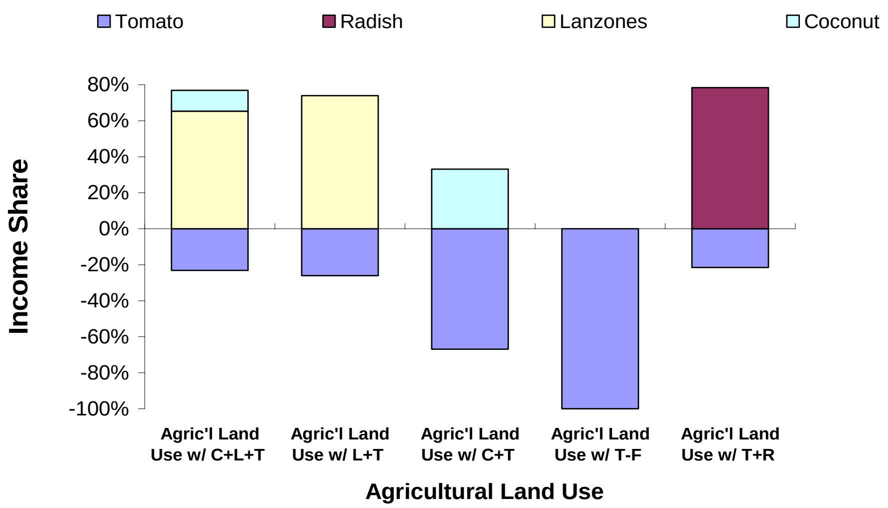


Figure 7.4. Income Share per Crop on Profitability of Different Agricultural Land Uses in Liliw,Laguna,Philippines, Crop Year 2002.

On the other hand, the fruit trees which did not have much role in soil protection, make a significant contribution to the financial benefits obtained from agricultural land uses where trees and vegetables are intercropped.

7.1.3. Capital Share per Crop

The highest capital investment input per hectare per year is for a vegetable crop, especially tomato as shown in Figure 7.5.

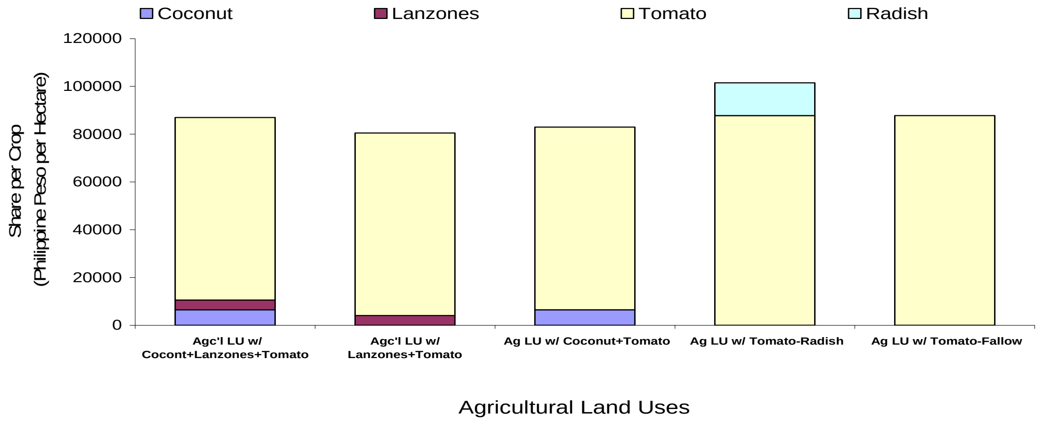


Figure 7.5. Average Annual Cost of Production in Different Agricultural Land Uses in Liliw,Laguna,Philippines (1994-2005).
Source: Field Survey,2003; BAS,2006

7.1.4 Crop Share in Marketable Yields

Average annual crop yields in different agricultural land use in Liliw, Laguna, are illustrated in Figure 7. 6. Contribution of each crop to the total crop yield is also indicated.

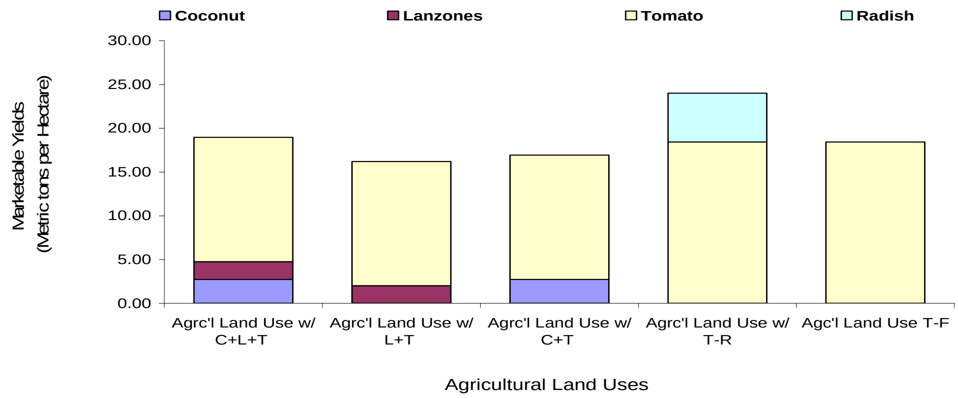


Figure 7.6. Crop Contribution to Marketable Yield in Different Agricultural Land Uses in Liliw,Laguna, Philippines (1994-2005).
Source: Field Survey 2003;BAS,2006

7.2 Productivity and Profitability of Individual Crop Components in Different Agricultural Land Uses

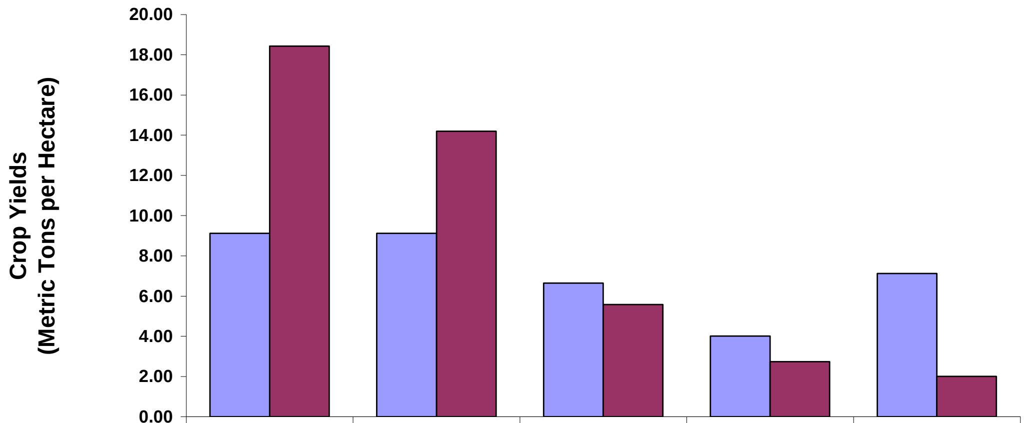
The following discussion concerns crop performance of individual crops that contribute to the productivity and profitability of the agricultural land uses in the study site. The economic importance and productivity performance of the crops at the national level is also cited. To describe crop performance during unfavorable cropping years, discussion is sometimes focused on the cropping year of 2002 (field survey in the study site), as an example.

7.2.1 Tomato as Monocrop and as Intercrop

Tomato is a seasonal vegetable fruit crop that is grown throughout the Philippines and the production region (CALABARZON) where the research site belongs, ranks third among the highest producing regions in the country (BAS, 2006). Average annual production of tomato in the country from 1994 to 2005 was 154,444 metric tons, occupying about 16,928 hectares, thus providing an average crop yield of 9.12 metric tons per hectare. Much (78%) of the total produce of the national production is consumed locally as fresh vegetable (primarily as a flavoring ingredient to meat/fish dishes), the rest is processed into paste and animal feed for local consumption. This crop is one of the 20 major crops grown in the country contributing to about 0.43% of the total value of agricultural production (BAS, 2006).

Crop Yields

Figure 7.7 below shows very good performance of tomato yield in Liliw, Laguna. The relatively higher yields of tomato in Liliw, compared to the national average, verifies the farmers' observation of the favorability of their area for growing tomatoes. Further, yield of tomato is higher when grown alone in Liliw than when intercropped with trees.



	Tomato-mono	Tomato-multicrop	Radish	Coconut	Lanzones
Philippines	9.12	9.12	6.65	4.01	7.12
Liliw	18.43	14.19	5.59	2.74	2.01

Figure 7.7.Annual Average Crop Yields in the Philippines and Liliw,Laguna, (1994-2005).
Source: Field Survey,2003;BAS,2006

In cropping year 2002, for example, marketable yield of tomato was estimated at an average of nearly 23 metric tons per hectare when grown alone and 15 metric tons per hectare when intercropped with tree crops. Further comparison of the marketable yields of tomato (Figure 7.8) shows that from agricultural land uses with multiple crops, it is lowest when intercropped with both coconut and lanzones. The yield of tomato is lower when intercropped with coconut alone than when intercropped with lanzones alone.

The lower yields of tomato in the intercropping system are expected as yields of annual crops are generally reduced by shading. Research reported in the literature showed that the reduction in yield varies from 8 to 80%, depending on the kind of crop and degree of shading (FSSRI, 1984). This is consistent with farmer observation in the case study area about the growth performance of tomato when grown alone and when intercropped with other crops, particularly with trees. Better growth performance of tomato is observed in the open area than in the shaded areas.

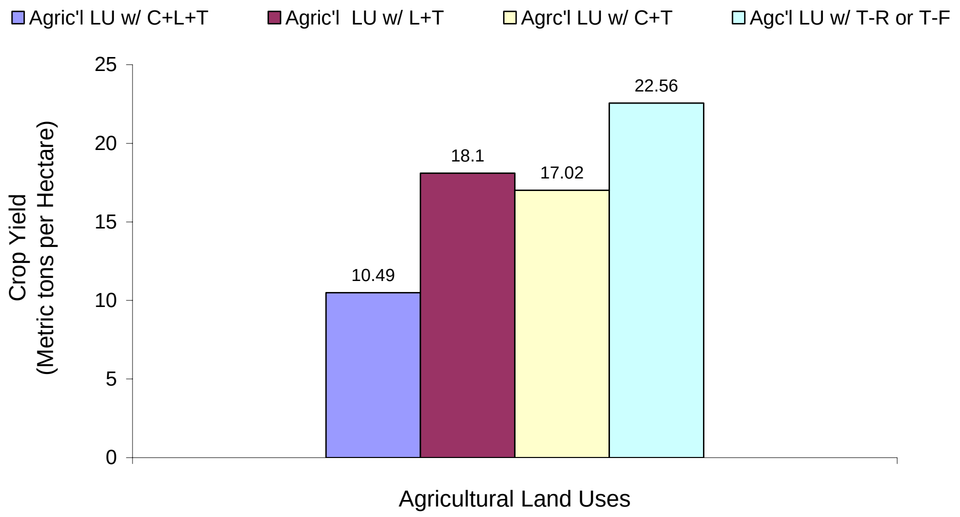


Figure 7.8. Crop Yield of Tomato in Different Agricultural Land Uses in Liliw Laguna, Crop Year 2002.
Source: Field Survey,2003

7.2.2 Radish as a Sequential Crop after Tomato

Unlike tomato, radish is considered a minor vegetable crop in the country. In national records, its productivity is reported along with other crops, grouped as roots and tuber crops or other crops. As illustrated in Figure 7.7 (above), the yield of radish is lower as compared to the annual average yields of other roots and tuber crops in the Philippines.

Crop Yields

As a sequential crop, radish is planted after tomato in agricultural land with vegetable monocrop, otherwise these lands are kept fallowed after tomato. The areas grown to radish are also relatively small compared to the areas for tomato. In Liliw, average annual yield of radish planted after tomato in the monocropping system is 5.5 metric tons per hectare. Radish is more often planted to about a quarter of the total land planted to tomatoes. In spite of this, radish has a significant contribution to economic productivity of agricultural land uses with vegetable monocrop in the research site. In agricultural lands with multiple crops, however, farmers in the Liliw do not plant radish because its planting coincides with the harvesting period for the lanzones fruit crop.

7.2.3 Lanzones in Agricultural Land Uses with Multiple Crops

Lanzones is one of the major fruit crops grown throughout the Philippines. The Province of Laguna (where the research site is located) is the second to top producing province for lanzones, both in terms of area planted, volume of production, and number of fruit-bearing trees. In 1994 to 2005, the Philippines produced an annual average yield of 103,089 metric tons, occupying about 14,519 hectares. In the province of Laguna alone, lanzones is grown in about 3,438 hectares, which is nearly 24% of the total area planted to lanzones in the entire country. Total production per year in Laguna is about 23,415 metric tons thus producing an annual average yield of six metric tons per hectare (from 1994 to 2005), which is almost on par with the national average of seven metric tons per hectare. Lanzones is mainly consumed locally due to its limited potential for export, being a highly perishable fruit. It is a seasonal crop, with its fruits available only for the months of August and September.

Crop Yields

Compared to the national and provincial level, the yield of lanzones in the Liliw is very low, a little over two metric tons per hectare annually (Figure 7.7). There are a number of reasons to this. First, minimum maintenance is provided for the lanzones trees in Liliw in spite the required maintenance for best crop yields like pruning, fertilizer application (especially at fruiting stage), and pest control. While much of the care and maintenance for lanzones trees is required at its early stage of growth (i.e., first year of planting up to its first fruiting stage), there are some activities that will help trees to give better yields. For example, as trees get older, at least 2 kg of complete fertilizer must be applied per tree annually, especially at the peak of its fruiting stage. In Liliw, farmers assume it is enough for the lanzones trees to share the fertilizers applied to the annual crops. Pruning trees of unproductive branches, removal of dead branches and clinging parasitic plants is likewise a practice that would allow better flowering and fruiting. Scraping or brushing off loose dried bark to expose and kill insect pest larvae or weekly chemical spraying would control insect pest damage to the tree trunks are other practices that might improve crop yields of lanzones in Liliw. Digging up of dead trees and burning them would also reduce the spread of disease among trees (STARRDEC, 2003). This is occasionally done in Liliw. Further, replacement of infected and dead trees is done by a few, but not all.

Apart from the care and maintenance required, lanzones has a narrow range of climatic adaptability. It is unable to withstand low temperatures and requires irrigation during dry months for optimum yields. When laden with fruit, lanzones could easily be blown down by typhoons and strong winds.

7.2.4 Coconut in Agricultural Land Uses with Multiple Crops

Coconut is one of the three major crops in the country. The Bureau of Agricultural Statistics (2005) reported that coconut has remained the dominant permanent crop in the country, accounting for 2.6 million farms planted with 320 million trees. In the period 1994-2003, there was an annual average of about 254 million coconut trees, occupying around 3.1 million hectares of the total agricultural land in the country. The Southern Tagalog Region (where Laguna province is located) ranks second highest in terms of area and volume of production for coconut. In Laguna Province alone (where the research site is located), there is an annual average of 3.6 million bearing trees planted in about 63,525 hectares of land from 1994 to 2003 (BAS,2006).

There are a variety of marketable products from coconut including coconut oil, desiccated coconut, fresh coconut and copra, which are the primary products, while by-products include: copra meal, activated carbon, coconut shell charcoal, and coconut coir and coconut coir dust. Coconut end-products include detergent, soaps, shampoo, cosmetics, margarine, cooking oil, confectionery, and vinegar and nata de coco. Coconut intermediaries include oleochemicals, such as fatty acids and fatty alcohols. About 80% of the local coconut production goes to the export market with the remaining 20% for domestic consumption. Coconut oil, copra, copra meal and desiccated coconut are the country's traditional coconut products for export. The country is reported to be the biggest supplier of coconut oil in the world (DA-AMAS, 2006).

Crop Yields

Average annual yield of coconut in Liliw in the period 1994 to 2005 was an estimated 2.74 metric tons per hectare, much lower than the national yield of 4.01 metric tons per hectare (Figure 7.7 above). This reported yield in the study area consists of mature and young nuts which are harvested every two months. Similar to the lanzones trees, very minimal care and maintenance is done for coconut trees in Liliw. Most trees are over 30 years old. Likewise no replanting is done for diseased, old and dead trees. Unlike lanzones trees, coconut is hardly affected or destroyed by natural calamities, such as typhoons and flood.

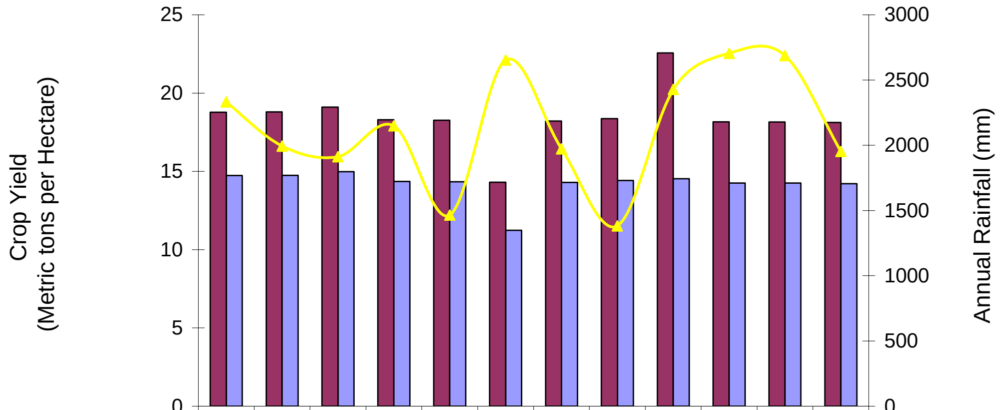
7.3 Security of Production

This subsection discusses long-term trends in productivity and profitability of the different agricultural land uses and the factors that may have influence stability of these trends including market-related and natural factors. Much of the information provided in this subsection is drawn from information elicited from the farmers. Long-term trends in income and harvests are also illustrated using secondary data.

7.3.1 Production Trends in Different Agricultural Land Uses

Trends in Production of Tomato in Different Agricultural Land Uses

Over a 12-year period (1994-2005), tomato exhibited a relatively stable crop yield. This trend is true for tomato grown either as a monocrop or as an intercrop to horticultural trees (Figure 7.9).



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Liliw LU-monocrop	18.77	18.80	19.10	18.30	18.27	14.30	18.21	18.36	22.56	18.16	18.15	18.12
Liliw LU-multiple crops	14.73	14.75	14.99	14.36	14.33	11.23	14.29	14.41	14.53	14.25	14.24	14.22
Rainfall	2331.5	1992.8	1911.8	2149.2	1464.1	2652.9	1971.6	1382.8	2427.4	2704.7	2686.8	1951.7

Figure 7.9. Tomato Production in Different Agricultural Land Uses and Annual Rainfall in Liliw, Laguna, Philippines (1994-2005).
Source: Field Survey,2003; BAS,2006;NAS-LB Agromet,2006)

Based on farmers' observation though, the quantity and quality of their tomato harvest varies yearly. For example, they may obtain bigger fruits at first harvests and smaller fruit size in succeeding harvests with more diseased fruits and increasing incidence of leaf rot. The farmers attribute these problems to a number of factors. The most cited factor is rainfall, as the following quotes exemplify.

> *"My harvest for tomato is not the same, sometimes good, sometimes low. It all depends on the rainfall. Good rains make the seeds happy. Harvesting must not coincide with typhoon season.*

But then we have to wait for the start of the rain to start planting. This year (2002), the weather was really good; four days rain then 2 days dry. But the problem then was too much harvest in the area. Pests are also a problem but this we can treat with agrochemicals." (Farmer respondent # 1)

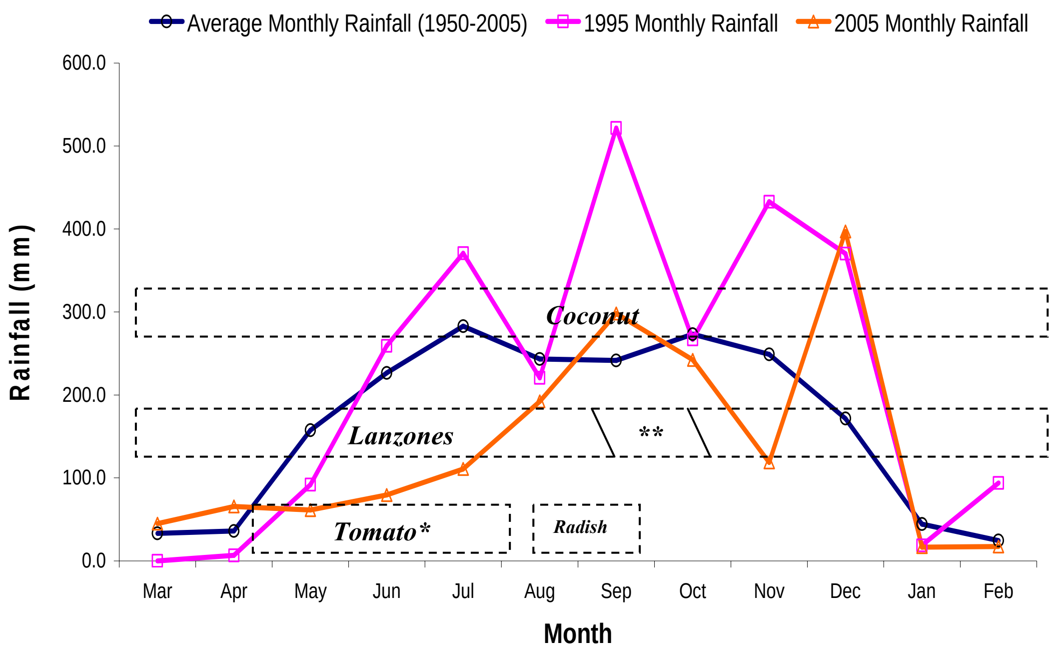
"In the past years, my crops were damaged due to extreme dryness. Weather here has changed, sometimes we get too much rain or sometimes it gets too dry."(Farmer Respondent # 13)

"Yield for tomato varies every year, if it is rainy during the vegetative stage of the crop, then harvest will be okay".(Farmer Respondent # 4)

"In 1997-1998, I harvested only about 200 crates; normally I would have about 350 crates. This is due to extreme dryness." (Farmer respondent #3)

"I recall, in 1999, we had too much rain. My crop was damaged so I got very low yield. "(Farmer respondent # 5)

Rainfall could indeed be a critical factor for the stability of crop yields for tomato because crop production in the area is rainfed. In fact, cropping pattern for vegetables in the area is based on rainfall. As shown in Figure 7.10, the cropping season for tomato in Liliw starts with the onset of rainfall, normally in late April to May. Based on the 50 year record (Appendix 7.1), monthly rainfall in Laguna in 1994-2005 was fairly similar though there were erratic years like in 1995, which was relatively wet, and 2005, which was relatively dry as compared to the usual rainfall pattern in the area. Favorable annual rainfall explains the stable trend on tomato crop yields in the area.



** onset of rainfall is critical for transplanting and succeeding rainfall months for vegetative growth of tomato;*
***flowering and fruiting of lanzones may coincide with heavy rainfall.*

Figure 7.10. Cropping Calendar in Liliw,Laguna, Philippines.

While rainfall may not have undermined the stability of crop yields and thus the security of crop production in agricultural land uses in Liliw, Laguna, a volcanic eruption that struck the country during the early 90's was cited as one factor that badly affected crop yields and harvest.

> *"In 1991, when Mt Pinatubo erupted, very few of us were able to harvest tomato. Ashes covered the plants and the fruits and most of the fruits can no longer be marketed. But then I got very good price for my tomatoes because there were very few tomatoes in the market". (Farmer Respondent # 5)*

Poor soil condition is yet another factor that was cited to have affected crop yields in the area. Farmers noted that the amount of fertilizer applied for tomato production increases every year.

> *"The quality of my tomato fruits is the same every year but the quantity of harvest varies every year. I think the soil is already tired' so the amount of fertilizer that I will apply the following year*

depends on the physical appearance of my fruits during the previous years."(Farmer Respondent # 23)

"I noticed smaller plants and lesser fruits in tomato. Also my plants die one and a half months after planting. According to the agricultural technician, it is due to bacterial wilt, but I think it is due to declining soil fertility. I need to apply more fertilizer." (Farmer Respondent # 26)

Other farmers attributed varying yields to improper cultural management. For example:

"I noticed declining crop stand and I suspect it is due to low quality seeds." (Farmer Respondent # 24)

"Different varieties of tomato performs differently, I noticed Del Monte variety produces sturdier plants". (Farmer Respondent 29)

"I believe that the higher crop yield I got this year is due to the brand new agrochemicals that I used." (Farmer Respondent # 21)

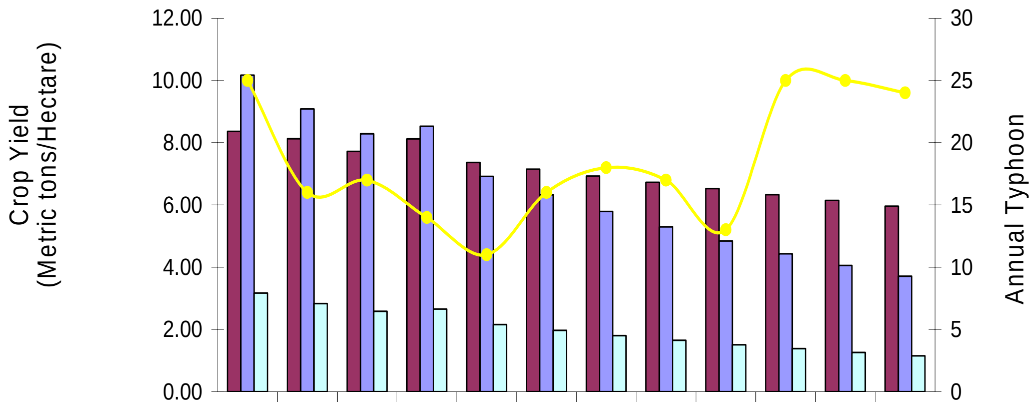
Trends in Production of Lanzones in Different Agricultural Land Uses

Production of lanzones in general has a declined from 1994 to 2005, not only at the national and provincial levels, but in Lilw as well (Figure 7.11). Declining yield in lanzones throughout the country can be attributed to the reported declining growth rate in area planted to lanzones and the declining growth rate of the number of fruit bearing trees particularly in Laguna. From 1994 to 1998, it was reported that the number of fruit bearing trees in Laguna had a -9.6% growth rate and the area of production had a -4.9% growth rate. In terms of area planted, Liliw contributed 10% to both the total land area planted to lanzones and total number of trees in Laguna (STARRDEC, 2003).

Low yields of lanzones was experienced by farmer respondents involved with intercropping of coconut, lanzones and tomato. Declining fruit yield is attributed by the farmers to not only typhoon and old age of the trees, but more so the land preparation for planting of tomatoes in between the trees. As one farmer said:

"Preparation of the land for tomato production could disturb and damage the roots of the lanzones trees causing failure to bear fruits. As such, land preparation technique for monoculture of tomato is different from the integrated lanzones and tomato production. Minimal soil cultivation is done in latter to make sure that the roots of lanzones are not disturbed"

Figure 7.11 does not reflect very well the effect of annual typhoon frequency on production of Lanzones in Liliw. However, flowering and fruiting season of lanzones (from August to October) may coincide with months of heavy rainfall (as in year 1999 shown in Figure 7.10) and typhoons (Figure 7.12). The Philippines, including Laguna province, can experience typhoons in any month of the year with an average of 20 typhoons a year. July to November are the peak months for typhoon (Appendix 7.2). Figure 7.12 below illustrates the risk to security of production of lanzones due to typhoons.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Philippines	8.36	8.13	7.72	8.12	7.37	7.15	6.93	6.73	6.53	6.33	6.15	5.96
Laguna	10.17	9.09	8.29	8.53	6.92	6.33	5.79	5.30	4.85	4.43	4.06	3.71
Liliw	3.17	2.83	2.58	2.66	2.15	1.97	1.80	1.65	1.51	1.38	1.26	1.16
Typhoon Frequency	25	16	17	14	11	16	18	17	13	25	25	24

YEAR

Figure 7.11. Lanzones Production and Typhoon Frequency in the Philippines 1994-2005.

Source:Field Survey,2003;BAS,2006;NAS-LB,2006

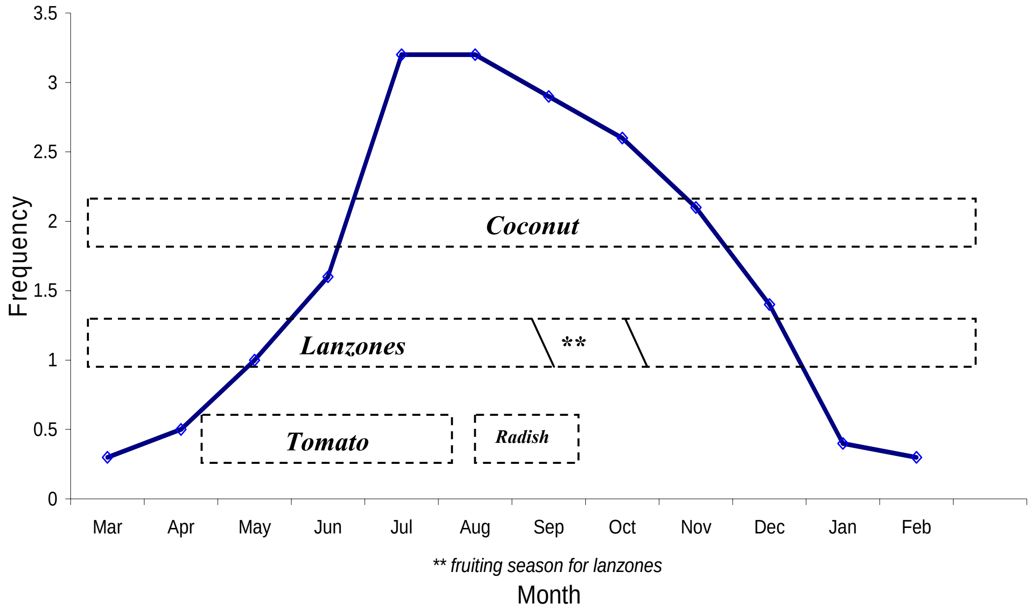


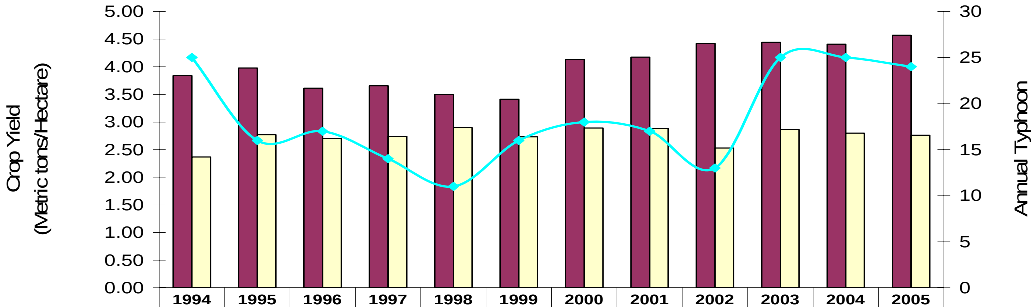
Figure 7.12. Typhoon Frequency (1950-2005) and Cropping Pattern in Liliw, Laguna, Philippines.

As regards to the observed disturbance caused by tomato cultivation under lanzones trees, this could be explained by the rooting structure of lanzones trees. Unlike other trees that have tap roots that grow deep into the soil, lanzones tress are shallow-rooted, with roots extending up to 2.5 meters from the base of the trunk. As such, land cultivation in between lanzones trees poses the risk of damage to the tree's roots. The recommended distance of planting lanzones trees is 6 meters X 6 meters if other crops are to be planted in-between the trees (STARRDEC, 2003). This distancing is not strictly followed in Liliw. Nevertheless, farmers involved with agricultural land uses, specifically those who have tomatoes planted under lanzones trees; apply minimum tillage for tomatoes, a practice very much different from land cultivation for tomatoes in agricultural land uses with vegetable monocrop.

Trend in Production of Coconut in Different Agricultural Land Uses

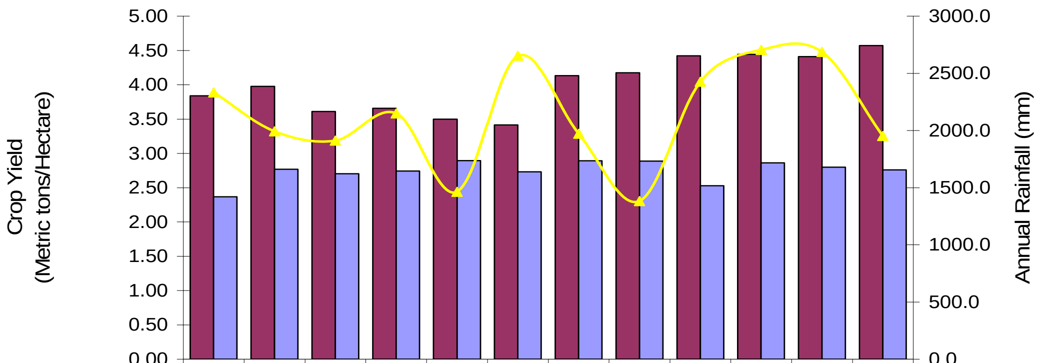
While there is an increasing trend in coconut production at the national level (Figure 7.13), there is an up and down trend in coconut production in Liliw.

Coconut is a robust crop, and is least affected by erratic rainfall and typhoons that disrupt stability of crop yields of other crops in the area.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Philippines	3.84	3.98	3.61	3.66	3.50	3.41	4.13	4.18	4.42	4.44	4.41	4.57
Liliw	2.37	2.77	2.70	2.74	2.90	2.73	2.89	2.89	2.53	2.86	2.80	2.76
Typhoon	25	16	17	14	11	16	18	17	13	25	25	24

Figure 7.13. Coconut Production and Typhoon Frequency in the Philippines from 1994 to 2005.
Source: Field Survey,2003; BAS,2006; NAS-LB,2006



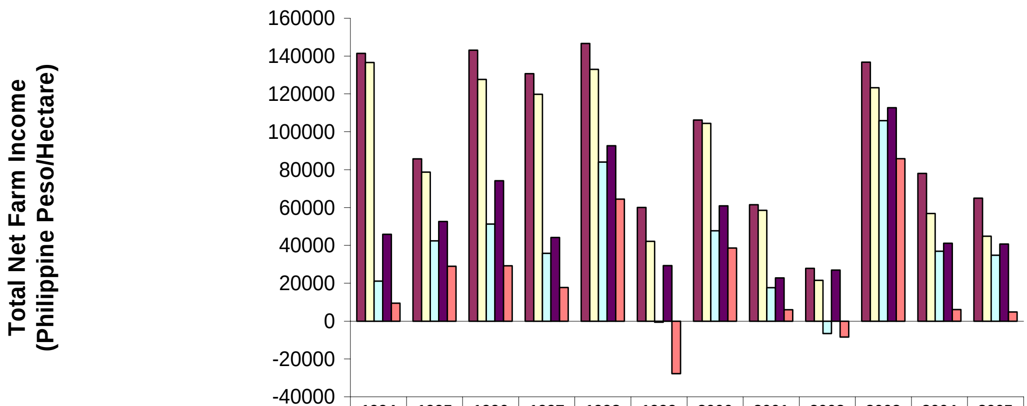
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Philippines	3.84	3.98	3.61	3.66	3.50	3.41	4.13	4.18	4.42	4.44	4.41	4.57
Liliw	2.37	2.77	2.70	2.74	2.90	2.73	2.89	2.89	2.53	2.86	2.80	2.76
Rainfall	2331.5	1992.8	1911.8	2149.2	1464.1	2652.9	1971.6	1382.8	2427.4	2704.7	2686.8	1951.7

Figure 7.14. Coconut Production and Annual Rainfall from 1994-2005.
Source: Field Survey,2003;BAS,2006;NAS-LB,2006

During interviews, the farmers involved in agricultural land uses with multiple crops attested to having experienced low yields from coconut. This was attributed by the farmers to the old age of many trees. Complete loss of harvest was however never experienced in Liliw. Nuts are harvested every two months throughout the year.

7.3.2 Profitability Trends in Agricultural Land Uses with Monocrop and with Multiple Crops

Liliw is a high-potential area for agricultural production, as shown by the profitability trend from 1994 to 2005 in Figure 7.15. During the 12-year period, in spite of the overall declining trend in profitability, there are more profitable years than not. This explains why the area is continuously, despite its undulating topography, high elevation, and distance from roads and market, being used for crop production. The farmers believe there are two major reasons for unprofitable years or years with very low profit: low farmgate prices due to market glut and increased prices of labor and material inputs. Trends in profitability are further discussed and illustrated below in relation to the above-mentioned factors.

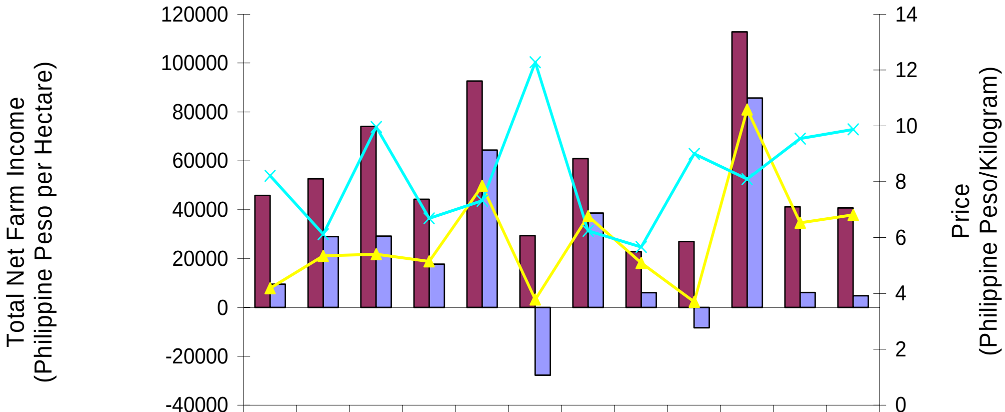


	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agc'l LU w/ Cocont+Lanzones+Tomato	141358	85651	143110	130634	146599	60073	106223	61492	27830	136788	77990	64896
Agc'l LU w/ Lanzones+Tomato	136547	78612	127677	119709	132943	42098	104438	58501	21519	123295	56828	44861
Ag LU w/ Coconut+Tomato	21087	42386	51211	35850	83967	-593	47696	17623	-6587	105934	36886	34812
Ag LU w/ Tomato-Radish	45852	52625	74079	44214	92587	29340	60914	22798	26878	112748	41134	40669
Ag LU w/ Tomato-Fallow	9480	28968	29176	17710	64383	-27768	38627	6012	-8383	85738	6095	4778

Figure 7.15. Profitability of Different Agricultural Land Uses in Liliw,Laguna,Philippines, (1994-2005)
(Source: Field Survey,2003; BAS,2006)

Profitability and Farmgate Prices

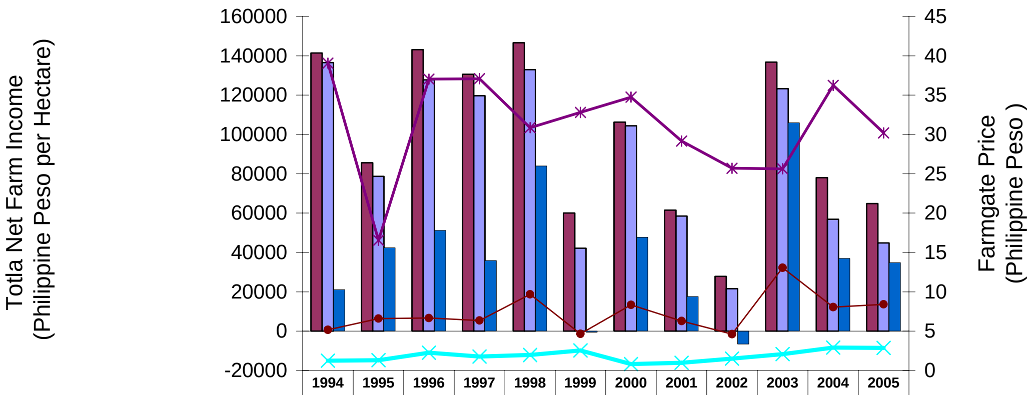
Figure 7.16 shows the great variation in price of vegetables and fruits (1999-2005) relative to the price of coconut per nut, which has remained very low. To gain profits in agricultural land uses with vegetable monoccrop, farmgate price of tomato in Liliw must be a minimum of 4.2 Philippine Peso per kilogram. Annual average price per kilogram of tomato ranges from 5.94 to 7.32 Philippine Pesos in agricultural land uses with vegetable monocrop and with multiple crops, respectively. Figures 7.16 and 7.17 further illustrate the trend in profitability of all agricultural land uses in Liliw to be following the trend in farmgate price of tomato. Figure 7.17 shows that when tomato prices are very low, profitability is helped by the income from radish. While in Figure 7.18, it shows that anyone relying on coconut alone would be left very poor while farmers with coconut and tomato only are left vulnerable to the fluctuating price of tomato.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ag LU w/ Tomato-Radish	45852	52625	74079	44214	92587	29340	60914	22798	26878	11274	41134	40669
Ag LU w/ Tomato-Fallow	9480	28968	29176	17710	64383	-2776	38627	6012	-8383	85738	6095	4778
Tomato Monocrop (PhP/Kg)	4.2	5.3	5.4	5.1	7.9	3.8	6.8	5.1	3.7	10.6	6.5	6.8
Radish (PhP/Kg)	8.2	6.1	10.0	6.7	7.3	12.3	6.2	5.7	9.0	8.1	9.5	9.9

Figure 7.16. Profitability of Agricultural Land Uses with Vegetable Monocrop and Farmgate Prices in Liliw, Laguna, Philippines (1994-2005).
(Source: Field Survey 2003;BAS,2006;FAOstat,2006)

Farmgate price is very much dependent on the manner by which the products are marketed in the area. The marketing system for each crop in the case study site varies. For tomato, there are two ways: one is by direct selling between a trader and the farmer; another is indirect, where a middleman refers to the trader the farmer who is ready to sell the produce or vice versa. In the latter, the middleman shares profit of the farmer. In both system though, the trader sets the price. In agricultural land uses with vegetable monocrop, the latter system of marketing is more common.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agc'l LU w/ Cocont+Lanzones+Tomato	141358	85651	143110	130634	146599	60073	106223	61492	27830	136788	77990	64896
Agc'l LU w/ Lanzones+Tomato	136547	78612	127677	119709	132943	42098	104438	58501	21519	123295	56828	44861
Ag LU w/ Coconut+Tomato	21087	42386	51211	35850	83967	-593	47696	17623	-6587	105934	36886	34812
Matured Coconut (PhP/Nut)	1.2	1.3	2.2	1.8	2.0	2.5	0.8	1.0	1.5	2.1	2.9	2.9
Lanzones (PhP/kg)	39.1	16.5	37.0	37.1	30.9	32.8	34.7	29.2	25.7	25.6	36.2	30.2
Tomato (PhP/Kg)	5.2	6.6	6.7	6.3	9.7	4.7	8.3	6.3	4.6	13.1	8.1	8.4

Figure 7.17. Profitability of Agricultural Land Uses wth Multiple Crops and Farmgate Prices in Liliw,Laguna, Philippines (1994-2005).
(Source: Field Survey 2003;BAS,2006)

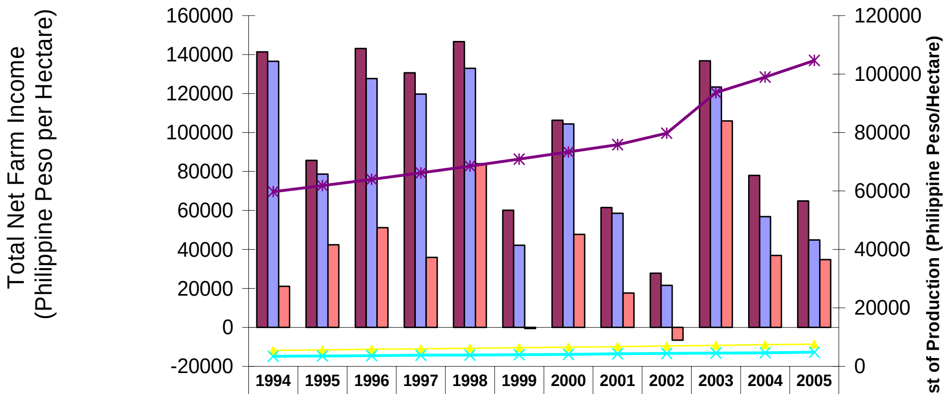
For lanzones, “sale by contract” is most common. This involves an agreement of the total price for the harvest, between the farmer and the buyer, way ahead of the fruiting stage. Unlike in tomato, the buyer assumes all responsibility for taking care of the trees until the fruits are harvested. More often, the agreement between the farmer and the buyer is verbal and payment is either in whole payment or in part, the balance to be paid between entering the agreement and harvesting. With this marketing system, the buyer takes the risk of production losses and price uncertainties.

Profitability and Costs of Production

There is an increasing trend in the prices of agrochemicals in the Philippines of about 10-12% annually before, and about 45% after the crop year 2000 (BAS, 2006). As well, payment for hired labor in Liliw increased by nearly 5% every year (Field Survey, 2002). Furthermore, payment for male workers is higher than for females by 20% and the male workers are more often hired for important (and strenuous) activities like preparation, spraying and hauling. The increasing trend in labor and material costs affects more the production of tomato than the production of the other crops in the different agricultural land uses in Liliw. In the area, tomato is a highly maintained crop that requires not only applications of agrochemicals (fertilizers and pesticides), but also hired labor from the time of land preparation through to planting and harvesting. In contrast, very minimal investment in materials is made for fruit and plantation crops, although for sustained high yields, more investment should be made specifically for the fruit crops.

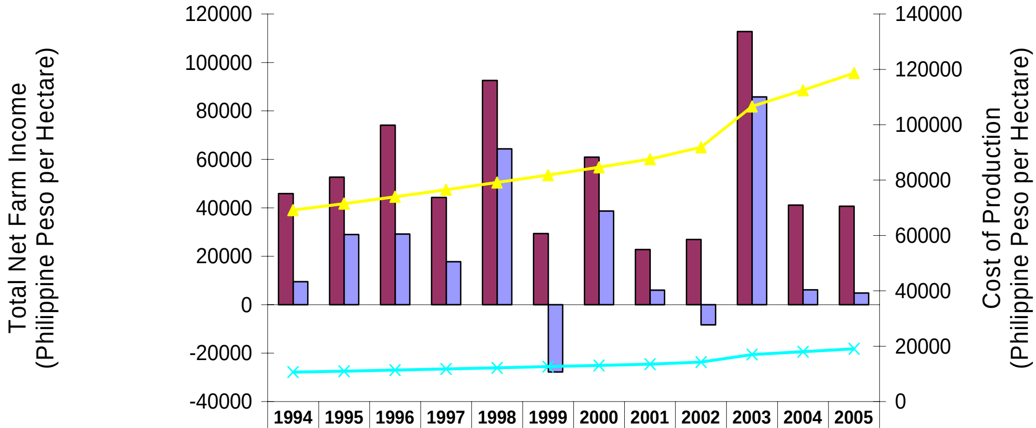
During the field survey in 2003, farmers cited low farmgate prices and increase payment for labor as the causes of bad crop years in terms of farm income. Data shows crop years 1999 and 2002 as the worst years for agricultural land uses with multiple crops as well as agricultural land uses with vegetable monocrop (Figure 7.18 and Figure 7.19).

In both agricultural land uses with multiple crops and vegetable monocrop, profit losses were attributed to low farmgate prices and increased cost of production, including costs of fertilizers, agrochemicals and payment for hired labor for producing tomato, particularly for crop year 2002.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agc'l LU w/ Cocont+Lanzones+Tomato	14135	85651	14311	13063	14659	60073	10622	61492	27830	13678	77990	64896
Agc'l LU w/ Lanzones+Tomato	13654	78612	12767	11970	13294	42098	10443	58501	21519	12329	56828	44861
Ag LU w/ Coconut+Tomato	21087	42386	51211	35850	83967	-593	47696	17623	-6587	10593	36886	34812
Coconut	5460	5629	5803	5983	6168	6359	6555	6758	6967	7176	7391	7613
Lanzones	3432	3539	3650	3764	3881	4003	4128	4257	4390	4523	4660	4802
Tomato	59770	61837	63978	66194	68488	70864	73324	75871	79736	93618	98937	10464

Figure 7.18. Profitability of Agricultural Land Uses with Multiple Crops and Capital Investment per Crop in Liliw,Laguna,Philippines (1994-2005).
(Source: Field Survey,2003; BAS,2006)



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ag LU w/ Tomato-Radish	45852	52625	74079	44214	92587	29340	60914	22798	26878	11274	41134	40669
Ag LU w/ Tomato-Fallow	9480	28968	29176	17710	64383	-2776	38627	6012	-8383	85738	6095	4778
Tomato Monocrop	69143	71510	73960	76496	79120	81837	84648	87559	91855	10662	11245	11868
Radish	10617	10989	11374	11773	12186	12615	13058	13518	14239	16959	17968	19053

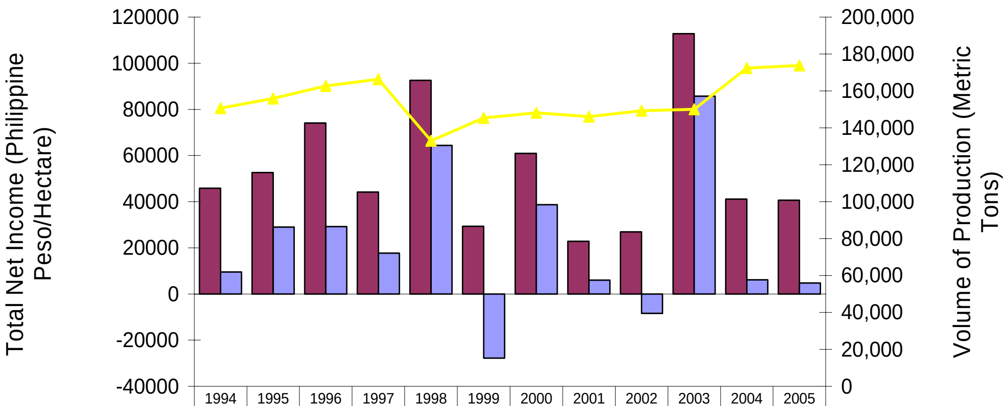
Figure 7.19. Profitability of Agricultural Land Use with Vegetable Monocrop and Capital Investment for Vegetables in Liliw, Laguna, Philippines (1994-2005).
(Source:Field Survey, 2003; Bureau of Agricultural Statistics,2006)

Profitability and Market Glut

Supply of similar crop products, particularly of tomato, in other municipalities and provinces affects profitability of agricultural land uses in Liliw. Figures 7.20 and 7.21 show the highest profit of agricultural land uses with vegetable monocrop in Liliw when the supply of tomato in the country is at its lowest.

In the case of coconut, which is harvested throughout the year (every 2 months in Liliw), Figure 7.22 shows changes in supply in the country have minimal influence on the profitability trend of agricultural land uses in Liliw.

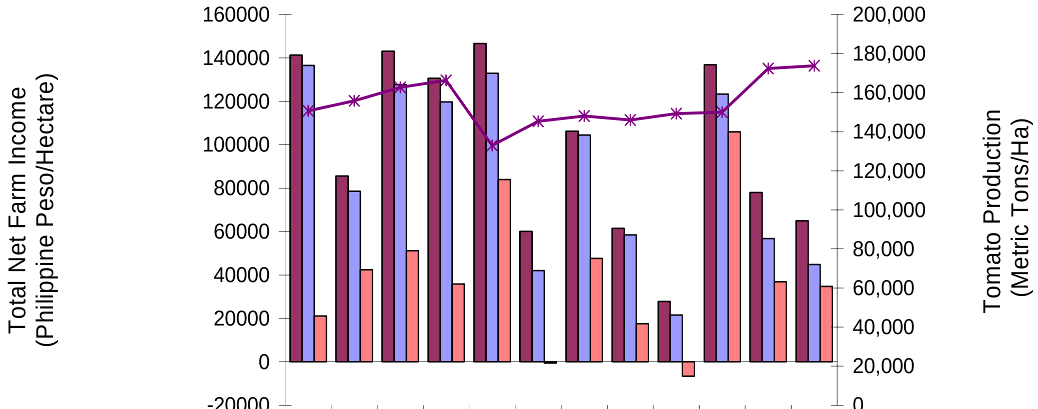
Similarly, in Figure 7.23, in spite of the important share of lanzones on the total net income of different agricultural land uses with multiple crops, changes in supply of lanzones at the national level have very little influence on the profitability trend of agricultural land uses in Liliw.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ag LU w/ Tomato-Radish	45852	52625	74079	44214	92587	29340	60914	22798	26878	112748	41134	40669
Ag LU w/ Tomato-Fallow	9480	28968	29176	17710	64383	-27768	38627	6012	-8383	85738	6095	4778
PHILIPPINES (Total Volume)	150,63	155,82	162,64	166,35	132,98	145,36	148,10	146,03	149,25	150,05	172,34	173,74

Year

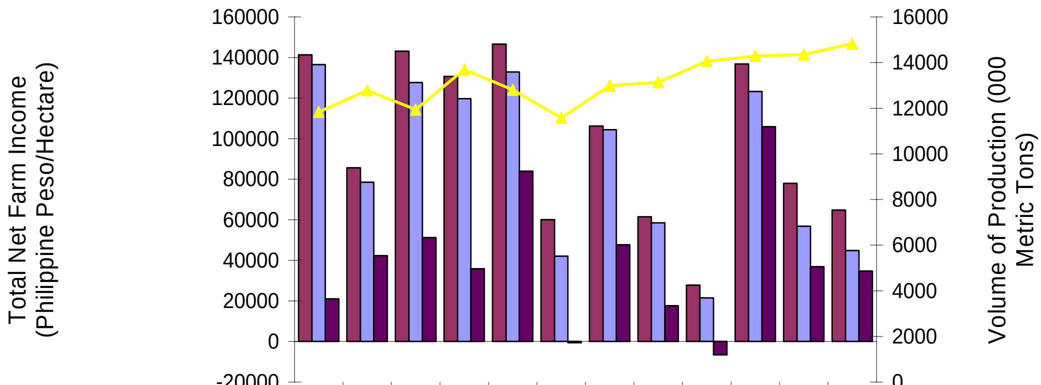
Figure 7.20. Profitability of Agricultural Land Use with Vegetable Monocrop in Liliw, Laguna and Supply of Tomato in the Philippines, 1994-2005.
Source: Field Survey, 2003; BAS,2006



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agc'l LU w/ Cocont+Lanzones+Tomato	141358	85651	143110	130634	146599	60073	106223	61492	27830	136788	77990	64896
Agc'l LU w/ Lanzones+Tomato	136547	78612	127677	119709	132943	42098	104438	58501	21519	123295	56828	44861
Ag LU w/ Coconut+Tomato	21087	42386	51211	35850	83967	-593	47696	17623	-6587	105934	36886	34812
PHILIPPINES (Total Volume)	150,63	155,82	162,64	166,35	132,98	145,36	148,10	146,03	149,25	150,05	172,34	173,74

Year

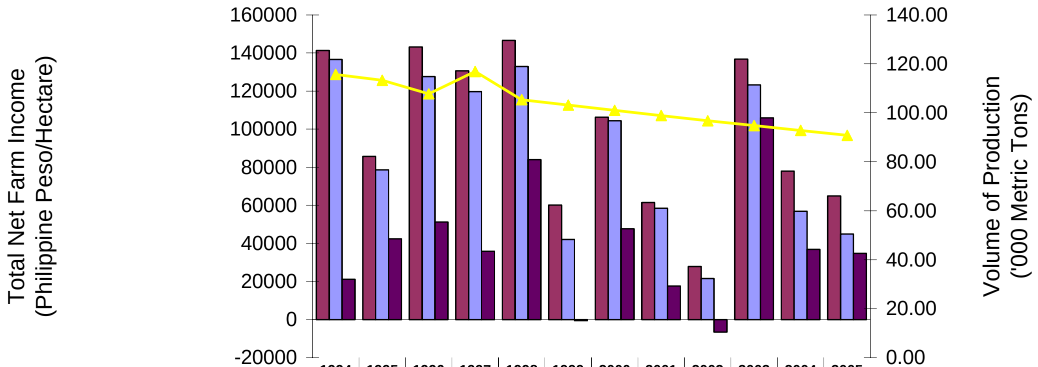
Figure 7.21. Profitability of Agricultural Land Use with Multiple Crops in Liliw, Laguna and Supply of Tomato in the Philippines,1994 to 2005.
Source:Field Survey 2003; BAS,2006



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agc'l LU w/ Cocont+Lanzones+Tomato	14135	85651	14311	13063	14659	60073	10622	61492	27830	13678	77990	64896
Agc'l LU w/ Lanzones+Tomato	13654	78612	12767	11970	13294	42098	10443	58501	21519	12329	56828	44861
Ag LU w/ Coconut+Tomato	21087	42386	51211	35850	83967	-593	47696	17623	-6587	10593	36886	34812
Cocont Philippines (000 Metric Tons)	11837	12791	11937	13708	12806	11589	12995	13146	14068	14294	14366	14825

Year

Figure 7.22. Profitability of Agricultural Land Use with Multiple Crops in Liliw, Laguna and Annual Supply of Coconut in the Philippines, 1994-2005.
Source: Field Survey, 2003; BAS,2006



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agc'l LU w/ Cocont+Lanzones+Tomato	14135	85651	14311	13063	14659	60073	10622	61492	27830	13678	77990	64896
Agc'l LU w/ Lanzones+Tomato	13654	78612	12767	11970	13294	42098	10443	58501	21519	12329	56828	44861
Ag LU w/ Coconut+Tomato	21087	42386	51211	35850	83967	-593	47696	17623	-6587	10593	36886	34812
Lanzones Philippines (000 Metric Tons)	115.65	113.30	107.76	116.87	105.36	103.15	100.99	98.86	96.79	94.76	92.77	90.82

Year

Figure 7.23. Profitability of Agricultural Land Use with Multiple Crops in Liliw, Laguna and Supply of Lanzones in the Philippines, 1994-2005.
Source: Field Survey,2003;BAS,2006

7.4 Discussion

Land use systems characterized by growing different species of woody perennials in association with field crops, in general, is viewed as having economic advantages because of the various products, thus combined income that can be obtained. This has continuously been a subject of research interest (Rasul, 2006; Golam et.al, 2006; Guo et al., 2006). Some even claimed not only economic but also environmental advantages (Gordon et al., 2006) because of the role of woody perennials in ecological processes, like nutrient cycling, soil protection, biodiversity restoration, and even carbon sequestration. However, quite a few would still argue that with a land use system that integrates trees and annual crops there would be trade-offs between economic and environmental functions (Nissen et al, 2001). On the other hand, others claim that monocropping is more profitable than having both trees and annual crops (Guo, et al., 2006). Nevertheless, the fact remains that there is a continuous need for empirical investigations on land use systems because the potential for economic and environmental performance will depend on a number of factors, including: vegetation structure; crop combinations; and adequate management of tree-crop association. Moreover, there is not as much information available on land use systems that involve horticultural crops, like in Liliw, Laguna.

This study showed that Liliw is a good area for agricultural production and has potential for even higher levels of productivity. Farmer-initiated agricultural land uses where horticultural trees and vegetables are integrated exhibited high potentials for productivity, in terms of crop yields and profitability. Such performance might even be sustained for an even longer period given favorable climatic and market conditions and improved management practices.

7.4.1 On Crop Productivity

In terms of the quantity of harvest for the annual crops like tomato and radish, Liliw, Laguna, is promising as exhibited by their high yields compared to the national level, especially for tomato. The perennials are not as productive and yields are much lower than the national average. But there is potential for improving the yields if proper care and maintenance is provided to these crops, especially the fruit crops whose productivity is declining yet has a very important contribution to make to the profitability of the agricultural land uses with multiple crops.

7.4.2 On Economic Viability

Despite the high yields of the annual crops, tomato entails high production cost of investment rendering it vulnerable to profit losses with low farmgate price, even when crop supply increases. The main costs of production are for labor and chemical pesticides. One major consequence of loss of diversity in agriculture, such as in monocropping systems, is vulnerability to pests and diseases. There is a history of worldwide reports on this (Pimentel, 1997; WRI, 1997; Thrupp, 1998). Other than this, the low farmgate price resulting from a poor marketing system can further reduce the economic viability of tomato production.

The other crops, particularly the tree crops, are important contributors to the profitability of the landuses when production of the annual crops becomes unprofitable. They serve as a buffer to income losses by the annual crops. This shows the advantage of having multiple crops rather than a monocrop or a single crop system. Yet, continuous neglect of the tree crops in the systems will likely erode long-term profitability and thereby its capability to serve as a buffer against losses from the annual crops.

In sloping areas, plantation and fruit trees are considered more appropriate than annual crops, but become inappropriate if markets do not exist (Roder et al., 1995). In the case of Liliw, there is a market for these products. However, the annual crop, specifically tomato, is at the time of the study the center of attention of the land users as indicated by the effort and resources placed on its production. The perennial crops, for example the fruit lanzones, are not given as much attention in spite of their high economic potential.

In places like Liliw there is declining interest in perennial crops. This would suggest a need for supportive approaches that strengthen the farmer community in managing agrobiodiversity and increasing options for agrobiodiversity enhancement for the farmers (Cromwell, 1999).

7.4.3. On Security of Production

Long-term crop yields and income of the different agricultural land uses in Liliw exhibited a relatively stable trend. There are more productive years, in terms of crop yields and profit, than unproductive years. The unproductive years are the result of income losses from the annual crops due to low farmgate prices. While climatic factors like rainfall are critical for crop productivity in the area, especially for vegetables, and typhoon occurrence are critical to fruit yields of lanzones. These factors did not affect stability, thus security of production in Liliw.

Even with abundant supply of similar products from other places, this did not greatly affect productivity of agricultural land uses in Liliw, particularly the perennial tree crops. Although there is a declining trend in the profitability of the fruit crops, (which serve as an important buffer to economic losses from producing vegetables), the long-term potential of fruit crops should not be ignored.

Using long-term trends for profitability as a basis for assessing security of production, vegetable monocropping is more at risk of income loss than the multiple cropping where horticultural trees and crops are integrated.

7.5 Summary and Conclusions

This chapter evaluated economic productivity of the different agricultural land uses in the case study site. Farmer-initiated agricultural land uses in Liliw, including vegetable monocropping and multiple cropping with combined horticultural trees and vegetables, are economically productive, producing relatively stable and high yields and income over a long period in spite of unavoidable circumstances like dry spells or too much rain and instances of natural calamities in the area. For sustained economic benefits from these land uses however, better market support for vegetables may be needed. Low farmgate prices could lead to losses in profits, particularly for the vegetables which eventually affects total net income. The "risky-nature" of having a single-crop compared to having multiple crops was also evident. The advantage of having other crops in the system, especially the fruit crops, was highlighted during unprofitable years for vegetables, particularly for tomatoes which is a cost-intensive crop. Also shown here is the important contribution of the fruit crops to total net farm income in spite the low maintenance for it in the area. If there is continuous neglect of the perennial crops, especially the fruit crops in the system, economic viability and security of production will eventually be affected.

For sustained economic benefits from the agricultural land uses in Liliw, further development of the land uses with multiple crops where horticultural trees and vegetables are combined, would be appropriate. As such, better cultivation practices, spatial arrangement of the crops and marketing system could be explored to overcome barriers to its development as a land use management tool in the uplands.

In the following chapters, reasons behind the different land uses and the social factors associated with vegetable monocropping and integrated production of trees and crops are explored (Chapter 8). This information was used to further explain what might be needed to overcome barriers to the development of diversified production as a management alternative for the uplands (Chapter 9).

CHAPTER 8

Social Factors Influencing Agricultural Land Use in an Upland Area: the Case of Liliw, Laguna

The two previous chapters evaluated environmental protection and economic productivity in agricultural land uses in Liliw (Objective 3). This chapter evaluates social factors associated with the way agricultural land uses are managed. It therefore addresses the fourth and final research objective: *to identify the social factors that influence management of agricultural land use in the uplands, in order to explain the potential for wider acceptability of agrobiodiversity enhancement as a management alternative for the uplands*.

More particularly, this chapter seeks from farmers the reasons why some of them engage in agricultural land use with vegetable monocrop while others engage in agricultural land use with intercropping of horticultural trees and vegetables, even though vegetable monocrop is much less profitable. The answers may provide information of use in showing how agrobiodiversity could be enhanced in upland areas by highlighting factors that constrain or foster the social acceptability of agrobiodiversity.

As explained in Chapter 5, a survey was used to gather data on socio-economic and farm characteristics, farmer personal traits, and farmer perceptions of the benefits and consequences of farming in the uplands. These various factors were analyzed in terms of their association with the way farmers managed agricultural land use. Farmers' reasons for the way agricultural land uses are managed were also directly elicited through the survey.

Description of the demographic characteristics of the farmer respondents in the research site is first presented in this chapter followed by farm characteristics. The reasons why farmers on agricultural lands with monocrop do not integrate trees and annual crops, while farmers on diverse farms (i.e., integrated perennials and annuals) do are then explored. Social factors associated with choice of agricultural land use are then analyzed using the Logit Model Analysis.

8.1 Farmer Traits and Characteristics

In this section, the personal traits and characteristics of the respondents are described. These include gender, age, and length of farming experience, educational attainment and with other sources of income. The characteristics of those farmers involved in agricultural land use with vegetable monocrop and those who are involved in agricultural land use where horticultural trees and vegetables are integrated are presented in Table 8.1 and discussed below.

8.1.1 Gender

As Table 8.1 shows, male farmers dominate direct management of agricultural lands in Liliw, being 83.33% of the total number of respondents. Women directly involved with managing agricultural land use in the area are a minority (16.67 %). All women respondents are involved in agricultural land use with intercropping of horticultural trees and vegetables. Agricultural land use with vegetable monocrop is all managed by male farmers. Nevertheless, women members of the community are visibly active in a number of farming activities as family or hired labor in planting, trellising, fertilizer application and harvesting, but not in physically strenuous activities like land preparation, hauling and agrochemical spaying.

8.1.2 Age

The farmer respondents in the case study site, whether agricultural land use with vegetable monocrop or intercropping of horticultural trees and vegetables, are mostly in their prime working years, from 35-44 years (33.3%) and 45 to 55years of age (41.67%). In these age brackets though, 35-44 years and 45-55 years, there

are more farmers who are involved in agricultural land use with vegetable monocrop, 40 and 50% respectively, than in agricultural land use with intercropping of horticultural trees and vegetables (Table 8.1). This could be due to the reported number of young people who, after earning vocational or university degrees, opted to grow high-value annual crops as their source of income rather than get employed in town or in the cities. On the other hand, older farmers in age brackets 55-64 and beyond are only involved with diversified land use (Table 8.1). These farmers said they are no longer physically able to perform strenuous activities required of the monocropping of annual and high value crops.

8.1.3 Years of Experience in Farming

Significantly, 40% of farmers involved in agricultural land use with vegetable monocrop have been farming for between 11-20 years and this rises to half (50%) when the 1-10 years group is added (Table 8.1). This perhaps reflects the more recent development of monocropping. More than half (57%) of those involved agricultural land use with intercropping of trees and vegetables, on the other hand, have been farming for a longer period of time (21 to over 50 years). Also, quite a few of those who are relatively new in farming (1-10 years) are involved in agricultural land use where trees and vegetables are intercropped (14.3%).

8.1.4 Education

Literacy among the farmers is very high and all respondents had formal education. Some had primary education (29.17%) while half (50%) had secondary education. Quite a number (20.83%) had vocational training, are college undergraduates or had university degrees. More (21.4%) of those who have high educational attainment are involved in agricultural lands with intercropping of trees and vegetables (Table 8.1). On the other hand, more (30%) of those involved in agricultural land use with vegetable monocrop often have primary education.

8.1.5 Leadership Quality

Leadership is measured by the farmers' involvement as leaders or officials in local and community organizations. Half of those involved in agricultural land use with intercropping of trees and vegetables serve as members of the village council or as officers in the vegetable cooperative (Table 8.1). Interestingly, those who are serving as officers in the local vegetable farmer cooperative are women and they comprise about 14.28% of the number of farmers involved in agricultural land use with intercropping of trees and vegetables. On the other hand, only 20% of those involved agricultural land use with vegetable monocrop serve as members of the village council.

8.1.6 Other Sources of Income

All farmers in the area avail themselves of loans through the banks, cooperatives, or personal sources. Loans are used as capital for farming. Income from farming is their source of repayment for such loans. As such, sources of income other than farming are necessary for augmenting their income.

Table 8.1. Characteristics of the Respondents.

Characteristics	Number of Respondents (%)		
	Agricultural Land Use with Vegetable Monocrop	Agricultural Land Use w/ Multiple Crops	All (24)
Gender			
Male	100.0	71.4	83.33
Female	0.0	28.6	16.67
Age			
25-34	10.0	14.3	12.50
35-44	40.0	28.6	33.33
45-54	50.0	35.7	41.67
55-64	0.0	14.3	8.33
65-74	0.0	7.1	4.17
Farming Experience (Years)			
<10&10	10.0	14.3	12.50
11 to 20	40.0	28.6	33.33
21-30	10.0	21.4	16.67
31-40	40.0	28.6	33.33
41-50	0.0	0.0	0.00
> 50	0.0	7.1	4.17
Education			
Primary	30.0	28.6	29.17
Secondary	50.0	50.0	50.00
University Degree/ Undergraduate	20.0	21.4	20.83
Village Position			
no post	80.0	50.0	62.50
w/ post	20.0	50.0	37.50
Off-farm Income			
With Off-farm	80.0	42.9	58.33
W/o Off-farm	20.0	57.1	41.67
Non-farm Income			
With Non-farm	40.0	21.4	29.17
W/o Non-farm	60.0	78.6	70.83

Other sources of income available to the farmers include off-farm and non-farm activities. Off-farm income sources are farming-related activities done outside their own farms while non-farm income sources are activities that are not related to farming at all. Many (58.33%) of the farmer respondents earn additional income through off-farm activities or farming-related activities done outside their own farms (Table 8.1). They are hired either as farm workers by the other farmers or they rent out their animals for hauling or for land preparation. A large number (80%) of those involved in agricultural land use with vegetable monocrop engage in farming activities outside their own farms. Also, some (42.9%) of those involved with agricultural land use with intercropping of trees and vegetables are also involved with off-farm farming activities. Yet, there are more farmers in agricultural landuse with intercropping of trees and vegetables who do not have off-farm income sources (57.1%).

Non-farm activities (e.g. carpentry, utility vehicle driver) are not very popular alternative sources of income among the farmers in the area. Less than one third (29.17%) of the total number of farmer respondents have non-farm activities as source of additional income (Table 8.1). This shows that farmers in the area are still highly dependent on farming and farming-related activities for livelihood and income.

8.2 Farm Characteristics in Different Agricultural Land Uses

This section identifies farm conditions that could also be a factor in influencing the way farmers manage agricultural land use. Farm characteristics, specifically land size and land tenure, are described and later tested for their association with the way agricultural lands are managed.

8.2.1 Farm Size

Farms in the area are small, sizes ranging mostly from half to one hectare (Table 8.2). The majority (62.5%) of the farmer respondents are working on a half-hectare of land or even smaller. About 37.5 % are working on one-hectare of land and more. Among those involved in agricultural land use where trees and vegetables are intercropped, half (64.3%) are working on half-hectare farms or less. Similarly, more than half (60%) of those involved in agricultural land use with vegetable monocrop, are working on farms measuring half hectare and less.

Table 8.2. Land Size and Tenure Arrangement in Different Agricultural Land Use in Liliw, Laguna, Philippines (Crop Year 2003).

Characteristics	Number of Respondent (%)		
	Agricultural Land Use w/ Vegetable Monocrop	Agricultural Land Use w/ Multiple Crops	All (n=24)
Land Size (Hectares)			
<0.5 to 0.5	60.0	64.3	62.50
>0.5 to 1.0 ha	30.0	35.7	33.33
> 1.0ha	10.0	0.0	4.17
Land Tenure			
Owner	40.0	57.2	50.00
Tenant	60.0	42.8	50.00

Overall, non-diverse farms tend to have larger holdings than diverse farms. As noted later in more detail, farmers involved in agricultural lands with vegetable monocrop are usually tenants. These farmers thus tend to lease wider areas.

8.2.2 Land Tenure

Land ownership in the area is based on certificates of right to cultivate the lands issued by the local government. Often these certificates bear the name of the original farmers and these certificates are left to the children as proof that they are the rightful owners of the land.

Based on this claim, half (50%) of the agricultural lands in the research site is owned and much of the other half (34.4%) are leased (Table 8.2). More than half (57.2%) of the lands planted with intercropping of trees and vegetables are owned. Less than half (40%) of the ands with vegetable monocrop are owned.

8.3 Awareness and Perceptions on the Effect of Upland Faming on Health of Environment and Farmworkers

Of the total number of farmer respondents, the majority (62.5%) are aware of degradation of the natural resources occurring in Liliw, Laguna (Table 8.3). Those who are involved in agricultural land uses with diversified production or who have integrated production of trees and vegetables are apparently more aware of such occurrence. Similarly, more of those in agricultural land use with diversified production or where horticultural tress and crops are integrated is more aware of incidence of poisoning due to agrochemicals among farmworkers (Table 8.3).

The observed natural resource degradation includes changes in the condition of the soil, water resources, vegetation, bird and insect population. The most observed among these is the changes in the soil condition, followed by changes in the flora and fauna then by the condition of the water resources that abound in the case study site (Table 8.4).

Table 8.3. Awareness of Natural Resource Degradation and Incidence of Agrochemical Poisoning among Farmworkers in Liliw, Laguna, Philippines (Crop Year 2003).

Characteristics	Number of Respondents (%)		
	Agricultural Land Use w/ Vegetable Monocrop	Agricultural Land Use w/ Trees and Vegetables	All (n=24)
A. Natural Resources			
Aware	60	64.28	62.5
Unaware	40	35.72	37.5
B. Health of Farmworkers			
Aware	60	64.28	62.5
Unaware	40	35.72	37.5

Table 8.4 Perceived Disturbances on the Natural Resources in Liliw, Laguna, Philippines, (Crop Year 2003).

Natural Resources	Number of Respondents (%)		
	Agricultural Land Use w/ Vegetable Monocrop	Agricultural Land Use w/ Multiple Crops	All (n=24)
Soil	50	21.43	33.3
Water	10	14.28	12.5
Flora and Fauna	20	21.43	20.83

Figure 8.1 further shows changes in the soil condition in the case study site was observed by half of those involved in agricultural land use with vegetable monocropping. Changes in water resources and flora and fauna were observed by many of those involved with diversified production where trees and vegetables are integrated.

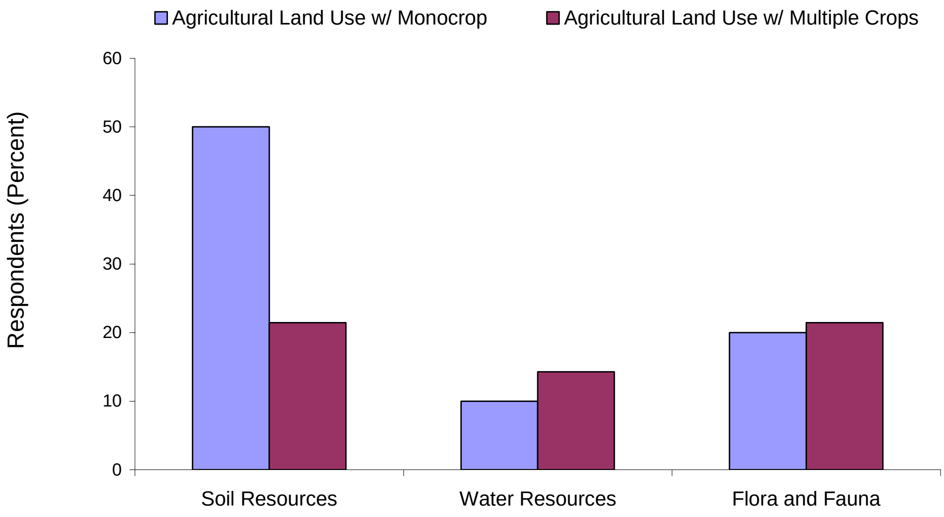


Figure 8.1. Perceived Disturbances on the Natural Resources in Liliw, Laguna, Philippines (2003).

Further elaboration made by the farmers regarding natural resource degradation in Liliw, Laguna is presented below. Soil erosion in steep slopes is most observed and there are different perceptions on the cause of such erosion, as indicated by these quotations:

> *"In steep slopes soil is heavily eroded during heavy rains; observed beginning 1990; probably due to cultivation because land is cleared before planting tomato; my lot is flat though so no erosion observed"*
> *(Farmer Respondent # 11)*

> *"Observed that soil has become sandy and reddish; might be due to farming; land is tired." (Farmer Respondent #25)*

> *"When it rains soil is eroded; loses fertility of the soil ("itaw") due to repeated cultivation". (Farmer Respondent 30%)*

Others attribute soil erosion not directly to farming, but to the clearing of the land of trees:

> *"Soil getting sandy; during heavy rains soil gets eroded; changes might be due to agricultural production, but reason really is due to trees being cut." (Farmer Respondent #30)*

> *"Soil erosion due to cutting of trees in higher areas; not due to agricultural production because cultivation is shallow". (Farmer Respondent # 26)*

> *"Soil gets eroded if land is cleared too much. Somehow soil erosion may be attributed to farming. However, if the lot is not used for farming, this will be used for resting place of draft animals (carabao) and the soil will become compacted". (Farmer Respondent # 2)*

While agricultural production in the area is rain-dependent and has no irrigation infrastructure, water resources abound like creeks and rivers. Some farmers tap these resources for watering their crops. One of the concerns of the farmers is the drying up of these rivers and streams.

> *"Less water is now flowing from the streams"(Farmer Respondent # 21)*

> *"There is also shortage of water supply in farms where there is water supply (all areas in the steep slopes are purely rainfed)". (Farmer Respondent #16)*

> *"During the rainy season, water from spring is less than during the dry season due to very strong downstream flow". (Farmer Respondent # 9)*

Many farmers have also observed changes in flora and fauna:

> *"There are lesser trees in the forest."(Farmer Respondent # 18)*

> *"Increased population of leaf miner and fruit fly".*
> *(Farmer Respondent #8)*

> *"There are times when insects are abundant, e.g., white fly".*
> *(Farmer Respondent # 16)*

"Springs might have been polluted with agrochemicals because farmers wash their sprayers in the springs; noticed that honey bees, butterflies and dragonflies are not as many as before due to chemical spray in ampalaya". (Farmer Respondent # 6)

8.4 Reasons for Maintaining Agricultural Lands for Vegetable Monocropping or for Intercropping of Trees and Vegetables

The reasons given by farmers for why they have agricultural lands with vegetable monocrop or intercropping of trees and vegetables are summarized in Figure 8.1. They include suitability of the area for crop growth, economic gain from producing the crops, land tenure status, personal preferences, soil protection and national ordinance. These are explained in turn below.

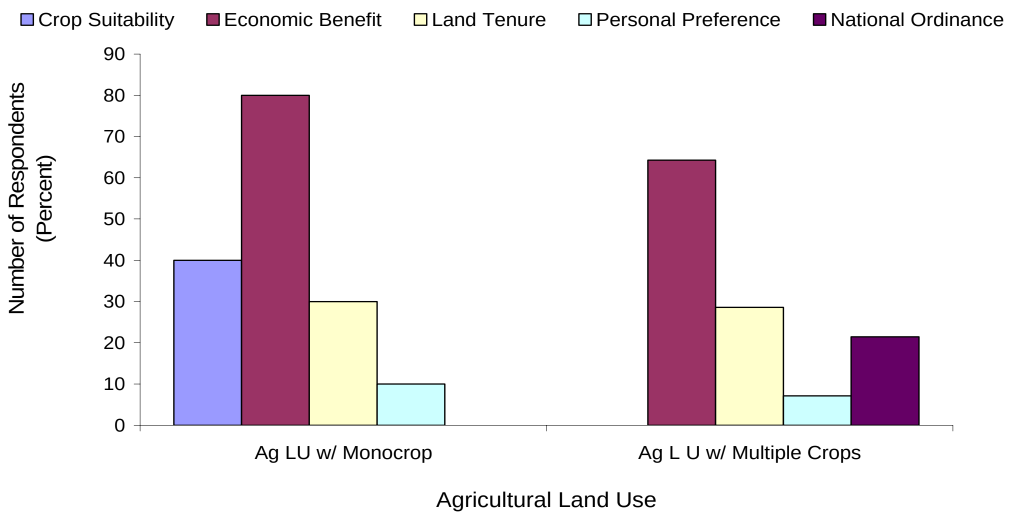


Figure 8.2. Cited Reasons for Maintaining Agricultural Lands with Vegetable Monocrop or with Intercroppping of Horticultural Trees and Vegetables.

8.4.1 Suitability for Crop Growth

The biophysical condition of the area and its favorability for growing high value vegetable crops is often a cited reason (40%) for monocropping of tomatoes in the case study site. Tomato grows well in unshaded conditions and low temperature. Shading caused by other crops could also lead to proliferation of insect pests that would damage the crop. As such, farmers involved with vegetable monocrop do not want to integrate other crops into their production systems.

As some of them said:

> *"Trees will affect the tomato plants; tomato plants are more susceptible to diseases when intercropped with trees" (farmer respondent #1)*
>
> *"Intercropping of trees and tomatoes results to more disease in tomato plants thus more damage on the tomato plants' (Farmer Respondent #18)*
>
> *"Tomato needs open space; other crops will disturb tomato" (Farmer Respondent #21)*
>
> *"I have planted tomato since childhood and this served as family wealth. Tomato is also a quicker way to earn income. I have planted trees along borders to prevent soil erosion, but if intercropped with tomatoes, tomatoes get infected with disease". (Farmer Respondent #30)*

On the other hand, some farms are located in areas where it is difficult to grow trees. This was cited by a number (25%) of those farmers in agricultural lands with vegetable monocrop. In highly-elevated and steep slopes, which are denuded of tree vegetation, the wind is reported to be too strong that trees could not thrive.

8.4.2 Economic Benefit

All of the respondents anticipate income from either the annual and perennial crops or both. The majority (64.3%) of those in agricultural lands with intercropping of trees and vegetables, believe that farming will provide them both long-term and short-term income. On the other hand, most (80%) of those in agricultural land with vegetable crops were concerned with the immediate return on their investment. This is especially true for those to whom vegetable farming is just one of their sources of income (or those with off-farm jobs).

Those with fruit trees in their lands cited that fruit trees are a good source of income. The coconut trees which do not provide as much income as the fruit trees though are still regarded by some farmers as an important component of their production system.

> *"When I get old, I cannot work in the farm anymore, but still have the trees to depend on. In fact a few years from now, I might stop planting annual crops and will have all trees in this lot. In this lot I still have some coconut trees and I do not intend to take them out of the system because it is very windy in the area".*
> *(Farmer Respondent #15)*
>
> *"Also earn from coconut; when already old, cannot plant vegetables anymore, at least I'm left with coconut; My sons suggested to cut the coconut trees, but I decided to have only the old trees cut".*
> *(Farmer Respondent #4)*

8.4.3. Land Tenure

Limited resources, specifically land and capital, encourage or discourage diversification. One important socioeconomic factor that determines whether or not farmers will integrate trees into their system is land tenure. This reason is cited by some (28.57%) of those who already have intercropping of trees and vegetables and also by some (30%) of those in agricultural land with purely vegetables (Figure 8.1)

For instance, many farmers involved with monocropping would plant trees along the borders if they owned the land. Planting of a permanent crop is solely the decision of the land owners.

> *"Just renting the lands so I can only plant annual crops; but I will definitely diversify by having trees so that I have something to leave my children; I personally prefer to plant lanzones in this lot even if it means losing tomatoes because I also earn from both coconuts and lanzones". (Farmer Respondent # 11)*
>
> *"Also do not own the land so will not plant permanent crops or trees; But if I own the lot will plant trees and vegetables other than tomatoes to be assured of market". (Farmer Respondent # 21*
>
> *"also do not own the land; If I own the land, will plant trees along the borders". (Farmer Respondent # 18)*

While the coconut trees are no longer as profitable as the fruit trees today, the reason for maintaining these trees in the system vary. Older members of the family, usually the mother who is the rightful owner of the lot, is recognized as the owner of the coconut trees and thus makes decisions regarding the coconut trees. For example:

> *"Maintains a diversified system to make full use of the available space especially in between trees; I cannot change the system because the land belongs to my mother; if the land is mine I will plant forest trees like mahogany to protect the lanzones from strong winds; Also the fruit trees is a source of livelihood". (Farmer Respondent #2)*
>
> *"Not a good idea to cut trees especially the lanzones trees because they are already there". (Farmer Respondent #14)*
>
> *"For economic reason; Will waste effort in planting the trees if to be taken out of the system today because it took a long time before the trees grow and bear fruit; will never take out the trees out of the system even the banana trees; Will not take out the trees even if tomatoes are affected; Also I cannot decide because I do not own the land". (Farmer Respondent # 7)*

8.4.4 Personal Preferences

About 10% of those involved in agricultural lands with vegetable monocrop are simply contented with their production system thus would not exert further effort to put on any other crop in their lands.
As one respondent said;

> "*I am already familiar with planting and management of tomato crops;*
> *I would not want to try another".*

Similarly, about 7.14% of those in agricultural lands with intercropping of trees and vegetables are satisfied and are thus inclined to continue as they have started.

8.4.5 National Ordinance

An important factor contributing to the maintenance of a diversified system in the study area is the national ordinance prohibiting the cutting of trees, specifically coconut trees. Compliance with the law restricting cutting of trees even within their own farms is a factor cited by 21.43% of farmers as contributing to the maintenance of a diversified system in the area (compared to the nearby provinces like Cavite, Quezon and Bicol where coconut logging is rampant, the law prohibiting cutting of coconut trees is observed in Liliw.)

8.5 Analysis of the Social Factors and Agricultural Land Use in Liliw, Laguna using the Logit Model

Earlier in Chapter 5, it was discussed there that in order to further find out the social factors that might influence the way agricultural lands are managed in the uplands, the logit model analysis would be used to explore the association of social factors (discussed above) with agricultural land use. It was hypothesized here that personal traits, farm characteristics, and perceptions on the influence of upland farming on the natural resources are associated with the way agricultural lands are managed.

With the logit model (as presented in Chapter 5), the assumptions are that: a) the farmer is faced with a choice between two alternatives, i.e., to diversify agricultural land use (where agricultural trees and annual crops are integrated) or not to diversify agricultural land use (monocrop of annuals); b) the choice the farmer makes depends on farm characteristics, his personal traits and perceptions on the influence of upland farming on the health of the environment and of the farm workers. In the model used for this part of the thesis, the choice to diversify agricultural land use by having multiple crops or integration of horticultural trees and vegetables are assigned a value of 1 and the alternative (agricultural land use with vegetable monocrop) as 0 (Table 8.5).

Of the social factors that were hypothesized to be associated with the way agricultural lands are managed in Liliw, the following were found associated with agricultural land with diversified production where trees and vegetables are integrated. These are leadership quality (as indicated by position in the village council of vegetable cooperative), land tenure, and farmer awareness of the effect of upland farming (specifically the use of agrochemicals) on the health of the farm workers. Length of farming experience, education, access to other sources of income whether related to farming or not, their perceptions on the influence of farming on the environment and land size were not found associated with agricultural land use that integrate trees and vegetables (Table 8.5). Gender and age were dropped from the model. All women respondents were involved with diverse agricultural land use as such the correlation was perfect. Age is highly correlated with years of experience in farming thus only one of them was considered in the logit model analysis.

8.6 Discussion

Due to the failure of agricultural innovations to be readily adopted, farmer acceptability of agricultural innovations has become a focus of interest in various research investigations. These studies reveal that farmer management of their production systems is influenced by a number of factors: ecological (biophysical), economic and social (personal, institutional). These factors can be internal to the site of production or external to it, involving even higher-level hierarchical factors (Smit, 1999; Guo, 1999; Pannell, 1999; Nelson, et al., 1998; Barbier, 1997; Cary, et al., 1997; Sajise, et al., 1996; Geritts, et al., 1996; Salafsky, 1995; Ali, et al., 1995; Cramb, et al., 1994; Fujisaka, 1994; Ndiaye, 1994). There are three models used to explain farmers' decisions on technology adoption (Makokha, 1999). These are the innovation diffusion model, the economic constraint model and the adopter-perception model. The innovation diffusion model considers extension contact and information about a particular technology to influence farmers' adoption behavior. The economic constraint model considers constraints on land, labor, capital and even risk-averse attitudes determine farmers' behavior towards introduced agricultural technologies. The adopter-perception model argues that farmers' perception of the innovative technology conditions adoption. All three models show that farmers' characteristics and economic circumstances and their knowledge and perceptions of agricultural technologies, influence the way they manage agricultural land use. These models provide support to the empirical data gathered in Liliw. Farmers' reasons for not integrating trees into their production systems or for not integrating trees in their production systems reflect personal and institutional factors, economic constraints and farmers' perceptions of the consequences of farming practices in the uplands. Based on this information, associations of the above-mentioned factors on the choice of agricultural land use are discussed below.

Table 8.5. Association of the Social Factors with Agricultural Land Use in Liliw, Laguna using Logit Model Analysis.

Independent Variables	Coefficients	Standard Error	Z	*P*>|Z|
Education	-.093	.953	-0.10	0.922
Farming Experience (years)	-.018	.048	-0.38	0.705
Leadership Quality (position in community organization)	2.381	1.561	1.53	0.127
Land Size	-.252	1.333	-0.19	0.850
Land Tenure Status	.852	1.204	0.71	0.479
Access to other source of Income (i.e. off-farm income)	-2.841	1.573	-1.81	0.071
Access to other source of Income (i.e. non-farm income)	-2.023	1.429	-1.42	0.157
Farmer Awareness of Environmental Degradation	-.381	1.396	-.27	0.785
Farmer Awareness of Adverse effects on Health	.681	1.356	0.50	0.616
Constant = 2.154				
LR chi2 (10) = 10.71				
Prob> chi2 = 0.296				
Log Likelihood = -10.945				
PseudoR2 = 0.328				
Level of Significance = 0.05				

Dependent Variable: 1 if agricultural land use with diversified crop production (tree crops and annual crops are integrated); 0-otherwise (agricultural land use with vegetable monocropping).

8.6.1 Farmer Characteristics

This study showed the association of some personal factors with the way farmers manage agricultural land use in Liliw, Laguna. Involvement in the community as leaders and land ownership were found associated with agricultural land use with diversified production where horticultural trees and vegetables are integrated. Other characteristics like level of education, years of experience in farming, awareness of natural resource degradation in the area, on the other hand, were not found associated with agricultural land use with diversified production.

Cramb, et al. (1999) in his research in an upland area in the Philippines found that farmers' personal characteristics like age, gender, and education do not significantly influence adoption of researcher- introduced soil conservation practices, specifically, hedgerow intercropping. This is, however, in contrast with the observation of other researchers in other tropical uplands in Asia. They recognize the importance of farmers' characteristics like age and level of education and involvement in community activities in the adoption of introduced technologies (Beedel, 2000; Makokha, et al., 1999; Taore, 1998; Ayuk, 1997; Ervin, et al., 1982). They have attributed association of these factors, particularly level of education and participation in community activities, with adoption of conservation practices due to enhanced awareness and recognition of environmental problems and knowledge of the benefits of soil conservation. On the other hand, the importance of age in adoption is associated with the convenience and labor requirement. Older farmers choose conservation practices that are less strenuous (Ayuk, 1997). Ervin et al., (1982) associated younger farmers' receptivity to wider range of introduced conservation practices with higher levels of education and lower risk aversions.

In Liliw, all women respondents were involved with agricultural land use with diversified production where trees and vegetables are integrated. Age, years of experience in farming, and educational attainments were just about the same for all agricultural land uses in Liliw. From the Logit model analysis, however, the significant association of community leadership and awareness of the effect of upland farming on the health of the farmworkers with agricultural land use where production is diversified through integration of horticultural trees and vegetables. Observations in the case study site together with the observations of the other researchers in the uplands all show that farmers' personal traits are important considerations for promoting agrobiodiversity in the uplands.

8.6.2 Farmers' Economic Circumstances

It is argued that economic factors and economic circumstances influence farmer adoption of technologies, especially of conservation practices (Pannell, 1999; Nelson, 1998; Scherr, 2000; Cary et al., 1997). Often, conservation practices are not adopted if economic benefits accrue in the future (Barbier, 1997; Cary, 1997; Fujisaka, 1994). In this study, it was seen how sources of income other than farming may influence the way agricultural lands are managed. While all agricultural land uses were seen as promising in the area, in terms of economic profitability (Chapter 7), those who earn from farming activities outside their own farms and those who earn from activities other than farming tend to be more involved with short-term, intensive farming in the uplands through vegetable monocopping. The Logit model analysis further shows that off-farm and non-farm income sources are not associated with those involved with agricultural lands with diversified production where horticultural trees and vegetables are integrated. This shows that in Liliw, those who have solely relied on farming for livelihood are the ones who tend to be more involved with agricultural land use with diversified production where horticultural trees and crops are integrated. This implies that economic gains in agricultural production in the uplands indeed influence the way these lands are managed. Thus, for enhanced agro biodiversity in the uplands, further development of diversified production systems towards making it a very profitable venture would be necessary.

8.6.3 Farm Characteristics

Land tenure status and size of the landholding could be important indicators of the economic circumstance of the farmers. Poorer farmers or those with limited land, labor, and capital are less likely to adopt agricultural innovations, especially conservation practices (Shively, 1999). In this study, almost all farmers have small pieces of land. And, land ownership was found to be an important factor that is associated with agricultural land with diversified production.

Understandably, tenants are less likely to plant permanents crops in land they do not own where landowners will reap future benefits. On the other hand, in studies on adoption of conservation practices, land ownership is a motivating factor to their use (Guo, 1999; Sajise et al., 1996; and Fujisaka, 1994). In the Philippines, especially, land ownership provides authority on the use of the land (Sajise et al., 1996). This was clearly implied in farmers' reasons for having monocropping systems or for integrating trees into their production systems. In this case, it can be seen that better tenure arrangements between land owners and tenants could make possible a more divers production system in the uplands.

8.6.4 Farmers' Perceptions on the Influence of Farming in the Uplands on the Health of Environment and Farmworkers

Natural resources in the tropical uplands are relatively prone to degradation because of sloping topography and the loss of tree cover. As such, natural resources, like soil and water resources become limiting factors to agricultural productivity in the uplands. One can thus assume that land users will tend to protect these resources by way of doing farming practices that will conserve them.

Furthermore, if the use of agrochemicals is causing health problems to the farmers then they will also do farming practices that might help reduce application of agrochemicals. However, results of this study at Liliw showed that farmers' awareness of natural resource degradation (including declining soil quality) is not associated with the adoption of diverse systems of farming. This indicates that farmer awareness of this problem does not necessarily translate into farming practices that might lead to the conservation of natural resources. This is likely because other factors, like economic returns and/or land tenure, are stronger motivating factors.

Perceptions of other farm problems have also been found to be not associated with adoption of recommended farming practices, particularly soil conservation practices (Cramb, et al., 1999; Makokha, et al., 1999; Taore, et al., 1998; Sinden, et al., 1990). Sinden (1990) explains that farmers' adoption of technologies is a three-stage process where perception of the problem and farming options is the first stage that could lead to adoption. Recognition that it is a farm problem is the second critical stage to adoption. Perception and recognition of farm problems could be influenced by a number of factors, like personal characteristics, stewardship incentives, and knowledge about the farming options to overcome the problems (Cary et al., 1997). There are, however, studies that argue that perception of economic benefits influence actual adoption (Pannell, 1999; Cary, et al., 1997; Parminter, 1994). Unless farming options will lead to economic gains, farmers do not tend to adopt recommended farming practices. If the perceived economic benefit accrues in the future, Cary, et al. (1997) argue that it is not surprising that awareness of, and concern for, natural resource degradation will still not necessarily promote adoption of conservation practices. Thus, while awareness of environmental concerns maybe a desirable prerequisite for encouraging appropriate conservation behavior, it is likely to influence only a few farmers because other personal and situational factors are stronger.

In terms of the effect of agrochemicals on the health of the farmworkers, farm options that will encourage reduction of its use are still needed. Enhancing agrobiodiversity of their production system through integration of trees and annual crops is not seen as an option for reducing the use of agrochemicals in Liliw. Rather, farmers in the study site simply hire labor for agrochemical spraying.

8.7 Summary and Conclusions

This chapter attempted to determine whether farmer traits, farm characteristics, and farmer perceptions and awareness of the effect of upland farming on the natural resources are associated with the way they managed agricultural land use. This was done to explain the potential for wider acceptability of agrobiodiversity enhancement as management alternative in the uplands. Farmer acceptability is very important in managing agricultural land use in the uplands, particularly the tropical uplands where the farmers are ones managing these lands.

Community leadership is found associated with agricultural lands with diversified crop production where trees and vegetables are integrated. Women and older farmers were also found more involved in agricultural land uses with integration of trees and vegetables, particularly in Liliw, Laguna. Those who have livelihood sources other than farming however, tend to be more involved with short-term intensive farming activities like vegetable monocropping. Likewise, tenants who are restricted from planting permanent crops in the lands have no choice but to resort to the growing of purely annual crops. Land owners, understandably, tend to maintain more permanent crops, in their lands. In such situations, better land tenure arrangement with supportive local or national ordinances regarding the integration of permanent crops into the production systems in the uplands would contribute to the further development of diversified production system in the uplands. It is likewise an advantage, if like the case of Liliw, Laguna, there are tenants who are enthusiastic to plant trees as borders.

While there is awareness among the farmers of environmental degradation in the uplands, there is an apparent need to inform the upland farmers, most especially land owners involved with vegetable monocropping, of the protective functions of integrating tree crops with annual crops. Farmer leaders and older farmers or those with exposure to the potential benefits of utilizing agricultural land for diversified production and having more permanent vegetation, could play important roles.

CHAPTER 9

Towards Agrobiodiversity Enhancement

The aim of the chapter is to synthesize the results from the evaluation of agricultural land uses in the Liliw case study (Chapter 6-8), in order to explore further the potential for agrobiodiversity enhancement in tropical uplands. The synthesis is achieved through the use of SWOT method of analysis, which enables barriers to and opportunities for, ABDE to be identified. This is turn provides the basis for exploring the intervention measures that might help to facilitate implementation of ABDE.

There are two parts in this chapter: the first part is a synthesis of results for evaluating agricultural land use in the uplands using mainly the SWOT Analysis. The second part discusses the implications of the analysis for developing an ABDE intervention program for the tropical uplands

Part 1. Integration of Horticultural Trees and Vegetables: A Potential for ABDE in the Uplands

Having analyzed and compared agricultural land uses with diverse and non-diverse production in Liliw, Laguna, Philippines, an attempt is now made to more fully identify the strengths and weaknesses of agricultural lands with diverse production and examine the biophysical and socioeconomic factors that contribute to, or detract from, diverse production. This will help to make clear how enhancement of agrobiodiversity may contribute to sustainable land management in the tropical uplands.

The main means used in this chapter for identifying strengths and weaknesses and barriers to and opportunities for agrobiodiversity enhancement in Liliw is the SWOT analysis technique. First, items in the SWOT matrix are described followed by a discussion of SWOT in relation to the protection, productivity, viability, security, and acceptability criteria for sustainable land management that formed a key component of the methodological framework presented in Chapter 4.

9.1 Strength-Weakness -Opportunity-Threat (SWOT) Matrix

Significant observations about the environmental, economic and social characteristics of agricultural land uses in Liliw case study are shown in Table 9.1. In the matrix, **S**trength refers to the factors that currently make the system able to meet the sustainability criteria of Protection, Productivity, Viability, Security and Acceptability. **W**eaknesses are the factors that currently inhibit sustainability. **O**pportunities are those factors that can be more readily fostered when considering ABDE (agrobiodiversity enhancement), through diversified production, as an alternative for the sustainable land management of the uplands in Laguna Province. **T**hreats are the constraints that need to be overcome or barriers that need to be lifted if ABDE is to become a management alternative for the uplands.

9.1.1 Strengths

Strength refers to the factors that currently make agricultural land use able to meet the sustainability criteria of Protection, Productivity, Viability, Security and Acceptability. Highlighted in particular, are factors that would facilitate agrobiodiversity enhancement in the uplands. This may include the biophysical condition in the area, on-farm factors affecting production and marketing of the products, and social factors like farmers' practices, characteristics and perceptions.

In terms of *protection of soil quality*, agricultural lands with diversified and non-diversified production exhibited high levels of soil fertility. However, those with diversified production -- where trees and annual crops are integrated -- proved more protective of the topsoil. In terms of soil nitrate there is indication of nutrient wastage in all agricultural land uses, but with the integration of trees, deeper nutrient capture is effected due to the tree roots.

In terms of *productivity*, Liliw was seen as a highly-suitable area for growing the annual crops, specifically tomato, and thus whether in diverse and non-diverse production, very high yields for this crop were obtained, even higher than the national and provincial yields. Crop yields for tomato is also higher when planted alone than when integrated with horticultural trees. All other crops in the area, including the horticultural trees (coconut and lanzones), have lower yield compared to national and provincial levels. Nevertheless, in agricultural land uses where they are integrated, crop yields are higher per unit of land per year. This contributes significantly to economic profitability.

In terms of *security of production*, there are disturbances that could disrupt crop productivity and economic profitability in Liliw, Laguna yet have not badly affected production in the 12-year period of study. Productivity is relatively secured as there is continuous production. With diversified production though, income from the horticultural tree crops, especially fruit crops (lanzones), buffered the effects of income loss from tomato. The presence of other crops in the diverse system enhanced total net farm income and reduced the risk of heavy loss due to dependence on one crop alone.

Productivity and economic benefits is most gained by owners of land with diversified production. It is therefore, these landowning farmers to whom agrobiodiversity enhancement through integration of horticultural trees and crops in the uplands would be most acceptable. Likewise, farmer leaders are more associated with diverse production. Older farmers, who are usually landowners and to whom long term cash income is more important, are also the ones who maintain diverse production.

9.1.2 Weaknesses

Weaknesses include factors that currently make agricultural land use with diverse production, where horticultural trees and crops are integrated, less able to meet the sustainable land management criteria of soil protection, productivity, and viability, security and farmer acceptability. Weaknesses also include on-farm difficulties or problems that could discourage diverse production in the uplands.

The main weaknesses of the diverse production in Liliw lie in the failure to maximize the productivity and economic potential for integrating perennials and annual crops. Relative to the care and maintenance given to the annual crops, very little is done for the tree crops in the diverse production systems. Thus, yields from these crops are much lower than they could be and are below national average.

In terms of farmer acceptability of diversified production systems, those farmers who have both farm and non-farm sources of income tend to be more involved with non-diverse production i.e., monocropping of annual crops which provide immediate income.

9.1.3 Opportunities

Opportunities consist of factors that can be looked into, pursued, or utilized when considering agrobiodiversity enhancement as a management alternative for the tropical uplands. These factors are generally beyond the farm level and therefore require support from stakeholders outside the farm.

In terms of *soil protection*, there is opportunity to enhance diversity in monocropping systems by means of encouraging the planting of trees along the borders or even short-term crop after tomato -- and a number of farmers in Liliw are willing to do this. Soil cultivation practices, such as application of green manure, chicken manure, and minimum tillage will enhance soil fertility in both the diverse and non-diverse systems.

In terms of *productivity*, there is also further opportunity for diversification through the use of tree crops other than lanzones and coconut with high economic potential. Other crop mixes or combinations of annuals and perennials could be tested in the area using crop species that are indigenous in the area to ensure crop suitability or tree and crop species that are preferred by the farmers. In order to achieve this, both in Liliw and similar areas, it will need a combination of research, extension services and government action. Tenancy and national ordinances are also possible mechanisms for preserving the tree crops in the Liliw uplands in particular and the Philippines in general. More importantly, improvement in the management and maintenance of the perennial crops will augment total net farm income and hence encourage preserving tree crops in the production system in the uplands. As well farmer leaders and land owners, who are usually the older farmers, involved with diversified production could be tapped for the promotion of agrobiodiversity enhancement in the uplands, thereby facilitating its wider acceptability.

9.1.4 Threats

Threats are constraints, problems, or difficulties that need to be overcome in order to enhance agrobiodiversity in the uplands. These threats may include off-farm factors or factors beyond the farm level.

At the farm level for instance, the high fertilizer application masks the adverse effect of soil loss, particularly in agricultural land with non-diverse production. This is misleading such that farmers are not able see and realize long-term losses caused by the thinning out of the topsoil with non-diverse production. Likewise, this practice has led to increasing dependence on fertilizer inputs, which in turn has contributed to the high cost of production.

With the monocropping systems, dependence on a single crop is threatened by the supply of similar crop in other areas or market glut which entails economic losses. The increasing farmers' loss of interest in coconut due to low income from this crop is a great threat to diverse production in the uplands and would be a great loss because of the apparently important role of coconut trees in maintaining thicker topsoil. Minimal maintenance of tree crops is reflected in low yields especially for the fruit crops. Planting of tomato in between the fruit trees is a disturbance to lanzones which highly contributes to the total net farm income. Lowest yield of tomato is obtained in the most diverse system. High amounts of chemical fertilizers applied in tomato increases the cost of production and lowers total net farm income.

The protective function of the diverse production systems is unknown to most land users in the uplands. Thus, in spite of awareness of degradation of soil resources in the area, this did not translate into production practices that might be able to deter such degradation, like the integrated trees and vegetable production.

9.2 Discussion of Results from SWOT Analysis

Using SWOT analysis, an attempt is now made to see how the criteria for sustainable land management (protection, productivity, viability, security and acceptability) are met.

9.2.1 Environmental Protection

Agrobiodiversity through integration of plantation, fruit tree crops, and annual crops exhibited an apparent advantage in terms of protecting the topsoil and in terms of preventing wastage of applied nutrients to the annual crops due to deep nutrient capture by the trees. An important contributor to the maintenance of the thickness of the topsoil is the rooting system of the tree crops. In the case study area, coconut trees showed potential for protecting the topsoil. However, in spite of the potential role of this tree crop on soil protection, it is unappreciated. The high soil fertility can be attributed to external sources of nitrogen being applied, including green manure, chicken manure and inorganic sources of nitrogen or the chemical fertilizers.

The declining interest among land users in replanting and maintaining coconut in the system is a threat to agrobiodiversity. The interest of land users in other tree crops is indicative also that the current structure of the agricultural systems might be altered in the future. Increasing interest in fruit tree crops, with anticipated economic benefit will most likely replace the coconut trees.

Land-users are unable to relate observed changes in the soil because soil degradation is masked by the effect of the high fertilizer applications, which is an indication of increasing dependence on them with consequent increases in the costs of production. This is a threat to sustainability.

9.2.2 Productivity, Economic Viability and Security of Production

Crop yields, especially for the annual crop, tomato, are high due to the suitability of the area to its crop-growth and the relatively intensive management provided by the farmers to this crop. This is not the same, though, for the other crops in the system, like the perennial crops and sequential crop, like radish. Crop yields of the fruit and plantation crops are low (compared to the provincial and national averages) as these crops are not as well attended as the annual crops.

The presence of tree crops and sequential crops in the system, however, buffer profit loss in the annual crop, tomato, to which the farmers invest labor and capital inputs the most. The economic viability and profitability of the annual crop alone is highly determined by market price, which is highly affected by supply of similar produce from other areas. The risk in producing a single crop is high. Income from fruits on the other hand, is almost always sure every year. Income from coconut while relatively lower than the annual and the fruit crop is obtained throughout the year.

Crop production has become a continuing activity in the sloping areas. Farmers' choice and decisions on what crops to plant is an important consideration for sustainable land management in the uplands.

9.2.3 Farmer Acceptability

Farmer choice and decisions about their production system is influenced by a number of factors, including personal traits, farm characteristics, and farmers' perceptions on the benefits and consequences of their farming practices in the uplands. It is important to understand the factors that influence farmers' decisions on the way lands are managed in order to avoid further experiences in the uplands where interventions are rejected by the very same people to whom they are intended for.

Farmer leaders and landowners (usually the older farmers) are more likely to be associated with diversified production. Thus, they could be instrumental for increasing the acceptability of an intervention program for agrobiodversity enhancement in the uplands. Community leaders are often the recipients of new information, farmer trainings and other extension support services. The lack of these for ABDE practices and their benefits would surely reduce social acceptability of ABDE practices. On the other hand, land tenure could limit acceptability of diverse production that involves integration of horticultural trees and crops to land owners. In spite of willingness of tenants to plant tree crops they are restricted to planting short-term crops because decisions on planting of permanent crops is solely the land owners'.

Women and older farmers or those who would opt for less strenuous farming activities are more open to diversified production. This only shows that if diversification would entail physically strenuous activities, it would be less acceptable.

Personal factors could also be deterrents to acceptability of ABDE in the uplands. As in the Liliw case study site, underlying reasons to personal preferences are attitudes toward risks and towards farming as opportunity for short-term economic investment. With the new generation getting into farming for income, tendency is to be involved with production of short-term cash crops. In contrast to older farmers who consider agricultural crops as family wealth to bequeath to younger generation. To the former, diversified production is less acceptable.

There is apparent lack of knowledge on the benefits of enhanced agrobiodiversity in the sloping uplands. As such, in spite of farmers' awareness of environmental degradation like soil erosion and declining soil fertility, non-diverse production system (monocropping system) in the sloping areas are prevalent and is likely to progress.

Education and information campaign on the protection function of diversified production systems could help for the promotion and wider implementation of agrobiodiversity enhancement practices. Farmers associated with diversified production systems could play important roles in this.

9.3 Conclusions for the SWOT Analysis

The SWOT analysis served as a useful tool for helping to integrate the results of the evaluation of diverse and non-diverse production systems in the upland situation of the Philippines. It helps to determine whether enhancement of agrobiodiversity in the uplands through integration of perennial and annual crops might be a sustainable management alternative for the uplands can be facilitated.

More weaknesses than strengths provide negative implications for agrobiodiversity as a management alternative. More threats than opportunities also indicate difficulties for making agrobiodiversity a sustainable land management for the tropical uplands.

Agrobiodiversity enhancement through integration of perennials and annual cash crops in the uplands of Laguna exhibited potential for minimizing soil loss, but not in minimizing nitrate accumulation in the soil. It provided higher total crop yield per year and year round harvest of crops. Monocropping of annuals is productive, but dependence on solely on one crop for farm income poses high risk of economic loss. Presence of other crops in the system augments total farm income.

Cost of production for the annual crops needs to be reduced and economic benefits from the annual crops need to be maximized. This will entail more attention to the maintenance of the perennial crops. The diverse system exhibited resilience to disturbances, but the annual crops are always at risk of failure due to market glut. The integration of perennials and annual crops is a farmer-preferred system and an economically viable source of livelihood, but poses high risk on the health of the farm workers because of the management practices for the annual crops.

Agrobiodiversity enhancement of the uplands, specifically integration of agricultural trees and crops, is a sustainable land management alternative for the uplands where the trend is towards monocropping of annual crops. For this to be achieved, however, significant constraints (identified weakness and threats) to productivity, protection, viability, security and acceptability, will have to be overcome and strengths and opportunities will need to be harnessed. Since ABDE is productive and protective, there is great opportunity to make possible its wider acceptability among the tropical upland farmers.

Table 9-1

SWOT Analysis for enhancing agrobiodiversity in the uplands through integration of perennial and annual crops (based on the results obtained in Liliw, Laguna, Philippines)

Characteristics	Strength	Weakness	Opportunity	Threat
Environmental Protection	Presence of tree crops in the system exhibited potential for reducing loss of topsoil; Despite continuous cultivation and with application of combined organic and inorganic fertilizer for the annual crops, diverse production with trees and annual crops showed signs of relatively high level of soil fertility;	As a consequence of annual crop production, relatively high risk of accumulation of nitrate –N in deeper layer of the soil but with the trees Nitrate-N is lower ;	Willingness of farmers to further diversify using other fruit crops of anticipated economic value; Farmers' willingness to plant trees along borders to prevent soil loss; Cultivation practices like minimum tillage, application of organic fertilizers are contributory to high organic matter in the soil ; With the tree crops, nitrate accumulation in deeper layer of the soil may be reduced due to deep nutrient capture of the tree crops; While fertilizer applied is intended for the annual crops, tree crops were also benefited;	Coconut trees aid in soil loss but not interesting to farmers due to low income; Effect of soil loss on soil fertility masked by high fertilizer input; Dependence on external input; Disturbance to the roots of fruit trees due to land preparation for annual crops for planting in between trees; High amount of Fertilizer N input can be the reason high Nitrate-N accumulation in the soil;

Characteristics	Strength	Weakness	Opportunity	Threat
Productivity	Production of the annual crops is highly suitable in the area; High elevations and relatively cool temperature and volcanic soil is favorable to high value annual crops Other marketable products include coconut fruits and annual crops	Neglect of production of the tree crops in terms of fertility management as farmers are content with the residual fertilizer s from annual crops as sufficient for the trees crops Higher incidence of pests and diseases due to shading of trees; Low yield of coconut; Low maintenance of fruit trees in spite of high yield ; Marketable yield of the annual crops is higher when planted alone;	Tenancy and national ordinance are preventive measures for cutting of coconut trees;	Pests and diseases in annual crops Further decline in productivity of coconut due to lack of interests-cutting of trees and zero replanting No replanting of destroyed or diseased trees; no maintenance for fruit trees in spite of income

Characteristics	Strength	Weakness	Opportunity	Threat
Economic Viability	The more crops in the production system, the more opportunity for income generation. This was both seen in tomato production alone and tomato monocrop followed by radish; as well as in the integration of trees and annual crops; Other crops in the systems like the second crop after tomato and trees served as buffer for losses incurred for tomato;	Sole dependence on one crop put at risk the total net farm income; Especially when nearby provinces would also produce the same crops Less than half of the farm households had total net farm income equal to the community average	Improve management and production of other crops in the system other than the annual crops more crops could enhance total net farm income; Diversify by including other crops either as intercrop or sequential crops, even other annual crops , not necessarily perennials, is important for having positive net farm income;	Market Glut and its effect of market price was shown to be prime factor that affect profitability especially of the annual crops; Market Glut Neglect of perennial crops might in the long-term fail to buffer the losses from the annual crop in the system
Security of Production	Able to produce every year in spite of natural disturbances as well as market failure			Confronted by a number of disturbances including natural factors and human-induced factors like market glut;

Characteristics	Strength	Weakness	Opportunity	Threat
Farmer Acceptability • **Farmer Traits**	Older Farmers who value long term income than immediate cash income tend to maintain production systems where trees and annual crops are integrated; Similarly women, community leaders and those who are higher levels of education tend to maintain a more diversified production systems	Farm households with the most diverse system experienced most poisoning; occurrence of pests and diseases in annual crops are mostly felt in the most diverse system thus farmers tend to apply more pesticides Small landholding is ideal for annual crop production	households are predominantly male; male farmers are associated with diversified production system, thus they can be involved in furthering agrobiodiversity in the uplands;	Due to good crop performance of high value vegetables, Vegetable monocropping is increasingly becoming an attractive source of livelihood in the uplands especially to new and younger farmers; It was also noted that those who have sources of income other than farming prefer to maintain short term crops and consider farming as additional income;
• **Farm characteristics**			Tenants in diverse systems are forced to maintain diversified system	Tenants in monocropping are restricted or are not willing to diversify their production system. Farmers in the area are mostly tenant.

Part 2: ABDE Intervention Program for the Tropical Uplands

Based on the information and insights gained from the analysis of agricultural land use in an upland area in the Philippines and the case of Liliw, Laguna, this chapter now deals with important considerations for developing an ABDE intervention program in the tropical uplands. In Chapter 2, and as exemplified by the Liliw case study, there is expected continuous cultivation of the tropical uplands for agricultural production. What is alarming though is the trend towards commercialization and continuous cultivation of short-term crops and the consequences of such practices on the natural environment including land degradation, pollution and biodiversity loss. As a recent assessment by the FAO (2003) indicates, there might be a decline in expansion in cropped areas in the tropical uplands in the future, but the existing cultivated areas may be cropped more intensively. This poses more risks to natural resource degradation.

ABDE, as a sustainable land management system for the tropical uplands, might be able to curb the trend towards environmentally harmful monocropping in the tropical uplands. This part of the chapter therefore attempts to define an ABDE intervention program for the tropical uplands. It sets forth the goal and aim that such a program might have, including its: scope or areas of concern; components at varying geo-political levels; suggested research and development activities; and constraints and opportunities that might hinder or facilitate its implementation.

9.4 What is an ABDE Intervention Program

An ADBE Intervention Program may be thought of as a Research and Development (R & D) program the aim of which is to provide alternative ways of managing the upland areas so as to use agricultural resources for both environmental conservation and production of food and fiber. The goal of such a program is to minimize the adverse impacts of using the uplands for short-term crops without threatening the source of livelihood of the farming community in the uplands. The main strategy of the integrated program is to diversify production systems in the uplands turning the areas into multi-strata or multi-species agroecosystem where more agricultural trees and crops are integrated. To be able to achieve this, there are a number of matters that need to be considered and these are summarised in Table 9.2 at the end of the Chapter (page 9-23). These matters include: program components that specify the activities that needs to be done; constraints and the potentials or the factors that may hinder or facilitate the implementation of the program components; and the critical requirements and the support needed so that the program components can be implemented. To be able to realize the benefits of enhancing agrobiodiversity in the uplands each of the abovementioned matters must be dealt with at varying levels or scales in the agricultural systems, which were discussed in detail in Chapter 2.

9.4.1 Scope of the ABDE Intervention Program

As defined in Chapter 2, agrobiodiversity covers a wide range of agricultural resources, from genetic resources to all biological resources with functional roles that contribute to the productivity of an agroecosystem. It is thus important at this point to define the scope that an integrated ABDE intervention program for the upland should cover.

There are some international institutions and groups that have initiated activities that directly or indirectly address some agrobiodiversity concerns. For example, the Global Plan of Action (GPA) by the FAO sets out a global strategy for the conservation and sustainable use of plant genetic resources for food and agriculture (Cooper et al., 1998). This complements the global effort towards conservation of biological diversity (CBD). The Global Plan of Action (GPA) also suggests that in the future agricultural systems will need to incorporate a broader range of crops, including crops which produce raw materials or are sources of energy. Increasing the range of crops grown is an important issue in arid and semi-arid marginal lands and links with the introduction of new crops and wider exploitation of underutilized species (Heywood, 1999). In connection with this, an International Centre for Underutilized Crops (ICU) was established to explore the potential use of hundreds of local crops that are currently underexploited. Its goal is food security, nutrition, economic welfare of human beings through assessing, developing, and utilizing the biological diversity of underutilized crops and species for sustainable and economic production and industrial raw materials.

PLEC (People, Land Management and Environmental Change), which is supported by the Global Environment Facility, is a program that also addresses some ABDE concerns, like: establishing demonstration farms to showcase diverse agricultural systems; not spreading technologies, but raising awareness among policy-makers that the alarming trend towards monocrop and heavy reliance on external inputs could be counter weighed by diverse agricultural systems; and that very diverse agricultural systems cannot only support people, but also protect the environment and be sustainable in the long-term (*New Agriculturist*, 2004).

This ABDE program will need to focus on promoting the use of agricultural tree crops, in order to enhance diversity of production systems in the uplands. This will involve discovering their environmental uses, as well as their economic potential, in order to make sure that not only is the need to conserve upland resources addressed, but also livelihoods enhanced. Such an intervention program should be initiated in areas with high potential for agricultural production or those that are now being used for monocropping of annual crops. It will have to focus on diversification of the upland agroecosystem by means of integrating agricultural trees into the production system, the products of which will have economic values to the farm household and to their livelihoods. As such, a major component of the intervention program will be to rediscover tropical fruit trees that will be suited for such integration in the uplands.

In order to be clear about what R and D activities to carry out, an ADBE Intervention Program for the tropical uplands must have components at different levels of the agricultural systems hierarchy. Each level must have its corresponding target goal and objectives. As discussed in Chapter 2, and as it applies in the tropical uplands, recognition of the hierarchical level in agricultural systems provides a guide for setting achievable goals thus providing a guide to lining up doable activities.

9.4.2 Program Goals and Components at Different Hierarchical Levels

At the farm level, it is necessary to provide tools that can be used to refine production systems in the uplands. It is also important to develop deep appreciation for enhancing agrobiodiversity in the uplands among the land users.

At the landscape level (i.e., from community to provincial levels), the goal is to promote collective effort to protect natural resources in the uplands by providing support services for agrobiodiversity and livelihood enhancement.

At the national level, the program goal would be to create awareness among policy makers and planners of the long-term impact and economic importance of ABDE by way of providing policy frames and decision-aid tools that can be used for land use planning at national, provincial and community levels.

At the international/global level, the aim would be to involve international institutions in promoting ABDE in different countries in the tropics that are having problems with agricultural land use in the upland areas by way of establishing networks with various international groups of similar interests.

Having set the goals for each program component, the following subsections discuss the suggested research and development activities under each component. Major factors that may constrain or facilitate implementation of these activities are also discussed.

9.5 Challenges and Opportunities at the Farm Level

As the goal at farm level is the provision of tools of use for refining production systems in the uplands, the focus of R & D activities will be on technology development and extension education support to those who directly use or manage the lands – the farmers. At this level, farmer decisions on land use are crucial in the development and implementation of R and D activities.

Two possible approaches to support land users' choice in managing land use are: 1) provision of viable technological options that fit not only biophysical, but also socioeconomic circumstance of the target users; and 2) education through non-formal means and active dissemination of information on benefits of ABDE and consequences of continuous land of the uplands that will hopefully change attitudes towards faming in the uplands. These are discussed further below.

9.5.1 Development of Viable Technological Options

There is a need for site specific technologies. Technologies refer to production practices that involve integration of agricultural trees and crops. These are technologies that can be used to modify or refine production system in the uplands. This requires knowledge of appropriate crop mixes and their requirements.

Generating production technologies especially for the uplands will definitely be confronted with biophysical and socioeconomic difficulties and these will have to be considered in any ABDE intervention program. For over two decades now, close collaboration with the target users of the technology has been professed as an effective way to ensure that technologies are used and adopted by the land users (Raintree, 1983). Participation of farmers in the technology development process is one of the reasons behind successful implementation of Farming Systems Research (FSR) projects during the 80's to the mid 90's.

In an approach advocated by FAO (1999) for improved land use and management practices called sustainable agricultural resources management (SARM), decisions about changes to existing land use practices should involve the full participation of the land users in identifying problems and opportunities, formulating and implementing appropriate courses of action, and in monitoring and evaluating results of doing so.

For an ABDE Intervention Program, farmer participation in the technology development process (i.e., technology generation, technology verification, technology testing and dissemination) will have to be considered. In relation to this, the following R & D activities are suggested for inclusion in an ABDE Intervention Program in the tropical uplands

9.5.2 R and D Activities for Generating ABDE Technological Options

1) Documentation of successful farming practices - information on potential tree crops for ABDE may be available already and thus just needs to be compiled for documentation;

2) On-station cropping systems research and in-depth study of agricultural trees and their roles in natural resource management;

3) On-farm Trials (researcher or farmer managed trials) on Domestication of indigenous trees crops or integrated production of horticultural trees and crops with high economic value; trees growth and productivity; ecological requirements; establishment and propagation; processing and product development;

4) Ethnobotanical research that will involve survey of farmer–preferred crops and tree species in different areas as well as integration of farmer knowledge in the development of crop management practices.

5) Assessment of market potential for all possible crops than can be integrated into the upland agroecosystem.

9.6 Challenges and Opportunities at Landscape Level: (Community to Provincial Levels)

As the target goal at the Landscape level is the provision of support services that will enhance farmers' appreciation of ABDE by way of enhancing their livelihoods, R & D at this level will need to focus on activities that deal with access to land, including local policies on land use and land use management.

A landscape would comprise a group of farms or community. Each farmer would have a unique circumstance with regard to household and farming goals, even though all farmers in the community might share common overall socio-economic goals. For example, in the case of Liliw, Laguna, those farmers who have sources of livelihood in addition to farming tend to engage in short-term cash cropping where they are able to get immediate income from their investment. Within this particular group is the younger generation many of whom have college or university degrees, but end up unemployed due to rising unemployment problems in the country. On the other hand, older farmers view farming as a family wealth to bequeath to the younger generation so they tend to go for a more permanent farming systems and thus favour having more permanent crops, like trees of high economic value giving good economic returns. What is being shown here is that while all land users have the same goal of providing the economic need for their family, still each individual would vary in perspective on how to achieve this goal which then affects their decisions on land use. This has to be well considered when developing an integrated ABDE Intervention Program for any tropical upland area. For a successful intervention program at the landscape or community level (successful in the sense that the favourable impact on the natural resources and on the economic condition on the farming community would be felt) managing land use in the uplands could not just be left alone on individual farmer decisions. There has to be a way by which landuse can be “regulated” through local development planning on land use, supported by carefully thought through local ordinances that genuinely aim at conserving the uplands and uplifting the economic status of the farming community.

Access to Land

Access to land is a very critical issue in any agricultural intervention that involves setting of permanent structures and permanent vegetation. Access to land is a common concern among developing countries today. As such, it is important for an ABDE intervention program to have support activities that may facilitate access to lands.

Land ownership and larger land size might be advantageous for the implementation of ABDE interventions as it involves integration of permanent trees in the upland agroecosystems. However, the reality in Asia and other developing countries is that land holdings are typically small and there is unequal access to lands.

There are many different forms of land tenure arrangement, varying widely from country to country or region to region within a country. That being the case there could be ways and means by which an integrated ABDE Intervention Program could still implemented in areas of varying kinds of land tenure system. Either the program could provide support to the development of technological options appropriate for the tenants or it could provide support roles to the development of local and provincial policies that facilitate access to lands or local ordinances that will encourage ABDE practices.

Various land tenure arrangements in different countries in Asia Pacific might also serve as models for implementing programs that aim at sustainable land use like ABDE. The following examples could be used as a basis for formulating local ordinances regarding land use and land use arrangements and as basis for implementing R and D.

In West Java Indonesia (cited from ASOCON, 1999), it was realized that differences in land tenure clearly influenced farmers' decisions on conservation practices, particularly on whether or not to invest in long-term land use improvements. It became clear that either alternative conservation practices would need to be developed for tenant farmers (i.e., for short-term benefits) or there would need to be a change to the tenancy agreements whereby the tenants can be compensated for any long-term investment if required to leave.

In the case of Fiji, the agricultural landlord and tenant act requires the tenant to compensate the owner should there be any dilapidation, deterioration, and damage to the land. However, such act is not strictly enforced hence short-term lease for inappropriate land uses continues in that country (FAO, 1999).

While land ownership issues are crucial for the implementation of an ABDE Intervention Program, there are also cases where communal land ownership has an apparent advantage over individual land ownership in terms of implementing sustainable land management systems. Examples of this are in Tonga where all lands belong to the kingdom, and in other socialist countries, like China, Vietnam and DP Korea where all lands are state lands.

In Tonga, customary ownership and tenure systems are closely associated with traditional conservation practices. Lands can be leased up to 20 years subject to certain conditions including: lands must be maintained in a reasonable state of cultivation and the land may not be abandoned for two years. Land areas not exceeding 0.2 ha and intensive agricultural production is discouraged. Tenants are required to continue traditional homegardens usually made up of mixed combinations of agricultural and forest trees. As such, land use is maintained and soil erosion is minimized. This land use system has protected the citizens from the economic, political and environmental problems where the best agricultural lands with the easiest access were often converted to monoculture plantations (FAO, 1999).

In China, land management contracts rather than certificates of land ownership are granted to individual households. The lands granted for lease have already been predetermined for specific purposes (i.e., for staple crops or for permanent crops). Contracts for permanent crops are longer (10-25 years) after which the next contactor will pay for permanent structures, like terracing. Even Longer term contracts are provided to households who intend to manage hilly lands or mountainous lands or reclaim wastelands. Similarly in Vietnam, larger plots may be allocated in denuded hills or bare lands for a maximum of 50 years for plantation and forest and 20 years for other agricultural lands.

One point to note which might be of importance in considering support activities for land use and land use management for an ABDE intervention program, is the fact that while land ownership is crucial to sustainable land management, land titling may not necessarily be the made a centrepiece of efforts to address access to land and land degradation problems. It will be useful however, to review experiences in land titling and any environmental changes following land titling to further find out if legal land title is indeed a requisite for sustainable agriculture (FAO, 1999).

9.7 Challenges and Opportunities at the National Level

The goal at National level is to create awareness among planners and policy-makers of the long-term impact and economic importance of ABDE, as well as the integration of R & D activities that must focus on the development of decision-aid tools of use for land use planning and policy development.

Enhancement of Agrobiodiversity in the uplands through diversification that includes adding more agricultural trees to the production system will require careful planning for producers not to suffer from adverse market conditions. The Liliw case has shown that economic productivity of agricultural land uses is highly affected by fluctuating market prices caused by over supply from other regions (Chapter 7). This reveals the importance of agricultural zoning not only based on biophysical suitability, but also with anticipation of market potential and prevention of market glut.

Zoning aims at classifying land uses within the broader landscape into discrete geographic units. This could be done for agricultural development purposes since all technological options are often site specific. The idea of agricultural zoning is no longer new, as it was already initiated in some parts of tropical Asia through the Farming system development programs (FAO, 1990). However, most often, agricultural zoning is based on biophysical suitability. The Liliw research shows that it is crucial to include the social-economic suitability of technological options as well in any ADBE Intervention Program.

The National Action Plan for the Philippines in 2004 states that weak land use planning in the Philippines is one of the reasons for land degradation in the country. This is due to the absence of comprehensive national land use policy and land use plans that will delineate land for agriculture, biodiversity, human settlements and industries and commercial centers. This has resulted in illegal conversions of agricultural lands to non-agricultural purposes, displacement of communities, and entry of commercial establishments in ecologically fragile lands (Philippine NAP, 2004).

One major constraint that an ABDE Intervention Program would have to deal with at the national level is the fact often governments are most likely to invest in industrial sector rather than agricultural sector because of the desire of politicians to show quick results from their actions. Politicians might also tend to invest more on or cheap food polices and quick increases in production than on how such gains would be maintained. Thus, decision-aid tools are needed that can show graphically the consequences of a range of decision options regarding resource allocation and land use. This is a crucial R and D activity for any ABDE Intervention Program.

9.8 Challenges and Opportunities at the International Level

At the International Level, the aim is to involve international institutions in promoting ABDE in the various countries of Asia. These activities will involve establishing and strengthening the network of various international groups and institutions with interests in biodiversity conservation, natural resource protection, and agricultural sustainability. This activity is to encourage international cooperation towards sustainably developing upland agroecosystems and the creation of worldwide awareness and appraisal of regional potential of ABDE in achieving both environmental conservation and agricultural productivity. Support activities, like international conferences to be held in different countries, and publications will be necessary to encourage international cooperation and support.

A major challenge is that international donors are also increasingly coming under political pressure from powerful lobbies in the west to take an environmental stance in the disbursement of aid. They are likewise constrained by their procedures to think in terms of fixed duration projects and will want to see funds disbursed and objectives achieved within a relatively short 3-5 year period.' (FAO, 1999). But an ABDE Intervention Program that integrates agricultural trees in upland agroecosystems already used for monocropping of annual crops, will take more than 5-10 years before favorable environmental, economic and social effects can be seen.

Table 9.2 Agrobiodiversity Intervention Program for Tropical Uplands

Hierarchical Level	Program Components	Constraints and Potentials	Critical Requirements/Support Needed
Farm Level	***Technology generation and development -***Development of Viable Technological options (Site specific technologies on integration of agricultural trees and crops; Farmer-initiated practices) ***Extension Education*** and skills enhancement for the technologies and their benefits;	Concerted Efforts from local R/E arms in discovering site specific, appropriate crop mix; Extension Activities	National and international support to research and extension; On-farm research ; agroecology; Start up funds for planting material
Landscape/Community Level	***Local ordinances on Land use*** Varying people and varying goals for farming e.g. in Liliw those who view farming as short-term investment would go for monocropping; compared to older farmers; Tenants are constrained to pant permanent crops;	Local Development Planning to encourage planting of trees even along borders; Local ordinances that will facilitate arrangement at the same time protect both landowners and tenants	FS approach to local development planning; Support from the national
Provincial and National Levels	***Land Use Planning*** -Planning or agricultural zoning To avoid impact of market glut on income of individual farmer;	Land use Planning not solely based on biophysical suitability but to link with market –related concerns	Bioeconomic modelling and IAM to simulate or show impacts;

Table 9.2 Agrobiodiversity Intervention Program for Tropical Uplands

Hierarchical Level	Program Components	Constraints and Potentials	Critical Requirements/Support Needed
Regional Level (SEA tropical uplands)	***Asian Networking on ABDE for Tropical uplands*** Exchange of ideas and experiences; on this aspect; at present there is none although AF is worldwide; More interaction and exchange on managing biodiversity in agroecosystems to achieve sustainability goals and continue provide livelihood to farmers;	More international support to networking especially in discovering tree crops suitable for restoring vegetation cover in the uplands e.g. underutilized fruit crops which is abundant in the uplands; Stronger linkage with internationally funded programs on Agroforestry, Biodiversity Conservation and Underutilized Fruit Crops and be at par or in same position as these programs International Conference to educate local development planners; Support from national policy makers	National policy that will encourage donor agencies to invest on ABDE Intervention program

9.9 Summary and Conclusion

The chapter attempted to synthesize the analysis of agricultural land use in a tropical upland using the SWOT technique to show how integration of horticultural trees and annual crops could enhance agrobiodiversity and become a sustainable management alternative for uplands. This was done using the methodology described in Chapter 4. The analysis showed there are strengths that should be harnessed and weaknesses to overcome so that enhancing agrobiodiversity through integration of perennials and annual crops may provide the environmental, socio-economic benefits to its fullest potential.

Based on such analysis, the chapter also attempted to develop an ABDE Intervention Program for tropical upland areas. It highlighted the program goals, and components and then went on to suggest research and development activities for application at different hierarchical levels.

This chapter showed the important role that agrobiodiversity enhancement has for managing agricultural land use in the uplands. However, this is not without challenges that need to be overcome yet there are also opportunities that must be taken advantage of to be able to develop and adapt ABDE as a management alternative for the sustainability of the tropical uplands.

The following chapter, which is the final chapter of the thesis, summarizes the entire thesis by way of presenting in brief the answers to the research questions posed in the first chapter.

CHAPTER 10
Summary and Conclusions

Agrobiodiversity as a concept and agrobiodiversity enhancement (ABDE) as a practice, argue that by having more agricultural resources in an ecosystem, productivity and environmental conservation would be reconciled. As such, in this thesis I argued that ABDE (agrobiodiversity enhancement) is a strategy worth exploring for the uplands of the humid tropics where intensive agriculture has become prevalent and biodiversity loss of great concern. There is, as yet, insufficient evidence to support the role that agrobiodiversity enhancement might play in the shaping of agricultural land use in the tropical uplands. The thesis attempted to address this knowledge gap.

The thesis arises from the problematic situation in the Philippine uplands where natural resource degradation is aggravated by the increase in monocropping systems and where agricultural productivity needs to be enhanced to support expanding populations. In situations where reforestation (of what otherwise were forested lands, but are now used for agricultural production) is no longer possible and introduced conservation technologies are not being adopted by the land users, the thesis posed this research question:

> *Would enhancing agrobiodiversity, through integration of perennial crops and annul crops, be an appropriate management alternative in the uplands?*

An appropriate management alternative for the uplands would be one that is environmentally protective of the natural resources, enhances economic productivity and is acceptable to the land users. Thus, corollary research questions were:

> *What would be the influence of agrobiodiversity enhancement on environmental protection and productivity in the uplands?*
>
> *What social factors might influence enhancement of agrobiodiversity of the production systems in the uplands?*

The general aim of the thesis was to explore the potential of agrobiodiversity enhancement as a management alternative for agricultural land use in tropical uplands, especially that of the Philippines, in terms of environmental protection, productivity and farmer acceptability. The objectives were:

> *Objective 1*: to describe the characteristics and properties of agrobiodiversity and agrobiodiversity enhancement (ABDE) as a concept and as a practice, in order to provide an understanding of its potential as a management alternative for agricultural land use in tropical uplands such as in the Philippines;
>
> *Objective 2*: to develop an integrated methodology (incorporating environmental, economic and social indicators) that could be used for evaluating agricultural land uses in tropical uplands, in order to evaluate the potential of agrobiodiversity enhancement as a management alternative in the tropical uplands such as in the Philippines;

Objective 3: To apply the integrated methodology developed in objective 2 , by evaluating the spectrum of agricultural land uses in the uplands and its influence on environmental protection and economic productivity in order to explore the potential benefits of enhancing agrobiodiversity ;

Objective 4: to identify the social factors that influence management of agricultural land use in the uplands, in order to explain the potential for wider acceptability of agrobiodiversity enhancement as a management alternative for the uplands.

In order to achieve the aim and the objectives of the thesis, the following tasks were done: *first*, agrobiodiversity and the agrobiodiversity enhancement concepts and their applicability in the uplands were reviewed and explained; *Second*, a methodological framework for evaluating different agricultural land uses in the uplands, that would allow an integrated assessment corresponding to the environmental, economic and social concerns in the uplands was developed and *Third*, an assessment of existing production systems in a case study site in the Philippines was conducted to compare their influences on the environment and farm productivity in an upland area as well as the social factors that influence the way production systems were managed and analyzed their implications for enhancing agrobiodiversity .

10. 1 Is ADBE an Appropriate Management Alternative for the Uplands?

A search of the literature showed that as yet there is no answer to the central research question for this thesis: *Would enhancing agrobiodiversity, through integration of perennial crops and annual crops, be an appropriate management alternative in the uplands?* Thus, research that helps to answer this question, even if only partially, could make an original contribution to knowledge.

The research for this thesis showed three areas of contribution:

1. integration of the environmental, economic and social aspects for understanding agrobiodiversity concept and its applicability at the ecosystem level, specifically in the upland agroecosystem;

2. a methodological framework for evaluating agricultural land uses that could lead to a better understanding of the influence of agrobiodiversity on the natural resources and productivity in the uplands and the social factors that might influence changes in agrobiodiversity in the uplands;

3. information about the influence of integrating agricultural trees and annual crops on the natural resources, specifically on soil fertility (the soil being the most important resource in the uplands), on farm productivity and the social factors that influence farmers' land use decisions.

The results underpinning these contributions are summarized in the following sub-sections.

10.1.1 Agrobiodiversity and ABDE as a Concept and as a Practice

Agrobiodiversity as a concept highlights the importance of agriculture in biodiversity restoration and conservation. Without it, agriculture will always be viewed as having no contribution to biodiversity enhancement and intensive agriculture will equate with biodiversity loss. Often agrobiodiversity is strictly associated with genetic diversity. This thesis showed how agrobiodiversity as a concept and practice could be applied at the ecosystem level, focusing more on species diversity in an agroecosystem. As the results have shown, this necessitates an holistic understanding and integration of various disciplines, particularly environmental, economic and social aspects, in order to fully appreciate and understand its importance in the tropical uplands and the case of the Philippines in particular. In this thesis I attempted to make use of the agrobiodiversity concept to provide a new perspective on crop diversification, not simply as a way to maximize land use, but as a strategy for achieving both environmental enhancement and increased production in the uplands.

10.1.2. Methodological Framework for Evaluating Agricultural Land Uses in the Uplands

In order to determine if enhancing agrobiodiversity might provide environmental and socioeconomic services that would address the environmental, economic and social problems in the uplands, an integrated methodology for assessing agricultural land uses was needed. From the review of integrated methodologies in agricultural research, more often only one or two of the above components are included. Most often, the social component dealing with farmer acceptability of a given practice is left out. One that attempted to include all three components was “sustainability assessment”, but it had not come up with a standard methodology nor with recommended indicators that could be followed. To fill this knowledge gap, the thesis set out to develop such a methodology (Chapters 3 and 4). It drew, on concepts and research methodologies that promote holism and integration across various disciplines relevant to the development of the upland agroecosystem. The aim was to develop a methodological framework for assessing agricultural land uses in the uplands in terms of environmental protection, productivity and farmer acceptability. The methodology aimed at allowing one to understand the influence of the production system on the natural resources and farm productivity as well as the social factors that will most likely influence land users to enhance agrobiodiversity of their production systems. The methodological framework includes a range of methods and techniques for gathering environmental, economic and social data in the uplands and indicates the circumstances under which each might best be utilized.

There are three important parts to the methodology that the thesis emphasized (Chapter4). First, the initial site assessment that allows one to briefly, but thoroughly, understand the biophysical and socioeconomic conditions in the uplands, which may vary in different locations. Second, identification and evaluation of the production systems in the area, of which the thesis provided a minimum set of indicators to use, in order to determine protection of the natural resources, productivity and farmer acceptability. Included are: the Shannon Diversity index (SDI), to quantify diversity of the production system; Soil Organic Matter (SOM), as a basic indicator of soil fertility, supported by depth of topsoil and nitrate accumulation in the soil; Total Net Farm Income (TNFI), as the basic measure of farm productivity supported by information related to crop yields and income from various crops in the system; Harvest and Income Losses as an indicator of security of production or its resilience to natural and human-induces disturbances to production; Farmer Traits, farm characteristics and farmer perceptions on the influence of farming on the health of the environment and of the farmer workers, as an indicator to determine the social factors that might influence the land users to enhance agrobiodiversity in the uplands. Third, tools for integration and analysis were devised to show and explain the interactions of the different criteria and indicators used. A qualitative analysis was designed to be able to include farmer and researcher insights, most often missed out in quantitative methodologies.

10.1.3 Integration of Agricultural Tree Crops and Annual Crops: Implications on ABDE in the Uplands

The third contribution to knowledge lies in the substantive information provided through studying the upland agroecosystem in Liliw, Laguna, Philippines where the production systems have never been the interest of other researchers (Chapters 5-9). The farmer-designed integration of agricultural tree crops and annual crops were assessed in terms of its environmental protection and productivity functions and for the factors that might influence the way farmers manage their production systems.

As results in Chapter 6 showed, in terms of soil protection, organic matter content was not significantly different where there is integration of plantation trees, fruit trees and annual vegetables with that of the monocropping of annual vegetable crops. This was in spite of indications of thinning of the topsoil in the monocropping of annual vegetable crops which would have adversely affected soil fertility. This was explained by the farmers' production practices in the area including application of high amounts of chemical fertilizers and chicken manure, fallowing and minimum tillage, which could have masked the effect of thinning out of the topsoil on soil fertility. An important observation, though, was the potential contribution of the rooting system of the plantation trees, e.g., coconut in preventing soil loss and nutrient wastage. Where there is coconut in the production system, there is thicker topsoil. Further, where there is integration of agricultural trees and annual vegetables, there is lower soil nitrate, an indication of less wastage of fertilizer nutrient applied to the crops. This was commonly observed in the most diverse systems where plantation tree crops, fruit tree crops and annual vegetable crops are integrated.

In terms of land productivity, results in Chapter 7 showed that crops yields of annual vegetable crops, tomatoes in particular, where farmers in the case study site invest most, were higher in the monocropping systems (40 % higher than the community average) than in the integrated systems. In terms of the farm productivity, though, the advantage of the integrated systems was once again highlighted as the monocropping system was subject to more losses due to natural disasters and market glut in the area. Total farm productivity, where in cases like Liliw, Laguna, losses in high cost of production for the annual vegetable crops, market failure and natural disasters, could be buffered by the income from the rest of the crops in the system, particularly from the fruit crops.

In terms of farmer acceptability, results in Chapter 8 showed that diversifying agricultural lands in the uplands are more likely acceptable to the leaders in the community and to the land owners. To older farmers and women farmers, diversified production is likely acceptable as well. Awareness of environmental disturbances that might result from agricultural production practices in the uplands does not translate into actions thus production practices that may conserve natural resources. Those who have farming as just one of their sources of livelihood tend to be associated with non-diversified production.

Possibilities, Barriers and Opportunities for Agrobiodiversity Enhancement

Enhancing agrobiodiversity (ABDE) of the tropical upland entails integrating more crop species into the system to not only provide protective and productive functions, but also those that are preferred by the land users. This research has shown that to enhance agrobiodiversity in the upland, an integration of 2-3 multi-species agroeocosystem (such as plantation, fruit and annual crops), it is important that the land users are not only knowledgeable of the environmental and economic benefits but also have the necessary means to act. As such, exposure to information through formal education or experience in farming would be important for the wider acceptability of ABDE in the uplands. In situations like Liliw, farmer leaders and elders in the community can play pivotal roles. Refinement of the integrated systems in the case study area would also provide opportunities for enhancing agrobiodiversity like encouraging restoration of vegetation cover using tree crops with economic potential, like fruit trees. As shown in the thesis, farmers are willing to grow them. Tenancy agreements and national ordinances could also be taken advantage of to encourage inclusion of more permanent crops into the production systems. However, economic viability and security of such production systems where perennials and annual crops are integrated would not be assured in the long-term if there is continued neglect of the perennial crops, as occurred in the Liliw case study site.

10.2 Limitations of the Study

10.2.1 This study suggested a range of indicators and data gathering methods for field assessment of agrobiodiversity enhancement practices The results and analysis obtained using the said indicators in the case study site, however, might be applicable only in areas of similar context, i.e. upland agroecosystems characterized by high rainfall, volcanic soil, insecure land tenure and with long history of agricultural production.

10.2.2 The relatively small sample size used in the analysis may not have captured the total variability of the case study site. Nonetheless, this study illustrated that the methodology is applicable and would yield the required information. The application of the methodology at higher hierarchical level with the landscape as the smallest sampling unit may better capture the variability of case study site particularly the ecological and the economic aspects.

10.2.3 This study has illustrated the use of the methodology through a one-period sampling. Periodic sampling and assessment however is recommended for the use of the methodology in the future to better capture the temporal variations of the production system thus, would not limit the applicability of the results of the evaluation to similar conditions under which the study was conducted.

10. 3 Recommendations for Future Research

10.3.1. An attempt to develop a methodological framework for evaluating agrobiodiversity enhancement (ABDE) in the uplands gave a minimum set of indicators and data gathering methods for field assessment of agrobiodiverity enhancement practices. Refinement of what was initiated in this research is worth pursuing in future research through testing across a range of sites and conditions. Suggested criteria and indicators here could be used further for developing a tool for preliminary assessment of ABDE practices in the uplands where an appropriate rating scale could be added. This research could also serve as an initial step to the development of a more quantitative methodology for assessing ABDE practices in the uplands where threshold values for the suggested indicators could be established.

10.3.2. Development of simple and measurebale indicators that extension workers and other community workers can use for assessing production practices for the uplands is a challenge for future research. Specific indicators that by themselves would integrate various characteristics, such as organic matter which reflects both the physical and the chemical quality of the soil, is a good example. Returns above variable cost and /or cost benefit ratio are economic indicators that reflect both the amount invested (labor and material) and the amount gained in a farming system. For resource-poor farmers, the amount gained from the limited investment placed into the enterprise is more important than high yield and profit. The use of integrated indicators would lessen the number of required indicators and simplify the implementation of the methodology. Exploring the use of indicators drawn from farmer-indigenous knowledge, such as their taste / feel of the soil, or visual signs of soil erosion also merits consideration in future research.

10.3.3. Enhancing agrobiodiversity in the uplands through integration of perennials and annual crops showed potential for soil protection and farm productivity. It is worth pursuing in future research to fully uncover the important roles of fruit trees and plantation crops in developing production systems in the uplands. Further assessment, thus, development of other production systems involving integration of fruit trees and plantation tree crops with annual crop production, would provide land users wider options for enhancing agrobiodiversity in the uplands.

10.3.4. Agrobiodiversity includes all biological organisms that contribute to the production process and thus includes both the planned and unplanned species in a production system. It will be interesting to investigate further the protective and productive functions of the unplanned species in the production system. Future research on this will contribute to the limited information on the role of weeds and underutilized plant species associated with plantation, fruit and vegetable crops, specifically on natural resource protection and its consequent impact on crop productivity.

10.3.5 Economic factors could both be a threat and a driving force to agrobiodivesity enhancement in the uplands. While this study has shown how economic factors could be a threat (e.g., high income from a particular crop discourages integrated cropping), it is worth pursuing in future research to study in more detail the economic factors as a driving force to the enhancement of agrobiodiversity in the uplands. For example, emerging markets for a new crop encourages planting of additional crop. Market demand and consumer preferences, could dictate the type of crop species that farmers in the uplands would plant and produce or would maintain in their farming systems.

APPENDIX 1

Sampling for the environmental protection, economic productivity and social data in the case study site

Sample No	Land Use *	Environment	Economic	Social
1	*T-alone*	*x*	*x*	*x*
2	*C+T*	*x*	*x*	*x*
3	*C+L+T*	*x*	*x*	*x*
4	*C+T*	*x*	*x*	*x*
5	T alone	x	o	o
6	*C+T*	*x*	*x*	*x*
7	*C+L+T*	*x*	*x*	*x*
8	*C+L+T*	*x*	*x*	*x*
9	L+T	x	x	x
10	T-alone	x	o	o
11	*C+T*	*x*	*x*	*x*
12	L+T	o	o	x
13	*T-alone*	*x*	*x*	*x*
14	*C+L+T*	*x*	*x*	*x*
15	T-alone	o	o	x
16	*C+L+T*	*x*	*x*	*x*
17	C+L+T	x	o	o
18	*L+T*	*x*	*x*	*x*
19	*T-alone*	*x*	*x*	*x*
20	*L+T*	*x*	*x*	*x*
21	*T-alone*	*x*	*x*	*x*
22	*L+T*	*x*	*x*	*x*
23	*T-alone*	*x*	*x*	*x*
24	T-alone	o	o	x
25	*T-alone*	*x*	*x*	*x*
26	T-alone	o	o	x
27	*T-alone*	*x*	*x*	*x*
28	T alone	x	o	o
29	T-alone	o	o	x
30	*T-alone*	*x*	*x*	*x*
31	C+L+T	o	o	x
32	T-alone	o	o	x
33	*T-alone*	*x*	*x*	*x*
34	L+T	x	o	o
35	*T-alone*	*x*	*x*	*x*
36	T-alone	o	o	x
37	*C+L+T*	*x*	*x*	*x*
38	T-alone	o	x	o
		n=29	n=25	n=32

Agricultural Land Use Types: T-Alone is Tomato monocrop; C+L+T is coconut, Lanzones and Tomato Intercop; L+T is Lanzones and Tomato Intercrop; C+T is Coconut and tomato Intercrop; O means no data;* ***Samples with complete set of environmental, economic and social data =24**.*

APPENDIX 2

Interview Questionnaire

Respondent number

Date of interview

1. General Information about the farmer

Name	Age (optional)	Gender
Educational Attainment		Number Years in Farming
Position in the Village		Home Address

2. Farm Attributes

B1.Number of land parcels being farmed (unit of measure, e.g Hectares for the case study site in Liliw Laguna Philippines)

B2.Detailed information about each parcel

Parcel Number	Size	Location	Cropping System	Land Tenure

3 Description of production system to be evaluated

3.1.Cropping system (E.g from the case study area –Liliw,Laguna, Philippines)

------- Vegetable monocrop

-------- Plantation Crop +Fruit Crop Vegetable Intercrop

-------- Plantation Crop + Vegetable Intercrop

-------- Fruit Crop + Vegetable Intercrop

3.2.Number of years this parcel of land is cultivated

3.3 Details about this particular production system during the last cropping season

Crop (specify varietal name)	Quantity of Harvest (kg/area)	Selling price (Ph peso/kg)

C4. Activities and Cost of production for all crops

Activity (Specify all)	Labor requirement		Material Requirements	
	Quantity	Costs	Quantity	Cost

4. Trend in Production for the last 10 years of the all crops

4.1 Observed trend in quality and quantity of harvest

Plantation Crops — Comments/Observations

------- Increasing quantity of harves

-------- Declining Quantity of harvest

-------- Enhanced Quality of harvest

-------- Reduced Quality

Fruit Crops — Comments/Observations

------- Increasing quantity of harvest

-------- Declining Quantity of harvest

-------- Enhanced Quality of harvest

-------- Reduced Quality

Vegetables — Comments/Observations

------- Increasing quantity of harvest

-------- Declining Quantity of harvest

-------- Enhanced Quality of harvest

-------- Reduced Quality

4.2. Occurrence of complete loss in harvest in this particular production system during the last 10 years (State year/s and reason/s for each crop in the system)

4.3. Occurrence of complete loss in income in this particular production system during the last 10 years (State year/s and reason/s for each crop in the system)

5. Farmer Indebtedness

51.Sources of income (rank according to importance)
------- On farm (specify)
------- Off farm (specify)
-------- Non farm (specify)
52.Access to credit facilities
(specify purpose/s andsource/s other comments)

6. Incidence of Poisoning

(Experience agrochemical poisoning, describe symptoms other comments)

7. Perceptions on land use management

What encourages you to diversify or not diversify your production systems?

Do you plan to change your production system in the future? In what way/s?

Are there any restrictions on changing your production systems?

Other comments

8. Perceptions on environmental degradation

Is there any observed degradation of natural resources in the area? Describe.

9. Other comments/additional information

APPENDIX 3

**Crops and Weed Species that contributes to Plant Species Diversity in Agricultural Land Uses in Liliw, Laguna, Philippines.
(Crop Year, 2001)**

Common name	Scientific Name
Weed Species	
Synedrella	*Synedrella nodiflora*
Tropical ageratum	*Ageratum conyzoides*
Yellow ginger-like	*Curcuma Longa*
Parachute-like	*Crassocephalum crepidiodes*
Spreading day flower	*Commelina diffusa*
Mikania (Bitter gourd-like)	*Mikania Cordata*
Alternathera	*Alternathera Sessiles*
Heartleaf dry mary	*Drymaria cordata*
Tobacco-like	*Elephantopus fomethosus*
Amaranthus	*Amaranthus espinosus*
Eleusine	*Eleusine Indica*
Peperomia (pansitan)	*Peperomia Pellucida*
Fern	
Annual Crops	
Tomato	*Lycopersicum esculentum*
Radish	
Yam (taro)	*Colocasia esculenta*
Perennial Crops	
Coconut	*Cocos nucifera*
Lanzones	Lansium domesticum

APPENDIX 4

Shannon Diversity Index and Soil Characteristics in Liliw, Laguna, Philippines (Crop Year 2001).

	SDI	Thickness of Topsoil (cm)	SOM at 20 cm depth (%)	SOM at 40cm depth (%)	NO3 at 40cm depth (ppm)	NO3 at 100cm depth (ppm)
SDI	-	0.438*	0.71	-0.317	-0.333	-0.133
Thickness of Topsoil (cm)	0.438*	-	-0.049	-0.111	-0.530	-0.140
SOM at 20 cm depth (%)	0.71	-0.049	-	0.645**	-0.109	0.076
SOM at 40cm depth (%)	-0.317	-0.111	0.645**	-	0.390	0.155
NO3 at 40cm depth (ppm)	-0.333	-530**	0.105	0.390*	-	0.037
NO3 at 100cm depth (ppm)	-0.133	-0.140	0.076	0.155	0.037	-

significant at 5% level; ** significant at 1% level (Person, one-tailed)

REFERENCES

Aarnink, W. 1999. Sustaining Agricultural Biodiversity and Agroecosystem Functions. Food and Agriculture Organization of the United Nationa Development Programme. Rome.

Ali, A. 1995. Population Pressure, Environmental Constraints and Agricultural Change in Bangladesh: Examples from Three Agroecosystems. Agriculture, Ecosystems and Environment , 55:95-109.

Altieri, M.A. 1989. Agroecology: A New Research and Development Paradigm for World Agriculture. Agriculture, Ecosystems and Environment, 27: 37-46.

Altieri, M.A. 1987. Agroecology The Science of Sustainable Agriculture. Westview Press, USA.

Altieri, M. A. 1999. The Ecological Role of Biodiversity in Agroecosystems. Agriculture, Ecosystems and Environment, 74:19-31.

Altieri,M.A., C.I. Nicholls and M.S. Wolfe. 1996. Biodiversity-a central concept in organic agriculture re: Restraining pests and diseases in Fundamentals of Organic Agriculture 11th IFOAM Scientific Conference Proceedings, pp 91-112.

Anderson, J.M. and J.S.I. Ingram. 1993. Tropical Soil Biology and Fertility Handbook of Methods (2nd Edition). CAB International, United Kingdom.

Arnold, J.E. and P.A Devees. 1995. Tree Management in Farmer Strategies: Responses to Agricultural Intensification. Oxford University Press, Oxford.

Ayuk, E.T. 1997. Adoption of Agroforestry Technology: the case of Live Hedges in the Central Plateau of Burkina Faso. Agricultural System,54(2): 189-206.

Azam, M.Z., M.E. Tusneem, P.J. Heytens and A.T. Perez. 1990. Sustainable Agricultural Concepts, Issues and Strategies. Asian Development Bank , Manila, Philippines

Bass, S.M.J. 1993. Ecology and Economics in Small Islands: constructing a framework for sustainable development. Chapman and Hall. Uk, London, pp156-175.

Barbier, E.B. 1997. The Economic Determinants of Land Degradation in Developing Countries. Philosophical transactions of the Royal society of London B. 352:891-899

Bautista, O.K. 1995 Commercial Vegetable Production in the Philippines in Commercial Horticulture, pp 201-205.

Bawden, R.J. and R.D. Macadam, R.J. Packham and I.Valentine. 1984. Systems Thinking and Practices in the Education of Agriculturists. Agricultural Systems, 13:205-225.

Beedel, J.D.C. and T. Rehman. 1999. Explaining Farmers' conservation Behaviour: Why do Farmers Behave the Way They Do? Journal of Environmental Management 57:165-176.

Bengtson, J. 1998. What Species?What Kind of Diversity? Which Ecosystem Function? Some Problems in Studies of Relations Between Biodiversity and Ecosystem Function. Applied Soil Ecology, 10:191-199.

Bland, W.L. 1999. Toward Integrated Assessment in Agriculture. Agricultural Systems, 60:157-167.

Broeke, M., J.D. Hack-ten, A.G.T. Schut and J.Bouma. 1999. Effects of Nitrate Leaching and Yield Potential of Implementing Newly Developed Sustainable Land Use Systems For Dairy Farming on Sandy Soils in the Netherlands. GEODERMA, 91:217-235.

Brookfield H. and Y.Byron. 1993. South-East Asia's Environmental Future the Search for Sustainability. United Nations University Press, Tokyo.

Brower, J.E., J.H. Zar and C.N von Ende. 1990. Field and Laboratory Methods for General Ecology (Third Edition). Win C Brown Publishers, USA.

Brown, A.J. 1999. Soil Sampling and Sample Handling for Chemical Analysis in Peverill, K.I., L.A Sparrow and D.J Reuter (eds), Soil Analysis An Interpretation Manual. CSIRO Publishing, Australia

Brown,K.D. 1987 Adoption of Improved Rice Technologies for Marginal Lands: A Philippine Case Study. Tropical Agriculture, 64:4.

Bruinsma, J. (ed). 2003. Agriculture and the Environment: Changing Pressures, Solutions and Trade-offs in World Agriculture; towards 2015/2030 An FAO Perspective. Earthscan Publication Ltd. Pp331-356.

Budelman, A. and F.Van der Pol. Farming Systems Research and the Quest for a Sustainable Agriculture. 1992. Agroforestry Systems19: 187-206.

Bureau of Agricultural Research. 1990. On-Farm Research Manual Cropping Systems Research. Department of Agriculture, Quezon City, Philippines.

Bureau of Agricultural Statistics.2006. Coconut Situationer. January – December 2006. Quezon City, Philippines.

Bureau of Agricultural Statistics.2006. Lanzones Factsheet . Quezon City, Philippines.

Bureau of Agricultural Statistics.2006. Situationer on Tomato. January – December 2006. Quezon City, Philippines.

Bureau of Soil and Water Management . 1987. Soil Survey and Classification of Laguna Province. Manila, Philippines.

C.K. Ong. 1996. A Framework for Quantifying the Various Effects of Tree-Crop Interactions Oxford,UK.

Caporali, F., P. Nannipieri, M.G.Paoletti, A. Onnis, P.E.Tomei and V.Tellarini. Concepts to sustain a Change in Farm performance Evaluation. Agriculture Ecosystems and Environment 27:579-595

Carg, V.K. 1998. Interaction of Tree Crops with Sodic Soil Environment: Potential for Rehabilitation of Degrdaded Environments. Land Degradation and Development, 9:81-93.

Cary, J.W and R.L. Wilkinson. 1997. Perceived Profitability and Farmers' Conservation Behavior. Journal of Agricultural Economics, 48(1): 13-21.

Chambers R. 1994. Participatory Rural Appraisal (PRA): Challenges, Potentials and Paradigm. World Development 22 (7) : 953-969.

Chudleigh P.D.1987. Farm Management Economics Course Syllabus. Division of Agriculture and Food Engineering. Asian Institute of Technology-Bangkok Thailand.

Cihacek, L.J., W.L. Anderson, and P.W. Barak. 1996. Linkages Between Soil Quality and Plant, Animal and Human Health in Methods for Assessing Soil Quality. Soil Science Society of America, Inc. Madison, USA. pp 9-22.

Clayton AMH. 1996. Sustainability A Systems Approach. Earthscan Publication Ltd., London.

Conway, G. 1986. Agroecosystems Analysis for Research and Development. Winrock International institutions for Agrocultural Development.

Conway, G. R. 1997. The Doubly Green Revolution Food for All in the 21st Century. Penguin Book Ltd., England.

Conway, G.R. 1993. Sustainable Agriculture: the Trade-offs with Productivity, Stability and Equitability in E.B.Barbier (Ed), Economics and Ecology: New Frontiers and Sustainable Development. Chapman and Hall, London, pp 47-64.

Conway, G.R. 1990. Agroecosystem in J.G.W. Jones and P.R. Street (Eds.). Systems Theory Applied to Agriculture and the Food Chain. Elsevier Applied Science, New York, pp 207 - 233.

Cooper, J.M.,R.R.B.Leakey, M.R.Rao and L. Reynolds. 1996. Agroforestry and the Mitigation of Land Degradation in the Humid and Sub-humid Tropics of Africa. Experimental Agriculture, 32:235-290.

Cornforth, I.S. 1999. Selecting Indicators for Assessing Sustainable Land Management. Journal of Environmental Management, 56:173-179.

Cox, T.S. and D. Wood. 1999. The Nature and Role of Crop Biodiversity in D. Wood and J.M. Lenne (Eds.) Agrobiodiversity Charaterization, Utilization and Management. CABI Publishing, Oxfon, UK, pp 35-58.

Crabtree B. and N.Bayfield. 1998. Developing Sustainability Indicators for Mountain Ecosystems: A Study of Cairngorms, Scotland. Journal of Environmental Management, 52: 1-14.

Cramb, R.A., J.N.M. Garcia, R.v. Gerritts and G.C. Saguiguit. 1999. Smallholder Adoption of Soil Conservation Technologies: Evidence from Upland Projects in the Philippines. Land Degradation and Development, 10: 405-423.

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

Cramb,R.A. and G.C. Saguiguit. 1994. Socioeconomic evaluation of Soil Conservation Technologies For Upland Farming Systems in the Philippines: Project Overview. SEARCA-UQ Upland Research Project Working Paper no.1. SEARCA Los Banos, Philippines.

Crasswell, E.T., A. Sajapongse, D.J.B. Howlett and A.J. Dowling. 1998. Agroforestry and the Management of Sloping Land in Asia and the Pacific. Agroforestry Systems, 38:121-137.

Craswell, E.T. and A. Maglinao. 2001. A Catchment Approach to Research on Soil Erosion in the Marginal Uplands in Suthipradit et al., (Eds) Sustainable Agriculture: Possibility and Direction. Thailand's National Science and Technology Development Agency, Thailand. pp 151- 162.

Cromwell, E. 1999. Agriculture, Biodiversity and Livelihoods: Issues and Entry Points (Final Report). Overseas Development Institute, London, 69pp.

Crossley J.W. 1996 Managing Ecosystems for Integrity: Theoretical Considerations for Resource and Environmental Managers. Society and Natural Resources, 9(5): 465-481.

Crosson, P. and J.E. Ostrov. 1990 Sorting out the Environmental Benefits of Alternative Agriculture. Journal of Soil and Water Conservation, 4(1): 34-41.

Cruz, M.C.J. 1986. Population Pressure and Migration in Philippine Upland Communities in Man, Agriculture and the Tropical Forest. Winrock International Institute for Agricultural Development, Bangkok, Thailand. pp 87- 118.

Dalsgaard J.P.T. and R.T. Oficial. 1997. A Quantitative Approach for Assessing the Productive Performance and Ecological Contributions of Stallholder Farms. Agricultural Systems, 55(4): 503-533.

de Vries, P.F.W.T., F. Agus and J. Kerr. 1998. Soil Erosion at Multiple Scales Principles and Methods for Assessing Causes and Impacts. CABI Publishing, United Kingdom.

Dent, J.B. and J.R. Anderson (Eds). 1971 System, Management and Agriculture. John Wiley and Sons Australasian Pty. Ltd. Sydney, pp 3-13.

Department of Agriculture –BSWM, Department of Natural Resources, Department of Sceince and Technology, Department of Agrarian Reform. 2004. The Philippine National Action plan to Combat desertification, Land Degradation, drought and Poverty, FY 2004-2010. Manila Philippines.

Department of Agriculture-Agribusiness and Marketing Assistance Service (DA-AMAS). Lanzones Industry Situationer Report. Quezon City Philippines.

Department of Agriculture-Agribusiness and Marketing Assistance Service (DA-AMAS). Coconut Situationer Report. Quezon City Philippines.

Department of Environment and Natural Resources. 1996. Upland Development Program a Decade and a Half. Quezon, City Philippines.

Department of Science and Technology (DOST)-PCARRD- STARRDEC. 2003. Program for Lanzones in Laguna [On line] available at http;//www.pcarrd.dost.gov.ph/consortia/starrdec/programs/lanzones/eng_about requ.htm

Diez, J.L., R. Caballero, R.Roman and R. Tarquis. 2000. Integrated Fertilizer and Irrigation Management to reduce Nitrate Leaching in Central spain. Jpurnal of Environmental quality 29(5): 1539.

Dixon, J. A and L.A. Fallon. 1989 The Concept of Sustainability: Origins, Extensions and Usefulness for Policy. Society and Natural Resources, 2(2): 73- 84.

Dixon, R.K, J.K. Winjum and P.E. Schoeder. 1993. Conservation and Sequestration of Carbon The Potential of Forest and Agroforest Management Practices. Global Environmental Change, 15: 159-173.

Dixon, R.K, J.K. Winjum, K.J.Andrasko , J.J. .Lee and P.E. Schroeder. 1994. Integrated Land Use Systems: An Assessment of Promising Agroforest and Alternative Land Use Practices to Enhance Carbon Conservation and Sequestration. Climate Change 27: 71-92.

Doing, H. 1997. The Landscape as an Ecosystem. Agriculture, Ecosystems and Environment, 63: 221-225.

Dooley D. 1995. Social Research Methods. Prentice Hall, New Jersey, USA.

Doran J.W and A.J. Jones. 1996. Methods for Assessing Soil Quality. Soil Science Society of America, Madison, Wisconsin, USA.

Doran, J.W., D.C. Coleman, D.F. Bezdicek and B.A. Stewart. 1994. Defining Soil Quality for a Sustainable Environment. Soil Science Society of America, Inc. Madison, Wisconsin, USA.

Doran, J.W., M. Saarantonio, M.A.Liebig. 1996. Soil Health and Sustainability in Advances in Agronomy Academic Press Inc, USA. 45pp

Duelli,P. 1997. Biodiversity Evaluation in Agricultural Landscapes: An Approach at Two Different Scales. Agriculture, Ecosystems and Environment, 62:81-91.

Dumanski, J. and C. Pieri. 2000. Land Quality Indicators: Research Plan. Agriculture, Ecosystems and Environment, 81:93-102.

Edwards, C.A.. 1990. the importance of Integration in Sustainable Agricutlural Systems in Sustainable Agricultural Systems.Soil and Water Conservation Society. St Lcie Press, Florida.

Edwards C.A. and M.K. Wali. 1993. The Global Need for Sustainability in Agriculture and Natural Resources. Agriculture and the Environment, 46: 99-121.

Edwards,C.A.,T.L. Grove, R.R. Harwood, C.J. Pierce Colfer. 1993. The Role of Agroecology and Integrated Farming Systems in Agricultural Sustainability, Elsevier Science Publishers BV. Amsterdam.

Ekanade, O. 1997. Hill Slope Agro-ecosystems and their Implications on Environmental Systems in Rural Southwestern Nigeria. Agriculture, Ecosystems and Environment, 61:97-102.

Ellis, E.C. and S.M.Wang. 1997. Sustainable Traditional Agriculture in the Tai Lake Region of China. Agriculture, Ecosystems and Environment, 61:177-193.

Ervin C.A and D.E Ervin. 1982. Factors affecting the Use of Soil Conservation Practices: Hypotheis, Evidence and Policy Implications. Land Economics 58:3: 277-292.

Farming Systems and Soil Resources Institute-University of the Philippines Los Baños 1984. Coconut-based Farming Systems in the Philippines: Status and Prospects. Los Baños Philippines.

Farshad A. and J.A. Zinck. 1993. Seeking Agricultural Sustainability. Agriculture, Ecosystems and Environment, 47: 1-12.

Fernandes, E.C.M., P.P. Motavalli, C.Castilla and L. Mukurumbira. 1997. Management Control of Soil Organic Matter Dynamics in Tropical Land Use Systems. GEODERMA, 79:49-67.

Filius, A.M. 1997. Factors Changing Farmers Willingness to Grow trees in Gunung Kidul (Java Indonesia). Netherlands Journal of Agricultural Sciences. 45:329-345.

Flach K.W. 1990. Low Input Agriculture and Soil Conservation. Journal of Soil and Water Conservation, 45(1): 42-47.

Flora, C.B. 1992. Building Sustainable Agriculture: A New Application of Farming Systems Research and Extension. Journal of Sustainable Agriculture 2:3:37-49.

Food and Agriculture Organization of the UNDP 1997. Technical Workshop on Farming Systems Approaches for the sustainable Use and Conservation of Agricultural Bio-diversity and Agro-ecosystems: Executive Summary and Conclusions.

Food and Agriculture Organization of the UNDP. 1989. The state of Food and Agriculture World Regional Reviews Sustainable Development and Natural Resource Management.

Food and Agriculture Organization of the UNDP. 1999. Sustaining Agricultural Biodiversity and Ecosystems functions.[Online] available at URLhtpp://www.fao.org/sd/epdirect/Epre0066.html.

Food and Agricultural Resource Organization of the United Nations Regional Ofice for Asia and the Pacific. 1999. Poverty Alleviation and Food Security in Asia: Land Resources. Rome.

Food And Fertlizer Technology Center. 2001. Managing Soil Fertility for Vegetable Production. [Online] available at URL: http://www.agnet.org/library/article/ac, pp 1-6.

Fujisaka, S. 1994. Learning from Six Reasons Why Farmers Do Not Adopt Innovations Intended to Improve Sustainability of Upland Agriculture. Agricultural Systems, 46:409-425.

Fujisaka, S. 1986. Change and Development in the Philippines in S. Fujisaka ,P.E. Sajise and R.A del Castillo (Eds) Man, Agriculture and the Tropical Forest. Winrock International Institute for Agricultural Development, Bangkok Thailand, pp1-12.

Fujisaka, S.,P.E. Sajise and R.A del Castillo (Eds). 1986.. Man, Agriculture and the Tropical Forest. Winrock International Institute for Agricultural Development, Bangkok Thailand.

Gameda, S. and J. Dumansky. 1995. Framework for Evaluation of Sustainable Land Management: A case of two rainfed cereal-livestock farming systems in Black Chernozemic Soil Zone of Southern Alberta, Canada. Canadian Journal of Soil Science, 75(4): 429-437.

Garrity, D.P. 1993. Sustainable Land-use Systems for Sloping Uplands in Southeast Asia in Technologies for Sustainable Agriculture in the tropics. ASA Special Publications, USA.

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

Gerrits, R.V. 1996. Some Myths about the Philippine Upland Development. SEARCA-UQ Uplands Research Project Working Paper no.17. SEAMEO Regional Center for Graduate Study and Research in Agriculture, Los Banos Philippines.

Gerritts, R.V., R.A Cramb and J.N.M. Garcia. 1996. Adoption and Adaptation of Hedgerow Intercropping in the Philippine Uplands. SEARCA-UQ Uplands Research Project Working Paper no.17. SEAMEO regional Center for Graduate Study and Research in Agriculture, Los Banos Philippines.

Giampetro, M. 1997. Socioeconomic Pressure, Demographic Pressure, Environmental Loading and Technological Changes in Agriculture. Agriculture, Ecosystems and Environment, 65: 201-229.

Giampetro, M. 1994. Using Hierarchy Theory to Explore the Concept of Sustainable Development. Futures, 26(6): 616-625.

Global Environment Outlook. 2003. Number 2.

Gomez, A.A., D.S.E. Kelly, K.J. Syers and K.J.Cougland. 199-. Measuring Sustainability of Agricultural Systems at the Farm Level.

Gomez, K.A. and A.A. Gomez. 1884. Statistical Procedures for Agricultural Research (Second Edition). John Wiley and Sons, New York.

Gough, C., N. Castells and S. Funtowicz. 1998. Integrated Assessment: An Emerging Methodology for Complex Issues. Environmental Modeling and Assessment, 3:19-29.

Gowda, M.J. C. and K.M. Jayaramaiah. 1998. Comparative Evaluation of Rice Production Systems for their Sustainability. Agriculture, Ecosystems and Environment, 69:1-9.

Gruhn, P., F.Goletti and M.Yudelman. 2000. Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture Current issues and Challenges. International Food Policy Research Institute. Washington DC. 31pp.

Guo, L.P., F.S.Zhang, X.R.Wang, D.R.Mao, and P.Xin. 2001. Effects of Long term Fertilization on soil Nitrate Distribution. Journal of Environmental Sciences, 1(13): 58-74.

Guo, Q. 1999. Mechanisms for Sustainable Agriculture: Effects of the Garden-Plantation System in Shaanbei, China. Journal of Sustainable Agriculture, 13(4): 23-37.

Guo,Z.,,Y.,Deegen, and H.Uibrig.2006. Economic Analyses of Rubber and Tea Plantations and Rubber-Tea Intercropping in Hainan, China. Agricultural Systems 66:117-127.

Halls, C.A.S and M.H.P. Hall. 1993. The Efficiency of Land and Energy Use in Tropical Economies and Agriculture Elsevier Science Publishers B.V., Amsterdam

Hart, R.D. 1984. Agroecosystems Determinants in D.A. Crossley, B.R. Stinner and G.J. House (Eds), Agrocultural Ecosystems Unifying Concept. John Wiley and Sons, New York .

Harrington, L. 1995. Sustainability in Perspective: Strengths and Limitations of Farming Systems in Contributing to a Sustainable Agriculture. Journal of Sustainable Agriculture, 5(1/2): 41- 59.

Hartemink, A.E., R.J. Buresh, B. Jama and B.H. Jansen. 1996. Soil Nitrate and Water Dynamics in Sesbania Fallows, Weed Fallows and Maize. Soil Science Society of America Journal, 60 (2): 568-574.

Haverson, J.J. 1996. Standardized Methods, Sampling and Sample Pre-treatment in Methods for Assessing Soil Quality. Soil Science Society of America, USA. pp 107-121.

Haynes, R.J. and R. Tregurtha. 1999. Effects of Increasing Periods under Intensive Arable Vegetable Production on Biological, Chemical and Physical Indices of Soil Quality.

Herzog, F. and N.Gotsch. 1998. Assessing the Sustainability of smallholder Tree Crop Production in the Tropics: A Methodological Outline. Journal of Sustainable Agriculture, 11(4): 13-37.

Heywood, V. 1999.Trends in Agricultural Biodiversity in Perspectives on New Crops and New Uses. ASHS Press Alexandra,VA.

Hess,G.R, C.L. Campbel, D.A. Fiscus, A.S.Hellkamp, B.F. MacQuaid, M.J. Munster, S.L.Peck; S.R. Shafer. 2000. A Conceptual Model and Indicators for Assessing the Ecological Condition of Agricultural Lands. Journal of Environmental Quality, 29: 728 - 737.

Hiemstra, W., C. Reijntjes and E.vd.Werf. 1992. Let Farmers Judge Experiences in Assessing the Sustainability of Agriculture. Intermediate Technology Publications.

Hill S.B. Environmental Sustainability and the Redesign of Agroecosystems in Ecological Agricultural Project (publication 23). [Online] Available at URL:http://www.eap.mcgill.ca/Publications/EAP34.htm. (Accessed on December 12-1999).

Hitzhusen, F. J. 1993. Land Degradation and Sustainability of Agricultural Growth: Some Economic Concepts and Evidence from Selected Developing Countries. Agriculture, Ecosystems and Environment, 41: 1-30.

Hurni, H. 2000. Assessing Sustainable Land Management. Agriculture, Ecosystems and Environment, 81:83-92.

IBON Foundation. 1997. The State of the Philippine Environment. IBON Foundation Inc., Manila, Philippines. 82pp

Ikerd , J. E. 1990. Agriculture's Search for sustainability and Profitability. Journal of Soil and Water Conservation, 45(1): 18-23.

Ikerd, J.E., D. Osburn and J.C. Owsley. 1998. Some Missouri Farmers, Perspectives of Sustainable Agriculture. [Online] Available at http://ssu.agri.missouri.edu/faculty/Jikerd/papers/tsu-surv.htm. (Accessed in October 16,1998).

Ikerd, J.E., 1993. The Need for a Systems Approach to Sustainable Agriculture. Agriculture, Ecosystems and Environment, 46:147-160.

Innis, D.Q. 1997. Intercropping and the Scientific Basis of Traditional Agriculture. Intermediate Technology Publications.

International Institute for Rural Reconstruction. 1989. The S.W.O.T. Analysis Technique. Paper presented in FSR/E Training Program. International Rice Research Institute, Los Baños.

International Rice Research Institute. 1983. Cropping Systems Manual. Los Baños Laguna Philippines.

Iqbal,S.M.M.,Ireland. C.R., and V.H.L.Rodrigo.2006. A Logistic Analysis of the Factors Determining the Decision of Smallholder Farmers to Intercrop: A case stsudy Involving Rubber-Tea Intercropping. Agricultural Systems 87:296-312.

Ison, R.L. and P.T. Maiteny and S. Car. 1997. Systems methodologies for Sustainable Natural resources Research and Development. Agricultural Systems, 55(2): 257-272.

Izac, A.M.N.,and M.J. Swift. 1994. On Agricultural Sustainability And Its Measurement in Small-scale Farming in Sub-Saharan Africa. Ecological Economics, 11: 105- 125.

Jama, B. 1998. Vertical Distribution of Roots and Soil Nitrate: Tree Species and Phosphorus Effects. Soil Science Society of America Journal, 62(1) 280-286.

Janssen W. and P. Goldsworthy. 1996. Multidisciplinary Research for Natural Resource Management: Conceptual and Practical implications. Agricultural Systems, 51: 259-279.

Japan International Cooperation Agency and National Irrigation Administration and National Irrigation Administration. 1995. Feasibility Study on the Upland Irrigation and Rural Development Project in Southern Luzon (Unpublished report).

Johnson, K.H., K.a.Vogt, H.J. Clark, O.J.Schmitz and D.J.Vogt. 1996. Biodiversity and the Productivity and Stability of Ecosystems. Trends in Ecology and Evolution, 11(9): 372-377

Johnson,R.T. 1992. At the Wrong end of the Cul-de-Sac? Philippine Land Use since 1903. (Paper presented during the 14th International Conference of Philippine Studies) Canberra.

Jordan,V.W.L , J.A. Hutcheon, G.V. D. Donaldson, and D.P. Farmer 1997. Research Into and Development of Integrated Farming Systems for Less-intensive Arable Crop Production: Experimental Progress (1989 - 1994) and Commercial Implementation. Agriculture Ecosystems and Environment, 64(2,3): 141-148.

Juillet, L and J. Roy. 1997. Sustainable Agriculture and Global Institutions: Emerging Institutions and Mixed Incentives. Society and Natural Resources, 10(3): 309-318.

Keeney, D. 1997. Linking Soil Quality, Water Quality and Agroecosystems Health. Korean Society of Soil Science and Fertilizer. Korea.

Kessler, J.J. and K.F. Wiersum. 1995. Ecological Sustainability of Agroforestry. Agriculture+Rural Development, 1:53.

Kleinman, P.J.A., D. Pimentel, R.B. Bryant. 1995. The Ecological Sustainabilty of the Slash and Burn Agriculture. Agriculture, Ecosystems and Environment, 52:235-249.

Kostchi,J.,A.W. Bayer, R. Adelhelm, and U.Hoesle. 1989. Ecofarming in agricultural development. Margraf Scientific Publishers, Germany.

Kummer, D.M. 1992. Upland Agriculture the land frontier and forest decline in the Philippines. Agroforestry Systems, 18: 31-46.

Lal, R. 1998. Agronomic Consequences of Soil Erosion in de Vries et al., (eds) Soil Erosion at Multiple Scales Principles and Metods For Assessing Causes and Impacts. CABI Publishing, United Kingdom, pp149-159.

Lal, R. 2000. A Modest Proposal for the Year 2001: We Can Control Greenhouse Gases and Feed the World with Proper Soil Management. Journal of Soil and Water Conservation, 55(4): 429-433.

Lal, R. (ed). 1994. Soil Erosion Research Methods. Soil and Water Conservation Society and St Lucie Press, USA.

Lasco, R. 1998. Carbon Sequestration of Philippine Tropical Forests: Implications to Global Warming. University of the Philippines Los Banos

Leaky,R.R.B. 1999. Agroforestry for Biodiversity in Agroecosystems in Collins, W and C. O. Qualset (Eds) Biodiversity in Agroecosystems. CRC Press, London, pp128 -145.

Lefroy, R.B.D., H.D. Bechstedt and M. Rais. 2000. Indicators for Sustainable land Management in Vietnam, Indonesia and Thailand. Agriculture, Ecosystems and Environment, 81:137-146.

Lewandowsky, I.M.Hardtlein and MKaltschmitt. 1999. Sustainable Crop Production: Defintion and Methodological Approach for Assessing and Implementing Sustainability. Crop Science, 39:184-192.

Lockeretz, W. 1989. Problems in Evaluating the Economics of Ecological Agriculture. Agriculture, Ecosystems and Environment, 27:67-75.

Lockeretz, W. 1991. Multidisciplinary Research and Sustainable Agriculture. Biological Agriculture and Horticulture, 8: 101-122.

Lowrance, R. 1990. Research Approaches for Ecological Sustainability. Journal of Soil and Water Conservation, 41(1) pp 51-52.

Lowrance R. 1992. Sustainable Agriculture Research at the Watershed Scale. Journal of Agricultural Science, 2(3): 105-111.

Lowrance, R., P. F. Hendrix, E. P. Odum. 1986. A Hierarchical Approach to Sustainable Agriculture. American Journal of Alternative Agriculture, 1(4): 169-173.

MacNaeidhe and N. Culleton. 2000. The Application Parameters Designed to Measure Nature Conservation and Landscape Development on Irish Farms. Agriculture, Ecosystems and Environment, 77:65-78.

Magdoff, F., L. Lanyaon and B. Liebhardt. 1997. Nutrient Cycling, Transformations, and Flows: Implications for A More Sustainable Agriculture. Advances in Agronomy, 60: 2-72.

Mannion, A.M. 1999. Past, Present and Future Relationships between Agriculture and Biodiversity. Department of Geography, the University of Readings Whiteknights.

Mansvelt, J.D.V. 1997. An Interdisciplinary Approach to Integrate A Range of Agro-landscape Values as Proposed by Representatives of Various Disciplines. Agriculture, Ecosystems and Environment, 63(2,3): 233-250.

Makokha M., H. Odera, H.K. Maritim, J.R, Okalebo and D.M Iruria. 1999. Farmers' Perceptions and Adoption of Soil Management Technologies in Western Kenya. African Crop Science Journal 7:4:549-558.

Manyong, A.M. and J. Degand. 1995. Sustainability of African Smallholder Farming Systems: A Case Study of Highland Areas of Central Africa. Journal of Sustainable Agriculture, 64: 17-43.

Marten, G. 1986. Traditional Agriculture in Southeast Asia. Westview Press, Boulder Co.

Matson, P.A., W.J. Parton, A.G. Power and M.J. Swift. 1997. Agricultural Intensification and Ecosystem Properties. Science, 277(5325): 504-509.

McLaren R.G. and K.C. Cameron. 1990. Soil Science Sustainable Production and environmental protection. Oxford University Press, Auckland New Zealand.

Meerman, F., G.W.J. Van de Ven, Keulen and H. Breman. 1996. Integrated Crop Management: An Approach to Sustainable Agricultural Development. International Journal of Pest Management, 42(1) 13-24.

Midmore, D.J. and D.D. Poudle. 1996. Asian Vegetable Production Systems for the Future. Agricultural Systems, 50: 51-64.

Moris,J. and J. Copestake. 1993. Qualitative Enquiry for Rural Development A Review Intermediate Technology Publications in behalf of Overseas Development Institute

National Research Council. 1989. Alternative Agriculture. National Academy Press, Washington D.C.

National Research Council 1993. Sustainable Agriculture and the Environment in the Humid tropics. National Academy Press, Washington DC, 702 pp.

National Statistics Coordination Board. 2000. A View of the Philippines. [Online] Available at http://www.nscb.gov.ph/view/geography.htm (accessed 28 January 2000)

National Agrometeorological Station-LB 2005. Climatological Normals (1950-2005) , Los Baños Philippines.

National Mapping and Resource Information Authority.1990. Topography Map for Laguna. Manila, Philippines.

Naveh,Z. 1995. From Biodiversity to Ecodiversity: New Tools for Holistic Landscape Conservation. International Journal of Ecology and Environmental Sciences, 21:1-16.

Ndiaye, S.M. and A.J. Sofranko. 1994. Farmers' Perception of Resource Problems and Adoption of Conservation Practices in a Densely Populated Area. Agriculture, Ecosystems and Environment, 48: 35-47.

Neher, D. 1992. Ecological Sustainability in Agricultural Systems: Definition and Measurement. Journal of Sustainable Agriculture, 2(3):51-61.

Nelson, R.A. and R.A. Cramb. 1998. Economic Incentives for Farmers in the Philippine Uplands to Adopt Hedgerow Intercropping. Journal of Environmental Management, 54:83-100.

Nelson, R.A. and R.A. Cramb. 1998. Economic Incentives for Farmers in the Philippine Uplands to Adopt Hedgerow Intercropping. Journal of Environmental Management, 54:83-100.

New Agriculturist Online Reporting Agriculture for the 21st Century. Taking ACloser Look at Agrobiodiversity. http://www.new-agric.co.uk/02-3/develop/dev04.html

Noordwijk, M.V. and B. Lusiana. 1999. WaNuLCAS, a Model of Water, Nutrient and Light capture in Agroforestry Systems. Agroforestry Systems, 43:217-242.

Oberle S.L. and D.R. Keeney. 1991. A Case for Agricultural Systems Research. Journal of Environmental Quality, 20:4-7.

Odum E.P. 1983. Basic Ecology. Saunders College Publishing. Philadelphia.

Odum E.P. 1975. Ecology: The Link Between the Natural and the Social Science. Holt Rhinehart and Winston. London.

Office of the Municipal Mayor.Undated.Socioeconomic Profile of Liliw, Laguna, 118 pp. (Unpublished Report)

Okey, B.W. 1996. Systems Approaches and Properties and Agroecosystem Health. Journal of Environmental Management, 48:187-199.

Ong C.K and P. Huxley (Eds) 1996. Tree-crop Interactions A Physiological Approach CAB International and ICRAF, Oxford, UK

Panell,D.J. and S. Schilizzi. 1997.. Sustainable Agriculture: A question of Ecology, Equity, Economic Efficiency or Expedience? [ONLINE] Available at http://www.general.uwa.edu.au/u/dpanell/spsp971f.htm.

Pannell D.J. 1999. Uncertainty and Adoption of Sustainable Farming Systems. Sustainability and Economics in Agriculture (SEA) Working paper 99/01, 1-11. UWA, Australia.

Paoletti, M.G. 1999. Using Bioindicators based on Biodiversity to Assess Landscape Sustainability. Agriculture, Ecosystems and Environment, 74: 1-18.

Parry,M. 1990. Climate change and World Agriculture. Earthscan Publications Ltd., London, 157 pp.

PCARRD-DOST-DENR-FMB-DA-UPLB-CFNR-FDC/ENFOR. 1999. Guidelines for Watershed Management and Development in the Philippines. Los Banos Laguna, Philippines. 241 pp.

PCARRD-DOST. 1992. the Philippine recommends for Coconut. Los Baños Philippines.

Philippine National Statistics Office. 2000. Annual Growth Rate Down to 2.0 Percent. 2000 Press Release [online] http://www.census.gov.ph/data/pressrelease/pr0060tx.html

Pierce F.J. and R. Lal 1994. Monitoring the impact of Soil Erosion on Crop Productivity in Lal R. (ed) Soil Erosion Research Methods. Soil and Water Conservation. St Lucie Press, USA. pp

Pimbert, M. 1991. Sustaining the Multiple Functions of Agricultural Biodiversity (IIED Gatekeeper Series 88). International Institute for Environment and Development, London, 24pp.

Pimentel,D.,J.Allen, A. Beers, L.Guinand, A.Hawkins,R. Linder, P. Maclaughlin,B.Meer, D.Musonda,D.Perdue, S.Poisson, R.Salazar, S.Siebert and K.Stoner. 1993. Soil Erosion and Agricultural Productivity in Pimente (Ed) World Soil Erosion and Conservation. Cambridge University Press, Great Britain. pp 277-292.

Poudel, D.D., D.J. Midmore and W.L. Hargrove. 1998. An Analysis of Commercial Vegetable Farms in Relation to sustainability in the Uplands of Southeast Asia. Agricultural Systems, 58(1): 107-128.

Pretty J.N. and Shah P. 1997. Making Soil and Water Conservation Sustainable: from Coercion and Control to Partnership and Participation. Land Degradation and Development, 8:39-58.

Puckett,L.J., T.K.Cowdery, D.L.Lorenz and J.D Stoner. 1999. Estimation of Nitrate Contamination of an Agroecosystem Outwash Aquifer using a Nitrogen Mass Balance Budget. Journal of Environmental Quality, 28: 2015-2025.

Rasul, G. and G.B. Thapa.2006. Financial and Economic Stability of Agroforestry as an Alternative to Shifting Cultivation. The case of Chittagong Hill tracts, Bangladesh. Agricultural systems 98article in press). [online] available at www.science direct .com.

Roberts, B. 1995. The Quest for Sustainable Agriculture and Land Use. University of New South Wales Press Ltd. Sydney, Australia

Robotham,M.P. 1998. Staying Alive: Sustainability in the Philippine Upland Management Systems. University of Hawaii. PhD thesis

Rosset P.M. and M.A. Altieri. 1997. Agroecology versus Input Substitution: A fundamental contradiction to Sustainable Agriculture. Society and Natural Resources, 10(3): 283-295.

Rothman, D.S. and J.B. Robinson. 1997. Growing Pains: A Conceptual Framework for Considering Integrated Assessments. Environmental Monitoring and Assessment, 46: 23-43.

Sainju, U.M., B.P. Singh, S. Rahman andV.R. Reddy. 1999. Soil Nitrate-Nitrogen under Tomato Following Tillage, Cover Cropping and Nitrogen Fertilization. Journal of Environmental Quality, 28:1837-1844.

Sajise P. and D.F Ganapin, Jr. 1990. An overview of Upland Development in the Philippines ACIAR, Canberra pp 31-44.

Sajise, P. and N. Briones. 1996. Environmentally Sustainable Rural and Agricultural Development Strategies in the Philippines (Lessons from Six Cases). SEAMEO Regional Center for Graduate Study and Research in Agriculture, Los Banos Philippines.

Sajise, P.E. 1996. Sustainable Land Use Systems in the Philippines: Some Lessons Learned. PURC News and Views, 1-6, Philippines.

Sajise, P.E. and D.J.Ganapin, Jr. 1991. An Overview of Upland Development in the Philippines in Technologies for Sustainable Agriculture on Marginal Uplands in Southeast Asia. Australian Center for International Agricultural Research, Canberra. pp 31-61.

Sajise. P. 1986. The Changing Upland Landscape in Man, Agriculture and the Forest. Winrock International Institute for Agricultural Development, Bsngkok, Thailand. pp 13-42.

Salafsky N. 1995. Ecological Factors affecting Durian Prodcution in the Forest Garden of West Kalimantan , Indonesia. Agroforestry System,32:63-79.

Samson, F.B. and F.L.Knopf. 1996. Ecosystem Management Selected Readings. Springer-Verlag, New York.

Sanchez, P.A and C.A Palm. Nutrient Cycling and Agrofoerstry in Africa.ICRAF.[Available online]http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/w0312E/w0312e06.htm/ March 17, 2006.

Schaller, N. 1993. The Concept of Sustainable Agriculture. Elsevier Science Publishers BV. Amsterdam.

Scherr, S.J. and P.B.R. Hazell. 1994. Sustainable Agricultural Development Strategies in Fragile Lands. EPTD Discussion paper no.1. International Food and Policy Research Institute, New York.

Scherr,S.J. 1999. Soil Degrdadation A Threat to Developing-Country Food Security 2020? Food, Agriculture and the Environment Discussion Paper 27. International Food Policy Research Institute, Washington, USA. 63pp

Schneider, S.H. 1997. Integrated Assessment Modeling of Global climate Change: Transparent Rational Tool for Policy Making or Opaque Screen Hiding Value-laden Assumptions? Environmental Modeling and Assessment, 2: 229-249.

Schiere,J.B., J.Lyklema, J. Schakel and K.G. Rickert. 1999. Evolution of Farming Systems And System Philosophy. Systems Research, 16:375-390.

Schulze, E.D and H.A. Mooney (eds). 1994. Biodiversity and Ecosystem Function. Springer-Verlag, Berlin.

Schulze, E.D. and H.A. Mooney. 1994. Biodiversity and Ecosystem Function. Springer-Verlag, Berlin.

SEARCA. 1995. Working Paper on Sustainable Agriculture Indicators. Philippines.

Selener, D., N. Endara and J. Carvajal. 1999. Particiaptory Rural Appraisal and Planning Workbook. International institute of Rural Reconstruction. Cavite, Philippines.

Senanayake, R. 1991. Sustainable Agriculture: Definitions and Parameters for Measurement. Journal of Sustainable Agriculture, 1(4): 7-28.

Shaner, W.W (Ed) . 1982. Readings in Farming Systems Research and Development. Westview Press.

Shepherd, G., R.J. Buresh and P.J. Gregory. 2001. Inorganic Soil Nitrogen Distribution in Relation to soil Properties in Smallholder Maize Fields in Kenya Highlands. GEODERMA, 101: 87-103.

Sidhu, A.S., H.S.Sur. 1993. Effect of Incorporation of Legume Straw on Soil Properties and Crop Yield in a Maize-Wheat Sequence. Tropical Agriculture, 70:226-229.

Siebert S.F. and J.M. Belsky. 1985. Some Socio-Economic Aspect and Environmental Aspects of Forest Use by Lowland Farmers in Leyte, Philippines and their

Implications for Agricultural Development and Forest Management . Philippine Quarterly of Culture and Society, 13: 282-296.

Sinden J.A and D.A king. 1990. Adoption of Soil Conservation Measures in Mailla Shire, New South Wales. Review of Marketing and Agricultural Economics.58:2,3 179-192.

Sisworo, W.H., M.M. Mitrosudhardjo, H.Rasjid and R.J.K. Myers. 1990. The Relative Roles of N fixation, Fertilizers, Crop Residues and Soil in Supplying N in Multiple Cropping Systems in a Humid Tropical Upland Cropping System. Plant Soil, 121: 73-82.

Smit, B. 1999. Implications of Global Environmental Change in Planning for Sustainable Future: the case of North American Great Plains [Online] available at URL: http://iisd.ca/agri/nebraska/smit.htm.

Smit, B. and J. Smithers. 1993. Sustainable Agriculture: Interpretations, Analyses and Prospects. Canadian Journal of Regional Science, 16(3): 499-524.

SmithC.S. and G.T. McDonald. 1998. Assessing the sustainability of Agriculture at the Planning Stage. Journal of Environmental Management, 52:15-37.

Smith,C.S., G. T. Mc Donald and R.N.Thwaites. 2000. TIM: Assessing the Sustainability of Agriculture Land Management. Journal of Environmental Management, 60:267-288.

Smyth, A.J. and J. Dumansky. 1995. A framework for Evaluating Sustainable Land Management. Canadian Journal Of Soil Science, 75(4): 401-406.

Soemarwoto, O. and G.R. Conway. 1992. The Javanese Homegarden. The Journal of Farming Systems Research-Extension, 2(3): 95-118.

Spedding, C.R. W. 1979. An Introduction to Agricultural Systems. Essex: Applied Science Publisher.

Spedding, C.R.W. 1996. Agriculture and the Citizen. Chapman and Hall, London.

Srivastava, J., N. smith and D.A.Forno. 1998. Towards a strategy for Mainstreaming Biodiversity in agricultural Development in Agriculture and the Environment Perspectives on sustainable Rural Development. A world Bank Symposium Washington DC

STARRDEC.2003. National Program for Lanzones Production. Los Banos Philippines.

Stinner, D.H. B. Stinner and E Martsolf. 1997.Biodiversity As An Organizing Principle in Agroecosystem Management: Case Studies of Holistic Resource Management Practitioners in the USA. Agriculture, Ecosystems and Environment, 62:199-213.

Stockdale J. 1989. Pro-Growth, Limits to Growth and a Sustainable development Synthesis. Society and Natural Resources, 2(23): 163-167.

Stockle C.O., R.I. Papendick , K.E. Saxton , G.S. Campbell and F.K. van Evert. 1994. A Framework for Evaluating the Sustainability of Agricultural Production Systems. American Journal of Alternative Agriculture, 9(1-2): 45-51.

Sunderlin, W.D. 1995 Managerialism and the Conceptual Limits of Sustainable Development Society and Natural resources, 8(6): 481-492.

Swift, M.J and J.M.Anderson. 1994. Biodiversity and Ecosystem Function in Agricultural Systems in Biodiversity and Ecosystem Function. Springer-Verlag, Berlin Germany, pp 15-41.

Swingland I.K. 1993. Tropical Forest and Biodiversity Conservation: A New Ecological Imperative. Chapman and Hall, London, pp. 118 - 129.

Syers, J.K., A. Hamblin and E. Pushparajah. 1995. Indicators and thresholds for the Evaluation of Sustainable Land Management. Canadian Journal of soil Science, 75(4): 423-428.

Tacq,J. 1997. Multivariate Analysis Techniques in Social Science Research. Sage Publications. London.

Taking a Closer Look at Agrobiodiversity.New Agriculturist Online Reporting Agriculture for the 21st Century. Http:/www.new-agric.co.uk/02-3/develop/dev04.html November 11, 2006.

Taylor, D.C., Z.A. Mohamed,M.N. Samsudin, M.G. Mohayidin and E.F.C. Chiew. 1993. Creating A farmer Sustainability Index: A Malayasian Case Study. American Journal of Alternative Agriculture, 8(4): 175-184.

Teague,W.R. 1996. A Research Framework to Achieve Sustainable Use of Rangeland, Agriculture, Ecosystems and Environment, 57: 91-102.

Tejada, A.W., L.M.Varca, SMF Calumpang, P.P. Ocampo, MJB Medina, C.M.Bajet, E.B. Paninbatan, J.R Medina, V.P. Justo, C. dL. Habito, M.R Martinez, and E.D. Magallona. 1992. Assessment of the Environmental Impact of Pesticides in Paddy Rice Production in Impact of Pesticiedes on Farmer Health and the Rice Environment. International Rice Research Institute. Philippines. 149-180.

Tejada, A.W., S M F Calumpang and E D Magallona. 1990. the Fate of Carbofuran in Rice-Fish and Livestock Farming. Tropical Pest Management 36:3:237-243

Tellarini, V. and F. Caporali. 2000. An Input/Output Methodology to Evaluate Farms as Sustainable Agroecosystems:An Application of Indicators to Farms in Italy. Agriculture, Ecosystems and Environment, 77: 111- 123.

Templet , P.H. 1995. Equity and Sustainability: An Empirical Analysis. Society and Natural Resources, 8:509-523.

Thrupp L.A. 1998. Cultivating Diversity Agrobiodiversity and Food Security. World Resources Institute. Washington DC.

Tisdell,C. 1999. Biodiversity, Conservation and Sustainable Development. Edward Elgar, UK.

Traore N, R. Landry, N.Amara.1998. On-farm Adoption of Conservation Practices: The Role of Farm And Farmer Charcteristics, Perceptions and Health Hazards. Land Economics 74:1:114-127.

Turner , R. K. and D.W. Pearce. 1993. Sustainable Economic Development: Economic Principles. Chapman and Hall, London, pp. 177 - 194.

UNEP. 1997. Convention on Biological Diversity (Report of the joint CBD Secretariat-FAO Workshop on Farming Systems Approaches for the Conservation and sustainable Use of Agricultural Biological Divesity and Agroecosystems. [Online] Available at URL: http://www.biodov.org/sbstta3i10.html.

UNEP, 2001. Agricultural Biological Diversity. Convention on biological Diversity. Novemeber 12-16, 2001. Montreal.

Vandermeer, J., M.V.Noordwijk, J. Anderson, C. Ong and I. Perfecto. 1998. Global Change and Multi-species Agroecosystems: Concepts and Issues. Agriculture, Ecosystems and Environment, 67:1-22.

Vergara, N. 1996. Technology in the Uplands: Development, Assessment and Dissemination. PURC News and Views, Philippines, pp. 14-20.

Vitousek, P.M. and D.U. Hooper. 1994. Biological Diversity and Terrestrial Ecosystem Biogeochemistry in Schulze,E.D. and H.A Mooney, Biodiversity and Ecosystem Function. Springer-Verlag, Berlin. pp 1-14.

Vorst,J.J. 1990. Research Needs for Sustainable Future. Journal of Soil and Water Conservation, 41(1):58-60.

Walker B. and W. Steffen (Eds). 1997. The Terrestrial Biosphere and Global Change: Implications for Natural and Managed Ecosystems. The International Geosphere-Biosphere Program (IGBP), Stockholm, Sweden.

Walters, D.T. Mortensen, C.A. Francis, R.W. Elmore and J.W. King. 1990. SPECIFICITY The Context of Research for Sustainability. Journal of Soil and Water Conservation, 41(1): 55-57.

Wang, X. and Z. Feng. 1995. Atmospheric Carbon Sequestration through Agroforestry in China. Energy, 20(2): 117-121.

Williams J. 1990. Social Traps and Incentives: Implications for Low-input, Sustainable Agriculture. Journal of Soil and Water conservation, 41(1): 28-30.

Wilson, K and G.E.B. Morren, Jr. 1990. Systems Approaches for Improvement in Agriculture and Resource Management. Macmillan Publishing Company, New York.

Wood R.C. and J.Dumanski. 1994. proceedings of the International Workshop on Sustainable Land Management .Agricultural institute of Canada, Ottaw.381pp.

Wood, D. and J.M. Lenne. 1999. Why Agrobiodiversity in D.Wood and J.M. Lenne (Eds)Agrobiodiversity Charaterization, Utilization and Management. CABI Publishing, Oxfon, UK

Wood, S., K. Sebastian and S.J. Scherr. 2000. Pilot Analysis For Global Ecosystems (PAGE) Agroecosystems. World Resources Institute, Washington DC.

Wood, S., K. Sebastian and S.J. Scherr. 2000. Agroecosystems Pilot Analysis of Global Ecosystems. International Food Policy Research Institute and World Resources Institute, Washington DC.

Yeates, G. W., M.F. Hawke and W.C. Rijkse. 2000. Changes in Soil Fauna and Soil Conditions under Pinus Radiata Agroforestry Regimes during a 25-year tree Rotation.
Biol Fertil Soils, 31:391-406.

Yiridoe,E.K. and A. Weersink. 1997. A Review and Evaluation of Agroecosystem Health Analysis: The Role of Economics. Agricultural Systems, 55(4): 601-626.

Young, A. 1989. Agroforestry for Soil conservation. CAB International, United Kingdom.

Young, A., K. Menz, P. Muraya and C. Smith. 1998. SCUAF Version 4: A Model to Estimate Soil Changes Under Agriculture, Agroforestry and Forestry (ACIAR Technical Reports Series No.41). Australian Center for International Agricultural Research, Canberra.

Yunlong, C.and B. Smit. 1994. Sustainability in Agriculture: A General Review. Agriculture, Ecosystems and Environment, 49:299-307.

Zinck, J.A. and A. Farshad. 1995. Issues of Sustainability and Sustainable Land Management. Canadian Journal of Soil Science, 75(4): 407-411.