The Economics of Soil Erosion and the Choice of Land Use Systems by Upland Farmers in Central Vietnam

Bui Dung The

December, 2001

Comments should be sent to the author, Bui Dung The at the Faculty of Economics, Hue University, 22 Phung Hung, Hue City, Vietnam.

Email: buidungthe@hotmail.com or kinhte@dng.vnn.vn

EEPSEA was established in May 1993 to support research and training in environmental and resource economics. Its objective is to enhance local capacity to undertake the economic analysis of environmental problems and policies. It uses a networking approach, involving courses, meetings, technical support, access to literature and opportunities for comparative research. Member countries are Thailand, Malaysia, Indonesia, the Philippines, Vietnam, Cambodia, Lao PDR, China, Papua New Guinea and Sri Lanka.

EEPSEA is supported by the International Development Research Centre (IDRC); the Danish Ministry of Foreign Affairs (DANIDA); the Swedish International Development Cooperation Agency (Sida); the Ministry of Foreign Affairs, the Netherlands; the Canadian International Development Agency (CIDA); the MacArthur Foundation; and the Norwegian Agency for Development Cooperation (NORAD).

EEPSEA publications are produced by Corpcom Services Sdn. Bhd. in association with the Montfort Boys Town, Malaysia. This program provides vocational training to boys from low-income families and home-based work to mothers. EEPSEA publications are also available online at http://www.eepsea.org.

ACKNOWLEDGEMENTS

The author would like to thank the following individuals and institutions that assisted in the preparation of this study:

The Economy and Environment Program for Southeast Asia (EEPSEA), especially Dr. David Glover, Dr. Herminia A. Francisco and Dr. Nancy Olewiler for their invaluable guidance, comments and suggestions during all phases of the study.

Mr. Nguyen Van Phat, Dean of the Faculty of Economics, Hue University, for administrative arrangements and the research team, especially Mr. Pham Xuan Hung, Mr. Nguyen Le Hiep and Mr. Nguyen Van Cuong for their cooperation in the data collection.

The staff of the Department of Agricultural and Rural Development, Thua Thien Hue Province, for their cooperation and especially Mr. Tran Van Hien and Mr. Hoang Trung An for their support in collecting the much-needed data and information.

Dr. Thomas Enters, Dr. Kenneth M. Menz and Dr. William H. Greene for their technical advice.

The people of Xuanloc commune, especially the farmers of the sample group, for their support and cooperation in the field survey.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THE ECONOMICS OF SOIL EROSION AND THE CHOICE OF LAND USE SYSTEMS BY UPLAND FARMERS IN CENTRAL VIETNAM

Bui Dung The

EXECUTIVE SUMMARY

Soil erosion is a significant problem in the uplands of the Central Coast of Vietnam. It affects the livelihood of farmers and could hinder the long-term economic development efforts in the uplands. Yet, trapped in poverty, upland farmers, especially the ethnic minority, are still using erosive land use systems to meet their immediate needs. This study demonstrates how the level of soil erosion varies across the typical land use systems. The fruit tree based agroforestry system is least erosive and most financially profitable. Measured by the annualized income loss, the on-site costs of soil erosion under upland rice-based and eucalyptus-based systems are VND 1,022 and 1,019 thousand/ha per year, respectively. That under the sugarcane system is VND 635 thousand/ ha per year, as compared (in all cases) to the fruit tree-based agroforestry system. The choice of land use system is influenced by farmers' attributes, land plot characteristics, and policy-related variables. Promoting the switch to agroforestry systems and the adoption of soil conservation measures is essential in reducing soil erosion and sustaining development in the uplands. It is, however, a very challenging task.

1.0 INTRODUCTION

The degradation of land resources is one of the most significant environmental problems in Vietnam. The quality of land in many areas has declined severely. In the Central Coast of Vietnam especially, there is a huge area of sloping uplands that is denuded and exposed to severe erosion (Quy 1997).

The Central Coast consists of 14 provinces with a total land area of about 97,000 km^2 and a population of more than 18 million inhabitants (General Statistical Office 2000). The whole region can be described as a very narrow and long strip of flat coastal land dominated by a large sloping area, leaning against the Truong Son mountain range. More than two-thirds of the Central Coast consist of hills and mountains. Compared with other regions in Vietnam, the Central Coast is the poorest and least agriculturally developed, mainly due to a hostile climate and a poor natural resource base (CBRM 1997). Thus, proper management of natural upland resources is of crucial importance to the region.

Land degradation is a very pronounced phenomenon in the region, especially in the sloping hilly areas where the ecosystems are very fragile. This problem is caused by both man-induced as well as bio-geographical factors. Erosive farming practice is often cited as one of the main causes of soil erosion. The inclement climate with intense rainfall and sloping topography makes the uplands in the region the most threatened. Some observed important indicators of land degradation in the region include loss of vegetation, loss of topsoil, frequent occurrence of flash floods during the rainy season, severe droughts during the dry season, and reduction in biodiversity. These observations find their roots in, inter alia, different land use systems that directly affect the physical structure and biochemical characteristics of the soil, as well as the vegetative cover of the land. In recent years, such degradation has been accelerated by, among other things, a rapid increase in population pressure, widespread rural poverty, and problems associated with open access (Dien et al. 1996)

To cope with these problems, the Vietnamese Government (both central and local), has issued and enforced the implementation of policies and programmes aimed at improving farmers' livelihood without further degrading the natural resources and environment. Forests and denuded hilly lands, which had long been state-owned or common property, have been allocated to farming households for long-term use. Environmentally-sound land use techniques have been promoted (Quy 1997). Many land use systems including agriculture, forestry, and agroforestry systems, have been adopted in the hilly areas. As masters of their land, farmers make use of natural resources in ways that best serve their needs within given constraints and opportunities.

Thua Thien Hue, where this study was situated, is one of the poorest provinces in the Central Coast. About three-quarters of its total land area is classified as uplands. In 1992, denuded hilly areas of the province were estimated at 170,600 ha and it is unlikely that this figure will decrease (Department of Forestry, 1993). The high amount of rainfall (about 3,300 mm per year) coupled with sloping topography makes the upland region highly erodible. Intensive and inappropriate land use practices hamper sustainable development and threaten the subsistence survival of upland people. In spite of substantial efforts and huge investments made on soil conservation, limited success has been achieved (DARD 1996). All of these factors make Thua Thien Hue a particularly relevant site for research on examining the erosion effects of different land use systems.

Past studies have shown the advantages and disadvantages associated with different land use systems. Agroforestry systems are often considered to be most environmentally-friendly and mono-cropping, the most erosive. However, the economic benefits of different land use systems that influence the behaviour of the land user has not been well studied. The cost of soil erosion, though perceived to be high, has never been estimated. There has been no solid basis on which to argue that a certain land use system is more economically desirable than another. Hence, what is needed is an accurate measurement of the cost of soil erosion and the benefits of adopting less erosive land use systems. It is critical for decision-making both from private and social perspectives that answers to the following questions are found:

1. What is the extent of soil erosion associated with different land use systems?

2. What is the cost of soil erosion?

3. What socio-economic factors determine a farmer's choice of land use systems?

4. What are possible interventions to promote the sustainable use of uplands in the region?

This research project was designed to find valid answers to these questions and to provide the individual land-user with the necessary information to make a correct choice on land use systems. The findings of the research are valuable inputs for formulating sustainable land use policies and plans. Incentives to encourage the upland farmer to adopt environmentally-friendly land use practices were identified.

Xuanloc, a hilly commune[1], was identified for the project. The study focused on four typical land use systems observed in the upland commune of Xuanloc. These included the (a) upland rice-based system, (b) sugarcane system, (c) fruit tree-based agroforestry (AF) system and (d) the eucalyptus-based system.

In Xuanloc, reforestation activities began quite extensively in the early 1990's when PAM (French acronym for World Food Program, the United Nations' food programme) and other reforestation programmes intervened. However, AF practice has not been widely adopted in the commune; it was found that only about 30% of farming households adopted AF which accounted for less than 20% of the commune's total agricultural land (Xuanloc People's Committee 1999).

As a result of the recent sugarcane promotion programme in the province, many farmers converted their forestry plots and other agricultural uplands to sugarcane fields. Many people, including policy-makers and upland farmers, expressed concerns and doubts about the relevance of the programme. This study measured and compared the erodibility and financial profitability of sugarcane farming with other land use alternatives.

[1] A commune in Vietnam differs from the western concept of commune and refers to a group of villages.

2.0 OBJECTIVES AND HYPOTHESES

2.1 Research Objectives

The general objective of this research was to formulate policy recommendations for the promotion of sustainable land use practices in the highly erodible hilly areas in Thua Thien Hue province. The specific objectives of the research were:

a) To assess the extent of soil erosion associated with different land use systems.

b) To estimate the on-site cost of soil erosion.

c) To empirically identify the socio-economic factors significantly influencing farmer's choice of land use system/s.

2.2 Hypotheses

The research aimed to test the following hypotheses:

a) That the upland rice-based system is more erosive than the other three systems (sugarcane, fruit tree-based agroforestry (AF) and eucalyptus-based systems).

b) That the fruit tree-based AF system is superior in terms of long-term financial profitability compared with the three other land use systems.

c) That policy-related variables such as credit, extension and land use incentives, significantly affect the land use choice of upland farmers.

3.0 REVIEW OF RELATED LITERATURE

3.1 Land Use Systems and Erosion

All land, regardless of the type of vegetation it supports, is subject to some degree of erosion. The rate at which soil erodes is influenced by how the land is used. Different land use systems result in different levels of soil erosion. The level of soil erosion of a given plot of land depends both on the type of crop planted as well as the agricultural techniques utilised (Miranda 1992).

Based on the type of tree or crop planted as well as the plant mix, land use systems can be grouped into three broad categories. These are: (1) agroforestry, (2) forestry, and (3) agriculture systems. Each of these has its advantages and disadvantages.

Agroforestry (AF) refers to land use systems in which trees or shrubs are grown in association with herbaceous plants (crop or pasture) in a spatial arrangement or time sequence, and in which there are both economic and ecological interactions between the tree and non-tree components of the system (Young 1989).

Unlike AF, land use under agriculture or forestry has only one component: crop or tree. Hence, agriculture with crops only or forestry with trees only can be considered as limited forms of AF.

It is essentially true that appropriate AF systems have the potential to control erosion, maintain soil organic matter and physical properties, and promote efficient nutrient cycling (Young 1987). Agroforestry is likely to be more favourable for the maintenance of soil fertility than arable agriculture alone. However, it should be noted that the presence of a given AF system is by no means sufficient to ensure maintenance of soil fertility. Equally important are: (1) the design of the system, in relation to the local environmental and socio-economic conditions, (2) good management of the system, and (3) the integration of AF into the farming system as a whole.

Under forestry systems, soil is well conserved if tree biomass is not taken out of the system. The effectiveness of tree/forestry systems in maintaining soil fertility can be clearly seen in the soils under natural forest, the use of tree fallow in shifting cultivation, and in the practice of reclamation of forestry on degraded land (Young 1987). Degraded land upon which forests are grown becomes fertile after a number of years.

The effectiveness of agricultural land use systems in controlling erosion and maintenance of soil fertility depends very much on the cropping techniques and type of crops planted. In general, in terms of erosion control, land use systems under agriculture are inferior compared with AF and forestry systems (Troeh et al. 1980).

3.2 The Economics of Soil Erosion

Soil erosion is the physical removal of topsoil by various agents, including falling rain, water flowing over and through the soil profile, wind, and gravitational forces (Lal 1990). Human activities such as crop production without appropriate conservation technology, over-grazing, mining (which disturbs the natural vegetation cover or alters soil properties), accelerate the natural erosion process (Francisco 1998).

Soil erosion has both on-site and off-site effects. The most important on-site effect is a decline in soil fertility due to loss of organic matter and nutrients, reduction of topsoil depth, and decrease in the water-holding capacity of the soil. This results in a decline in on-site farm productivity, which in turn, constitutes the on-site cost of soil erosion. The off-site costs of soil erosion may be considered to be the present value of forgone net economic benefits of downstream economic activities due to erosion (Barbier 1996).

Soil erosion results in loss of current income and increased risk affecting particularly the marginal farmer (Barbier, 1996). The impact of soil erosion on crop growth may be more dramatic in the tropics than in temperate conditions due to the relative fragility of tropical soil and more extreme climatic conditions (Lal 1990). In developing countries, the cost of land degradation may be more than 15% of the gross national product (Barbier and Bishop 1995).

Many studies estimate the on-site costs of soil erosion using the “change in productivity approach” and the “replacement cost approach”. The application of these two approaches is usually flawed and may lead to an over-estimation of the on-site cost of soil erosion because both assume that the comparison is between “with” and “without” erosion situations. Unfortunately, a “no-erosion” situation is neither technically possible nor economically desirable. Furthermore, soil conservation is not a “costless” exercise (Barbier 1996).

The methodologies for measuring the off-site costs of soil erosion are usually standard approaches to estimate environmental externalities. The methodologies employed are usually specific to the type of downstream impacts (Francisco 1998).

Barbier (1996) suggested using “the opportunity cost approach” to measure the on-site cost of soil erosion. According to this approach, the on-site cost of soil erosion is the loss in the long-run profitability of the farming system from not investing in an economically worthwhile alternative farming system. In other words, the on-site cost of soil erosion is the difference between the present values of the net financial returns of alternative land use systems with different degrees of erosion. This difference is subject to a number of factors such as choice of crops, crop management and erosion.

3.3 Economic Considerations in Land Use Systems

In theory, land use choice is straightforward: land is devoted to the use that provides the greatest value to its owner, as measured by the net present value (NPV) of the stream of net benefits expected in future years (USDA 1998). Landowners are, at best, concerned only with internal cost and benefits, which they must bear and enjoy. Therefore, from the viewpoint of a landowner, private (financial) NPV is the best criteria to evaluate economic viability of a land use system. The NPV can be estimated by comparing cost and benefit figures over the life span of the land use project and then computing the present value of the stream of net benefits using the prevailing discount rate[2].

[2] The prevailing discount rate is not always easily determined, especially when studying semi-subsistence farmers at the margins of the market economy.

In general, if the farmer owns the land and if the farmer's discount rate is reasonably close to the social discount rate, the optimal (land use) allocation of the farmer would be socially efficient in the absence of any kind of market failure. However, in reality, external costs or environmental damage associated with land use is unavoidable. A typical negative externality of soil erosion of agricultural land is the sedimentation of downstream reservoirs, hydroelectric facilities or irrigation channels (Barbier 1996). This implies that what is optimal for an individual is not necessarily optimal for society. Therefore, the economic viability of any land use system needs to be assessed from the viewpoint of the society.

Using the cost-benefit framework, Current and Scherr (1995) analysed financial and economic benefits of 56 AF systems in Central America and the Caribbean. They found that 75% of the AF systems analysed had positive NPVs at a 20% real discount rate. In two-thirds of the cases, the NPVs and the returns to labour were superior compared with alternative uses of land, agricultural crops and pure stands of trees (i.e. only forestry trees). Many high return AF systems were, however, sensitive to agricultural and tree product prices. They also had high marketing risks or faced limited market demand.

Lutz, Current, and Scherr (1995) found that many AF systems were profitable to farmers under a considerable range of economic conditions. When externalities were incorporated, AF systems showed positive NPVs, even at discount rates of 20% or higher.

Foltz et al. (1995) estimated the economic returns and environmental impacts of 72 alternative land use systems under agriculture in the Eastern Corn Belt. Multi-attribute rankings of these land use systems were analysed from profitability and environmental quality perspectives. Environmental consequences were simulated using EPIC (Erosion Productivity Impact Calculator) and GLEAMS (Groundwater Loading Effects of Agricultural Management Systems). This study found that groups of farmers, who appeared to have different ranking of preferences, could find alternatives that simultaneously satisfied their goals.

It should be noted that most economic analyses suffer from the dearth of time series data and difficulties in valuing environmental impacts of soil erosion. They are, therefore, usually partial or incomplete. Therefore, care should be taken in interpreting the results as well as in formulating policy recommendations. Environmental impacts, which are not valued, should be described and benefit transfer methods should be used if applicable.

3.4 Choice of Land Use System

The literature on the adoption/choice of technology is generally divided into two opposing schools of thought. Griliches (1957) was the proponent of the first school, which emphasises the dominant role of economic incentives in explaining the use of a certain technology. The other school of thought places primary importance on non-economic variables in the adoption process. Nevertheless, although each school advocates the relative importance of their own approach, they still recognise the role of their counterpart (Garcia 1997).

Past literature has shown that there is a wide array of factors ranging from field-level variables to industry and macro policies that interact to shape the decision of upland farmers to adopt a certain land use system. Rerkasem and Rerkasem (1996), as cited by Garcia (1997), identified three key elements that played a significant role in sustainable land use management. These are: (1) the presence of appropriate and cost-effective technological solutions, (2) social organisation and communal resource management, and (3) the ability of local people to participate in making crucial decisions related to land management.

Young (1987) claims that there are three main constraints to the application of a land use system. These are: (1) type of land, (2) extent of land, and (3) supply problems. Most non-AF methods suffer from one or more of these constraints. Various AF systems are applicable to a wide range of environmental conditions, and do not require costly inputs. The loss of crop production due to the tree component can be compensated either by a higher crop yield or by the value of products from the trees. Thus, AF is widely applicable as a practical land use management option.

However, due to its ecological and economic complexity compared to other systems, AF is not widely practised. Farmers in developing countries often face problems in designing and managing AF systems. For example, it is not easy at all to identify a proper combination of crop and tree. Even when the composition of crop and tree is well established, managing the system well is still very challenging. Furthermore, widespread poverty and food shortage discourage farmers from adopting AF.

The choice of a land use system is also affected by the security of land ownership. The possession of a legal title contributes to capital formation and land improvement (Feder and Onchan 1987). Most analyses of AF adoption emphasise the significant importance of technical, social, and cultural factors in shaping the land use decisions of farmers (Kerkhoff 1990).

The above review of literature on technological choices with regards to land use systems is indicative rather than exhaustive; it is sufficient to say that there are many factors, which are likely to affect a farmer’s land use choice. These include factors associated with the adopter farmer and the technology as well as the institutional, socio-economic and physical environments under which the choice is made. However, the impact of these factors varies and does not follow a predetermined pattern.

4.0 METHODOLOGY

The modelling process was carried out in three stages. First, a physical model of erosion was developed under four different cropping systems. Second, the net present value of each system was estimated using economic data. Third, the choice of cropping pattern at household level was examined.

4.1 Research Objectives

4.1.1 Research Objective 1

The erosion-productivity model; Soil Changes Under Agriculture, Agroforestry and Forestry (SCUAF) version 4.0 (Young et al. 1998) was employed to estimate the soil loss due to erosion associated with each land use system. Annual estimates of soil loss due to erosion provided by SCUAF allowed the testing of research hypothesis number 1, using a t-test.

SCUAF is a simple, deterministic model, designed to predict the effects of interactions between AF systems and soil. The model predicts the changes in soil fertility, crop yield, and tree biomass over time by simulating the breakdown rate of plant material and the soil nutrient uptake by plants. It can be used to compare AF systems with those under agriculture or forestry; thus, its name. While it does not directly include an economic component, SCUAF can be used as a basis for economic analysis by providing input and output values (Young et al. 1998).

The validity of the model was tested from previous applications of SCUAF. In Zimbabwe, SCUAF was used to simulate soil nutrient dynamics and plant productivity for the Miombo woodlands and adjacent maize crops (Vermuelen et al. 1993). It was judged to provide reasonable predictions for maize and tree growth. For the study of hedgerow systems in the Philippines, Nelson et al. (1996) compared the results from SCUAF and the results from a more complex dynamic process model, APSIM (Agricultural Production Systems Simulator). SCUAF was found to produce similar estimates of trends for medium-term yields. Ranola et al. (1997) also asserted that the SCUAF model was very useful in overcoming the dearth of time series data. A series of studies using SCUAF to evaluate land use systems in Southeast Asia has also reported the validity of SCUAF (Young et al. 1998).

4.1.2 Research Objective 2

The opportunity cost approach was adopted to estimate the cost of soil erosion. Using the cost-benefit framework, the net present value (NPV) of the four land use systems was calculated. It should be noted that future returns/crop-yields were predicted using SCUAF.

A bio-economic valuation framework used to attain the research objective is shown in Figure 1.

The cumulative net present value of the systems over 'n' years was computed using the following equation:

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

where B_t is the total benefits in year t,
C_t is the total costs in year t, and
r is the discount rate.

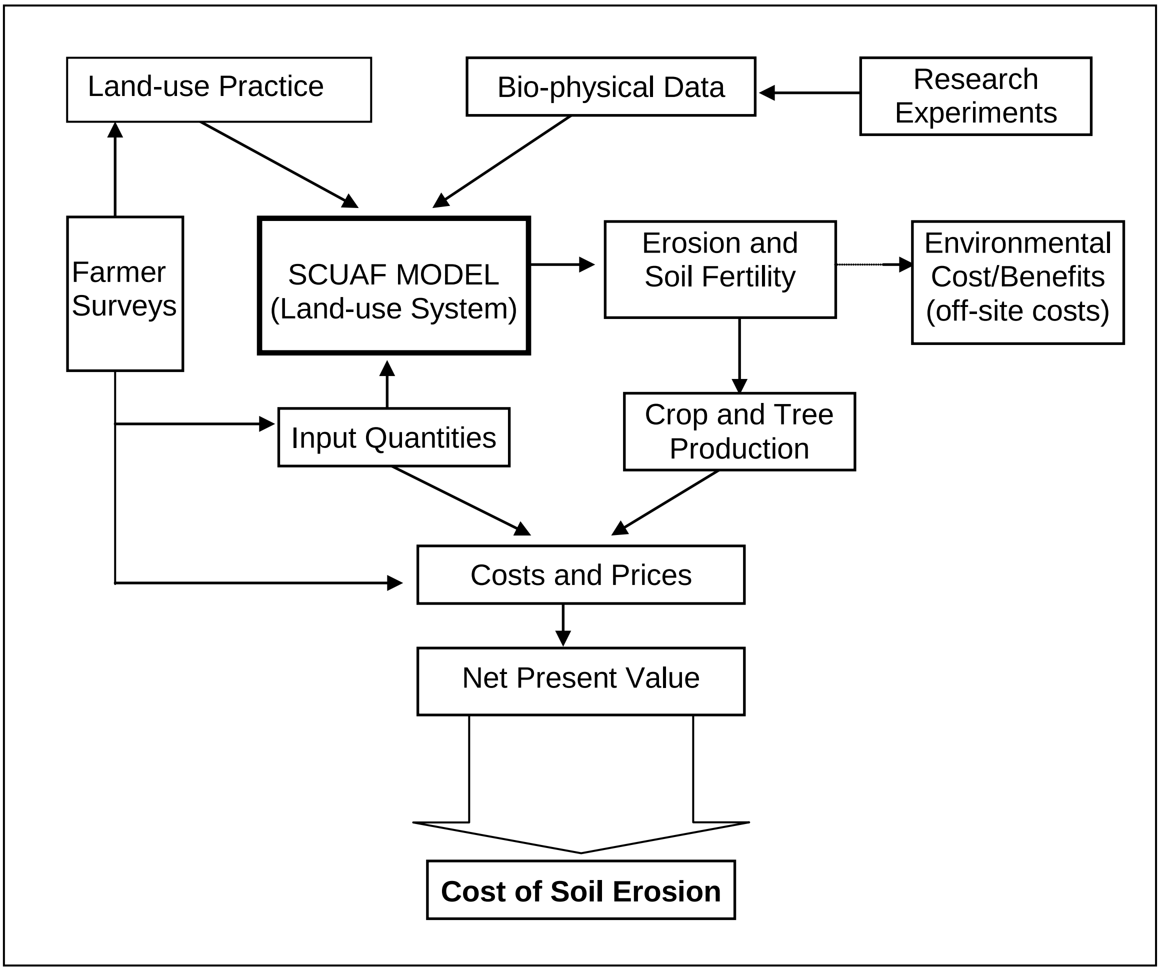


Figure 1. Bio-economic framework for the study

In financial analysis, market prices are used to estimate input costs and benefits. Private benefits will be calculated by multiplying the farm gate price by marketable outputs of the systems resulting from a SCUAF simulation.

In economic analysis, all costs and benefits, both internal and external, are taken into account. Shadow prices or efficiency prices are used to estimate the values of all inputs and outputs. Economic analysis then states the cost and benefit to society in opportunity cost or in values determined by the willingness to pay (Gittinger 1982).

Externalities of different land use systems are mainly due to soil erosion[3] and the use of chemicals. There are many possible downstream or off-site impacts of soil erosion that result from runoff. These impacts include: reservoir sedimentation; loss to navigation and irregular flow of irrigation (both due to sedimentation) as well as adverse effects on agricultural, fishing and industrial production in lowlands and coastal regions; water quality; droughts and flood cycles (Barbier 1996). These impacts are location-specific and vary from place to place. In this study, given the limited availability of resources, no attempt was made to value these external impacts of soil erosion.

Following the approach by Barbier (1996), the opportunity cost per unit of soil loss was derived from the NPV and soil loss (due to erosion) estimates of alternative land use systems.

4.1.3 Research Objective 3

To achieve research objective number 3, a multinomial logit model was constructed and estimated. The multinomial logit model can be viewed as a special case of a general model of utility maximisation (Greene 1995).

For a given plot of land, an upland farmer is assumed to have preferences defined over a set of alternative land use systems (namely, sugarcane, upland rice-based, eucalyptus and fruit tree-based AF systems). A certain land use system will be chosen by the farmer, for a given plot only if the expected utility from the chosen land use option is greater than the utility obtainable from other available alternatives.

$$\text{Observed } Y = \text{choice } j \text{ if } U(\text{alternative } j) > U(\text{alternative } k) \quad \forall\, j \neq k. \tag{2}$$

The general form of the multinomial logit model is:

$$\Pr ob[choicej] = \frac{e^{\beta_j' x_{jt}}}{\sum_j e^{\beta_j' x_{jt}}} \tag{3}$$

where t indexes the observation, or individual farmer, and
j indexes the choices.

[3] A comprehensive discussion on the economics of soil erosion can be found in Francisco (1998).

The dependent variable is y, coded 0, 1, ..., j (alternative land use systems). The empirical logistic model to examine the choice of land use systems by upland farmers is:

$$\begin{aligned} CHOICE = {} & \beta 0 + \beta 1_1 FLABOUR + \beta_2 EDUC + \beta_3 AGE + \beta_4 NPLOT + \\ & \beta_5 FARM + \beta_6 PLOT + \beta_7 FAR + \beta_8 SLOPE + \beta_9 INCOME + \\ & \beta_{10} INCENT + \beta_{11} EXT + \beta_{12} CREDIT \end{aligned} \quad (4)$$

The explanatory variables of the multinomial logit model include three groups (Table 1). These are: (1) socio-economic attributes of the land user, (2) characteristics of the land plot and (3) policy-related variables.

Experienced and educated farmers often take into account the long-term effect of soil erosion in their land use planning. Educated farmers are likely to have the right understanding of the trade-off between current and future benefits and costs. It is reasonable to assume that a farmer's knowledge, which is determined by his education, experience and living conditions, is an important exploratory variable in the adoption process.

As observed in the commune of Xuanloc, there is a striking difference between the two groups of people, the Kinh and the Van Kieu. Differences in culture, tradition and economic status result in different land use choices. Most Van Kieu farmers use their land to grow food crops to cope with the problem of food shortage while the Kinh people are more commercially-minded.

Plot characteristics such as plot acreage, slope, soil fertility, and distance from farmer's house also affect a farmer's land use decision. In addition to other policy-related variables, credit is another important exploratory variable in land use decisions, especially when farmers are poor and unable to finance their economic activities. Without access to credit facilities, farmers may settle for an inferior land use system simply because it requires low capital.

The logit model was estimated using LIMDEP (LIMited DEPendent variables) version 7.0 (Greene 1995). LIMDEP is a flexible computer programme for estimating qualitative response models, limited dependent variable models, duration models, stochastic frontier models as well as panel data models with fixed or random effects. Using the likelihood ratio test and the analogous t-test for choice models[4], research hypothesis number 3 was tested and verified.

4.2 Data Collection

4.2.1 Study Site

Given the research objectives, the Xuanloc commune in the Phu Loc District was selected as the study site. Such a choice was made for several

[4] Discussion on statistical tests for the multinomial logit model can be found in Greene (1993).

reasons. First, the soil and land use systems found at the commune were typical of the uplands in the Central Coast. Second, the commune was inhabited by two typical groups of people, the Kinh (lowlanders) and the Van Kieu (ethnic minority group), who represented the upland population of the central region. Therefore, findings of this research can be generalised to most upland areas of the Central Coast. Third, the data needed for calibrating SCUAF to the site was already available to some extent.

Table 1. Definition of Variables[5] Used in the Multinomial Logit Models

Variable	*Description*
CHOICE	0 if eucalyptus system is chosen; 1 if sugarcane is chosen;
	2 if AF is chosen; and 3 if upland rice is chosen
LABOUR	Availability of family labour (no. of workers)
EDUC	Education of farmer respondent: 1 if higher than secondary school level, 0 if secondary school level or lower
AGE	Age of the farmer respondent (years)
NPLOT	Number of plots
FARM	Total landholdings (ha)
PLOT	Plot area (ha)
FAR	Distance from the plot to farmer’s house (km)
SLOPE	Average slope of the plot (degree)
INCOME	Annual household income (million VND)
INCENTIVE	1 if farmer received incentive for choosing the land use system, 0 for otherwise
EXT	1 if the farmer received extension services, 0 for otherwise
CREDIT	Amount of production credit (million VND)

4.2.2 Secondary Data

Secondary data necessary for the study was obtained from different relevant sources. The Department of Agriculture and Rural Development and the Statistical Bureau of Thua Thien Hue Province were the two main sources of secondary data. Moreover, visits to other statistical offices, agricultural offices, and district extension centres were made to collect more detailed data required by the study.

[5] Land capability class was excluded because it was strongly correlated to the SLOPE variable.

Complementary data was generated from relevant studies, especially from a research project on community-based uplands resource management conducted by the College of Agriculture and Forestry, Hue University.

4.2.3 Primary Data

The nature of the study required detailed primary data and information on land use practices and farmers. The disproportionate, stratified and purposive sampling design was used to select a sample of 260 farmers for interviews. The distribution of the sample is shown in Table 2.

Questionnaires, which focused on land use practices, inputs and outputs of the land use systems as well as the socio-economic and institutional characteristics of the farmers, were used in the interviews. The respondents were the current farm operators; the heads of the farm households who made land use decisions.

Table 2. The Distribution of the Sample According to Land Use System and Ethnic Group

	Total (Farmers)	*Kinh*	*Van Kieu*
Whole sample	260	136	124
Upland rice-based system	45	0	45
Sugarcane system	72	45	27
Fruit tree-based AF	70	48	22
Eucalyptus-based system	73	43	30

Biological data on crops and trees as well as data on soil properties was obtained through the review of recent literature and the conduct of relevant laboratory experiments and on-site trials. Data on temperature, rainfall and air humidity were obtained from the Meteorological and Hydrological Station of Thua Thien Hue Province.

5.0 CHARACTERISTICS OF THE STUDY SITE

5.1 Location

Xuanloc is a relatively large hilly commune within a larger upland/hilly area of the Thua Thien Hue Province. The commune is surrounded by mountains, which form the watershed of the Huong and Nong Rivers. The commune is located between the low coastal area and the Truong Son mountain range. The area is representative of the hilly land of the Thua Thien Hue Province as well as the central region where erosion and land degradation is a serious environmental, ecological and economic concern (CBRM 1997).

Located in such a transitional zone, Xuanloc has a complex, diverse and undulating topography. Its elevation ranges from 80 to 120 m above sea level and the slope from 3 to 38 degrees. The elevation increases from south-west to north-east. Small, relatively flat plots are found along creeks.

Although Xuanloc is a hilly commune, it is relatively accessible. The provincial road, number 14, goes through the commune in an east-west direction. That is the only road that allows Xuanloc inhabitants access to other lowland and upland communes. Villages of the commune are connected by trails.

5.2 Biophysical Conditions

5.2.1 Climate

There are two distinct seasons in Xuanloc. The dry season, which comes with the hot south-west wind, lasts for four months, from April through to August. During the dry season, the air temperature sometimes reaches 41^0C in the months of July and August. Droughts and forest fires threaten the people and the environment during this season.

The rainy season with high and unevenly distributed rainfall is from September to March. The annual rainfall ranges from 2,000–7,500 mm, with an average of 3,000–3,300 mm. About 80% of the total rainfall falls during this rainy season, the wettest months being November and December. Storms, floods, soil erosion and landslides are threats to the natural environment during this season.

On the average, there are about 180 sunny days a year with an average temperature of about 28^0C during the hottest periods and 19^0C during the coldest months. Compared with other regions of Vietnam, Xuanloc in particular and the Central Coast in general, have inclement climatic conditions.

Table 3. Distribution of Rainfall, Temperature and Humidity *

Month	*Rainfall (mm)*	*Temperature (^0C)*	*Humidity (%)*
January	165.2	18.3	89.7
February	80.8	18.7	89.3
March	52.0	21.7	85.0
April	146.5	23.2	82.3
May	221.2	24.2	82.3
June	157.2	25.8	79.0
July	125.6	25.6	80.7
August	134.3	24.9	81.0
September	564.4	23.2	89.3
October	570.7	22.1	90.0
November	1,340.0	20.3	91.7
December	587.1	17.6	93.0
Total/Average	**4,145.5**	**22.1**	**86.1**

Source: Thua Thien Hue Statistical Yearbook, 1999

* Average of three years, 1997–1999

5.2.2 Land and Water Resources

Xuanloc has a total land area of about 4,500 ha. Agricultural land accounts for only about 10% of the total area. More than 70% of the land is natural/planted forest. There is an open area of about 750 ha of sloping grassland and a denuded area that can be used for agricultural production. Yellow feralit soil, developed from acid magma (granite and liparite), and alluvial soil, are the two main soil types found at Xuanloc (Table 4). The feralit soil is sandy loam, which is infertile with poor water-holding capacity. Most soils found in Xuanloc are acidic, with pH ranging from 4.5 to 5.5. Based on experience, Xuanloc farmers have classified their soils into three categories: sandy soil, silty soil and granite soil. Granite soil with a shallow cultivable layer and poor water-holding capacity, dominates the hilly areas, which are usually devoid of good vegetative cover. Granite soil in Xuanloc is sandy loam and is typical of the soil of most mountainous areas of the Central Coast. In addition, red basaltic soil is also found within a village of the commune where the Van Kieu people reside. This basaltic soil is rich in nutrients. It has good cultivable depth but low water-holding capacity.

Xuanloc is a rain-fed area; hence the people have no control over water availability for agricultural production. The commune has two main springs with several small tributaries. Due to the poor vegetative cover and the uneven rainfall distribution of the area, the water flow from these springs fluctuates dramatically. During the rainy season, the water flow increases significantly causing severe soil erosion. In contrast, during the dry season, the springs sometimes run dry. The commune often suffers from water shortage during the dry season. Xuanloc farmers have constructed some irrigation structures such as overflow dams and gravity canals for their lowland rice. However, these rain fed-irrigation systems are far from satisfactory.

Table 4. Some Selected Properties of Soils at the Study Site

Soil types	*% of total areas*	*Plough depth (cm)*	*Soil characteristics*
1. Yellow feralit soil	70	30-50	Acidic, medium texture, sandy, stony
2. Alluvial soil	20	50-70	Light, sandy, acidic
3. Other soils	10	20-50	Stony/sandy, acidic

Source: Field survey and lab analysis (2000)

Rainwater is the most important water source for upland crops such as upland rice, cassava, tobacco and fruit trees such as lemon and orange. Crop yields depend greatly on the amount and timing of rain. Under the climatic conditions of the area, the farmers have learnt through trial and error, which crops and trees are suitable to grow at different times – they have developed a crop calendar so as to make good use of the rainwater. However, socio-economic constraints as well as unpredictable climatic conditions prevent the farmers from making sustainable use of natural resources.

5.2.3 Flora and Fauna

Due to illegal logging, hunting, fire and the conversion of forests to agricultural lands, natural forests at Xuanloc have decreased in both quantity and quality. In 1996, about 45% of Xuanloc was covered with natural forest. This was reduced to only 39% in 1999. Within three years, from 1996 to 1999, about 200 ha of natural forests disappeared. This figure would be higher if forest clearance statistics had been fully accounted for to include the “hidden” clearance of forests for tobacco planting. The slash and burn activities take place in the period from October to January. Tobacco is grown in February and harvested from April to June. Tobacco is planted only once in newly opened areas – it is reported that the yield of tobacco decreases dramatically if grown for the second time in the same plot (due to disease and poor soil).

Natural forests at Xuanloc are rich in plant and animal species. The most common plant species are those belonging to the following families: *Thysanolaena, Saccharum, Imperata, Eupatorim, Brucea, Melastoma, Mallotus, Macaranga, Mimosa, Rubus and Centella.* Xuanloc farmers commonly plant about 24 main plant species, including food crops and fruit trees. A number of rare animal species such as *Susscrofa* (yellow monkey), *Paradoxutu* (weasel), *Ratuza bicolor* (flying squirrel) are found in the natural forest of Xuanloc. The biodiversity at Xuanloc is, however, decreasing due to forest clearance and hunting (CBRM 1997).

Compared with natural forests, planted forests at Xuanloc have a much lower level of diversity of animals and plants. Eucalyptus and acacia (*Acacia auriculiformis*) are the two main tree species for reforestation. About 70% of planted forest area is eucalyptus and the rest is acacia and pine (*Pinus merkusii*). Most forest plantations/plots were established in 1991 and 1992 as the result of the Government's policy to assign land ownership to individual households for long-term use, as well as the intervention of the United Nation's Food Programme (PAM) and the Vietnamese Government's Reforestation Project (PR-327).

To the south of the Xuanloc watershed is the Bach Ma National Park. To protect this valuable park, its surroundings (including the Xuanloc watershed) have been considered as buffer zone around the park. Any environmentally destructive activities in the buffer zone would threaten the conservation of the national park.

5.3 Socio-economic Characteristics

The commune at Xuanloc is inhabited by two distinct groups of people: (1) the Kinh (lowlanders) and (2) the Van Kieu (ethnic minority group). At present, there are 412 farming families with a total population of 2,218 people. About one-third of the population is Van Kieu. This racial mix results in a variety of land use practices.

During the period from 1975 to 1980, due to the Government‘s population distribution policy, people from the coastal villages of Loc An, Vinh Hung, Vinh My and Loc Son in the Phu Loc District migrated to settle in Xuanloc. Despite support from the Government, they encountered many difficulties in the beginning, such as poor infrastructure and lack of experience in upland farming. They had to adapt to the new environment, which was very different from the one they used to live in.

The first group of Van Kieu people from the Mo O commune in the Ba Long area of Quang Tri Province came to settle in Xuanloc in 1983. Like other ethnic minorities, they practised shifting cultivation and forest exploitation for their livelihood. For generations, they had practised slash and burn farming, growing rice, maize, cassava and other food crops. Most of them were illiterate.

Traditions and norms governed their way of life. As development and social progress took place, they gradually integrated into the general Vietnamese community.

The spirit of equality among Van Kieu is very highly regarded. This is why the gap between the people in terms of well-being is very narrow. Van Kieu people are united, closely-knit, and governed by an informal institution that exists alongside the formal administration of the commune. This self-governing institution includes a community head *(Xuat vil)* in charge of military/defence and security, one head of land management (*Xuat cu te)* and one head of lineage affairs (*Xuat mu)*. The Head of the community is the most important and powerful person. His ideas and decisions are respected absolutely by all the people in the community and his leadership is exercised through traditional and informal regulations that have been in force for generations (CBRM 1997).

Most Xuanloc people, both Kinh and Van Kieu, engage in agricultural production and forest exploitation (hunting, logging, fire wood collection) as their main sources of livelihood. Common crops grown in the commune include rice, cassava and tobacco. Recently, a number of Kinh and Van Kieu people have started to grow fruit trees and cash crops.

The Van Kieu people suffer from food shortage for three to five months annually. This may last up to seven or eight months if the year experiences crop failure. In the absence of other alternative income sources, the people resort to exploiting forest products such as firewood, timber, and rattan and sell these for food. They also work as labourers at low wages of about VND 20,000 (USD 1.4)[6] per day.

Non-farm activities do not play an important role in Xuanloc. Carpentry and other trades absorb only a few workers. Therefore, the opportunity to improve the livelihoods of the people depends very much on how they manage and use their land resources.

6.0 CHARACTERISTICS OF RESPONDENT FARMERS AND THEIR LAND USE SYSTEMS

6.1 Policies, Programmes and Institutions Related to Land Use

Land use is governed by a number of policies and institutions. There have been programmes to promote land use systems under agriculture (such as sugarcane) and under forestry (such as eucalyptus). Little attention has been given to AF. This results in a bias in extension provision towards other land uses over AF.

[6] 14,500 Vietnamese dong (VND) = 1 United States dollar (USD)

6.1.1 New Economic Zone Policy

The establishment of the Xuanloc commune came about with the introduction of government population redistribution policy. This policy was implemented in the North in 1960 and in the South in 1975 when the country was just united and poverty was a nationwide problem especially in densely populated areas. The aim of the policy was to establish new economic zones and to get people from the densely populated lowland areas to settle in the uplands.

In 1975, with the support of local government authorities, people from the coastal villages of the Phu Loc District came to settle at Xuanloc. They were the first group. To survive in the new environment, they cleared the forest and grew upland crops in the hills and wet rice in the small valleys and alluvial areas alongside springs. Due to the absence of a master plan for proper use of the abundant land, the new settlers used the land at their disposal for short-term benefits. Without experience in sloping upland farming, they used the land in a very destructive manner (CBRM 1997).

6.1.2 Sedentary Farming and Settlement (SFS) Programme

In Vietnam, most ethnic minorities live in uplands, practising slash and burn cultivation, which is one of the main causes of forest loss and land degradation. Furthermore, it also makes people management by the Government difficult. Therefore, the Sedentary Farming and Settlement (SFS) Programme was formulated to get the ethnic minority people to settle permanently and to practise sedentary farming. The programme aimed to move ethnic people living deep in the forests and mountains to suitable areas identified by the Government. Support from the SFS programme included infrastructure, extension services, health services and basic necessities to support the ethnic settlers and enable them to eventually earn their own living through sedentary farming.

The SFS programme was implemented in North Vietnam in 1954 and in South Vietnam in 1975. The settlement of the Van Kieu in Xuanloc began in 1983. Due to resource and other constraints, the results of the programme have been far below expectations. At present, the Van Kieu people in Xuanloc have very low living standards and continue to practise slash and burn cultivation as they have always done. To produce enough food from limited lands, they have to shorten the fallow period – this is unsustainable use of the land.

6.1.3 Land Ownership

In principle, all lands and natural resources in Vietnam are state property. State ownership is comprehensive ownership which determines/governs other forms of ownership. The state awards rights to organisations or individuals to use and enjoy the benefits accrued from lands. In Xuanloc, there are three forms of land ownership.

- *State ownership:* This ownership form applies mainly to forests that need to be conserved because of their strategic importance to the ecology and environment of the region as a whole. Respective communes manage the forests but state authorities make major decisions concerning the management of the forests.

- *Group ownership:* This occurs where the right to manage a particular land area is given to a group of people who belong to the same village or production group[7]. The land becomes the exclusive common property of that group. Before 1986, most land in communes was under this sort of ownership. Today, however, the land area under group ownership has decreased as more land is now assigned to individual households for long-term use.

  The Van Kieu have a complicated land ownership system. Each Van Kieu village has its own land boundary, which is informally recognised by the people in the commune. All the people living in the village have the right to cultivate and graze animals on village land. Outsiders have to ask for permission from the *Xuat cu te* if they want to farm the land and normally have to pay a fee for such permission.

- *Individual ownership:* This is where the right of land use is given to individuals/households. Land under this kind of ownership includes residential areas, home gardens, and agricultural and forest lands assigned to individual households. Land developed through the initiative of a private individual is also informally recognised as land owned by that individual. Normally, individuals make use of land at their disposal. However, they have to pay annual land tax that is determined according to land classification. Van Kieu people are however, exempted from this tax due to their very low living standards.

6.1.4 PAM Programme and PR-327 Project

The PAM and PR-327 have a bearing on the current land use scenario in Xuanloc. Through the PAM programme, capital and other material incentives were given to Xuanloc villagers to enable them to establish forest plantations. The more trees they grew, the more incentives they got. So, to gain more from the programme, villagers grew forest trees in gently sloping areas that should have been used for crop production. This is why in Xuanloc, land use appears somewhat irregular; forest trees are grown on low slope plots and crops are grown on steep slope plots.

[7] Before 1986, farm households of agricultural cooperatives were organized in production groups. Each cooperative would have a number of production groups. Cooperatives have now been reorganized to use the contract system without production groups.

PR-327 is a government-sponsored project closely attached to the policy of giving people stewardship rights to forest and forestland. Capital incentives were given to the people of Xuanloc to plant forests on bare hills and to protect and manage natural forests. The income obtained from the forests would be shared out among the community according to pre-agreed proportions.

6.1.5 Sugarcane Promotion Programme

With the approval from the Ministry of Planning and Investment, Kecepe Vietnam Industry Limited - KCPVIL (a 100% foreign investment project funded by Kecepe Pte Ltd, Singapore) established a sugar mill to process 2,500 tonnes of cane per day in the Phong Dien District of Thua Thien Hue Province in 1998. To meet the capacity of the mill, a promotion programme was implemented to encourage farmers in both the uplands and lowlands to grow sugarcane.

Motivated by the programme, upland farmers in Thua Thien Hue (including in Xuanloc), cleared their forest plantations and claimed open areas to grow sugarcane. The new land use option was at the time considered as an antidote for poverty in the rural areas, especially the upland regions. By the end of 1999, it was estimated that the sugarcane area of Thua Thien Hue covered 5,085 ha of which about 3,500 ha was planted on sloping uplands. For Xuanloc, sugarcane covered about 150 ha.

6.1.6 Informal Local Institutions

As mentioned earlier, the Van Kieu people have an informal institutional framework that has a direct bearing on the management of their natural resources including land. For instance, they are not supposed to exploit for any reason whatsoever, the “ghost forests” where their ancestors are buried. Therefore, these “ghost forests” are well protected. No one dares to clear these forests for other land use options (CBRM 1997).

The people are also prohibited from exploiting and practising slash and burn cultivation in primary forests. Those who violate this informal rule are considered guilty of disturbing their god and will be punished.

6.2 Typical Land Use Systems

6.2.1 Upland Rice-based System

In Xuanloc, only Van Kieu farmers grow upland rice. It is their staple food crop, grown in April and harvested in October. Slash and burn cultivation techniques are practised with this crop. Land plots, relatively fertile with slopes of less than 30 degrees, are selected. Clearing of the plots is normally done in February. Clearing starts from the bottom of the slope and moves upwards.

Vines, bushes and small trees are cleared first; big trees are cut later on. Labour exchange is a common practice in land clearing.

Burning is done in March. To prevent unintended fires, farmers do burning in the daytime when there are no strong winds. About one week after the first burning, the second burning may be done if necessary to ensure that all cut plants are burnt. During this period, due to the absence of vegetative cover, the plots will be exposed to severe erosion if there is heavy rain.

Planting of upland rice starts in late March and lasts until the end of April. Men and women do planting jointly. The men walk ahead, making holes about 20 cm apart in the soil with a pointed stick. The women follow behind, placing rice seeds in the holes and then covering the holes with soil using their feet. Holes in rows are usually made across the slope to reduce soil erosion. Some farmers plant banana or sugarcane on plot boundaries to prevent soil erosion.

Neither chemical fertilisers nor manure is applied to the crops. The feedback was that Van Kieu people could not afford to buy chemical fertilisers and that they considered manure too dirty to apply to the crops. The lack of fertilisers makes the soil degrade rapidly and consequently, the rice yield decreases dramatically.

Women and children often do weeding two months after planting. Van Kieu farmers have no idea about pest and disease management. However, they keep an eye on wild animals, particularly wild pigs, which can destroy the crops. If the rice plots are far from their houses, the farmers make temporary guard tents near the plots to watch over their crops.

Harvesting is done in October before the start of the heavy rains. The farmers put the rice into locally-made back-carried rattan containers. Rice straw is left at the fields as mulching material. To have good seeds for the next planting season, rice panicles with many big grains are selected. Van Kieu farmers prefer growing their local rice varieties which are drought-tolerant and pest resistant but which give low yields.

Rice is grown on the plots in the first two/three years after the slash and burn exercise while the soil is still fertile. After two seasons, the soil gets eroded and degraded and is no longer suitable for rice. Cassava is the successor crop for the plot. The soil then becomes exhausted after two seasons of cassava. A fallow period of four years then follows. After the fallow period, the plot is full of *Thysanolaena maxima*, *Imperata* and shrubs. The plot then will be cleared for another four-year period of rice and cassava production. A crop-fallow cycle is about eight years. In some cases, after five or six crop-fallow cycles, stones and rocks emerge and the plot has to be abandoned.

Cassava is the second most important food crop to the Van Kieu. It is planted in February and harvested in November and December. Similar to rice cultivation, neither chemical fertiliser nor manure is applied to cassava. Cassava farming is erosive; cassava roots have sometimes emerged after heavy rains indicating soil erosion.

6.2.2 Upland Sugarcane System

As mentioned earlier, sugarcane was introduced to Xuanloc in 1998. As recommended by the sugarcane promotion programme, fertile areas with slopes less than 25 degrees were chosen to grow sugarcane. The promising results of the sugarcane trials in the sloping uplands by the provincial Department of Agriculture and Forestry encouraged upland farmers including both the Van Kieu and Kinh at Xuanloc to clear their forest plantations to grow sugarcane.

With the assistance of extension agents and approval from local authorities, upland farmers identify areas/plots for sugarcane growing. Then a formal contract between KCPVIL and the individual farmer is signed, witnessed by the local authorities. With a signed contract, a farmer can obtain credit from specified banks.

In Thua Thien Hue, sugarcane can be planted in the winter-spring season (December to March) or in autumn (August and September). Land preparation is hard work and so is done by machines. Farmers have to pay for land preparation services. Row cropping techniques are applied. Rows are 80 to 90 cm apart across the slope of the hill to reduce soil erosion. Manure is applied once when the sugarcane stocks are planted. As recommended, nitrogen and potassium fertilisers are applied to the crops four times, once every month during the first four months after planting. Because of the acidic nature of the soil in the uplands, lime application is also recommended.

Three weeks after planting, the sugarcane shoots emerge and if the density is less than 3 shoots per m^2, then additional planting is required. Weeding and mounting for sugarcane is done twice, after the first and second month of planting. Old leaves are pruned and used for mulching the plot.

Harvesting is done 11 to 12 months after planting. All sugarcane leaves are normally left in the field and burnt later to add nutrients to the soil and to kill the insects. The sugarcane stumps left under the soil after harvesting are planting materials for the next cropping season. This method is only applicable twice. The cultivation of the sugarcane regenerating from the stumps is the same as described above.

6.2.3 Fruit Tree-Based Agroforestry System (Fruit Tree AF)

An agroforestry system refers, as mentioned earlier, to a land use system in which trees or shrubs are grown in association with herbaceous plants (crops or pasture) in a spatial arrangement or time sequence, and in which there are both economic and ecological interactions between the tree and non-tree components of the system (Young 1989).

In Xuanloc, there are a number of AF systems with different crop and tree compositions. It was found from a field survey that AF systems at Xuanloc are generally fruit-tree based in nature. The typical system described below is generalised from the various systems adopted by Xuanloc farmers. Xuanloc farmers have been conducting trials to identify the best AF system suitable to their environment.

The typical AF system found at Xuanloc is fruit-tree based. Lemon and banana are typically planted in association. When the system is well established, 70% of the land is under lemon trees, 20% under banana trees and the remaining 10% is under crops such as sweet potato and vegetables. In addition, a few forest trees may be planted along the edges of the plot.

In Xuanloc, the fruit tree AF system is adopted in home gardens. The advantage is that these are near to the farmers' residence enabling close management of the gardens. Furthermore, labour costs can be reduced using sub-labour such as old people and children. However, the management of the AF system is more complex as compared with other land use systems. This is due to the complex biological and economic interactions among the tree and crop components of the system.

Weeding, fertilisation and mulching are carried out regularly in AF systems. During the dry season, farmers use leaves collected from the forest to mulch their AF plots. This cover helps to maintain humidity, suppress weeds and reduce the erosive force of raindrops. Furthermore, the mulching materials supply nutrients to the soil as the decomposing process takes place.

6.2.4 Eucalyptus-based System

Eucalyptus and acacia are the most common forest trees planted in Xuanloc. At present, the planted forest of Xuanloc is estimated at 1,238 ha. Most forest plantations at Xuanloc were established in the 1990's. With PAM and PR-237 support, farmers claimed open areas covered with shrubs and grass to grow eucalyptus and acacia. The density of planted forest ranges from 1,500–2,000 trees per hectare.

Taking advantage of the PAM and PR-327, lowlanders, especially the local officials in the commune, claimed large areas with gentle slopes to establish forest plantations. The poor had to grow forests in areas with moderate and steep slopes as recommended. Aside from seedlings, other material inputs for tree planting were limited to chemical fertilisers that were applied in the first year. On the average, for one hectare of forest plantation, only 85 kg of nitrogen fertiliser, 70 kg of phosphorus fertiliser and 70 kg of potassium fertiliser were applied.

The management of planted forest was not given much attention. For one hectare of planted forest, about three to four labour-days were spent every year for pruning and suppressing the invasion of shrubs and grass while the trees were still small. The harvest of the planted forests is done when the trees are at least nine years old. Clear cutting is normally adopted. Farmers get income from planted forests (selling timber and firewood) only in the cut year.

6.3 Respondent Farmers and Their Land Use

6.3.1 Demographic Characteristics of Respondent Farmers

Table 5 presents the selected demographic characteristics of respondent farmers. For the whole sample, the family size ranged from 3 to 12 people with an average of 6.1 and the household's equivalent labour headcount was 3.72. The family with the largest size of 12 people was found in the Van Kieu community. Across groups of respondent farmers, the average family size was not much different.

The mean age of respondent farmers was about 45 years, which means that most of them were born in the 1950s. This is one of the explanations for their low education attainment; elementary Grade Five. When they were of schooling age, the country was at war and the opportunity to attend school at the time was practically non-existent, especially for rural people. Most of them attained education through the illiteracy eradication programmes offered mainly to illiterate adults by the Government after the liberation in 1975. Many farmers reported that they had finished the first three grades of elementary education a long time ago and had forgotten what they had learnt. They had now become illiterate. The poor education level of these upland farmers prevented them from taking advantage of new knowledge and technologies.

Xuanloc is a newly established commune with a 24-year history. Most of the Kinh people settled at Xuanloc in the period from 1976 to 1980. The Van Kieu came later, in the 1983–1988 period. Although their stay at the commune has been shorter, it has been long enough for them to adapt to the environment.

The average number of wage labour days that a farmer household worked in the year 1999 was only about 20. This indicates the under-development of the labour market in the commune. During slack periods of agricultural production, most farmers collect firewood. As nearby forests have already been exhausted, they have to go farther. They leave their homes early in the morning and return home late in the afternoon. The next day they sell the collected firewood at the local market. This is why the opportunity cost of labour is very low; about VND 12,000–20 ,000 (USD 0.8–1.4) per day.

Table 5. Selected Socio-economic Characteristics of Respondent Farmers

	Whole sample (n=260)	*Upland rice (n=45)*	*Sugarcane (n=72)*	*Fruit tree AF (n=70)*	*Eucalyptus (n=73)*
Mean household size	6.1 (2.08)	5.98 (2.07)	6.42 (2.08)	5.57 (2.18)	6.37 (1.93)
Mean family labour	3.72 (1.51)	3.58 (1.44)	3.96 (1.67)	3.11 (1.03)	4.15 (1.60)
Mean schooling years	4.66 (2.33)	3.02 (2.18)	5.17 (2.43)	5.29 (1.71)	4.58 (2.39)
Mean age	44.91 (10.68)	42.64 (11.48)	45.4 (10.62)	40.96 (8.15)	49.62 (10.65)
Mean length of stay (year)	18.63 (5.04)	14.33 (2.35)	19.32 (4.82)	20.1 (4.65)	19.18 (5.49)
Wage labour days (man-days)	19.9 (30.98)	19.67 (19.18)	27.04 (44.61)	15.14 (13.80)	17.56 (31.70)

Source: Field survey, 2000

Note: Standard deviation in parentheses

6.3.2 Income

Household income was defined in the survey as the sum of cash income from livestock, timber, fruit and forest products sales and non-farm activities, and the value of crop production. It was found that the annual income level of respondent households was very low, about VND 7,300 thousand (USD 500) and varied across groups of respondents (Table 6). A high proportion of about 67% of the income generated was from crop production. Income from animal production and forestry accounted for a small proportion. This is because at present, few farmers have yet harvested their forest plantations. Income from forestry is expected to increase in the near future. Upland rice respondents had the lowest income levels. All of them were Van Kieu. Meanwhile, AF respondents had the highest annual incomes. The majority of AF respondents were Kinh people who were more business-minded and lived in more advantageous locations compared with the Van Kieu.

On a per capita basis, the average annual income of the Van Kieu group was estimated at VND 450,000 (USD 31). With such a low income level, they live in abject poverty, suffering from severe food deficiency for three to eight months every year. Their standards of living are well below subsistence level. This implies a high discount rate for this group of people.

Table 6. Annual Income of Respondent Households

	Whole sample (n=260)	*Upland rice (n=45)*	*Sugarcane (n=72)*	*Fruit tree AF (n=70)*	*Eucalyptus (n=73)*
Total income ('000 VND)	7,295.37	2,704.16	6,561.56	11,036.84	7,261.62
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Income sources					
Crop production	4,871.93	1,566.60	4,528.58	8,765.91	3,514.16
	(66.78)	(57.93)	(69.02)	(79.42)	(48.39)
Animal production	916.58	443.78	454.17	528.57	2,036.16
	(12.56)	(16.41)	(6.92)	(4.79)	(28.04)
Forestry	322.46	24.89	90.83	708.14	364.52
	(4.42)	(.92)	(1.38)	(6.42)	(5.02)
Other sources	1,184.40	668.89	1,487.99	1,034.21	1,346.78
	(16.23)	(24.74)	(22.68)	(9.37)	(18.55)

Source: Field survey, 2000

Note: Percentage of total income in parentheses

A question often raised is why Xuanloc farmers did not take advantage of large grazing areas to increase their herds of herbivorous animals such as buffaloes, cattle, and goats. The farmers' response was that they did not have the money to buy calves or kids. Furthermore, there are so many risks associated with raising these animals, such as disease due to poor veterinary services and loss due to theft and death by lightning. The poor farmers do not invest in risky business even though the financial returns may be high.

For Van Kieu farmers, income from hunting and collection of forest products is of significant importance to their lives. This income helps them to cope with the problem of food shortage during the between-harvest periods.

6.3.3 Land Use

The socio-economic and topographical complexity of Xuanloc determines the land use patterns of farming households as presented in Table 7.

Although Xuanloc is an upland area with a low population density of about 50 people per km^2, the cultivated land area per household was found to be only 3.5 ha or 0.57 ha per capita. However, it should be noted that the actual landholding acreage may have been underestimated because a number of Kinh farmers at Xuanloc illegally grew tobacco in conserved forests and these tobacco parcels were neither reported nor statistically accounted for. On the average, each household had about four to five land parcels. For the Van Kieu group, landholdings and number of parcels per household were a little greater than the average for the whole sample as they practised slash and burn cultivation.

Of the whole sample, more than two-thirds of household landholdings were used for sugarcane and forest plantations. Land use under AF accounted for a small proportion of household landholdings. Land for both upland rice and wet rice was only about one-half hectare per household. This limited area coupled with the low rice yield resulted in food shortage for the commune.

Table 7. Land Use of Respondent Farming Households

	Whole sample (n=260)	*Upland rice (n=45)*	*Sugarcane (n=72)*	*Fruit tree AF (n=70)*	*Eucalyptus (n=73)*
Number of parcels	4.5 (1.42)	5.64 (1.46)	4.92 (1.53)	3.67 (0.96)	4.19 (1.01)
Total landholding (ha)	3.49 (2.25)	3.75 (2.27)	4.47 (2.43)	2.78 (1.84)	3.05 (2.06)
Upland rice (ha)	0.44 (0.72)	0.87 (0.58)	0.34 (0.52)	0.43 (1.06)	0.27 (0.43)
Wet rice (ha)	0.12 (0.21)	0.12 (0.12)	0.17 (0.27)	0.05 (0.09)	0.14 (0.24)
Sugarcane (ha)	0.85 (1.41)	0.44 (0.45)	1.31 (1.30)	0.99 (2.09)	0.53 (0.87)
Forest plantation (ha)	1.56 (1.74)	1.69 (1.99)	2.18 (2.07)	0.61 (0.79)	1.77 (1.52)
Agroforestry (ha)	0.22 (0.32)	0.16 (0.35)	0.15 (0.21)	0.48 (0.37)	0.09 (0.11)
Other plants (ha)	0.3 (0.38)	0.47 (0.43)	0.31 (0.40)	0.22 (0.32)	0.26 (0.36)

Source: Field survey, 2000

Note: Percentage of total in parentheses

6.3.4 Characteristics of Investigated Parcels

Table 8 presents selected characteristics of investigated parcels by land use system. Due to the undulating topography of the area, it is not feasible for farmers to claim and cultivate large parcels of land. The parcel size ranged from 150 m^2 to 5 ha with an average of just less than one hectare. Across land use systems, the average parcel size was significantly different at one percent level. Agroforestry parcels had the smallest average size of about 0.5 ha. Forestry parcels had the largest average size of about 1.5 ha, which is three times that of AF parcels.

Agroforestry parcels were close to farmer's house while other parcels were more than 1 km away (Table 8). This allowed for close monitoring and intensive care as required by the AF system.

There was a small market at the commune. All parcels were actually not very far from the market. However, the poor infrastructure and complicated topography made it difficult for the farmers to get to the market especially when carrying a heavy container on their backs. The road from the Van Kieu village to the commune centre was in bad condition, broken by small creeks. This is why Van Kieu farmers had to sell their cassava at a much lower price than the commune market price.

Table 8. Selected Characteristics of Investigated Parcels

	Whole sample (n=260)	*Upland rice (n=45)*	*Sugarcane (n=72)*	*Fruit tree AF (n=70)*	*Eucalyptus (n=73)*
Parcel size (ha)	0.97	0.68 [bcd]	1.01[acd]	0.49 [abd]	1.58 [abc]
	(0.94)	(0.37)	(0.70)	(0.36)	(1.35)
Parcel to home (km)	0.91	1.19[c]	1.07[c]	0.23[abd]	1.25[c]
	(1.18)	(1.20)	(1.21)	(.26)	(1.40)
Parcel to market (km)	2.81	3.88 [bcd]	2.38[a]	2.72[a]	2.67[a]
	(2.55)	(1.88)	(1.87)	(3.54)	(2.21)
Slope (degree)	16.98	20.38 [bc]	14.17[abc]	10.24 [abc]	24.14 [bc]
	(10.08)	(9.25)	(8.05)	(9.42)	(7.26)

Source: Field survey, 2000

Notes: Standard deviation in parentheses
[a] significantly different at 1% level from the respective mean of upland rice parcels
[b] significantly different at 1% level from the respective mean of sugarcane parcels
[c] significantly different at 1% level from the respective mean of AF parcels
[d] significantly different at 1% level from the respective mean of eucalyptus parcels

The average slope of the sugarcane and AF parcels was significantly different from other parcels. The slope range for all parcel groups was between 3–35 degrees. One of the rules for growing sugarcane put forth by the local authorities was that the parcel must have slopes of less than 25 degrees. However, sometimes such rule was not strictly followed.

6.3.5 Erosion Control

To gain an insight into land use practices, respondents were asked whether they currently adopted any erosion control measures on the parcels of interest. The percentage share of parcels with erosion control was about 56% for the whole sample and varied across land use systems (Table 9). For upland rice, parcels with erosion control accounted for only 20% of the group's total. The percentage was slightly higher for forestry and sugarcane systems. It was found out that erosion control was adopted on all AF parcels.

Table 9. Adoption of Erosion Control on Investigated Parcels

	FREQUENCY				
	Whole sample	*Upland rice*	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
Total no. of parcels investigated	260 (100.00)	45 (100.00)	72 (100.00)	70 (100.00)	73 (100.00)
Without erosion control	115 (44.23)	36 (80.00)	30 (41.67)	0 (0.00)	49 (67.12)
With erosion control	145 (55.77)	9 (20.00)	42 (58.33)	70 (100.00)	24 (32.88)
1. Contour farming	47 (32.41)	0 (0.00)	28 (66.67)	12 (17.14)	7 (29.17)
2. Hedgerows	28 (19.31)	0 (.00)	8 (19.05)	18 (25.71)	2 (8.33)
3. Stone wall	13 (8.97)	6 (66.67)	4 (9.52)	0 (0.00)	3 (12.50)
4. Mulching	75 (51.72)	3 (33.33)	18 (42.86)	42 (60.00)	12 (50.00)

Source: Field survey, 2000

Notes: Percentages in parentheses
More than one measure may be adopted in a parcel

Among the erosion control measures, contour farming and mulching were the most popular. However, the adoption of erosion control was likely to be related to, among other things, the land use system as well as the site characteristics. Mulching was found most commonly practised on AF and forestry parcels while for sugarcane parcels, the most popular measure was contour farming.

On sloping uplands, the adoption of soil erosion control is usually considered to be very important. However, one should note that the effectiveness of the erosion control measures varies. The succeeding discussion provides a brief description of the erosion control technologies adopted by farmers in Xuanloc.

Contour farming is the technique of growing crops or trees along the contour line. Contour beds or strips are made first and then plants are grown on them. In some cases, the contour bed is gradually formed as the care and management of the crops is carried out.

Hedgerows found at Xuanloc were mainly natural vegetation (grass and shrubs) growing on the boundaries of land parcels. Besides preventing soil erosion, hedgerows also protect the parcel from unwanted interference. Farmers did not expect any income from the hedgerows. It is likely that not enough attention has been paid to hedgerows.

Stonewall as observed at Xuanloc consisted of simple structures and is applied only to parcels that were severely affected by the surface flow of rainwater. Farmers made use of stones from their land parcels to establish structures to stem the erosive force of rainwater flowing down from the hilltops. Farmers built rock walls in critical places prone to severe erosion. The stonewall method was also applied at the lower boundary of a parcel to hold the soil there.

Two types of mulching strategies were observed at Xuanloc. The first one was of active nature. Farmers collected materials from elsewhere to mulch their land parcels. This was commonly done on AF parcels. The second strategy, commonly applied in the sugarcane system, was to use the by-products or residuals such as rice straw, and pruned leaves and branches of plants grown in the parcel, to mulch the plot.

6.3.6 Farmers' Reasons for Not Adopting Soil Erosion Control Measures

As seen from the previous section, parcels without erosion control accounted for about 44% of the whole sample and varied across the land use systems. Respondent-farmers were asked to provide the reasons for not adopting erosion control in these parcels. The interview results are presented in Table 10.

Among the reasons given, "Not necessary" (meaning to say that adoption was not necessary for the plot) was the most frequent response. The explanation given by Van Kieu upland rice farmers is: natural resources including land were still serving the needs of the people. With such a mentality, the use and management of natural resources by these farmers tends towards exploitative rather than conservative nature. Some farmers said that they had lived for years without erosion control and they could continue in the same way. However, as population increases and cultivable land and forest resources become scarcer, the awareness of the necessity to conserve natural resources will soon dawn on them. The explanation for the lack of soil erosion control on sugarcane and forestry plots was that these land use systems were not erosive.

Table 10. Farmers' Reasons for Not Adopting Erosion Control Measures

	FREQUENCY			
	Whole sample	*Upland rice*	*Sugarcane*	*Eucalyptus*
Parcels without erosion control	115 (100.00)	36 (100.00)	30 (100.00)	49 (100.00)
Reasons				
Not necessary	81 (70.43)	22 (61.11)	13 (43.33)	46 (93.88)
Lack of capital	11 (9.57)	0 (.00)	11 (36.67)	0 (0.00)
Lack of labour	2 (1.74)	2 (5.56)	0 (0.00)	0 (0.00)
Lack of knowledge	13 (11.30)	4 (11.11)	6 (20.00)	3 (6.12)
Not worthwhile	29 (25.22)	8 (22.22)	6 (20.00)	15 (30.61)

Source: Field survey, 2000

Notes: Percentages in parentheses
More than one cause may be given for a parcel
All AF parcels are with erosion control and are, therefore, excluded

Only two Van Kieu farmers reported the lack of labour as the reason why they did not adopt erosion control measures on their upland rice parcels. Capital shortage was not a reason for not adopting erosion control on upland rice and forestry parcels, while it mentioned in more that 35 % of sugarcane parcels. What this may imply is that erosion control for sugarcane fields is more capital demanding than for upland and forestry parcels.

For the whole sample, the non-adoption of soil erosion control on about 11% of the parcels was due to technical constraints termed as "lack of knowledge". A higher frequency of non-adoption of soil erosion due to this constraint was found for sugarcane parcels since sugarcane was a newly introduced crop.

"Not worthwhile" was reported as a reason for not adopting erosion control on about a quarter of the parcels. The frequency of this response varied slightly across land use systems. A number of respondent farmers reported that it would be better to do other jobs or even relax rather than work on erosion control.

From the above analysis, it is worth noting that the farmers' apathetic attitude towards natural resource management and the economic disincentive of applying available erosion control technologies were the main reasons for the non-adoption of soil erosion control in Xuanloc.

6.3.7 Farmers' Perception of Changes in Soil Fertility

Perceived changes in soil fertility over time may have affected a farmer's land use decision to incorporate erosion control measures into an existing system or to adopt a new land use system on the plots. Possible causes of changes in soil fertility include the application of fertiliser, insecticide and herbicide, erosion and climatic changes. In the sloping upland areas, erosion was often cited as one of the main causes for reduction in soil fertility. Respondent-farmers were asked to report their perception of changes in the soil fertility of their parcels. Interview results are presented in Table 11.

Table 11. Farmers' Perception of Changes in Soil Fertility

	FREQUENCY				
	Whole sample	*Upland rice*	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
No. of parcels investigated	260 (100.00)	45 (100.00)	72 (100.00)	70 (100.00)	73 (100.00)
Changes in soil fertility					
No change	44 (16.92)	2 (4.44)	12 (16.67)	19 (27.14)	11 (15.07)
Decreased	192 (73.85)	41 (91.11)	53 (73.61)	45 (64.29)	53 (72.60)
Increased	24 (9.23)	2 (4.44)	7 (9.72)	6 (8.57)	9 (12.33)

Source: Field survey, 2000

Note: Percentages in parentheses

The percentage of parcels without change in fertility was about 17% of the whole sample, and varied across land use systems. Agroforestry had the highest proportion of parcels without change in fertility. Only two out of 45 rice parcels were perceived to have had no fertility change. For all land use systems, a high percentage of parcels with decreased fertility were reported. Meanwhile, increased fertility was observed on only a few parcels. This implies that the land resource at Xuanloc was not managed in a sustainable way. Therefore, effective soil conservation policies are urgently needed.

6.3.8 Farmers' Perception of the Incidence of Soil Erosion

Table 12 presents the incidence of soil erosion as perceived by respondent- farmers on their parcels. The incidence of soil erosion was high on all parcels under different land use systems. About 90% of parcels under upland rice and sugarcane systems and more than 70% of parcels under AF and forestry systems were reported to have soil erosion. Almost three-fifths of upland rice parcels were perceived to be severely eroded, whereas only about one-fifth of sugarcane and forest parcels and about one-eighth of AF parcels were reported to suffer severe soil erosion.

The problem of soil erosion was a significant environmental problem based on perception of the farmers (Table 12). Among the four alternative land use systems, the upland rice-based system was perceived to be most erosive and AF, the least erosive.

Table 12. Farmers' Perception of Soil Erosion

	FREQUENCY				
	Whole sample	*Upland rice*	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
No. of parcels investigated	260	45	72	70	73
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Erosion extent					
No erosion	49	5	7	18	19
	(18.85)	(11.11)	(9.72)	(25.71)	(26.03)
Little erosion	148	14	52	43	39
	(56.92)	(31.11)	(72.22)	(61.43)	(53.42)
Severe erosion	63	26	13	9	15
	(24.23)	(57.78)	(18.06)	(12.86)	(20.55)

Source: Field survey, 2000

Note: Percentages in parentheses

6.3.9 Farmers' Perception of Productivity Changes

One criterion that needs to be considered when evaluating a land use system is the productivity trend of the system over time. The preferred state is that the system's productivity steadily increases or at least, remains stable. To have an indication of the sustainability of the land use systems, respondent farmers were asked to express their perception of the productivity trend of the land use system of their parcels. The interview results are given in Table 13.

Of the whole sample, about two-thirds of the parcels were reported with decreased productivity; about one-tenth, with lightly increasing productivity; and more than one-fifth, without any productivity change.

Across the land use systems, the upland rice-based system was reported to have the highest percentage (about 95%) of parcels with decreasing productivity. Decreased productivity was reported for 61% and 54% of sugarcane and AF systems respectively. The AF system had the highest percentage (about 45%) of parcels with stable productivity.

Table 13. Farmers' Perception of Productivity Changes

	FREQUENCY			
	*Whole sample**	*Upland rice*	*Sugarcane*	*Fruit tree AF*
No. of parcels investigated	187 (100.00)	45 (100.00)	72 (100.00)	70 (100.00)
Productivity changes				
No changes	41 (21.93)	0 (.00)	9 (12.50)	32 (45.71)
Lightly decreasing	64 (34.22)	8 (17.78)	28 (38.89)	28 (40.00)
Dramatically decreasing	61 (32.62)	35 (77.78)	16 (22.22)	10 (14.29)
Lightly increasing	21 (11.23)	2 (4.44)	19 (26.39)	0 (0.00)

Source: Field survey, 2000

Notes: Percentages in parentheses
* The eucalyptus system was excluded due to the irrelevance of the question with respect to it

About a quarter of sugarcane parcels were reported to have slightly increasing productivity. It should be noted that for sugarcane, the second harvest normally has a higher productivity than the first. Therefore, it would be erroneous to attribute the increased productivity totally due to improved soil fertility. A crop's biological features also play a role in shaping its productivity trend.

6.3.10 Comparative Perception of Farmers Regarding Land Use Systems

Farmers are rational decision-makers. Given their socio-economic constraints and the characteristics of the land as a resource, they choose among alternative land use systems, the one that brings them the greatest benefit. Therefore, they are deemed to be able to make comparisons between land use systems.

On this basis, respondent farmers were asked to make comparisons between different land use systems in terms of financial profitability, erodibility and risk. With regards to financial profitability, the question was phrased this way:

> "For a land parcel with moderate slopes and granite soil as commonly found at Xuanloc, which of the four alternative land use systems would

bring about the highest financial return and which one would bring about lowest financial return?”

Questions on erodibility and risk were similarly phrased. The interview results are presented in Table 14.

The fruit tree AF system was considered the most profitable by more than one-third of respondent farmers while one-third considered the forestry system most profitable. Upland rice and sugarcane systems were considered as the most profitable land use systems by only about 10% and 17% of the respondents, respectively.

Upland rice was reported to be the least profitable system by about two-fifths of the respondents. Only about one-tenth of respondent farmers considered the AF system to be the least profitable. The number of respondents considering sugarcane the most profitable system was almost the same as the number of respondents considering it least profitable. The forestry system was reported to be least profitable by about one-third of the respondents.

Upland rice and sugarcane systems were reported to be most erosive by about two-thirds and a quarter of respondent farmers respectively. The forestry system was perceived to be least erosive by the majority of respondents. Only one out of every fifty farmers considered upland rice to be the least erosive. It is controversial that the sugarcane system was ranked the second most erosive and also the second least erosive. A plausible explanation for this may be the limited number of years the farmers have been growing the crop.

Table 14. Farmers' Perceptions of Financial Profitability, Erodibility and Risk of Different Land Use Systems

	FREQUENCY			
	Upland rice	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
Financial profitability [a]				
Most profitable	25 (10.25)	42 (17.21)	90 (36.89)	87 (35.66)
Least profitable	96 (39.34)	44 (18.03)	23 (9.43)	81 (33.20)
Erodibility [b]				
Most erosive	167 (66.53)	62 (24.70)	17 (6.77)	5 (1.99)
Least erosive	5 (1.99)	45 (17.93)	29 (11.55)	172 (68.53)
Risk [c]				
Most risky	81 (32.79)	108 (43.72)	31 (12.55)	27 (10.93)
Least risky	50 (20.24)	25 (10.12)	87 (35.22)	85 (34.41)

Source: Field survey, 2000

Notes: [a] The number of responses for comparative financial profitability was 244
[b] The number of responses for comparative erodibility was 251
[c] The number of responses for comparative risk was 247
Percentages in parentheses

About 11% of the respondents considered the fruit tree AF system the least erosive. This has something to do with the management intensity varying across land use systems. The farmers visited their fruit tree AF plots more often and so were able to address erosion problems on AF plots in a timely manner.

With regard to risk, 33% and 44% of respondent farmers reported upland rice and sugarcane, respectively, to be most risky. Sugarcane was considered a risky crop because the sugar mill had been moved to another province and sugarcane growers would have problems in selling their produce. The AF and forestry systems were considered less risky by respondents, compared with the other land use systems.

6.3.11 Farmers' Access to Credit and Extension Services

Access to credit and extension services is a possible explanatory variable in the land use choice made by farmers. Access to credit may help farmers overcome their capital difficulties, allowing them to adopt a certain land use system or erosion control measures which are capital demanding. Information and technical services made available to farmers through extension personnel also play a role in determining farmers' land use decisions. Therefore, it is necessary to have an idea of the farmers' access to production credit and extension services.

Table 15 shows that about three-quarters of farmers had access to credit with an average loan of about VND 5 million (equivalent to USD 340). Farmers had access to different credit lines. Poor farmers could borrow from the Bank for the Poor without collateral. Sugarcane farmers could borrow from banks specified in the Sugarcane Promotion Programme. Other formal credit sources included the Agricultural Bank and the Investment and Development Bank. However, loan applications and approvals were complicated and time-consuming.

Many farmers reported that it was difficult to get loans due to complicated procedures. However, they emphasised that knowing how to use the loans efficiently was even more difficult for them. Some farmers did not dare borrow because they did not know what to do with the money. They (especially the Van Kieu farmers) needed financial management and technical training. There were, however, some farmers who wanted to take bigger loans for longer terms to invest in perennial crops.

Of the whole sample, about two-fifths of the farmers had access to extension services. For upland rice respondents (the Van Kieu farmers), only a quarter of them had access to extension services. This partially reflects the marginality of the Van Kieu farmers who lived in scattered locations, which were quite difficult to reach. However, it should be noted that extension services at Xuanloc were limited to general technical guidance; there was no focus on specific problems faced by the farmers (Department of Agriculture and Rural Development 1998). Therefore, the farmers' access to extension services did not ensure that their technical problems were solved.

Table 15. Farmers' Access to Credit and Extension Services

	FREQUENCY				
	Whole sample	*Upland rice*	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
1. Access to production credit					
Mean production credit* ('000 VND)	5,006.28	3,472.97	6,280.00	7,097.22	3,094.34
No. of households with credit	191	37	65	36	53
	(73.46)	(82.22)	(90.28)	(51.43)	(72.60)
No. of households without credit	69	8	7	34	20
	(26.54)	(17.78)	(9.72)	(48.57)	(27.40)
2. Access to extension services					
Households with extension services	111	11	37	26	37
	(42.69)	(24.44)	(51.39)	(37.14)	(50.68)
Households without extension services	149	34	35	44	36
	(57.31)	(75.56)	(48.61)	(62.86)	(49.32)

Source: Field survey, 2000

Notes: Percentage share in parentheses
* Per household with credit

6.3.12 Land Use Difficulties

Table 16 presents the frequency distribution of difficulties faced by upland farmers at Xuanloc. It should be noted that these were difficulties farmers encountered in using their land resources (all the land parcels they had, including the selected parcels).

Of the whole sample, more than two-fifths of farmers had the problem of capital shortage, especially the majority (more than four-fifths) of upland rice respondents who reported a lack of capital to buy production inputs such as seeds, fertilisers, and pesticides. Another common problem that about four-fifths of the respondents faced was the lack of technical know-how. They had problems in choosing suitable crops to grow, and how to plant and manage their crop/tree systems. Van Kieu farmers, especially, were in dire need of assistance on agricultural production technology.

Other problems faced by most of the farmers were manpower shortage (70%) and transportation (48%) related. It should be noted that manpower shortage is a seasonal problem associated with agricultural production. It happens even in rural areas where persistent unemployment exists. The poor roads, which do not allow for the use of vehicles, make the transportation of farm inputs and outputs difficult. Many farmers had to spend much time and effort to carry their timber and sugarcane to places accessible to vehicles.

About a quarter of the farmers had marketing problems. Van Kieu farmers were at a bargaining disadvantage in selling their cassava as supply exceeded demand. The same problem was faced by farmers who sold timber and firewood harvested from their forest plantations.

Table 16. Land Use Difficulties

	FREQUENCY				
	Whole sample	*Upland rice*	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
Lack of capital	167 (64.23)	37 (82.22)	44 (61.11)	52 (74.29)	34 (46.58)
Know-how problem	211 (81.15)	45 (100.00)	59 (81.94)	45 (64.29)	62 (84.93)
Manpower shortage	183 (70.38)	41 (91.11)	45 (62.50)	51 (72.86)	46 (63.01)
Marketing problem	62 (23.85)	15 (33.33)	18 (25.00)	0 (0.00)	29 (39.73)
Transportation problem	126 (48.46)	24 (53.33)	34 (47.22)	30 (42.86)	38 (52.05)

Source: Field survey, 2000

Note: Percentage share in parentheses

6.3.13 Reasons For Adopting a Land Use System on Parcels

Given a land parcel, a farmers' land use decision is determined by his perception about available land use options and the resource constraints and institutional settings he faces. Sometimes the land use option actually adopted on the parcel is not the desired one but the one, which the farmer is compelled to choose under the circumstances. To understand farmers' land use decisions, they were asked to provide reasons for adopting their respective land use systems on the selected parcels in the survey. The interview results are presented in Table 17.

About three-quarters of the respondents reported that they grew upland rice for food. Tradition was also a reason given by more than two-fifths of rice growers. Only about a quarter of respondents reported that they grew rice because the crop suited parcel characteristics. The unavailability of alternatives was another reason given by a quarter of the respondents. It was seen that recommendations by local authorities and perceived financial profitability of the crop had nothing to do with the decision of respondent-farmers to grow upland rice.

Most sugarcane respondents grew the crop because of the recommendations of the local authorities and the support received under the sugarcane promotion programme. Less than one-tenth of the respondents reported that they grew sugarcane because the crop was suitable with respect to parcel characteristics. About one-fifth of the respondents grew sugarcane for its high financial returns.

With reference to the fruit tree-based AF system, high financial returns was the reason for adopting the system for about one-third of the respondents. Other reasons such as parcel characteristics, recommendations by local authorities and unavailability of better alternatives were given by about a quarter of the respondents.

Table 17. Reasons for Adopting Land Use Systems

	FREQUENCY				
	Whole sample	*Upland rice*	*Sugarcane*	*Fruit tree AF*	*Eucalyptus*
No. of parcels investigated	260 (100.00)	45 (100.00)	72 (100.00)	70 (100.00)	73 (100.00)
For food subsistence	33 (12.69)	33 (73.33)	0 (0.00)	0 (0.00)	0 (0.00)
Suited to parcel characteristics	68 (26.15)	12 (26.67)	7 (9.72)	17 (24.29)	32 (43.84)
Traditions/following other people	31 (11.92)	20 (44.44)	0 (0.00)	9 (12.86)	2 (2.74)
As recommended by local authorities	115 (44.23)	0 (.00)	59 (81.94)	17 (24.29)	39 (53.42)
High financial return	39 (15.00)	0 (.00)	13 (18.05)	25 (35.71)	1 (1.37)
Better alternatives not available	43 (16.53)	12 (26.67)	6 (8.33)	18 (25.71)	7 (9.59)

Source: Field survey, 2000

Notes: Percentages in parentheses
More than one reason may be given for a choice

As for the eucalyptus system, about two-fifths reported that they planted eucalyptus because of suitable parcel characteristics, and a half due to recommendations of local authorities. Only one out of 73 respondents reported that eucalyptus was planted because of its high financial return and one-tenth of respondents grew eucalyptus because of the unavailability of better alternatives.

In summary, it can be concluded that there are several reasons for adopting a certain land use system on a given parcel. The frequency distribution of the reasons varied across land use systems. The objective of food subsistence was relevant mostly for upland rice farmers. The farmers' decision to grow sugarcane was mainly due to the sugarcane promotion programme and recommendations of local authorities. Both parcel characteristics and recommendations and programmes by local authorities played an important role in shaping the farmers' decision to grow eucalyptus. Excluding the reason of food subsistence, all the reasons mentioned played a role in determining the farmers' decision to adopt the fruit tree-based AF system.

6.3.14 Farmers' Short-term Land Use Planning

As revealed by respondent farmers, soil erosion and land degradation are significant problems, which threaten their livelihood. To get an indication of what farmers would do with their land parcels in their present circumstances, respondents were asked to express their short-term land use plans for the selected parcels. The interview results are presented in Table 18.

The majority of farmers who currently grew upland rice wanted to continue growing the crop on the parcels because upland rice was the staple food crop for them. Only one-tenth of rice respondents would adopt a new land use system on the parcels currently growing rice. It is likely that there will be no changes with upland rice parcels if there are no external interventions to discourage the use of this land use option. All farmers currently growing sugarcane wanted to adopt a new land use system. Due to the poor supply of cane and its low economic performance in the last two years, the KCPVIL had recently decided to move the mill to another province. That was why farmers had to quit the crop. Some farmers planned to grow forest trees. Others wanted to try with fruit trees or industrial perennial crops. More than one-fifth of respondents did not know what to do with their recently cleared parcels, but observed that the land was being exposed to severe erosion. Assistance and guidance from relevant organisations such as the provincial Department of Agriculture and Rural Development and extension centres are urgently needed.

With respect to parcels under the fruit tree-based AF system, only about a quarter of the respondent farmers wanted to continue with the system. Less than two-fifths of the farmers wanted to improve their basic AF system or replace it with a new land use system. The reason why they wanted to make a change was because their fruit trees had pest and disease problems and solutions to these problems had not been found. About 37% of the respondents did not know what to do about their fruit tree-based AF system and were only waiting for recommendations from local authorities and for better alternatives discovered by their peers.

Table 18. Farmers' Short-term Land Use Planning

	FREQUENCY				
	Whole sample (n=260)	*Upland rice (n=45)*	*Sugarcane (n=72)*	*Fruit tree AF (n=70)*	*Eucalyptus (n=73)*
Continuing current practice	107 (41.15)	40 (88.89)	0 0.00	17 (24.29)	50 (68.49)
Adopting a new system	96 (36.92)	5 (11.11)	57 (79.17)	27 (38.57)	7 (9.59)
Do not know what to do	57 (21.92)	0 0.00	15 (20.83)	26 (37.14)	16 (21.92)

Source: Field survey, 2000

Note: Percentage share in parentheses

More that two-thirds of the farmers using the eucalyptus system wanted to continue with it. This is because it was not the right time to harvest their forest plantations. Furthermore, they could not find any better alternatives. Only about one-tenth of the farmers wanted to make a change. They found that their parcels had become more fertile and suitable to grow high value crops other than forest trees. These farmers were relatively rich, progressive and creative in outlook and prepared to take risks.

In summary, given the farmers' socio-economic constraints, if there are no effective interventions, many changes would take place with lands currently under sugarcane and fruit tree-based AF systems in the near future. New land use alternatives would be adopted by different farmers. However, no changes to upland rice parcels and forest plantations are expected because no possible replacement crops for upland rice are identified and most forestry plantations are not old enough to cut.

7.0 ON-SITE COST OF SOIL EROSION

7.1 Soil Loss and Productivity of Typical Land Use Systems

7.1.1 Calibrating SCUAF to the Typical Conditions of the Sloping Uplands

This section discusses the parameters used to calibrate SCUAF to the typical conditions of the sloping hilly areas of the province of Thua Thien Hue. As structured in the model, the values of the parameters of the physical environment such as climate, slope class, soil drainage, parent material, soil texture, soil reaction and organic matter status were set based on data obtained from the site. As discussed in Section 5.2.2, feralit soil is the dominant soil order in Xuanloc. The soil is acidic and of low fertility (CBRM 1997). With reference to topography, about three-quarters of the commune's land fall into the intermediate slope class, with slopes ranging from 5 to 17 degrees. The area has an altitude of 80-120 m above sea level, and according to criteria used in SCUAF, the area is classified as "humid lowlands". In short, the physical environmental conditions of the model were: humid lowlands, moderate slopes, free drainage, Felsic parent material, medium soil texture, acid soil reaction and intermediate organic matter status.

Based on the results of the experiment, soil depth of 1 m and the topsoil depth of 20 cm were specified in the SCUAF. The bulk densities, as reported by CBRM (1997), of 1.3 for topsoil and 1.5 for subsoil were used. The nutrient composition of the plant parts was based on the laboratory analysis results. The USLE (universal soil loss equation) input parameters for different land use systems were derived from CBRM (1997) and Kiet (1995). The initial yields of the crops and trees were based on survey data.

The time span for the simulation of the SCUAF model was 60 years. A number of SCUAF default values of parameters for carbon, nitrogen and phosphorus transformation in the specified physical environment was accepted. This was due to time constraints and the unavailability of such data at the site. However, the initial values of soil carbon, nitrogen and phosphorus were set based on the results of the laboratory analyses and the values reported by the Community-Based Upland Resource Management Research Project (CBRM 1997) and the Department of Agriculture and Rural Development (DARD 1997).

It should be noted that to ensure comparability across land use systems, the physical environment calibrated was the same for the four land use systems. The four land use systems are adopted on intermediate slope lands, which dominate the area. The slope range of land parcels under the four land use systems is the same.

7.1.2 Soil Loss Due to Erosion

The magnitude and pattern of soil loss differ greatly across land use systems. The upland rice-based system had the highest estimated annual soil loss. Its minimum soil loss levels were even greater than the maximum values of other land use systems in the same period. Under the rice-cassava-fallow system, soil loss due to erosion rapidly increased from the first year of the crop-fallow cycle and reached a maximum at the end of the cropping period. Soil erosion decreased throughout the fallow and reached a minimum at the end of the fallow period. By year 50, the annual soil loss under the upland rice system is estimated at around 121 tonnes/ha.

With reference to the sugarcane system, soil loss was at a maximum in the first year of the three-year cycle. During the cycle, soil loss was at a minimum in the second year. The explanation for this was the fast regeneration of the sugarcane from the stump left after the first year's harvest, which reduced the time period the land was exposed to erosion (due to poor vegetative cover). In the third year, erosion increased because of the poor regeneration of sugarcane from the second growing and the land preparation for additional planting.

The erosion pattern of the fruit tree-based AF system is more complicated. This is due to the frequent changes of the fractions of the land under the crop and tree components as the system evolves. During the ten-year cycle, the proportion of land under the tree component increases while that of the crop component decreases accordingly. As practised at Xuanloc, the system is re-established every ten years, which seems unjustifiable. The explanation given by respondent farmers was that the design of the system in terms of plant placement in the next cycle must be different from that of the current cycle to reduce risk of disease and to take advantage of different soil quality. Interviewed farmers reported that a lemon tree planted exactly in the same place where there had been a lemon tree earlier would give a low yield and would have a high probability of disease infection.

As for the eucalyptus system, the cycle is also 10 years. Erosion decreases steadily and reaches a minimum in the cut year (year ten of the cycle). Due to clear cutting, the plot is exposed to severe erosion and soil loss is at a maximum during the first year of the next cycle. When asked why they did not adopt selective cutting, the farmers answered that selective cutting was technically difficult and very labour consuming. Furthermore, the transport of timber and firewood was troublesome.

For a 50-year frame, the annual average soil loss figures for the upland rice and sugarcane systems were quite high; 89 and 60 tonnes/ha, respectively. Those of the fruit tree AF and the eucalyptus systems were 46 and 47 tonnes/ha, respectively. It should be noted that the mean of annual soil loss between the fruit tree AF and eucalyptus systems was not significant.

Figure 2 presents the cumulative soil loss under different land use systems. By year 50, the cumulative soil loss under the upland rice-based system would be 4,427 tonnes/ha; double that of the fruit tree AF and the eucalyptus systems. It is clearly shown in Figure 2 that upland rice is the most erosive land use system and that eucalyptus and the fruit tree AF systems, the least erosive. This coincided with the farmers' perceptions on this (Table 14). As compared to other land use systems, the cumulative soil loss under the sugarcane system is second lowest by year two and the second highest in year six.

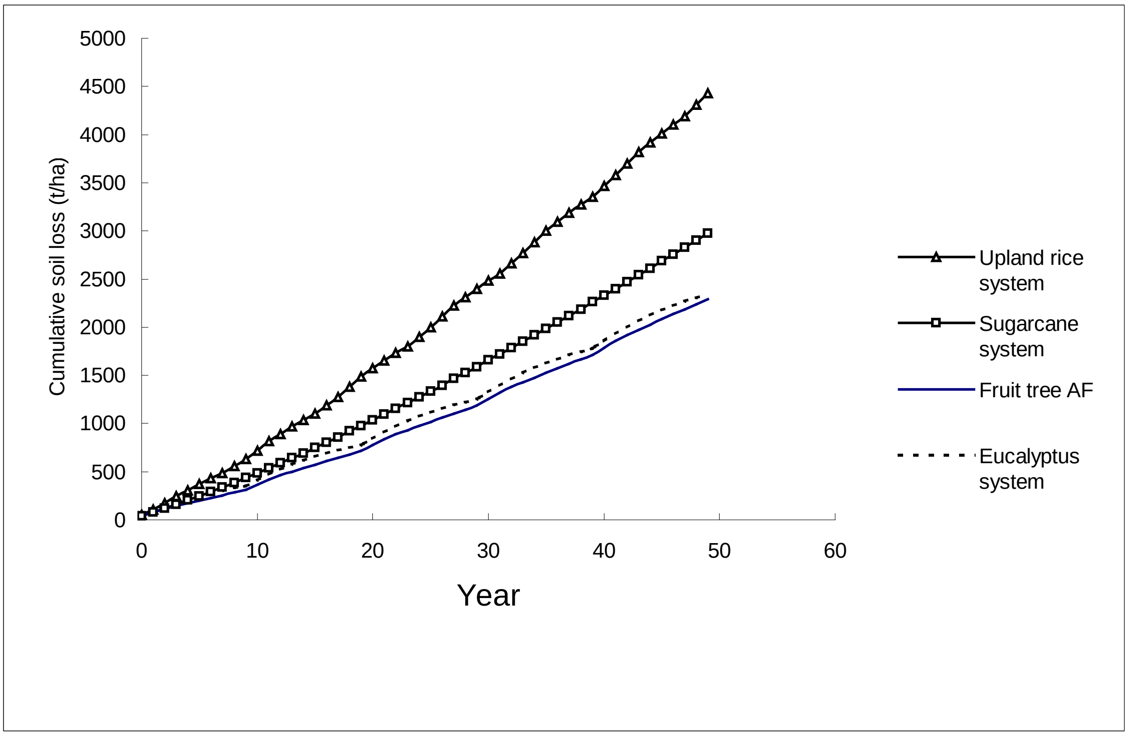


Figure 2. Modelled Cumulative Soil Loss Under the Land Use Systems

One of the on-site physical impacts of soil erosion is the reduction in the depth of cultivable soil. To have an indication of how this happened under the four land use systems, the modelled soil depth over time is presented in Figure 3.

Under the upland rice-based system, the depth of soil declines by 33%, from 100 to 67 cm by year 50. The rate of erosion increases over time as soil fertility declines and the capacity of the soil to maintain vegetative cover is reduced. It was revealed from the SCUAF output projections that by year 33 (after four crop-fallow cycles), the entire topsoil layer would be lost. The soil depth would have declined at an average rate of about 0.6 cm per year. From year 34 onwards, the depth of soil would reduce by 1 cm per year. The accelerated soil loss would most probably be due to the low fertility of the subsoil to sustain vegetative cover.

The reduction in soil depth under the sugarcane system, compared with the upland rice-based system, is less pronounced. On the average, about 0.56 cm of soil depth would be lost every year. By year 45, all topsoil would be washed away. Yet, a four-year fallow cropping system is commonly adopted by many upland farmers (Menz and Grist, 1996). It is obvious that by any measure, the upland rice-based system as practised by upland farmers at Xuanloc, is a profoundly unsustainable system.

With respect to the reduction in soil depth, the fruit tree AF and eucalyptus systems showed the same trend. Over the 50-year frame, the average reduction in soil depth under these systems would be 0.34 cm per year, about one half of that under the upland rice-based system.

In summary, soil loss due to erosion varies across the four land use systems in terms of magnitude and time pattern. The fruit-tree-based AF and eucalyptus-based systems are least erosive and upland-rice based system is the most erosive land use system.

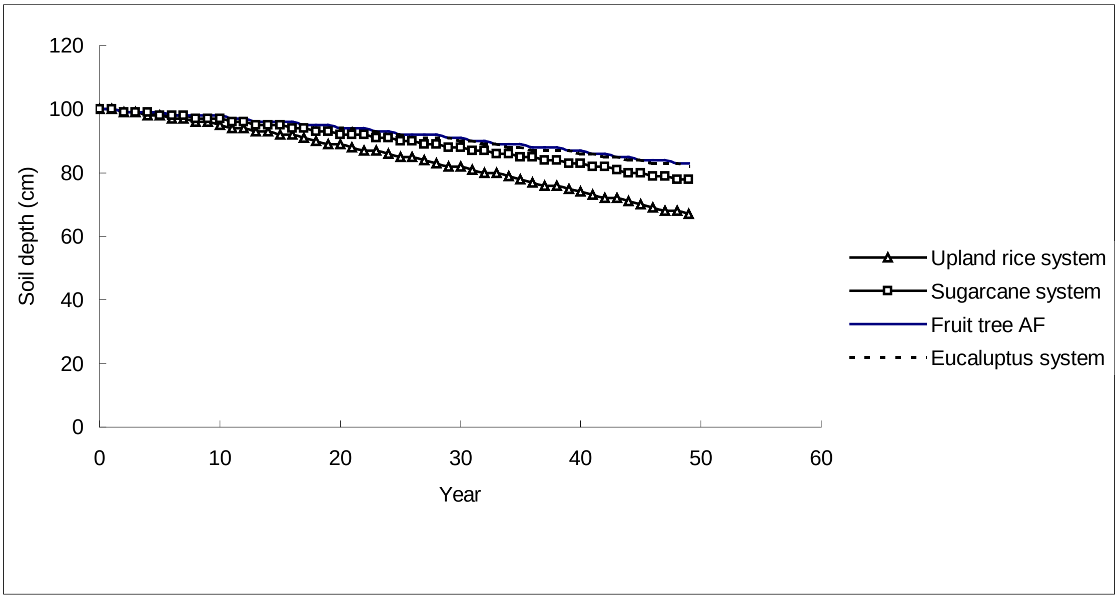


Figure 3. Soil Depth Over Time Under the Land Use Systems

7.1.3 Productivity of Typical Land Use Systems

Upland Rice-based System

As discussed earlier, rice and cassava are the two crops in the upland rice based system. Rice is grown and harvested in the first two years and cassava in third and fourth years of the eight-year crop-fallow cycle. Projected yields of rice and cassava show rapid decline over time. It should be emphasised that in the absence of input supplementation, the crop yields would be influenced mostly by erosion (examined in previous sections).

Rice yield dramatically decreases over time and falls to less than a quarter of its initial level by year 49 (the beginning of the seventh cycle). This would be due to a higher rate of soil erosion and a significant reduction in soil depth. It should be noted that the decreasing yield could be caused by a number of reasons (Enters 1998, cited in Bio et al. 1995). For sloping uplands, however, erosion is the most significant factor. Furthermore, other nutrient loss processes may be erosion-borne or erosion-led.

Cassava yield also rapidly declines over time. By year 51, it falls to less than a quarter of its initial level. This declining trend of cassava and rice yields indicates that with a fallow duration of four years, soil fertility is not able to recover sufficiently to provide a sustainable system. This is also in accordance with the findings of Menz and Grist (1996), who reported pronounced downward trends in rice yields under the four-year *Imperata* fallow system.

Sugarcane System

Sugarcane yield also shows a downward trend. The declining availability of nutrients in the soil mainly due to erosion and inadequate fertilisation has a direct bearing on this. The survey results show that fertiliser application by the farmers was far below the levels recommended by extension programmes. This was not only due to the limited availability of capital but also because of the farmers' risk aversion towards crop failure. The sugarcane system as adopted by farmers at Xuanloc is unsustainable from an economic standpoint as productivity of the crop declines rapidly.

It should be noted that sugarcane yield declines gradually over time at a rate that is much lower than that of rice and cassava yields under the upland rice-based system. By year 50, sugarcane yield is about two-thirds of its initial level, i.e. yield would have declined by 0.2 tonne per year on average. This is related to the lower rate of soil loss under the sugarcane system.

Fruit Tree-based AF System

The main tree component of the AF system is lemon and its crop component consists of sweet potato and banana. Sweet potato is planted between lemon rows during the first three years when lemon trees have not fully shaded the ground.

Lemon yield also shows a downward trend. Due to its immaturity, lemon yield in the first two years of the ten-year cycle is quite low. It reaches a maximum by year four and then declines. Minimum yield is associated with year one of every cycle. Minimum, maximum as well as mean yields of a given cycle are always smaller than their respective values in the previous cycle and greater than respective values of the next cycle. The average yield of cycle five is 2.43 tonnes/ha, approximately two-thirds that of cycle one. It seems that the biological characteristics of the tree coupled with soil erosion jointly determine the yield trend.

Sweet potato yield also declines over time. By year 51, sweet potato yield goes down to 2.8 tonnes/ha, approximately 46% of its initial level. The sharp decline in sweet potato yield could be attributed to both soil erosion as well as strong competition for nutrients between the system components. In addition, sweet potato is not a main crop; most fertilisers are applied to lemon, which takes top priority.

Another crop of the fruit tree AF system is banana. Banana yield declines sharply over time. By year 50, banana yield falls to 1.6 tonnes/ha, approximately 28% of its yield in year two. (Year one is the establishment year.) Therefore, it can be seen that banana yields are quite low. The sharp declining trend in banana yield was investigated. Like sweet potato, banana is not a primary crop. In the plots, it is planted in places less favourable than those reserved for lemon and receives inadequate tending and fertilisation. Farmers do not expect much income from banana due to its low price.

In summary, the fruit tree-based AF system, although less erosive than the upland rice and sugarcane systems, was not a sustainable system by any physical or biological measure. As emphasised in the review of related literature, the practice of a given AF system is by no means sufficient to ensure maintenance of soil fertility. Equally important are: (1) the design of the system in relation to the local environmental and socio-economic conditions, (2) good management of the system and (3) the integration of agroforestry with the farming system as a whole.

Eucalyptus-based System

Timber yield of the eucalyptus-based system declines gradually over time. This is associated with the low rate of soil loss of the system. The fifth harvest (in year 50) was about 37 m^3, less than the first harvest (in year ten) by only 25%. Timber yield could be sustainable if selective cutting was adopted. Furthermore, selective cutting would allow for a more frequent income flow, which could alleviate the problem of capital shortage often faced by upland farmers.

7.2 On-site Cost of Soil Erosion

According to the opportunity cost approach proposed by Barbier (1996), the on-site cost of soil erosion is the loss in the long-term profitability of the farming system from not investing in an economically worthwhile alternative farming system. The on-site cost of soil erosion is therefore, the difference between the present values of the net financial returns of alternative land use systems with different extents of erosion. Therefore, the steps to estimate the on-site cost associated with a unit of soil loss include: (1) quantifying the soil loss due to erosion, (2) calculating the financial NPV of alternative land use systems and (3) comparing the NPV and soil loss across alternative land use systems and deriving the cost per unit of soil loss based on the concept of opportunity cost.

The first step has been taken already. The following discussion focuses on the calculation of NPV of the four land use systems and the derivation of the opportunity cost per tonne of soil loss due to erosion.

7.2.1 Financial Profitability of the Land Use Systems

Some Practical Issues

(a) Choice of Discount Rate and Time Horizon

The calculation of NPV requires the determination of an appropriate discount rate. The real rate of discount is a much-debated issue (Enters 1998). The selected discount rate obviously influences the results of the cost-benefit analysis (CBA). In this study, a discount rate of 12% was chosen for the calculation of the NPV. This is the estimated opportunity cost of capital in the study area. In addition, the NPVs of the land use systems were also calculated at discount rates of 15%, 20% and 25% to examine the sensitivity of findings to the choice of discount rate.

The NPV is not only very sensitive to the discount rate but also to the time horizon. Upland farmers at Xuanloc grow not only annual crops but also perennials. This implies that they look far ahead to the future. They are not "short-sighted" which would make a CBA of perennials cultivation meaningless (Enters 1998). Given such justification, a time horizon of 30 years was chosen for this study.

(b) Opportunity Cost of Labour

Family labour is one of the most important inputs to farming. The opportunity cost assigned to family labour influences very much the outcome of the CBA. The identification of an appropriate opportunity cost of labour depends on the nature of the activity to be performed, the characteristics of the workers and the availability of non-farm and off-farm employment (Enters 1998). As mentioned earlier, the employment market at Xuanloc is undeveloped. One farming household with about four workers can find work as paid labour for only 20 days in a year (Table 5). The wage earned ranges from VND 12,000–20,000 (USD 0.8–1.4). Farmers could earn the same amount by collecting firewood in the forest. Another opportunity for them to make money is to collect *Thysannolaena maxima* (a plant used to make brooms). However, the opportunity to do so has become limited as government policies on forest protection are more effectively enforced. Most respondent farmers were willing to work as paid labour at a rate equivalent to 4 kg of rice (about VND 8,000). Given the situation, the opportunity cost used to calculate NPV in this study was VND 8,000 per man-day.

NPVs of the Different Land Use Systems

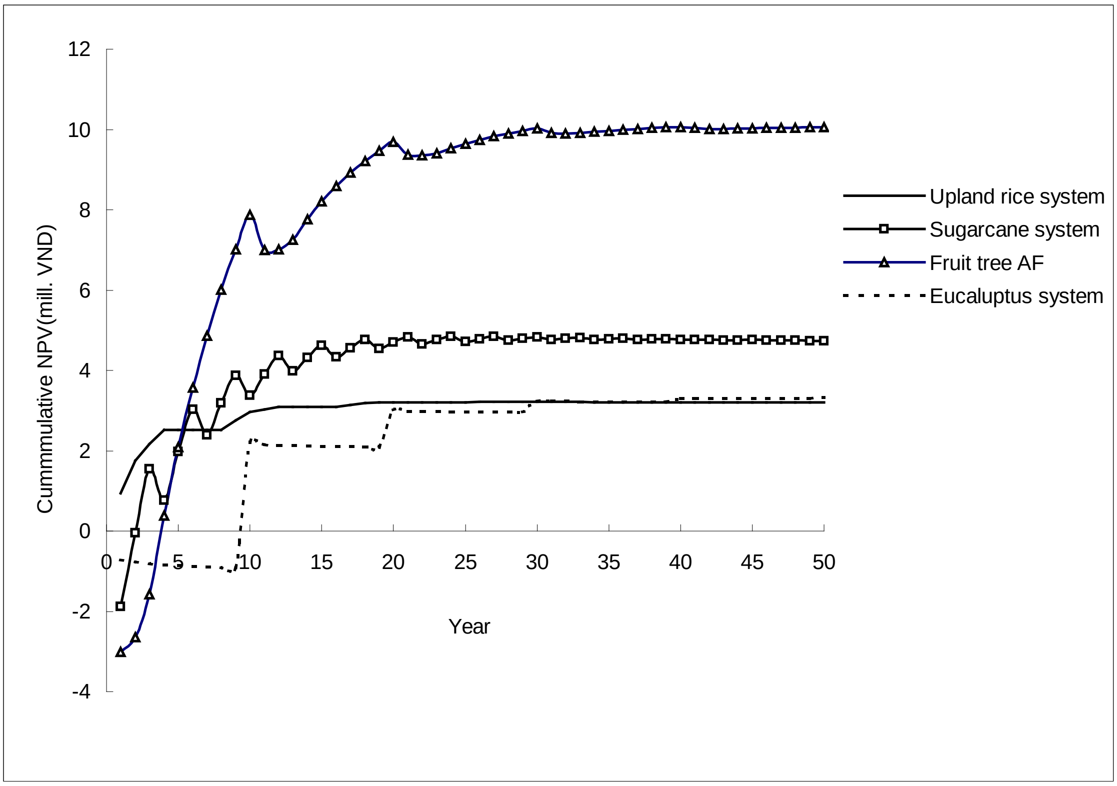
The NPVs of the different land use systems is presented in Table 19. All of them turned up positive, even at a discount rate of 25%. The AF system showed a higher profitability than the other systems, followed by the sugarcane system. At the discount rate of 12%, the NPVs of the upland rice- and eucalyptus-based systems were almost the same. The NPVs of all systems, except for upland rice, were quite sensitive to changes in the discount rate, especially the eucalyptus system.

Financial profitability is one of the most important criteria in a farmer's land use choice. Since the time horizon may differ from farmer to farmer, it is worth taking a look at the cumulative NPVs of the land use systems over time (Figure 4).

Table 19. Financial NPVs of the Land Use Systems

Land use systems	*$NPV_{(T=30)}$ ('000 VND per ha)*				
	r = 0.10	*r = 0.12*	*r = 0.15*	*r = 0.20*	*r = 0.25*
Upland rice-based system	3,469	3,212	2,900	2,511	2,227
Sugarcane system	7,368	6,332	5,146	3,790	2,891
Fruit tree-based AF	13,837	11,443	8,792	5,891	4,051
Eucalyptus-based system	4,372	3,241	2,080	955	350

Note: r is the discount rate



Note: r = 0.12

Figure 4. Cumulative NPVs of the Land Use Systems Over Time

By year five, the NPVs of the upland rice, sugarcane and AF systems are almost the same and NPV of the eucalyptus system is negative. With a time horizon of five years, the upland rice-based system is the best option. This could be a plausible explanation as to why Van Kieu farmers, whose living standards are well below subsistence level, prefer upland rice. After year five, the AF system is much more superior than other systems in terms of profitability. Therefore, farmers with a longer time frame and enough capital would adopt the AF system. The eucalyptus appears financially inferior compared with other systems. This is why most forest plantations at Xuanloc had to be established with the subsidies provided by PAM and PR-327.

7.2.2 Estimated On-site Cost of Soil Erosion

The on-site cost of soil erosion is the loss in the long-term profitability of a farming system from not investing in an economically worthwhile alternative system. In other words, it is the forgone present values of the net financial returns of (rejected) alternative land use systems with different extent of erosion. A farmer may, however, want to find out the yearly income loss equivalent to the forgone NPV (Francisco 1998). Therefore, it is relevant to measure on-site cost of soil erosion using the value of annualized income (Table 20).

Table 20. Soil Loss and Annualized Income* of the Land Use Systems

Land use system	*Soil loss (tonnes/ha per year)*	*Annualized income ('000 VND/ha per year)*
Upland rice-based system	80	399
Sugarcane system	53	786
Fruit tree-based AF	40	1,421
Eucalyptus-based system	42	402

Note: *at the discount rate of 12 % for 30 years

Given the four land use systems with their respective estimated annual soil loss and annualized incomes, the on-site cost of soil erosion associated with a land use choice is the forgone annualized income associated with the rejection of the next best alternative land use system. Measured by the annualized income loss, the on-site costs of soil erosion under upland rice-based and eucalyptus-based systems are VND 1,022 and 1,019 thousand/ha per year respectively. Under the sugarcane system, it is VND 635 thousand/ha per year, as compared (in all cases) to the fruit tree-based AF system.

8.0 ECONOMETRIC ANALYSIS OF FARMERS' LAND USE CHOICES

In this study, there are two distinct groups of farmers, the Kinh and the Van Kieu, whose choice sets differ from each other. The set of typical land use systems of Kinh farmers includes sugarcane, AF and eucalyptus systems; that of Van Kieu includes not only these three land use systems but also upland rice. Therefore, it is necessary to do a separate logistic analysis for each group of farmers.

8.1 Land Use Choice of Kinh Farmers

The results of the multinomial logit analysis for the Kinh farmers are summarised in Table 21. The effect coefficients are estimated with respect to the eucalyptus land use category, the base case. Therefore, the inference from the estimated coefficients for each choice category is made with reference to the base case.

The chi-square test statistic for the estimated model is 160.42 with 24 degrees of freedom. The null hypothesis that the non-intercept coefficients are jointly zero is rejected at the 0.01 level. This means that the empirical logit model is highly significant in explaining the land use choice by upland farmers. The likelihood ratio index of 0.72 indicates that 72% of the total variation in the probability of land use choice is explained by the independent variables included in the model. The predictive power of the model is rather convincing. The choice of eucalyptus, sugarcane, and AF systems is correctly predicted for 81%, 83% and 97% of the sample, respectively.

The probability that the sugarcane system is chosen is seen to decrease if the farmer has more plots of land. This reflects the fact (as reported by farmer respondents) that farmers with more plots of land have been actively involved in the reforestation programmes. The predicted coefficients of the PLOT, FAR, and SLOPE variables are negative and statistically significant. This indicates that sugarcane is more likely to be chosen for plots with smaller acreage, lower slopes, and proximity to the farmer's house. The negative and significant coefficient of the INCENTIVE variable is related to the fact that the incentives given to farmers were mostly associated with the reforestation components of the PR327 and PAM programmes. Credit schemes, a supportive component of the sugarcane promotion programme, has proven to be effective in encouraging farmers to grow the crop, indicated by the positive and significant coefficient of the CREDIT variable.

As for the AF system, all the statistically significant coefficients have negative signs. The probability of the AF system being chosen decreases if the farmer is older and more educated. This has to do with the farmer's attitude towards risk and uncertainty. Older farmers are likely to be more conservative and less open to new technology such as the AF land use system. This coincides with the descriptive analysis result that most farmers practising AF are younger than the mean age of the sampled population (Table 5). Similar to the sugarcane system, the AF system is less likely to be adopted on plots with steep slopes that are far from the farmer's house. As indicated by the negative and statistically significant coefficient of the INCENTIVE variable, the land use incentive system is biased towards the eucalyptus-based system. As mentioned earlier, there have been programmes such as PAM and PR-327 giving farmers incentives to plant eucalyptus and other forest trees. There have been no programmes, however, to promote the adoption of the AF system in the area.

To examine the impacts of the set of policy-related variables (INCENTIVE, EXT, and CREDIT) on land use choice, a likelihood ratio test was done. The calculated chi-square statistic was 30.26. The null hypothesis that the set of policy related variables does not affect a farmer's land use choice significantly is rejected at 0.01 level. This implies that policy variables, as a whole, play an important role in shaping a farmer's choice of land use system.

The marginal effect of the independent variables on the probability that a land use system is chosen was estimated at the sample mean values. It should be noted that the sign and magnitude of these marginal effects have no direct relationship to any specific coefficient but depend on the sign and magnitude of many coefficients.

The results show that the probability of the eucalyptus-based system being chosen is significantly affected by a marginal change of any independent variable included in the multinomial logit model. The variables with significant marginal effect on the probability of the sugarcane system being chosen include the number of land plots, farm size, plot area, slope, extension, and credit. None of the variables have significant marginal effect on the probability that the AF system is chosen. This implies that it would be very challenging to encourage upland farmers to adopt the AF system although it is more financially profitable and less erosive. The limited adoption of the AF system is due to the fact that the establishment of AF requires high capital cost. Furthermore, according to the feedback from the respondent farmers, the management of an AF system is complicated both technically and economically. The negative sign of the estimated marginal effect of the policy-related variables indicates that policy interventions are biased towards the eucalyptus system and must be redirected towards the AF system.

Table 21. Multinomial Logit Estimates of Kinh Farmers' Land Use Choices

Variables	*Sugarcane*	*Fruit tree AF*
Constant	12.337**	44.861***
	(5.462)	(12.732)
LABOUR	0.597	1.457
	(0.386)	(1.152)
EDUC	-0.173	-2.194***
	(0.254)	(0.817)
AGE	-0.067	-0.425**
	(0.062)	(0.182)
NPLOT	-1.040**	-1.750**
	(0.467)	(0.882)
FARM	0.715*	0.615
	(0.420)	(0.640)
PLOT	-2.325***	-2.200
	(0.810)	(1.538)
FAR	-1.347**	-7.205**
	(0.669)	(2.906)
SLOPE	-0.152**	-0.364***
	(0.065)	(0.125)
INCOME	-0.069	0.132
	(0.791)	(0.191)
INCENTIVE	-2.590**	-7.214***
	(1.230)	(2.280)
EXT	-1.625	0.974
	(1.143)	(2.424)
CREDIT	0.680**	-0.421
	(0.270)	(0.615)
Likelihood ratio test statistic		160.42***
Likelihood Ratio Index		0.72
Correct predictions		
Forestry		0.81
Sugarcane		0.83
Agroforestry		0.97

Notes: Numbers in parentheses are standard error
Number of observations is 102
***, **, * indicate statistical significance at 1%, 5% and 10% levels respectively

8.2 Land Use Choice of Van Kieu Farmers

A similar logistic analysis was done for the Van Kieu farmers. The results of the logit estimates are presented in Table 22. The eucalyptus land use system is the base case to which the multinomial logit coefficients were estimated. The likelihood ratio test rejects at 0.01 level, the null hypothesis that the non-intercept coefficients are jointly zero. This means that the empirical logit model is highly significant. As much as 74% of the total variation in the probability that a land use system is chosen is explained by the independent variables included in the model. The predictive power of the empirical logit model is rather convincing. The choice of eucalyptus, sugarcane, AF and upland rice systems is correctly predicted for 90%, 70%, 91% and 89% of the sample respectively.

The probability that sugarcane system is chosen decreases with the age of the farmer. The negative and statistically significant coefficients of the PLOT and SLOPE variables indicate that sugarcane system is more likely to be chosen for small plots with moderate slopes. The likelihood of adopting the sugarcane system is negatively affected by the level of household income. Households with lower income were very anxious to grow the crop because sugarcane was thought to be the antidote for their poverty. Also, farmers could get credit if they grew the crop. Furthermore, as mentioned earlier, the Van Kieu people are very united and practise the spirit of equality. Poor households were given priority to grow sugarcane. The positive and statistically significant coefficient of the CREDIT variable indicates the effectiveness of the credit component of the sugarcane promotion programme in encouraging farmers to grow the crop.

The likelihood that the AF system is chosen decreases for farmers with more land plots and higher incomes. This implies that newly claimed plots are more likely to be used to grow forests, provided there are no changes in the intervention structure. Extension affects the choice probability of the AF system negatively. This reflects the fact that the extension programmes have been mostly directed at promoting reforestation activities.

The upland rice-based system is more likely to be chosen for small plots with moderate slopes. Farmers with more farming experience adopt upland rice cultivation less frequently. This may be due to their awareness of the impact of soil erosion on the sustainability of the upland rice-based system in the long term. Household income is negatively correlated to the choice of upland rice. Greater availability of income alternatives would discourage farmers from growing upland rice.

A likelihood ratio test was done to examine the impacts of the set of policy-related variables (INCENTIVE, EXT, and CREDIT) on land use choice by Van Kieu farmers. The null hypothesis that the set of policy-related variables as a whole, does not significantly affect a farmer's land use choice was rejected at 0.01 level. This means that land use incentives, extension services and credit play an important role in shaping a farmer's choice of land use system.

Table 22. Multinomial Logit Estimates of Van Kieu farmers' Land Use Choices

Variables	*Sugarcane*	*Agroforestry*	*Upland rice*
Constant	34.037***	31.181**	34.776***
	(12.326)	(12.574)	(12.546)
LABOUR	-1.057	-0.264	0.284
	(0.669)	(0.743)	(0.789)
EDUC	-0.548	-0.061	-0.438
	(0.404)	(0.452)	(0.380)
AGE	-0.284***	-0.128	-0.281***
	(0.104)	(0.115)	(0.102)
NPLOT	0.418	-2.006**	0.114
	(0.732)	(0.905)	(0.716)
FARM	1.184*	1.163	1.020
	(0.677)	(0.798)	(0.682)
PLOT	-7.103***	-3.033	-8.664***
	(2.571)	(2.572)	(2.712)
FAR	-0.793	-4.231	0.046
	(0.502)	(3.188)	(0.509)
SLOPE	-0.447***	-0.330**	-0.423***
	(0.152)	(0.158)	(0.146)
INCOME	-1.748***	-1.329**	-1.607**
	(0.662)	(0.663)	(0.675)
INCENTIVE	0.154	-3.239	-16.242
	(1.796)	(2.072)	(15.600)
EXT	1.145	-5.104**	1.478
	(1.737)	(2.495)	(1.476)
CREDIT	1.086**	0.751	0.378
	(0.546)	(0.609)	(0.548)
Likelihood ratio test statistic			248.87***
Likelihood Ratio Index			0.74
Correct predictions			
Forestry			0.90
Sugarcane			0.70
Agroforestry			0.91
Upland rice			0.89

Notes: Numbers in parentheses are standard error
Number of observations is 124
***, **, * indicate statistical significance at 1%, 5% and 10% levels respectively

The marginal effect of the independent variables on the choice probability was estimated at the sample means. Only a few marginal effect values pass the statistical significance test. Given the opportunities and constraints presented, the farmer's choice of land use systems would be affected only if there are sufficiently large changes in the choice determinants such as income, education, credit and extension. This implies that it would be very challenging to affect a farmer's land use choice. Appropriate interventions with focus redirected towards the promotion of AF system are needed.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

This study measured the on-site cost of soil erosion and analysed the choice of land use alternatives by upland farmers in the Central Coast of Vietnam. An assessment of the erodibility and financial profitability of typical land use systems in the area, namely the upland rice-based system, sugarcane system, fruit tree-based agroforestry (AF) system and eucalyptus-based system, was undertaken. The descriptive analysis of data from survey interviews of 260 farmers in Xuanloc, a typical upland commune in the Thua Thien Hue Province indicates that soil erosion is a significant problem in the region. Soil erosion has adversely affected the livelihood of upland farmers and presents a real hindrance to long-term economic development efforts in the uplands.

Results from the SCUAF simulations indicate that among the four typical land use systems, the fruit tree AF and eucalyptus-based systems are the least erosive and the upland rice-based system, the most erosive. Although less erosive than the upland rice system, the sugarcane system, the most recently introduced land use option, has an annual soil loss level much higher than the soil loss tolerance value. With respect to financial profitability, the results of a cost-benefit analysis with a time frame of 30 years showed that among the four typical land use systems, the AF system is the most financially profitable, and upland rice and eucalyptus systems, the least profitable.

How much the on-site cost of soil erosion is depends on which land use option is chosen from the available land use alternatives. Measured by the annualized income loss, the on-site costs of soil erosion under the upland rice-based and eucalyptus-based systems are VND 1,022 and 1,019 thousand/ha per year, respectively. That under the sugarcane system is VND 635 thousand/ha per year, as compared (in all cases) to the fruit tree-based AF system.

Empirical results from the multinomial logit analysis show that the choice of land use system is influenced by: farmer attributes such as education, age, landholding and income; land plot characteristics such as acreage, slope and distance from the farmer's house; and policy-related variables such as land use incentives, extension services and credit facilities. It was established in this study that the set of policy-related variables was important in explaining the land use choice of upland farmers. It also shows that the interventions in the past were biased towards reforestation and sugarcane production. Inadequate attention has been paid to the AF system. It is a great challenge to persuade upland farmers to adopt sustainable land use practices such as the AF system because it requires high establishment/capital cost. In addition, the management of the system is complicated both biologically and economically. The complicating situation is that upland farmers in the area are poor, lowly educated and live in rather isolated environments. Trapped in poverty, upland farmers, especially the ethnic minority, are still using erosive land use systems to meet their immediate needs.

9.2 Implications and Recommendations

A number of policy implications can be taken from this research:

Firstly, appropriate measures to reduce soil erosion are urgently needed to prevent possible irreversible damage to the land currently under the upland rice-based system. Possible measures include the introduction of soil conservation technologies to this land use system and the shift from upland rice to other less erosive land use systems. For the ethnic minority in the region, upland rice is the most important food crop. It is estimated that about a quarter of the landholdings of minority households is taken up by upland rice. Therefore, it would be advisable to introduce soil conservation techniques to the upland rice-based system rather than to replace it with other land use systems that are less erosive.

Secondly, as a consequence of the sugarcane programme, upland farmers in Thua Thien Hue converted about 4,000 ha of sloping lands under other land use systems to sugarcane production. All these farmers now want to adopt a new land use system on the present sugarcane parcels. This is because the sugar mill has recently been moved to another province. Some farmers plan to grow forest trees. Others want to try growing fruit trees or industrial perennial crops. More than one-fifth of respondents do not know what to do with their recently cleared parcels, but observed that the land was being exposed to severe erosion. Timely assistance and guidance from relevant organisations such as the provincial Department of Agriculture and Rural Development, and extension centres should be given to these farmers so that they can choose the right land use option and adopt it on the plots which were used to grow sugarcane.

Thirdly, promoting the adoption of the AF system is a promising solution to sustaining upland development as it can minimise soil erosion while bringing about higher financial benefits to upland farmers. However, there are several limiting factors to the adoption of the AF system: it requires high investment and is complicated in design and management. Future interventions such as credit, incentives and extension services should be directed towards the promotion of the AF system. A sufficient level of intervention should be identified to ensure that these limiting factors could be mitigated. Intervention approaches should take into account the differences between the two groups of farmers, the Kinh and the Van Kieu, in terms of economic status, education, values and local institutions.

Fourthly, it is important to encourage upland farmers to adopt soil conservation measures. As discussed earlier, there have been no programmes specifically targeted at soil conservation. Assessments of farmer-practised soil conservation technologies should be made. Profitable and appropriate soil conservation measures (such as the use of hedgerows and cover crops) should be made available to upland farmers. The adoption of profitable soil conservation measures is as important as the shift to less erosive and more remunerative land use system such as the AF system. These two approaches are not mutually exclusive. A more remunerative land use system would improve the return to investment in soil conservation. In turn, profitable soil conservation measures would facilitate the shift to a more remunerative land use system.

Finally, the shift to less erosive and more remunerative land use systems such as the AF system and the adoption of profitable soil conservation would effectively benefit farmers if they had access to improved technologies and better transportation and marketing infrastructures. Due to the poor current infrastructure, upland farmers are left isolated. They have difficulty in selling their agricultural produce (cassava, cane, fruits) and buying production inputs (fertiliser, seeds). Therefore, investment in rural infrastructures to facilitate mobility, and policies for the development of an efficient marketing system would encourage desirable changes in the farmers' use of the uplands.

9.3 Issues for Further Research

Erosion normally results in sedimentation which in turn causes crop losses and damage to irrigation and hydropower infrastructures as well as to coastal resources. The shift to less erosive land use systems such as AF would generate off-site benefits, namely, the avoidance of such sedimentation damages. As it is society that stands to gain from such off-site benefits, should not the shift be subsidised by the public sector? To justify such subsidy and to determine its level, an evaluation of the off-site benefits derived from the shift to less erosive land systems is necessary.

The recent transformation in Asian upland agriculture towards high-value industrial crops such as rubber, pepper and other cash crops is partly induced by macro and sectoral policies and other factors outside upland systems (Lucia et al. 1999). Assessing the impacts of such variables on the dynamics of land use changes in the uplands is important in formulating institutional and policy interventions for sustaining the development of the uplands.

REFERENCES

Barbier, E. 1996. The Economics of Soil Erosion: Theory, Methodology and Examples. Special Paper, EEPSEA, Singapore.

Barbier, E. and J.T. Bishop. 1995. Economic Values and Incentives Affecting Soil and Water Conservation in Developing Countries. Journal of Soil and Water Conservation (March-April).

Bio, Y. et al. 1995. Rethinking Research on Land Degradation in Developing Countries. World Bank Discussion Paper 289. The World Bank. Washington DC, USA.

CBRM (Community-Based Upland Resource Management Research Project). 1997. Final technical report. College of Agriculture and Forestry, Hue University, Thua Thien Hue, Vietnam.

Current, D. and S. J. Scherr. 1995. Farmer Costs and Benefits from Agroforestry and Farm Forestry Projects in Central America and the Caribbean: Implications for Policy. Agroforestry System, 30, 87-103.

DARD (Department of Agriculture and Rural Development). 1997. Thua Thien Hue, Vietnam. Annual Report, 3-7.

Department of Forestry. 1993. Forest Inventory Report 1992. Thua Thien Hue, Vietnam.

Dien, T.V. et al. 1996. Sloping Land Agriculture: Challenges and Potentials. Agricultural Publishing House, Hanoi, Vietnam. (In Vietnamese.)

Enters, T. 1998. Methods for the Economic Assessment of the On- and Off-site Impact of Soil Erosion. Issues in Sustainable Land Management. No. 2. International Board for Soil Research and Management, Bangkok, Thailand.

Feder, G. and T. Onchan .1987. Land Ownership Security and Farm Investment in Thailand. American Journal of Agricultural Economics. No. 69, 311-320.

Foltz, J. C. et al. 1995. Multiattribute Assessment of Alternative Cropping Systems. American Journal of Agricultural Economics. No. 77, 408-420.

Francisco, H.A. 1998. The Economics of Soil Conservation in Selected ASIALAND Management of Sloping Lands Network Sites. Issues in Sustainable Land Management. No.5. International Board for Soil Research and Management, Bangkok, Thailand.

Garcia, Y. T. 1997. Analysis of Decision Models for Upland Soil Conservation in Argao, Cebu. University of the Philippines, Los Banos, Philippines. PhD dissertation.

General Statistical Office. 2000. Statistical Year Book 1999. Statistical Publishing House, Hanoi, Vietnam.

Gittinger, J.P. 1982. Economic Analysis of Agricultural Projects. The John Hopkins University Press, Baltimore, USA.

Green D. A. G.; D. H. Ng'ong'ola. 1993. Factors Affecting Fertiliser Adoption in Less Developed Countries: An Application of Multivariate Logistic Analysis in Malawi. Journal of Agricultural Economics, 44(1), 99-108.

Greene, W. H. 1993. Econometric Analysis. Macmillan Publishing Company, New York, USA.

______ 1995. LIMDEP Version 7.0: User's Manual. Macmillan Publishing Company, New York, USA.

Griliches, Z. 1957. Hybrid Corn: An Exploration in the Economics of Technical Change. Econometrics 25 (4), 501-522.

Gujarati, N. D. 1988. Basis Econometrics. Second edition. McGraw-Hill, New York, USA.

Kerkhoff, P. 1990. Agroforestry in Africa: A Survey of Project Experience. Panos Institute, London, UK.

Kiet, H. 1995. Application of the Wischmeier Equation to Predict Soil Erosion in the Sloping Lands of Thua Thien Hue and Quang Tri Provinces. Hanoi Agricultural University, Hanoi, Vietnam. MSc thesis.

Lal, R. 1990. Soil Erosion in the Tropics – Principles and Management. McGraw-Hill, New York, USA.

Lucia, L.; S. Pandey and H. Waibel. 1999. Adoption of Contour Hedgerows by Upland Farmers in the Philippines: An Economic Analysis. Discussion Paper No. 36. IRRI (International Rice Research Institute).

Lutz, E.; D. Current and S. J. Scherr. 1995. The Costs and Benefits of Agroforestry to Farmers. The World Bank Research Observer, Vol. 10, No. 2 (August), 151-80.

Menz K. and P. Grist. 1996. Changing Fallow Length in an *Imperata/*Upland Rice Farming system. Paper 96/6 of Project "Improving Smallholder Farming Systems in *Imperata* Areas of Southeast Asia: Alternatives to Shifting Cultivation." ANU-CRES (The Australian National University – Center for Resource and Environmental Studies).

Miranda, M.L. 1992. Landowner Incorporation of On-site Erosion Costs: An Application to the Conservation Reserve Program. American Journal of Agricultural Economics. May. 74:434-43.

Mishan, E. J. 1982. Cost-Benefit Analysis. George Allen & Unwin Ltd., London, UK.

Nelson, R. et al. 1996. A Cost-Benefit Analysis of Hedgerow Intercropping in the Philippines Using SCUAF. Paper 96/2 of Project "Improving Smallholder Farming Systems in *Imperata* Areas of Southeast Asia: Alternatives to Shifting Cultivation." ANU-CRES (The Australian National University – Center for Resource and Environmental Studies).

Nordhaus, W. 1993. Optimal Greenhouse Gas Reduction and Tax Policy in the 'DICE' Model. American Economic Review 82(2), 313-317.

Pindyck R.S. and D.L. Rubinfel. 1981. Econometric Models and Economic Forecasts. International Student Edition. McGraw-Hill Book Company, New Delhi, India.

Quy, V. 1997. Environmental Issues in Vietnam: An Overview. *In* Mercker, H.; P. H. Vu, ed. Environmental Policy and Management in Vietnam. German Foundation for International Development (DSE), Berlin, Germany.

Ranola, R.F. Jr. et al. 1997. Two Approaches for Estimating the On-site Costs of Soil Erosion in the Philippines. Paper 97/8 of Project "Improving Smallholder Farming Systems in *Imperata* Areas of Southeast Asia: Alternatives to Shifting Cultivation." ANU-CRES (The Australian National University – Center for Resource and Environmental Studies).

Rerkasem, B. and K. Rerkasem. 1996. Influence of Demographic, Socio-economic and Cultural Factors on Sustainable Land Use. 9th Conference of the International Soil Conservation Organisation (ISCO): Towards Sustainable Land Use: Further Cooperation Between People and Institutions. Bonn, Germany.

Shakya, P.D. and J. C. Flinn. 1985. Adoption of Modern Varieties and Fertiliser Use in Eastern Terai of Nepal. Journal of Agricultural Economics, 36(3), 409-419.

Sharma, V.P. 1997. Factors Affecting Adoption of Alkali Land Reclamation Technology: An Application of Multivariate Logistic Analysis. Indian Journal of Agricultural Economics, 52(2), 244-251.

Troeh et al. 1980. Soil and Water Conservation for Productivity and Environmental Protection. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA.

USDA (United States Department of Agriculture). 1998. Agricultural Resources and Environmental Indicators, 1996-97. Agricultural Handbook No. 712. Washington DC, USA.

Vermuelen, J. et al. 1993. Use of the SCUAF Model to Simulate Natural Miombo Woodland and Maize Monoculture Ecosystems in Zimbabwe. Agroforestry Systems 22, 259-271.

Young, A. 1987. The Potential of Agroforestry for Soil Conservation: Part II. Maintenance of Fertility. ICRAF (International Council for Research in Agroforestry) Working Paper No. 43. Nairobi, Kenya.

______ 1989. The Potential of Agroforestry for Soil Conservation and Sustainable Land Use. ICRAF (International Council for Research in Agroforestry) Reprint No. 39. Nairobi, Kenya.

Young, A. et al. 1998. SCUAF Version 4.0: A Model to Estimate Soil Changes Under Agriculture, Agroforestry and Forestry. ACIAR (Australian Center for International Agricultural Research). Technical Report 41.