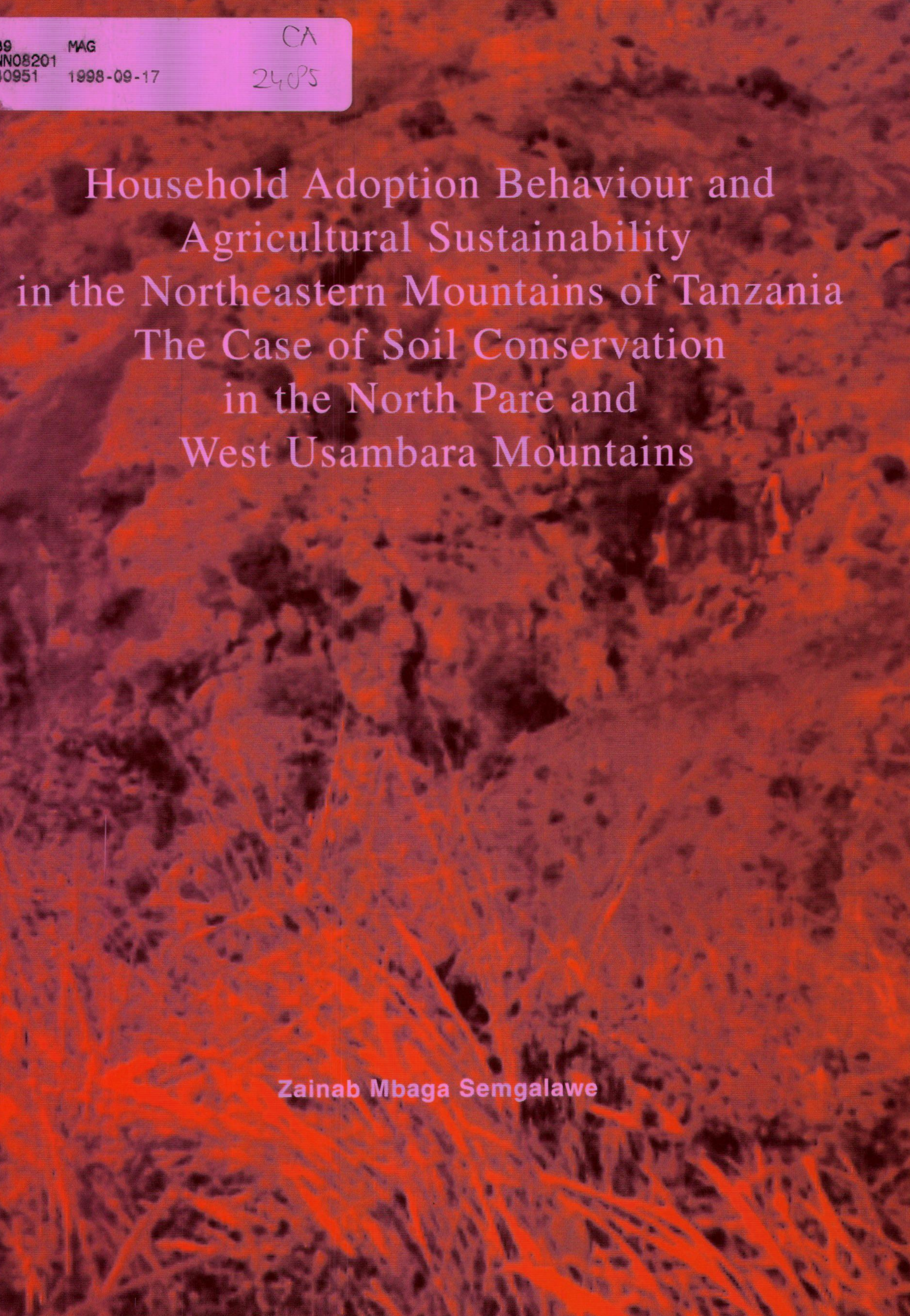

Household Adoption Behaviour and Agricultural Sustainability in the Northeastern Mountains of Tanzania The Case of Soil Conservation in the North Pare and West Usambara Mountains

Zainab Mbaga Semgalawe

Propositions

1. Adoption of improved soil conservation measures are means for achieving a sustainable production system in the northeastern mountains (*this study*).

2. Perception of soil erosion problem does not guarantee the use of effective soil conservation technologies in the northeastern mountains (*this study*).

3. SWC programmes play a key role in enhancing farmer's awareness of soil erosion problem and the use of effective soil conservation technologies (*this study*).

4. Adoption process is like learning how to walk: "one step at a time".

5. The "traditional" soil conservation practices should serve as the starting point for development of improved soil conservation technologies.

6. New farming technologies do not always fit into existing production system nor the policy context in which they operate.

7. Farmers may be unwilling to adopt new technology if the technology requires too much adaptation to farmers' conditions.

8. Technological shift must be backed by adequate research on technologies that reflect the needs, resource endowments and socio-economic circumstances of the users.

9. Attitudes towards a natural resource determines an individual's decision on conservation of a particular resource.

10. If you have never been hated by your child you have never been a parent (Bette Davis).

11. Perhaps the greatest social service that can be rendered by anybody to the country and mankind is to bring up a family (George Bernard Shaw).

12. Forget not those who attempted it before you. Had they refused to clear the way it would have been impossible for you to find the gold.

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In Memory of my mother, Zainabu-Mwaro Mndewa (Mama Asinan)

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CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Agricultural sustainability and land degradation

The concept of sustainability has drawn much attention from both politicians and economists in the world. The concept became popular through the the report of the World Commission on Environment and Development (WCED) of 1987, known as the "Brundtland report". In this report sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The report further emphasizes that the goals of economic and social development must be defined in terms of sustainability.

In Sub-Saharan Africa (SSA), agriculture contributes the largest share to social and economic development. In these countries it is impossible to talk about sustainable economic and social development without addressing the issue of agricultural sustainability, which means an increasing or non-negative trend in per capita productivity and efficient use of resources. Therefore, in order to achieve sustainable social and economic development, the agricultural sector in SSA should be managed in such a way that land productivity improves over time. This can only be achieved if pressure on land is minimized to avoid land degradation. Land degradation reduces agricultural productivity and land's potential uses, causing an adverse impact on economic and social development. The WCED report points out that there is a close linkage between poor economic and social development (poverty) and natural resource degradation. Poverty and population pressure lead to extensive cultivation of marginal land, such as steep slopes and fragile lands, increasing the risk of soil erosion (Kuiper, 197).

Land degradation is a serious problem in Sub-Saharan Africa. Oldeman (1992) reported that 14 million hectares in SSA are affected by physical degradation and 62 million hectares are subject to chemical degradation. Land area prone to accelerated water erosion in SSA is estimated to be 227 million hectares (Lal and Sigh, 1995).

Land use and soil management are the most important aspects of agricultural sustainability. Sustainable land use and soil management can only be achieved by using appropriate soil and water conservation technologies. Such technologies include those which are capable of reducing soil degradation, hence improve soil quality and water availability to crops.

1.2 Land degradation and soil conservation

1.2.1 Soil degradation

Different definitions of land degradation can be found in the literature. These definitions differ in some aspects but most of them indicate that soil degradation is a form of land degradation where soil erosion is its major component. Soil degradation is therefore defined as deterioration of soil quality, and hence its productivity potential, caused by nutrients loss through erosion and other processes such as leaching and salinity. Soil degradation processes consist of chemical, physical and biological processes, affecting the self-regulating capacity and productivity of the soil. These processes result in deterioration of soil structure, leaching and loss of organic matter. Factors responsible for soil degradation are both man-induced and natural catalysts. Man-induced factors include intensive cropping and inappropriate land use and management practices.

Different types or forms of soil erosion can be distinguished according to causal factors. The most important erosion forms are *water erosion* and *wind erosion.* Water erosion is classified further according to four forms based on the formation process. These forms are *splash erosion:* defined as detachment and transport of soil particles, resulting from the impact of rain drops; *sheet erosion*: whereby soil is removed by moving water in more or less uniform layers; *rill erosion:* defined as removal of soil particles by concentrations of flowing water, leading to deep rills; and *gully erosion:* which also involves removal of soil by concentrations of water, leading to gullies. Despite the differences in these forms, they are all induced by identical factors namely rainfall (precipitation), land form (relief) and vegetation cover.

Soil erosion reduces yield directly via poor seedling establishment, water logging and crop burial. Indirectly, erosion affects crops through loss of essential nutrients (nitrogen, phosphorous and potassium) and organic matter, moisture deficiency and general deterioration of the structure of the soil, as well as reducing the utilization efficiency of other inputs (Lal, 1985; Walker, 1982). Yield loss is not the only on-site effect of erosion, but there are other damages. These include: higher fertilizer application rates, and accumulation of stones at the field which have to be collected, thus increasing production costs (Lutz et al., 1994). Erosion also leads to damages of the environment surrounding the erosion site. Off-site effects of erosion include water pollution, sedimentation and siltation of rivers, lakes, dams, waterways and harbours and disruption of aquatic ecology. Siltation of lakes, rivers and dams has in some cases, reduced hydroelectric power generation leading to poor performance of the industrial and social services sectors. Another effect of erosion is the fact that it produces externality to future generation by reducing the capacity for agricultural production (Lal, 1995; De Groot, 1994; Pimentel et al., 1995; McConnell, 1983: in Kuiper, 1995).

1.2.2 Soil conservation

Soil conservation involves the use of biological and physical measures to offset the effects of land degradation. Biological or agronomic measures refer to farming practices, which help to minimize erosion, improve fertility and soil structure. Examples are contour cultivation, strip cropping, use of crop residue and mulching. Biological measures also include cropping practices such as crop rotation, intercropping, agroforestry and others. Physical or structural measures include earthworks aimed at controlling and diverting the runoff in arable areas. These measures are applied to maximize infiltration, to drain excess water from rain storms and to retain moisture in the soil for plant use. Examples of physical measures are terraces, cutoff drains and infiltration ditches.

Biological measures are easy to adopt and hence widely used, because they involve routine farming practices. Physical measures which sometimes involve changing land form are difficult to implement and hence their use is limited. Therefore, successful adoption of physical measures depends on farmer's willingness and ability to voluntarily construct and maintain them.

Soil conservation is an economic activity which involves costs. Short-term investment costs are often mentioned as the main determinant of adoption decisions for soil conservation measures. High short-term investment costs are associated with lower adoption of soil and water conservation technologies (SWC)[1]. In this regard, monetary variables, such as income, access to credit, financial support and off-farm income are considered important factors influencing investment in SWC measures. The fact that the returns of soil conservation are realized in distant future discount rates, planning horizons and risk are additional factors.

no, they are the main factors

1.3 The soil degradation problem in Tanzania

Land degradation caused by soil erosion has been a major environmental threat to agricultural development in Tanzania. Many parts of the country have been experiencing severe soil erosion. The rate of soil loss in selected areas of the country increased from 1.4 tons/ha/year in 1960 to 105 tons/ha/year in 1965 to 224 tons/ha/year in 1980 (MTNRE, 1994). Factors such as population growth, deforestation and poor farming techniques have been cited as the cause of the soil erosion problem. It has been established that population growth has resulted in increased human activities and land demand. These have triggered overgrazing, deforestation and use of inappropriate farming methods, thus causing soil erosion. Population increased from 21 million in 1984 to 28 million in 1994 (Table 1.1). It has been estimated that between 300,000 and 400,000 hectares of forest are cleared every year to meet the increased demand for farmland, timber and firewood (Bagachwa and Mbelle, 1994) while tree regeneration and replacement is only 25,000 hectares per year (Mayawalla, 1994).

Table 1.1: Tanzania: Population 1963 - 1994 (Million)

Year	1963	1967	1972	1977	1980	1984	1987	1990	1994
Popul	11.11	12.26	14.00	16.92	18.58	21.06	23.33	25.63	28.24

Source: Tanzania Bureau of Statistics, 1990; World Bank, 1969-1995.

[1]Whenever the term "soil conservation" is used we refer to "soil and water conservation" (SWC).

The severity of soil erosion is visible in most parts where fertile top soil has been washed away, exposing poor, unproductive subsoil. The red brown colour of streams and silting up of dams and reservoirs downstream are evidence of soil erosion from the mountain areas (MTNRE, 1994). Stoovogel and Smaling (1990) have estimated that the annual net average removal of nitrogen from agricultural land in Tanzania is about 27 kg N/ha and annual removal of phosphorous is 4 kg/ha. These figures indicate that the resource base for agriculture in Tanzania is eroding very fast. It is therefore evident that land productivity and per capita food production will continue to decline unless measures are taken to reverse the situation (Aune, 1994). Maize productivity in the northeastern highlands of Tanzania, for example, is predicted to drop from 3,000 kg/ha to 2,000 kg/ha within a period of 15 years at 25 tons/ha of soil loss (Aune and Lal, 1995).

1.4 Soil conservation policies in Tanzania

Soil and water conservation has been identified as a problem since the colonial era. The British colonial government established the Soil Conservation Committee in 1930 to guide and advise the government on soil conservation issues. This committee developed policies, programmes and plans for soil conservation in the country. On the advice of this committee the government adopted a land use improvement policy which focused on reduction in the number of livestock, ridge cultivation, construction of terraces in mountain areas, gully control and rotational grazing. Successful implementation of this policy was recorded in early 1950 (Sianga, 1994). However, due to problems related to the top-down approaches used to implement this policy, most farmers had abandoned soil conservation measures introduced in their areas by late 1950. This was mainly because the colonial government did not instill awareness in people about the land degradation problem and its detrimental impact on land productivity in the areas concerned. In addition to this, the needs and indigenous knowledge of communities involved in implementation of this policy were not explored and incorporated into designing the land use policy. In some cases, force was used to accelerate adoption of these technologies. Therefore, due to hard work and high labour demand involved in making terraces and other physical soil erosion control structures, people (especially in the eastern and northeastern mountains) associated the activities of land use policy with colonial oppression, imposition of irrelevant interventions and restrictive colonial regulations. This led to resistance against this policy (Sheinmann, 1986; Sianga, 1994).

After independence, soil and water conservation received low priority. The main reason for this was that during the independence struggle land use policies and programmes were cited by local leaders to condemn the colonial government. As a result, the enforcement of land and water conservation laws was neglected, resulting in uncontrolled use of natural resources (e.g clearing forests for agricultural use, cultivation in very steep slopes and along river banks). This resulted in an alarming land degradation.

The impact of soil degradation on agricultural production was evident by 1980. The efforts to reduce land degradation were initiated and were made an integral part of agricultural and natural resources policies. In 1983, the National Environmental Management Council (NEMC) was established to coordinate and advise on environmental problems and conservation activities. The council became the central organ to monitor and ensure proper utilization of natural resources (land, water and atmosphere). The key responsibility of this council is to formulate environmental policy and to ensure that policies, including those for development and conservation of natural resources take adequate account of environmental effects. Soil conservation programmes and research activities were also initiated in various areas to address land degradation problems. Institutions such as the Natural Resource Board and the National Land Use Commission were created to support and guide natural resource conservation programmes. Other actions include the development of soil and water conservation programmes and a National Forestry Action Plan.

1.5 Tanzanian agricultural sector

Tanzania has been experiencing a declining rate of economic growth over the past twenty years. This is partly attributed to poor performance of the agricultural sector, which is the main source of national income, employment and export earnings. As indicated in Table 1.2, in 1996 agriculture provided 55.7% of total GDP compared to the industrial sector (6.5%) and mining (1.4%) (Bank of Tanzania, 1996).

The growth rate of agricultural productivity has been declining since 1970. This situation has mainly been caused by various environmental, economic and technical factors such as land degradation, population growth, institutional failures and poor technological advance. Poor performance of the agricultural sector has led to declining domestic per capita food production, increased rate of food grain imports, decreasing rate of agricultural exports and lower per capita GNP (World Bank, 1992; FAO, 1980). This situation has made the country unable to attain its long-term objectives of food self-sufficiency and sustainable economic growth.

In 1980 the Tanzania government, in response to poor performance of the agricultural sector and realizing its role in economic growth, reoriented its development policies, which were initially biased towards supporting the industrial sector. These changes were aimed at promoting the agricultural sector. In 1982 the agricultural policy was formulated to provide guidelines and strategies for supporting the development of agriculture. The policy emphasized higher producer prices, increased agricultural credit, improved agricultural marketing services, expanded agricultural research and extension services, and placed emphasis on mechanization and long-term land tenure to farmers. The implementation of this policy included the identification of potential areas for food crops, followed by 50%-80% increase in food crops producer prices. Furthermore, research institutions were restructured to improve their efficiency in developing farmer-oriented technologies. The link between research and extension was strengthened to ensure smooth dissemination of technologies to farmers. Rural Development banks were expanded to improve farm credit, and the agricultural marketing system was reorganized to improve efficiency. Along with the agricultural policy the government initiated structural adjustment programmes (SAPs) aimed at improving the performance of the economy as a whole. These include the Five-Year National Economic Recovery Programme (ERP I) of 1981, which addressed the problem of food scarcity and foreign earnings. This policy was followed by the three-year Structural Adjustment Programme (SAP) which started in 1983 to restructure economic activities, rationalize production and improve planning and control mechanisms. Another Economic Recovery Programme (ERP II) was initiated in 1986 for three years. Measures related to the agricultural sector in the SAP and ERPs included increased producer prices and interest rates and crop trade liberalization.

Despite the fact that economic policies and programmes are important in improving, supporting and guiding the development of the Tanzanian economy, it is important to realize that sustainable development of the agricultural sector, and rural development in general,

Table 1.2: Contribution of different sectors to total GDP (% share)

Year	Total GDP*	Agriculture	Industry	Mining	Other sectors
1985	101,684	50.8	9.6	0.3	39.3
1986	108,389	51.9	9.4	0.4	38.3
1987	114,775	49.8	10.6	0.5	30.1
1988	121,598	59.9	7.3	0.5	32.3
1989	126,049	58.3	8.9	0.4	31.8
1990	132,813	54.3	8.9	1.0	36.4
1991	140,384	56.1	7.9	1.4	34.6
1992	145,682	54.8	8.2	1.9	35.9
1993	151,398	54.8	7.9	1.4	35.9
1994	155,991	54.8	7.3	1.6	36.3
1995	163,003	56.8	6.7	1.4	35.1
1996	170,657	55.7	6.5	1.4	36.4

* Million TZS, at factor cost by industrial origin
Source: Bank of Tanzania, 1996

depends on how natural resources are utilized and managed at farm level. The agricultural development policies together with various institutional support strategies such as prices, exchange rates, credit schemes, land tenure and resource rights need to be reoriented to encourage adoption of appropriate soil conservation technologies, to improve long-term farm income and land productivity. Efforts should be aimed at assessing the behaviour of farm households towards adoption of soil conservation technologies and the long-term impact of various conservation measures on the productivity and welfare of the farm households. Since some of the soil conservation technologies, especially those related to soil erosion, involve large investments, such investments need to be assessed to establish their long-term impact on the ecological sustainability and the well-being of society.

1.6 Aims of research

1.6.1 *Problem statement*

The northeastern mountains make up the major part of agricultural land in Tanzania. These areas have been experiencing rapid population growth, leading to increased demand for food, fuelwood and agricultural land. It has been observed that, due to this condition together with continuous changes in the social and economic situation, farmers have resorted to various land use systems and land management practices that meet their multiple socio-economic goals, namely increased food production, fuelwood and income. They have also expanded the amount of land dedicated to agriculture and settlement by forest clearing and cultivation of marginal lands and other practices. While some of these practices have resulted in short-term increased productivity and economic returns, they accelerated degradation of the natural resource base. Most parts of the slopes have been experiencing declining soil fertility and severe soil erosion. As a result, agricultural productivity has declined, leading to serious food shortages (Figure 1.1).

1.6.2 Research focus

The northeastern mountains have a long history of external efforts to reverse soil degradation and to improve land productivity through soil and water conservation techniques. Several institutions and organizations have been involved in developing effective (improved) soil conservation technologies through development projects and programmes. Most of the technologies introduced in the area consist of components such as soil erosion control, water harvesting techniques, afforestation and irrigation. Though the increase in yield recorded in some of these areas is believed to have resulted from these interventions, there is no evidence of their adoption rate and distribution at farm level. Just and Zilberman (1985) observes that in developing countries introduction of many new technologies has met with only partial success as measured by observed rates of adoption, due to constraints to rapid adoption such as lack of credit, limited access to information, risk aversion, labour and capital shortages. Though many development projects have attempted to remove some of these constraints to enhance adoption, this expectation have been only partially realized. Some innovations have been adopted by only a very small group of farmers while some of them are partially adopted or abandoned after sometime. Ervin and Ervin (1982) observe that unsustainable adoption of soil conservation measures is due to a lack of an understanding of the relationships and interactions between farm operators and factors that influence their behaviour towards

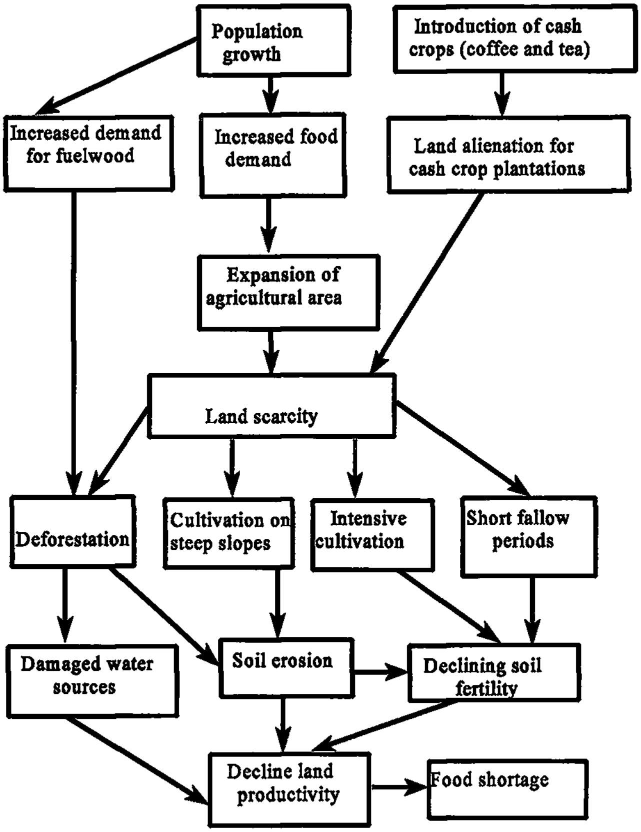

Figure 1.1: Land degradation in the northeastern mountains

adoption of these technologies.

In order to develop soil conservation strategies that will enhance sustainability of agricultural production systems in the northeastern mountains, the improved soil conservation technologies introduced through soil and water conservation (SWC) programmes need to be assessed not only in terms of their technical performance, but also in terms of their acceptability by land users. The assessment needs to consider all economic and non-economic factors which influence "household's" decisions[2] on investment in improved soil conservation technologies. These factors include those related to household's characteristics, beliefs and attitudes; institutional and economic incentives and physical characteristics of the land. Such an assessment will provide a useful guide for designing appropriate and sustainable soil conservation technologies and help to identify, assess and design effective soil conservation programmes and support services for the study area.

In the northeastern mountains, there is little empirical research, which has integrated farm households' behaviour and adoption of soil conservation measures. Therefore, the main objective of this study was to develop an empirical model at farm level for explaining farm household attitude towards the soil erosion problem and adoption of soil conservation measures to reduce soil erosion and reverse declining soil productivity in the northeastern mountains. The study was also intended to examine implications of household's adoption behaviour for policies and institutional support for the study area. The study was particularly intended to answer the following questions:

1. What influences the household's perception of the soil erosion problem?

2. What influences the household's decision to adopt different types of improved soil and water conservation technologies?

3. What influences efforts devoted to soil and water conservation among adopters?

4. How can policies and institutional support be reoriented to ensure sustainable use of soil and water conservation technologies?

The study was expected to link the household's attitude towards soil erosion problem to his adoption behaviour. The aim was to develop a farm household adoption model for the study area which will provide the basis for estimating sustainability of the agricultural production system. The empirical model of farm household adoption behaviour will help to identify policy options and institutional support programmes critical to sustainable adoption of soil and water conservation technologies, given the current land use intensification and population growth rate in the study area.

1.6.3 Theoretical approach

Adoption behaviour in this study has been analysed based on the economic utility maximization theory and the socio-economic theories and models of innovation adoption

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[2]Household/farm household in the context of this study is defined as a group of people who jointly work and depend on the same piece of land and other production resources. Although we recognize the intra-household decision making interactions, we assume that the head of a household makes all the production decisions. Therefore, the term household/farm household or farmer as used refers to individual head(s) of households. Also, although we recognize that many farmers in the study area are women and in our study we involved several of them, the standard practice of using themasculine form of the third person pronouns is followed to avoid using he/she and his/her.

elaborated on in chapter 4. The hypothesis is that rational farm households have production preferences expressed in terms of expected utility. Their goal is to maximize this utility in terms of profit, given the production technology alternatives they have. The households therefore chooses those production technologies which are perceived to maximize profitability subject to the resource constraints and production preferences they possess, conditioned by household characteristics, social factors and institutional environment. This implies that the adoption of soil and water conservation measures and efforts devoted to conservation activities are influenced by the household's preference for higher farm profit. But the preference for higher profit is determined by personal characteristics of the household (e.g age, education), sociological factors such as social status, social networks and attitude and institutional factors like extension services and development programmes. Therefore, the framework to explain adoption behaviour of farm households in this study uses an interdisciplinary approach, whereby both economic and sociological decision variables are integrated to explain farm household's adoption decisions.

Many adoption studies show that the economic approaches define households as independent entities whose decisions are determined by intra-household economic conditions such as farm size, expenditure level, income, credit and labour. Little attention has been paid to inter-household social dynamics and institutional factors, which can have profound effects on how the household perceives and manipulates his environment. Economic variables alone, which represent the perceived profit incentive from adopting new technologies do not provide a strong basis for determining adoption behaviour of the farm household. Sociological variables play a key role in explaining household's preferences. Adoption of new technologies is to a large extent influenced by household characteristics and/or sociological factors. It is understood that these factors have an influence on a person's behaviour and hence determine the farm household's interest in new innovations and his willingness to acquire information. It is therefore believed that social status and existing social interactions influence household's access to resources, such as labour required for applying soil and water conservation measures and technical support from extension agents and soil and water conservation programmes. Also, farm household's attitude towards soil conservation and his perception of the seriousness of the erosion problem explain variations in adoption of SWC technologies among farm households. This is determined by knowledge about soil erosion, beliefs and values which a person holds on the occurrence and existence of soil erosion and its detrimental impact on agricultural productivity.

Many authors recognize the overriding need for an interdisciplinary approach to adoption of soil conservation technologies. Ervin and Ervin (1982) have developed a farmer decision-making framework for using soil conservation practices, which incorporates farmer's personal characteristics, physical factors, economic factors, institutional factors and sociological aspects such as perception and attitude towards soil conservation. Napier et al. (1991) used the interdisciplinary approach to examine social, economic and institutional factors, which affect the adoption of soil conservation practices at farm level in Asia. Other research which relates adoption of soil conservation practices to various socio-economic factors included farm operator's characteristics, farm economic aspects and erosion potential (Pampel and van Es, 1977; Gould et al., 1989; Nowak and Korsching, 1979).

This study considers household decision making on adoption of soil conservation technologies a dynamic process involving three stages: 1) perception of the soil erosion problem explained by the household's knowledge about soil erosion and attitude towards occurrence of soil erosion; 2) adoption of soil and water conservation technologies, focusing on whether or not a farmer uses improved soil and water conservation measures, and 3) efforts devoted to soil conservation, explained as the household's level of investment in improved soil conservation technologies. We conceptualize that adoption of soil conservation measures is a decision-making process with three sequential stages. Each of these stages is influenced by personal, socio-economic and institutional factors. Furthermore, we hypothesize that household's decision to use improved soil conservation measures is determined by his willingness and ability to use the improved soil conservation technologies. In the context of this study sustainability of the agricultural production system depends on the decision taken by the households to offset soil degradation and their ability to sustain conservation efforts.

1. 7 The study area

The northeastern mountains include four mountain ranges in the northeastern part of Tanzania. These are the Kilimanjaro, Meru, Pare, and Usambara mountains (Figure 1.2). These mountains have common physical features, environmental conditions, land use potential and socio-economic conditions.

A study designed to address the objectives of the study was carried out in 1995/1996 in the west Usambara mountains (Lushoto district) and the north Pare mountains (Mwanga district). In selecting the study sites our main concern was to have larger, comparable areas of the northeastern mountains and an adequate number of adopters and non-adopters representing different socio-economic, technical and institutional situations, such as the time period SWC programmes have been operating in the area (i.e., level of exposure to improved SWC technologies), rather than trying to capture the differences in adoption of SWC technologies between the two areas. The most important selection criterion was based on the fact that the two districts share a lot of historical characteristics and have comparable land use systems and socio-economic situations. In addition to this, these districts have two similar integrated soil and water conservation programmes under the support of Technical Aid of Republic of Germany (GTZ) and the Dutch Volunteer Service of the Netherlands (SNV). The GTZ Soil Erosion Control and Agroforestry Programme (SECAP) has been operating in the west Usambara mountains for the past sixteen years. The focus of the programme is to promote and strengthen soil and water conservation measures and agroforestry systems so as to increase soil productivity. A sister project was initiated in the north Pare mountains about four years ago with the same objective. Activities of SNV started in the two areas five years ago focusing on improving traditional irrigation. Soil erosion control is a major pre-condition for household access to irrigation facilities. Therefore, the west Usambara and the north Pare mountains, in addition to providing a wide range of socio-economic situations, provided a reasonable sampling frame for both adopters and non- adopters of soil and water conservation measures with different levels of conservation exposure and participation in SWC programmes, attributed to the time difference SWC programmes have been operating in the two areas.

The farm-level data was collected from a sample of heads of households drawn from the two study sites. The heads of households were interviewed using a structured questionnaire. The interviews focused on household characteristics, socio-economic aspects

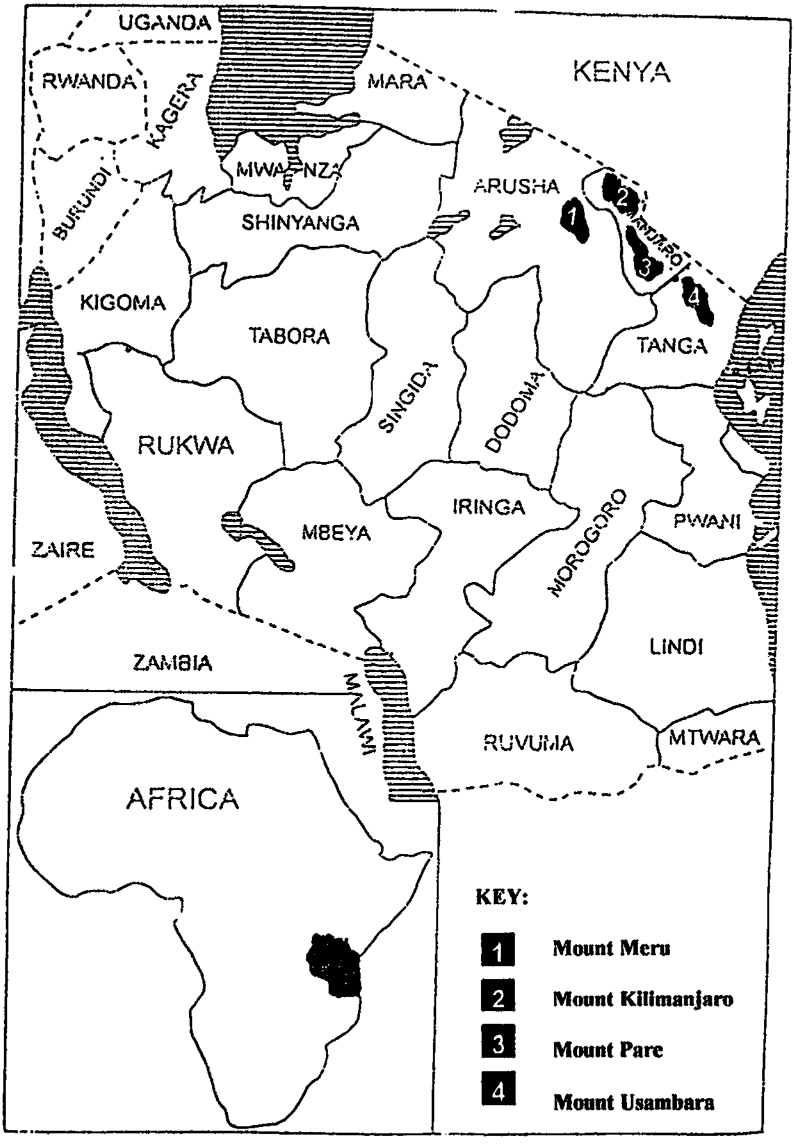

Figure 1.2: Location of the northeastern mountains

of the soil erosion problem, soil conservation measures used, beliefs and attitude towards soil erosion and conservation, participation in soil conservation support programmes, extension services and economic attributes such as income, farm size, labour, livestock herd size, and wealth level. We also assumed that information sources and institutional support, such as SWC programmes and extension services, play a key role in enhancing adoption of soil and water conservation innovations. Therefore, the interviews paid attention to household's access to various information sources and whether or not the head of the household participated in SWC programmes. Our main objective was to capture the differences in household characteristics and socio-economic situations between adopters and non-adopters.

1.8 Outline of the study

Chapter 2 provides an overview of the physical and environmental description of the northeastern mountains. Aspects discussed include an environmental description of the study area, focusing on physical features, climate, land use and cropping patterns, population and settlement pattern and the soil erosion problem. This is to help us gain a better understanding of the research problem and to provide the basis for analytical framework presented in chapter 5. We also provide a historical review of land degradation and soil conservation activities indicating the important factors which have played a role in accelerating land degradation, and people's reaction to the consequences of land degradation. The traditional soil conservation practices currently used in the area are outlined together with improved technologies introduced by soil and water conservation programmes. In chapter 3 we develop the conceptual framework for the study. First we discuss concepts, definitions and interrelationships between various components and indicators of soil conservation and sustainability found in the literature together with economic approaches used to measure sustainability. The operational definition of sustainability and the conceptual model for the study are then developed to explain the links and interrelationships between various factors associated with land degradation in the study area and the aspect of sustainability. We pay attention to the role played by the household's conservation decisions in determining sustainable soil productivity and factors influencing these decisions. Lastly, we examine important economic theories and concepts underlying soil erosion and soil conservation.

Chapter 4 discusses sociological and economic theories and models explaining the innovation adoption process. In addition we provide a review of empirical studies on adoption of soil conservation technologies to indicate how sociological and economic theories have been applied to explain household behaviour towards adoption of soil conservation technologies.

Chapter 5 presents the theoretical model/framework for assessing factors which influence adoption of soil conservation technologies in the study area. The conceptual model developed in chapter 3 together with the economic and sociological theories discussed in chapter 4 are integrated to develop the analytical approach, indicating the household's adoption decision making process conceptualized for the study. Chapter 6 explains the procedure and methods of data collection and organization. The design of field work is outlined indicating problems and limitations encountered, which may influence the accuracy and reliability of data. In chapter 7 the estimated empirical models for explaining perception of the soil erosion problem, adoption of SWC technologies and conservation efforts are presented and discussed in relation to the theoretical model/framework devised in chapter 5. Chapter 8 presents the summary and main conclusions of the study. The implications of the findings for soil and water conservation programmes and institutional support in the study area are highlighted. Also, further research areas on the use of soil and water conservation technologies are discussed.

CHAPTER 2

ENVIRONMENT, LAND DEGRADATION AND SOIL CONSERVATION IN THE NORTHEASTERN MOUNTAINS

2.1 Introduction

The profile of the agricultural potential in Tanzania described by the Land Resource Development Centre (LRDC) categorizes the country according to six resource zones using physical environment, resource endowment and land use potential as the zonation criteria. The northern highland mountains is one of the six resource zones identified. This area includes four major mountain ranges in the northeastern part of Tanzania. These are the Kilimanjaro mountains, Meru mountains, Pare mountains and Usambara mountains. According to this classification, these mountain ranges have common physical features, resource endowment, land use systems and agricultural production potential (LRDC, 1987; Conyers et al., 1970; Kocher, 1976; Berry; 1977).

The northeastern mountains comprise steep slopes located at high altitudes. The mountains have an altitude range between 600 m to above 3000 m. The highest point can be found at the snow-capped Kibo peak of mountain Kilimanjaro, which is at 5,895 m above sea level, the highest point in the continent of Africa. At lower altitudes the slopes are gentle with a gradient of 0-10% and at higher altitudes the slopes are very steep, with a gradient often exceeding 30% (Conyers, 1970; Feierman, 1984; Anderson, 1982).

This chapter provides an overview of the physical and environmental conditions of the northeastern mountains focusing on physical features, climate, land use and cropping system, population and settlement pattern and the soil erosion problem. A historical overview of the land degradation problem and soil conservation activities is given, together with traditional and improved SWC measures used in the area. The discussion is focused more on the study area, the Pare and Usambara mountains.

2.2 Physical environment

2.2.1 Physical features

The Pare mountains occupy 10,000 square kilometres of land with steep ridges sloping down towards plains on either side (Lebulu, 1979). The mountains comprise of two mountain ranges south of the Kilimanjaro mountains, namely North Pare and South Pare mountains. The North Pare mountains can be found in Mwanga district and they occupy about 2,600 km^2. They consist of extensive highland plateaux separated by steep slopes from the surrounding plains with an altitude ranging from 800 m to more than 2200 m. (Land Resource Development Centre, 1987; Mshana, 1992; Kimambo, 1991).

The Usambara mountains are bordered by the Pare mountains in the northwest and the Masai steppe in the south. The mountains are divided into two mountain blocks known as west

Usambara and east Usambara mountains. The west Usambara mountains occupy 90% of the total area of Lushoto district (3500 km^2). They rise from the surrounding plains at about 600 metres above sea level to more than 1900 metres above sea level. The highest point can be found at 2300 metres above sea level. The eastern block is situated at a lower altitude of about 1200 metres above sea level (Mwihomeke, 1986; Kajembe, 1994).

The soils in the west Usambara mountains are mainly humic ferralitic and feralsols of high altitudes. These soils have a dark-red topsoil with a relatively high humus content if not eroded (Lundgred, 1978; SECAP, 1987). The soils in the north Pare mountains were originally fertile, but currently are highly eroded with low organic matter, nitrogen and phosphorous (Fungameza and Frischenich, 1992).

The mountains have several permanent and seasonal rivers and streams flowing through the slopes. Most of them originate from the sub-surface of forest reserves.

2.2.2 Climate

The areas have two rainy seasons (bi-modal). Short rains fall in October through December, and long rains from March to May, with peaks in November and April respectively. The mean annual rainfall in Usambara mountains ranges from nearly 2,000 mm a year in the southeastern part to 650 mm in the northwest (Feierman,1984). The Pare mountains have a mean annual rainfall ranging from 800 mm to 1,600 mm. Due to mountainous relief these mountains experience rainfall variations in terms of amount, duration and distribution. Some parts experience longer rainy seasons, while others have shorter ones. The areas located at high altitude receive much more rainfall than other parts. For example, the humid-warm zone of west Usambara slopes at an altitude of 1000 m to 1300 m receives up to of 1700 mm rainfall annually. The mountains have tropical mountain temperatures. Cool temperatures usually occur between May and August, with an annual mean maximum temperature of 16.4°C. Warm temperatures are between January and April, with an annual mean maximum temperature of 31.7°C (EAMD, 1975).

2.2.3 Land use and cropping systems

The intensity and type of land use in the study area are mainly influenced by climate, socio-economic factors and population. The slopes of the north Pare mountains are intensively cultivated with arabica coffee, bananas and shade trees, maize, beans, cassava, yams and sweet potatoes. Coffee and bananas are generally cultivated in all areas above 800 m, in intensive homegardens. Maize and beans can be found on gentle and steep slopes. Coffee is the main cash crop in the area, while bananas, maize, beans and cassava are the main food crops. The average farm size per household is 0.5 ha.

The main crops grown in the west Usambara mountains are: maize, beans, round potatoes cassava, sugarcanes, tea, vegetables (tomatoes, onions, cabbages) and temperate fruits (pears, apples and plums). Vegetables and fruits are the main cash crops. They are grown in valley bottoms, while fruit trees can be found on both slopes and in valley bottoms. Beans, round potatoes and maize are grown on gentle and steep slopes of the mountain. Tea is grown by both smallholder farmers and on large-scale commercial tea plantations. The smallholder farm size in west Usambara mountains varies from 0.7 to 4.1 ha, with an average size of 2.5 ha per household (SECAP, 1987; Svein, 1991).

Both the west Usambara and north Pare mountains have a diverse and fragmented land holding pattern. The average farm household has an average of about 6 scattered plots at an average walking distance of 40 minutes from the homestead. There is also severe land scarcity attributed to the high population. This has created stronger individual relationships with land and possessiveness about land rights. The situation is explained by the increasing number of land disputes. A household without land or with severe land shortage can acquire additional land through purchasing or borrowing. Land can be purchased by paying money or in case of the north Pare mountains, through the traditional arrangement (*mbuta*), where the buyer gives the landlord a potful of local beer, *dengelua,* annually. However, given the existing land shortage problem, land purchase is not common (Mshana, 1992). In most cases farmers borrow a plot of land from a neighbour, friend or relative to cultivate for one or more seasons. This is only possible when for one reason or another, the land owner is unable to cultivate all his plots.

Cattle keeping under zero-grazing is common among the smallholder farmers in the north Pare and west Usambara mountains. Cattle are permanently housed and fed on crop residues and pastures in their stalls. On average farmers keep 1-3 cattle and several local goats and sheep. Forestry is also important in the area. Parts of the mountains are production forests. These are important sources of indigenous hardwoods. In the west Usambara mountains there are some soft wood plantations. Also, the slopes have remnants of many plant species where small-scale beekeeping is practised (Scheinmann, 1986).

Intercropping is a common farming practice in these areas. Usually maize is intercropped with beans and other food crops. In some cases sugarcanes and trees are intercropped with food crops.

2.2.4 Population and settlement patterns

The mountains are occupied by people originating from various parts of the country and the neighbouring country, Kenya. The ancestors of the major proportion of the inhabitants of the north Pare mountain are said to have originated from the Kilimanjaro mountains. They moved to these mountain slopes due to clan conflicts in the early 19th century. There were also some movements of people from the Usambara mountains to the Pare mountains and vice versa.

The northeastern mountain slopes are among the most densely populated areas in Tanzania. As indicated in Table 2.1, total population in the two mountain ranges is about 710,094 people (1988 census). At altitudes between 1000 m and 1800 m population density is as high as 700 people per km^2 . Average population density in the West Usambara mountains is 102 people per km^2 . The Pare mountains appear to have a lower population density. This is because the population presented here includes the sparsely populated lowlands. The population density in the north Pare mountains is estimated to be 200-150 and 22-50 people per km^2 in the highlands and lowlands respectively (TFAP, 1992). In 1996, population in the north Pare mountains was estimated to be 120,050 with an average population density of 110 people per km^2 .

In the Pare mountains people live in villages located at high elevations. The villages consist of scattered homesteads surrounded by intensive coffee/banana homegardens. In the Usambara mountains people live in villages consisting of clusters of homesteads with about 60 - 80 households. In each cluster of homesteads, the fields run downhill from the homesteads.

Population is unevenly distributed and is directly related to agroecological potential and accessibility.

Table 1: Population for Usambara and Pare mountains

Mountain range	Population	Households	Average household size	Average density (people per km^2)
South Pare	170,053	30,012	5.7	30[c]
North Pare	98,260	17,487	5.5	45[c]
Total for Pare mountains	268,313	47,499	5.6[a]	37.5[a]
West Usambara	357,531	60,247	5.5	102
East Usambara	84,032	15,333	5.5	48
Total for Usambara mts.	441,563	75,580	5.5[a]	75[a]
TOTAL/AVERAGE	710,094	123,079	5.5[b]	74.6[b]

[a] Figures indicate averages for the area
[b] Figures indicate total average for study area
[c] Figures include the sparsely populated lowlands

Source: Bureau of statistics, 1993

2.3 Land degradation and soil conservation

2.3.1 Historical overview

In the beginning of the 18th century most of the northeastern mountains were covered with natural forests. The major part of arable land was uncultivated, covered with natural vegetation. Land was owned by clans and the clan chief was responsible for allocating land to clan members. Once allocated to the household land became an inheritable property. Shifting cultivation and fallow practice were used to maintain soil fertility. Farmers cultivated the virgin land for two years and opened up new land to allow soil regeneration (Ruthenberg, 1969; Scheinmann, 1986).

In the 1920s the population started to increase at a very fast rate. As the population increased, more land was put into cultivation. By 1936 all arable land was under cultivation. At this point pressure on land became severe, leading to land scarcity. Also, soil conservation practices (shifting and fallow cultivation) could not be applied anymore.

Land alienation by the German and British colonial governments also contributed to land pressure. In the 1950s considerable areas of land were taken by the European settlers for establishing coffee and tea plantations in the Kilimanjaro and Usambara mountains respectively. In addition, more land was alienated as forest reserves, thereby squeezing people into a smaller land area.

In response to increased land scarcity at high altitudes farmers acquired lands in the low land for cultivation of annual food crops, mainly maize, beans and rice. Also, in trying to meet their land needs, farmers resorted to cultivation of very steep slopes and encroachment of forests, valley bottoms and wetlands, which play a key role in the protection of the environment. People started to clear parts of natural forests for crop production, livestock grazing, settlement and firewood. As a result of these practices, most of the soil cover was removed, river and springs dried up and land productivity started to decrease due to soil degradation. However, Ezaza (1992) observes that land scarcity attributed to population pressure is not the only cause of natural resource degradation in the northeastern mountains. Socio-economic factors such as traditional values and economic policies have also contributed to influencing people's perception and behaviour towards resource utilization. Introduction of poll-tax, for example, led to increased cash needs. This together with introduction of smallholder cash crops (coffee and tea) triggered the demand for land to cultivate tea and coffee in order to meet the increased demand for cash (Ezaza, 1992). environment

Together with expanding agricultural land, farmers adopted various land management and soil conservation practices aimed at improving soil productivity. Such practices include mulching, crop rotations, intercropping and minimum tillage. Also, farmers started to transport manure from livestock barns to food and cash crop fields near the homesteads and valley the bottoms. Irrigation structures such as furrows were developed to transfer water from the rivers and streams to fields during the dry seasons. At the same time an intensive cultivation system was developed to improve the productivity of the coffee/banana homegardens. In addition to farmers' efforts the colonial government initiated various activities aimed at reversing the soil degradation problem in the mountain areas. These included research programmes on soil loss, advisory services and introduction of physical measures for reducing soil erosion. In 1930s several conservation trials were conducted in the northeastern mountains. Demonstration plots were also initiated to make farmers aware of the use of soil conservation measures to maintain soil fertility.

In 1947 the British colonial government introduced several soil conservation techniques in different areas under the Land Usage Schemes (LUS). The schemes were enforced in the Usambara and Pare mountains between 1946 and 1958. The objectives of these schemes were: 1) to develop an agricultural production system which would rehabilitate eroded areas and 2) to generate information and experience on soil conservation. The focus was on controlling land degradation and ensuring that land could be cultivated without damaging the soil. The main activity was to reduce soil erosion in order to improve crop yield. Activities of LUS included construction of bench terraces and tie-ridges, contour cropping, demarcation of forest boundaries and tree planting. In addition, LUS included introduction of new cash crops and on-farm demonstrations of improved agricultural practices. Together with these activities laws were passed to the local authority (chiefs) to put into effect. The laws prohibited cultivation on slopes over a certain degree of steepness; mandatory tree planting on hill crests; prohibited cultivation of land near the streams and grass burning. Each household was required to construct terraces and a 10-yard wide contour strip of permanent crops in at least half an acre of fields with slopes exceeding 25% and slopes under 25% respectively. The agricultural staff were mobilized to enforce these laws. The chiefs and extension personnel turned police, forcing people to implement LUS activities and laws. A large number of people were prosecuted by chiefdom courts for not implementing LUS conservation measures or breaking LUS laws. As a result, LUS as well as extension personnel became unpopular among people. This led to passive resistance against the schemes and in some areas protest meetings and riots occurred. In 1955 the scheme collapsed (Kimambo, 1991; Mshana, 1990).

After independence in 1961, there was very little mention of the soil conservation measures. The colonial soil conservation laws received no emphasis and people started to cultivate in formerly prohibited areas like on very steep slopes and in forest reserves. In 1963 the district authority in the west Usambara mountains for example, allocated 36,000 ha of Shume Forest Reserve to farmers for cultivation to ease the land scarcity problem. Agricultural development programmes did not include soil conservation as a major theme either. Research efforts on soil conservation received minimum attention and emphasis was put on the introduction of technologies with short-term returns such as new crop varieties and chemical fertilizers among other things.

By 1970 destruction of natural resources in northeastern mountains became severe. In the Usambara and Pare mountains major area of forests were cleared for agricultural production. Some of the natural forests and woodland were turned to grazing areas. Continuous cultivation on the gentle and steep slopes made the soil loose and bare with little cover. These conditions accelerated soil erosion by water, even from low intensity rainfall (Shelukindo, 1993; Shenkalwa, 1989; Kimambo 1991).

2.3.2 The soil erosion problem

Soil erosion is the most serious problem on the slopes of northeastern mountains. In most parts of the mountains top soil has been washed away leaving poor sub-soils. Three types of soil erosion can be distinguished: Sheet erosion, rill erosion and gully erosion (for descriptions see chapter 1). The degree and type of soil erosion vary with topography (land form/slope), farming practices, land use system, soil type and rainfall intensity. The topography is the most influential factor contributing to soil loss through erosion in these areas. As reported by Lal (1977) convex steep slopes tend to disperse surface runoff and cause extensive sheet erosion, while concave and gentle slopes converge surface runoff and cause gullies. Rill erosion occurs on both steep and gentle slopes with shallow soils and average rainfall intensity. The areas affected most by erosion are steep slopes of high and medium altitudes in food crop fields. These fields experience serious nutrient depletion attributed to erosion, continuous cultivation and limited fertilizer use. It is estimated that fertilizer is applied to only 41% of the farm area of maize in the northeastern mountains (Nkonya, 1995). The inadequate use of fertilizers and other fertility improving practices has led to declining soil productivity in food crop fields. In banana/coffee intensive homegardens soil erosion is very little or non-existing due to adequate vegetative cover and nutrient recycling provided by this cropping system.

The off-site erosion damages include flooding of lowlands, siltation of rivers and water streams, hence reducing water levels. Other effects are contamination of ground and surface water sources with nutrients and soil particles from the slopes and damage to the infrastructure such as roads and bridges.

2.4 Current traditional soil conservation practices

We have seen that farmers in the northeastern mountains started to develop various cropping practices and land use systems in response to changes in their socio-economic and environmental conditions. The aim has been to improve productivity of their land, using techniques which are suitable and compatible with the existing circumstances. Therefore, the traditional soil and water conservation methods refer to practices built upon farmers' indigenous knowledge and experience. They include intensive cultivation, zero-grazing, agroforestry, forestry (woodlot), furrow irrigation, trash lines, grass strips, minimum tillage, and biological or agronomic methods such as cereal-legume intercropping, crop rotation and mulching.

Intensive cultivation:

This is the oldest practice in the northeastern mountains[3]. It is referred to as homegarden. A small area (0.4-0.6 ha) is efficiently used for cultivation of several annual and perennial crops and combination of several tree species, enough to sustain the farm household throughout. Ninez (1985) conceptualized homegarden land as having several vegetative storey or layers. The top storeys consists of tall trees which form a protective canopy against the tropical sun, providing shade to other crops underneath. They also supply the soil with humus from their fallen leaves contributing to spontaneous soil regeneration and help to maintain soil moisture. Trees also provide fuelwood and fodder, as well as timber. The height of this storey may go as high as 30 m. The next layer consists of banana canopy with some fruit and fodder trees. Below this layer is a bush-level growth of crops such as coffee, maize, beans, with a few young trees and shrubs. The lowest layer consists of climber and root and tuber crops such as taro and yams. Intensive cultivation found in homegardens provides a balanced system, in which various components interact to maintain soil productivity.

Zero-grazing:

Farmers in the northeastern mountains started livestock keeping several years back. Most farmers keep a limited number of cattle, goats and sheep. Because of land scarcity farmers developed stall-fed livestock production practice, in which they cut and carry pasture grasses (e.g Guatemala) and natural pasture from the homegardens around the homesteads, river banks, streams and furrow edges and along footpaths or forests to feed the animals. Banana stems and leaves as well as crop residues from beans and maize are also important sources of animal feed.

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[3]Mainly the Kilimanjaro and Pare mountains.

Animals are also fed with fodder trees and shrubs. Cow dung from livestock barns is used as manure for homegardens and food crop plots near the homesteads and vegetable plots in valley bottoms.

Agroforestry and forestry:

Tree planting is a popular practice among farmers in the study area. Farmers plant trees in their crop fields (agroforestry) for providing shade to crops underneath, firewood and fodder. They have also established tree plots known as woodlot. These are small-scale forest plantations established for the purpose of supplying households with their basic wood needs, firewood and building materials. Trees are also planted around homesteads for providing fruits and shade, to serve as a windbreak and for ornamental use. From conservation point of view tree planting improve the vegetative cover of the soil, reduces runoff and hence helps to reduce soil erosion. In addition, tree roots stabilize the soil, thus reduce the impact of rain drops (Thomas, 1991). Some leguminous tree species are known to improve soil fertility by a nitrogen fixation process. They also shed leaves, which improves the soil organic matter, texture and structure.

Furrow irrigation:

The traditional furrow irrigation is a practice which has been used by farmers for over 200 years to ensure efficient utilization of water resources. Despite the problem of poor management of furrows and dried-up water sources, this practice still plays a key role in agricultural production of the northeastern mountains. Pike (1965) stated that "there are probably not many areas in the world with highly developed complex and successful furrow systems of irrigation, and transport of water from an intake high up in the mountain stream for miles down the slope, and distributed to homegardens throughout the mountain". The fact that these areas have much rainfall, one would wonder why people constructed these irrigation furrows. The main reason for furrow construction was to supply water to homesteads and for irrigation during the dry season (January-February). This is a strategy to make maximum use of land and other resources, such as labour, during the dry months.

Grass strips:

This is a one-metre wide ribbon-like band of fodder grass planted on cultivated land along the contour at an interval of up to 20 m apart. The most common fodder grasses used for this purpose are Guatemala and elephant grasses. This practice is a traditional strategy used to control soil erosion on maize/bean plots located in both gentle and steep slopes. Grass strips help to reduce runoff and to filter out sediments carried by runoff. This method is suitable on soils with good infiltration for dense grass development and in gentle slopes (less than 12%). In a few places where this method has been properly applied, the strips have built up into terraces (SECAP, 1992; Shelukindo; 1995; Thomas, 1991).

Trash lines:

This is a traditional practice used to reduce soil erosion on gentle slopes. Crop residues and twigs are piled along the contours 10-15 metres apart to reduce the speed of water movement downhill and at the same time clear the field for cultivation. In the following year the residues and twigs are ploughed under the soil. The new line is constructed in another location. In addition to check runoff, trash lines improve soil organic matter, texture and structure.

Minimum tillage:

Farmers plant annual crops, mainly maize without tilling the land. Once the plants reach a height of 30 cm the land is tilled, combining weeding and land preparation. Though this practice is meant for labour saving, it also helps to reduce the intensity of continuous cultivation.

2.5 Soil and water conservation support programmes

As a result of a policy shift in the 1980s towards supporting the agricultural sector, and the worldwide concern for the environmental degradation, various development agencies such as NGOs, international and local organizations have initiated various activities to address problems associated with natural resource management and soil conservation in mountain areas. Farm-level soil conservation programmes have been initiated in areas with severe land degradation to reverse declining soil productivity and improve sustainability of the agricultural production system, using improved soil and water conservation technologies. Integrated technologies which include components such as agroforestry, zero-grazing and soil erosion control are being promoted in northeastern mountains. Most of these technological packages are built upon farmer's traditional soil conservation practices, which have proved to be inadequate. People participation approaches are used to facilitate adoption of these technologies. This section summarizes soil and water conservation activities carried out in the study area (see Appendix 1 for details).

Integrated soil and water conservation:

In 1979/80, the Government of Tanzania in collaboration with the Regional Integrated Rural Development Programme (TRIDEP) supported by the technical aid of Germany (GTZ), initiated an integrated Soil Erosion Control and Agroforestry programme (SECAP) to promote soil erosion control throughout the west Usambara mountains (Lushoto district). The programme focused on two main aspects: 1) reducing environmental destruction and 2) restoring the ecological balance in the target areas in the west Usambara mountains. The programme aims at achieving sustainable land use systems in the west Usambara mountains by applying improved soil and water conservation measures and agroforestry systems, so as to increase land productivity (Shelukindo, 1993).

SECAP developed a technology package known as macrocontour line (MCL). The MCL is defined as a permanent horizontal hedge planted densely with perennial crops parallel to the contour lines of the hill. They consist of various components such as: fodder plants, trees, bananas and pineapple. The components of the MCL depend on what a particular farmer grows in his plot, other enterprises he has such as cattle, his needs, preferences and priorities. The strips between the MCL are planted with food crops. This package is intended to meet farmers' multiple needs: fodder for cattle, firewood for fuel, food and cash (e.g from sugar cane, pineapple and fruits) and to control soil erosion. In addition to MCL, SECAP is also promoting the use of physical measures of soil and water conservation such as cut-off drains, infiltration ditches and terraces. SECAP has also launched a catchment forestry programme (CFP). This programme intends to reafforest the area by planting trees to control erosion and improve water retention.

The programme also promotes practices like zero-grazing, green manuring, mulching, crop rotation and use of farm yard manure.

In 1992 GTZ started another soil and water conservation programme in the north Pare mountains known as the Tanzania Forestry Action Plan (TFAP). The programme focuses on encouraging and assisting farm households to attain sustainable use of natural resources. The main components of soil and water conservation are soil erosion control, soil fertility management, site specific crop and tree management, water management and buffer zone management. Activities carried out involve construction of improved physical soil erosion control measures (bench terraces, *fanya juu* terraces, infiltration ditches and cut-off drains)[4], improving agroforestry, afforestation of catchment areas, protection of river banks, use of manure and promotion of biological measures for improving soil fertility.

In order to promote adoption of improved SWC technologies, the GTZ programmes provide various support to farmers. To reduce labour constraints they have revived the traditional labour sharing-groups known as *kiwili* and *vikwa* in the west Usambara and north Pare mountains respectively [5]. Labour groups are used mainly for construction of physical soil erosion control structures (terraces). The TFAP programme in the north Pare mountains have assisted people in forming village-level land use planning committees (VLUPC) responsible for planning and oversee the implementation of SWC activities including afforestation. The programme also provides farm inputs such as improved seed varieties and implements for construction of SWC structures at subsidized prices. Villagers are also assisted in establishing tree nurseries to promote agroforestry and afforestation. They also receive technical assistance required for laying out physical SWC structures from village-based TFAP facilitators. To enhance awareness of the soil degradation problem and soil conservation, the programmes carry out field tours and training on soil conservation methods. Technical information is provided through extension services, video shows, leaflets and pamphlets.

Both the west Usambara and north Pare mountains are under the traditional irrigation project (TIP) supported by the Netherlands Government under the Dutch Volunteer Service (SNV). The project started in 1989. The objective of this project is to improve management of the existing traditional irrigation structures and improve access to irrigation water for majority of people in the mountains. The project is aimed at rehabilitating traditional furrow irrigation systems by improving water availability and utilization for irrigation. The main activity is the improvement of water reservoirs (known as *ndiva* in the north pare mountains). The project organizes farmers into *water-user groups* and provides materials and technical support required for construction the irrigation systems. In collaboration with the SECAP/TFAP programmes TIP encourages construction of terraces in fields located on the slopes as a pre-condition for utilizing

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[4]**Bench terrace** is defined as a sloping land converted into a series of alternating steps (horizontal) and risers (vertical walls) to control flow of water down hill. ***Fanya juu*** ("through up hill" in *Kiswahili*) is a terracing process whereby a trench is excavated to form an embarkment on the upper side by throwing the excavated soil uphill. *Fanya juu* is recommended for slopes of 12%-35%. **Cut-off drain** (diversion ditch) is an open, graded trench with an embarkment used to protect the cultivated land against runoff from higher elevations. They have an outlet water into a natural or artificial waterway or uncultivated grassland. **Infiltration ditch** is a leveled cutoff drain designed for retention of runoff (water harvesting). It is recommended for areas with low rainfall.

[5]Traditionally people in the area used to have labour groups for farm work. The groups were also used as a way of socializing. After farm work the group host was obliged to offer food and local beer. However, because of modernization and emergence of individualism the use of group labour ceased to exist.

the improved irrigation system[6]. In addition to encouraging the use of soil erosion control measures, this condition is based on the fact that irrigating sloping fields without soil erosion control structures would accelerate soil erosion and result in inefficient water utilization. TIP also carries out promotional activities, such as farmer training and extension services.

Agroforestry:

Various non-governmental organizations sell tree seedlings to farmers, conduct tree planting campaigns (e.g the popular "plant a tree to cut a tree" campaign) and provide training on agroforestry husbandry practices. The trees are meant for supplying firewood and to meet other household needs for wood. The International Centre for Research in Agroforestry in collaboration with the national forestry and agroforestry programmes is testing various agroforestry technologies in the farmers' fields in various parts of the northeastern mountains. The activities include screening and evaluation of multipurpose tree species (for firewood, fodder and fertility) appropriate for various agro-ecological zones and socio-economic conditions.

2.6 Summary

From this overview it becomes clear that the northeastern mountains are endowed with enormous natural resources and favourable climatic conditions offering opportunities for development. However, given the sloping land form and high rainfall intensity, the environment in these areas is classified as fragile and sensitive to any kind of disturbance or destruction. We have seen that population pressure has resulted in serious environmental destruction attributed to land scarcity, hence reducing the capacity of the land to support lives of people living in these areas now and in the future. This problem has drawn attention from the government and other development institutions. The main emphasis has been to reverse land degradation and develop a sustainable agricultural production system. The fact that it is not possible to reverse population growth in a short time period, *land/soil conservation* has been identified as a substitute to population reduction.

The conservation methods applied to date include those emerged from farmers' reaction to the consequences of land degradation (traditional methods or indigenous technology) and those resulted from external interventions such as SWC programmes. The external technological interventions are intended to supplement and/or improve traditional conservation methods which have been proved to be less effective in circumventing soil erosion. The main objective of these interventions is to develop effective conservation methods and hence improve the quality and resource base of the land to ensure sustainable production.

The success of the SWC programmes depends on the extent to which the improved soil and water technologies are accepted and adopted by farm households. It is recognized that the characteristics of improved technologies and the behaviour of households play a key role in the adoption process. The characteristics of technology refer to the easiness to test and/or use the respective technology. This is determined by the types and level of inputs and knowledge

[6] For farmers to qualify for allocation of irrigation water the respective field has to be completely terraced.

required in order to be able to use a particular technology. The ability to acquire inputs and knowledge for technology use and the households' willingness to use new technologies depend on the characteristics of an individual farm household, socio-economic and institutional factors. These determine the individual's behaviour and attitude towards new innovations. To influence people's adoption decisions on improved soil and water conservation technologies, the programmes have introduced information flow mechanisms and training activities to enhance people's awareness of the land degradation problem and their knowledge on the role of soil conservation in improving soil productivity. They have designed strategies for improving access to inputs, such as labour and technical information. The extent to which these strategies and mechanisms are effective in influencing the perception of the degradation problem and adoption of improved soil conservation technologies needs a thorough assessment.

CHAPTER 3

CONCEPTS, DEFINITIONS AND LINKS

3.1 Introduction

Sustainability of agricultural production is an important aspect of attaining social and economic development in the northeastern mountains. Deterioration of the natural resource base caused by land degradation has reduced the level of land output (food and income) leading to poor social and economic welfare of the society. Therefore *agricultural sustainbility* has become a key issue in addressing agricultural development of the northeastern mountains in Tanzania.

There is a wide scope of application and diversity in interpretation of the term *sustainability*. Therefore, before we address the issue of *agricultural sustainability* in the study area, it is important to analyse and understand the concept of *sustainability,* its components and indicators first. Recognizing the existing diversity in application of the concept, an operational definition is needed for this study to guide the development of the conceptual model for assessing the land degradation problem and *soil conservation* in the study area.

In this chapter we provide definitions and discuss interpretations of the notion of *resource conservation* and various definitions of *sustainability* which are given in the literature. This includes perspectives various authors have used to describe sutainability based on economic development, social and biological contexts. For each perspective, the components and indicators of sustainability are identified and discussed. Approaches for measuring agricultural sustainability are also outlined, indicating how the indicators to define sustainability have been used in empirical research related to sustainability of the production system in relation to resource conservation. Then, we present the conceptual framework for the study. This includes the operational definition of sustainability on which this study is based. In this definition we spell out the components and indicators of sutainability dealt with in the study. Also, the conceptual model for the study is presented and discussed. The model shows the links and relationships between various components of the agricultural production system associated with *sustainability and resource conservation* in the study area. Since this study is concerned with *agricultural sustainability*, we restrict our assessment of the components to land degradation and soil conservation. Lastly, we discuss economic theories and relationships explaining sustainability components included in the operational definition and conceptual model (land degradation, soil erosion and technological change and adoption of improved soil conservation measures). The discussion focuses on the relationships between land degradation and population growth, soil erosion/topsoil loss and yield, impacts of soil erosion and technical change on adoption of soil conservation technologies.

3.2 Definitions

3.2.1 Definition of resource conservation

The literature provides various definitions for the term conservation. Economists have interpreted the term *resource conservation* by using an intertemporal approach, whereby resource *conservation* is defined as redistribution of resource use rates towards the future. That is, having more preference for future utilization of a resource rather than its present use. Therefore, an alternative to resource conservation is *resource depletion,* which refers to distribution of resource use rates towards the present (Van Kooten, 1993). According to Ciriacy-Wantrup (1968), resource conservation requires some benchmark or reference point for distribution of use rates for a resource. This implies that *conservation* is a relative concept and that one cannot judge whether something is conserving or depleting without a reference to some benchmark. Another definition that relates directly to sustainability has been provided by Scott (1973) ..."*Conservation* is a public policy which seeks to increase through investment the potential future use rates of one or more natural resources above what would be in the absence of such policy. This does not include only those policies which encourage investment of social income in restoration, education, and research but also policies of reservation and hoarding of stocks". Scott's definition emphasizes that in assessing resource conservation the focus should be on a single resource within a defined geographical region and that resource conservation should be measured in physical units and not in monetary terms. This definition also recognizes that *conservation* is a political as well as a biophysical, social and economic concept (Van Kooten,1993). This implies that *resource conservation* is a complex process, influenced by goals and behaviour of the society towards resource utilization over time. The goals and behaviour of the society are in turn influenced by knowledge and skills, economic policies and political and environmental conditions.

Morgan (1986) defines resource conservation with respect to *soil conservation* as...."to maintain a sustainable level of production in the long term from a given piece of land while maintaining the soil loss at a level which allows the natural rate of soil formation coupled with utilization of external inputs to be in equilibrium with the rate of soil erosion". The key idea is to reduce soil erosion to a level where a long-term sustainable agricultural production system is maintained. Kayombo and Mrema (1994) note that such levels of soil loss tolerance are difficult to estimate. Furthermore, the definition indicates that the soil loss tolerance values are very much dependent on the action taken by soil users to reduce soil loss e.g., the use of external inputs.

The above definitions of resource conservation indicate that land or soil as a natural resource needs to be conserved such that the rate of its use is redistributed towards the future, within the socio-economic, biophysical and economic policy setting. In other words, given that the quality of land is limited, it is important to use it in such a way that a particular piece of land meets the present and future needs of the society. In view of this, the Advisory Council for Research on Nature and Environment (1994) emphasizes the need to maintain long-term productivity of the land. The council recommends that land should be used and at the same time be conserved to meet the production needs of the future generation living and depending on the land.

In the literature, there is general agreement that the present and future productivity of land depends to a large extent on the land management practices applied by the society during the production process (Altieri, 1987; Klennert, 1986; FAO, 1990; Schipper et al., 1995). Lal (1987) advocates that the production system will be stable and biologically efficient only if appropriate production practices are used to restore and maintain its productivity, thus ensuring a sustainable production system. This brings us to the concept of *sustainability*.

3.2.2 Definition of sustainability

The concept of sustainability has drawn attention of scientists, policy makers and politicians throughout the world. The concept grew out of the limited growth debate of the early 1970s, which focused its concern on the impact of economic growth on the environment (Meadow et al., 1972; Cole et al., 1973). The general concern was on the continued waste of non-renewable resources, destruction of ecosystems, and over exploitation of renewable resources. In 1993 a resolution to the problem was reached and it was agreed that economic development could be sustained indefinitely, only if development is modified to take into account its ultimate dependence on the natural environment (Pezzey, 1989). Thereafter, the concept of sustainability was discussed in several international forums and publicized to draw worldwide attention. Main publications include the World Conservation Strategy (IUCN, 1980), World Bank Landmark Paper (World Bank, 1987) and the Brundtland report (WCED, 1987).

There are several definitions of the concept of *sustainability*. These definitions are based on various indicators such as economic development, environmental, social and cultural and biological indicators. The general definition of the term sustainability in the Brundtland report is: "*....development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs*" (WECD, 1987, in Pezzey, 1989). Since then, attempts have been made to use the term sustainability in a definition that suits semantic, conceptual and operational purposes.

There are several operational interpretations of *sustainability*. These are based on partial criteria and components such as sustainable development, sustainable economic growth, sustainable agriculture, sustainable resource use, among others. Even within these partial definitions, various indicators are used to operationalize the sustainability component being addressed. Given the focus of this study, we focus the discussion on agricultural sustainability or sustainable agriculture.

The broad definition of *sustainability in agriculture* is provided by FAO (1991) as ".....the management and conservation of natural resource base, and orientation of technological and institutional change in such a manner to ensure the attainment and continued satisfaction of human needs for the present and future generations". This definition is based on the WCED report with special emphasis placed on food security (Kruseman et al., 1993). In this definition management of technological change and natural resources are linked with production, stability and equity in the short run and agro-ecological sustainability in the long run.

The FAO definition suggests that management of resources (in this case land) is the key element of agricultural sustainability. To ensure agricultural sustainability technologies and institutions need to be developed to facilitate resource management and hence create long-run benefits of the agricultural system[7]. Based on this, the general definition of sustainable agricultural system is given by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) as ...... "successful management of resources for agriculture to satisfy the changing society needs while maintaining or enhancing the quality of the environment and conserving natural resources" (CGIAR, 1989). Along the same lines the American Society of Agronomy provides a definition of sustainable agricultural production system as:...."a system that over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fibre needs; is economically viable and enhances the quality of life for farmers and society as a whole (Anonymous, 1989). Again, these definitions emphasize the role of land management in the process of building a sustainable agricultural production system and the ultimate food security and socio-economic welfare of society. One of the important components of sustainability in this regard is the stock of land resources (quality), whose change and flow determine the sustainability of the agricultural production system. This implies that changes in resource management strategies or practices to sustainable land use could contribute to the conservation of the quality of land, and hence influence the well-being of the farm household. Sustainable land use is therefore one of the criteria that can be used to explain sustainability of the agricultural production system. Stomp and Fresco (1991) interpret a sustainable agricultural system in terms of land use. They describe sustainable land use as the one guaranteeing continuous land productivity without deterioration of land.

While most authors focus their definitions on land utilization and conservation, others use indicators such as agricultural production level or output and productivity as criteria for defining sustainability of the production system. For example, Idachaba (1987) interprets sustainability of agricultural production system as "the ability of the system to maintain production level without falling". Pearce et al. (1988) define agricultural sustainability in terms of sustaining output level. The authors view sustainability as a non-declining output. They indicate that a non-declining output is possible only if natural resource stock is preserved. Related to Pearce's definition is that one of Lynam and Herdt (1989) who define sustainability as the capacity of a system to maintain output at a level approximately equal to or greater than its historical average, with approximation determined by the historical level of variability. The authors suggest that a sustainable system is one with a non-negative trend in output, and that technology contributes to sustainability if it increases the slope of the trend line. Conway (1985) defines sustainability in terms of productivity. He refers to sustainability as the ability of the system to maintain productivity in spite of a major disturbance, such as one caused by intensive stress or large perturbation. The author defines productivity as output of valued product per unit of resource input. From this definition, Conway and Barbier (1990) identify stability as another important indicator that has some bearing on the concept of sustainability of the agricultural production system. The authors describe stability as "the constancy of productivity in the face of small disturbing forces arising from normal fluctuations and cycles in the surrounding environment ". These are rather narrow definitions which consider yield/output as the only variable for explaining sustainability of the production system.

[7]Agricultural system is defined as a collection of enterprises managed by the household, responding to the physical, biological and socio-economic environment, in accordance with household goals, preferences and resources.

Fresco and Kroonenberg (1992) interpret the concept of sustainability as an absolute value in terms of agro-ecological concerns or a relative value in terms of trade-offs between agro-ecological sustainability and economic efficiency. The authors identify four conceptual components to analyse sustainability: 1) production in terms of total output over time; 2) efficiency defined as rate of conversion of inputs into outputs from the ecosystem including energy loss; 3) stability, as degree of fluctuation around the output trend; and 4) resilience, the speed of restoration of output trend after major disturbances. The concepts used by the authors to define sustainability are very much similar to those used by others like Conway, Pearce, and Lynam and Herdt but incorporate a wider range of components for analysing output trend.

It is important to note that the diversity in the existing definitions of agricultural sustainability can result in confusion and different interpretations. It is therefore useful to define sustainability on a case by case basis. That is, the appropriate operational definition for the situation and the problem being addressed need to be provided in advance. This is important considering the prevailing complexity and variations of the agricultural production systems we deal with.

3.3 Measuring sustainability

3.3.1 Focus and scope

From the above review, it is evident that there are several criteria available for assessing sustainability of the production system. Because of this, measuring sustainability also becomes problem or situation specific. Tisdell (1995) recommends that before we think of methods for measuring sustainability it is necessary to answer the following questions:
1) sustaining what and in what sense? and 2) over what time frame? He recommends that in order to integrate sustainability appropriately into meaningful measures we must step back and ask ourselves these questions and define the focus of sustainability assessment beforehand. The author identifies two ways in which sustainability can be addressed in relation to production systems and resource conservation:

(1) Sustainability may be used to describe a property or characteristic of the output level of the production system[8]

(2) Sustainability may refer to whether the improved production systems will be maintained.

The first sense or dimension focuses on productivity growth indicated by output trend which is determined by the quality of resources and methods used in agricultural production. The second

[8]Production system includes all enterprises and production methods applied.

sense suggests that we view sustainability of a production system in terms of ability to maintain the sustainable production system once achieved. This depends on whether or not land users are able to use and maintain the sustainable land management practices. While the two ways of addressing sustainability focus on different aspects, they are very much related and, in practice, cannot be separated. When the first sense is used, the second has to be considered. The trend of output level depends on the extent to which sustainable land management practices are used. On the other hand, when sustainability of the production system is measured using the second sense, the first one is still relevant because output level influences the adoption of sustainable land management and conservation practices.[9]

In addition to considering the way sustainability is assessed, Tisdell (1995) recommends that when evaluating sustainability in relation to land management, it is important to decide on the category of practices we are focusing on. Land management practices can be viewed in terms of *actual choices* or in terms of *ideal choices.* The former refers to practices used by farmers (positive focus), and the latter refers to practices that should be used from a technical point of view (normative focus). This suggests that in measuring sustainability based on conservation, we need to identify the starting point. That is, defining actual practices and what ought to be ideal for attaining a sustainable agricultural system.

It is clear that the operationalization of the sustainability concept involves a lot of judgements. The decisions made with regard to the above issues and questions are situation-dependent. They depend on the component of the production system being addressed.

3.3.2 Approaches and methods

The definitions advocated by various groups have been used to develop frameworks and models for measuring sustainability of the agricultural production systems. Approaches developed for measuring sustainability have used indicators such as output level, economic viability, and productivity focusing on various elements of the production systems, such as soil erosion and soil fertility.

Both economists and biological scientists have used various indicators of sustainability provided in the definitions above to establish whether or not a particular production system is sustainable. Economic approaches provide some grip for the determination of output, productivity, costs and benefits of the production system associated with specific resource management and conservation practices over time. Most approaches used by biological scientists are focused on only one dimension of the production system, e.g., soil nutrients. The idea is that, by improving this factor, productivity can be increased until the next factor limits productivity. Here we review some of the approaches and methods commonly used for explaining sustainability of the production system. They include the output and productivity trend approach, mathematical optimization models, cost-benefit analysis and system modelling including simulations.

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[9]It is assumed that income derived from increased output is an incentive to invest in application of appropriate land management practices and vice versa, assuming constant prices.

Output trend approach:

Lynam and Herdt propose a measure of sustainability at cropping and farming system level. They focus on a single criterion of sustainability, "output", and attempt to provide it with an operational content. Based on their definition of sustainability presented above, they suggest that the "appropriate measure of output by which to determine sustainability at crop, cropping system or farming system level is the total factor productivity (TFP), defined as the total value of output produced by the system during one production cycle divided by total value of all inputs used by the system during one production cycle of the system. A sustainable system has a non-negative trend in total factor productivity over the period of concern". Other authors like Ehui and Spencer (1992) used the Lynam-Herdt approach to measure sustainability and economic viability of a cropping system in terms of its *productive capacity over time*, determined or measured using Total Factor Productivity (TFP)[10] associated with various resource management scenarios, paying particular attention to valuation of the natural resource stock.

The Royal Tropical Institute (KIT) (1993) observes that the output/productivity approach is not stable nor realistic. It is argued that productivity increase will eventually cease with time if nothing is done to other factors needed to sustain the initial productivity increase. The author recommends that sustainability measure should include all factors involved in the production process. Also, because of their partial nature these methods do not indicate whether the productivity/output level attained from conservation practice will be maintained and for how long. Furthermore, methods based on output trends are only useful in situations where there is sufficient information to establish output trends. In situations where market-oriented production is practised, income from increased output (profitability) needs to be considered and output and input prices become important.

Mathematical programming models:

Mathematical programming involves the use of mathematical procedures to solve certain types of management problems performed within formalized sets of instructions and conditions (Dykstra, 1984). The mathematical programming models have been designed to determine the optimal solution of the problem under consideration.

Many authors have modelled the agricultural system's response to resource conservation practices using mathematical programming models. In these models it is assumed that farmers will invest in soil conservation technologies so as to maximize the present value of future profits plus the value of the resource base of the production system over a specific time period. Such stylized models allow soil to evolve in response to three factors, namely investment, which improves soil quality at a specified rate; soil regeneration; and intensity of production as measured by output. Assuming the developed markets for labour, capital and output to exist, it is possible to obtain a solution for an optimal programme of investment in land conservation technologies, which results in a long-run sustainable level of agricultural production (Mills and Kagwanja, 1994).

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[10] Total Factor productivity is defined as an average product of all inputs.

In most empirical applications these models are used to assess the optimum combination of land use management and conservation techniques. Linear Programming is the optimization model most used to address sustainability associated with land degradation. The method provides greater flexibility in the sense that more than one land degradation problem (e.g., soil erosion and salinity) can be analysed at a time using several conservation techniques and land uses, organized as sets of activities and constraints. The method can be used to analyse decision problems at a certain point in time and those involving a sequence of interrelated decisions over several periods (multi-period LP). For example, Kevin (1994) used a linear programming (LP) model to examine the impact of farming activities on land degradation and to assess the trade-off between profitability and resource depletion by incorporating economic aspects influencing farmer's decision making in Eastern Australia. Cárcamo et al. (1994) used Linear Programming to examine factors affecting the cost to farmers of applying soil loss reduction strategies on the hillsides of Tegucigalpa, Honduras. A representative farm model was constructed using field surveys. The model was solved by using the LP procedure, with an objective of maximizing net returns subject to various levels of soil loss and risk. In some cases Linear Programming is used in combination with other methods, especially Cost-Benefit Analysis and crop simulation models (e.g., Thomas, 1989; Dumsday and Oram, 1990). In these examples, the LP model is used to asses sustainability where the analysis links more than one resource with several land use options.

The practical limitation of LP is that the analysis requires a lot of data which may not be available. Also, the valuation of so many costs and benefits involved may be difficult, and therefore much of the analysis may have to be based on assumptions and sensitivity analysis. Furthermore, due to the multidisciplinary nature of the approach (involving different aspects of resources), diversified expertise (multidisciplinary team) is needed to carry out the analysis.

Dynamic programming is another widely used mathematical programming approach to assess sustainability of production systems. The approach is used to solve decision problems that involve a sequence of interrelated decisions in such a way that overall effectiveness is maximized (Dykstra, 1984; Kennedy, 1986). Lórez-Pereira et al. (1984) used the whole-farm dynamic programming to determine the potential farm-level income effects of soil conservation and seed-fertilizer technologies on erosion-prone steep hillsides in Honduras. The Discrete Stochastic Programming (DSP) was used to analyse farmer's decision making under uncertainty through time. A utility function that reflects farmer's characteristics and risk attitude was developed. Miranowski (1984) used the approach to illustrate intertemporal productivity impacts of soil loss in crop production and management in Iowa, United States.

The salient characteristic of mathematical programming models is that the sustainability evaluation process is based on the economic rationality assumption (utility maximization). Therefore, only economic parameters are included in the assessment.

Cost-Benefit Analysis (CBA) approach:

The Cost-Benefit Analysis (CBA) approach has been extensively used in measuring sustainability of the production system in relation to land degradation. Since the 1950s Cost-Benefit Analysis (CBA) has become the most widely used method to optimize the use of natural resources. In Cost Benefit Analysis all factors contributing to benefits and costs of natural resource use are taken into account (KIT, 1993). In this approach costs and benefits are expressed in money terms over the time frame under consideration or sub-periods within the time-frame, e.g., each year for the 10-year period. The method is used to identify the system of land management which gives the highest economic benefit to cost ratio. The assumption is that resource conservation technology will only be adopted by farmers if it yields a higher cost-benefit ratio than the alternative practice or technology.

Cost-Benefit Analysis starts with identification, specification and evaluation of the expected effect of an intervention in the production system. Future costs and benefits are included in the analysis by using discounted values, called Net Present Value (NPV). These values are estimated using a specified discount rate. The lower the discount rate used, the greater the weight placed on the future net benefits compared with the current ones and therefore, more emphasis is placed on the long-term sustainability of the benefits. A high discount rate places great weight on short-term benefits. In most cases CBA analysis is carried out to compare *with* and *without* conservation scenarios. For example, Attaviroj (in Dixon et al., 1990) used CBA to examine the economic dimensions of current and proposed land use practices in the upland rainfed agricultural area in northern Thailand in relation to soil erosion. Three land management alternatives were evaluated over 15 years using different levels of discount rates. Bőjo (1989) carried out an economic analysis (CBA) of the Farm Improvement Soil Conservation (FISC) project in Lesotho, using with and without scenarios. Valuation of costs and benefits of the project incorporated sustainability aspects. The main objective was to estimate the surplus the society could be expected to gain over the lifetime of the project.

Again, the CBA decision criteria such, as NPV, are economic rationality-oriented. It is assumed that rational farm households will opt for conservation alternatives with the highest Net Present Value of returns.

System modelling approach:

Many scientists have modelled the production system's response to long-term impact of land degradation (e.g., through soil erosion and nutrient loss) on soil productivity (in terms of changes in yield), and also for assessing long-term effects of land management practices and conservation (in terms of changes in soil properties) on soil productivity. The models predict long-term sustainability in various cropping systems and practices by quantifying productivity and other bio-economic parameters. By modelling and using computer simulation models, combinations of different resource conservation scenarios that the agricultural production system represents as to sustainability are analysed. This is accomplished by predicting the system's response to different actions by producers within a particular agro-ecosystem. Leon-Verlarde et al. (1995) express sustainability in quantitative terms using Lynam and Herdt's (1989) definition of non-negative slope. They define sustainability as a change in slope of bio-economic response over time. A zero or positive slope indicates bio-economic sustainability for the characteristic studied; while a negative slope indicates non-sustainability and the need for technological intervention. Aune (1994) have used a productivity simulation model to predict future yield and soil properties (nitrogen level, soil pH, soil organic carbon) affected by soil and crop management for all crops grown in Zambia and Tanzania. The main focus was to establish a relationship between changes in supply of nutrients and productivity and the interaction between nutrient supply and other factors affecting productivity such as pests and diseases.

System modelling, simulation and prediction models provide useful tools for measuring long-term sustainability of the production system by predicting long-term changes in yields and land quality. However, sufficient background information and time series data on parameters to be included in the model are required. In some cases, especially where soil nutrient parameters are included in the analysis, field experiments may have to be carried out to obtain data for the model. Also, the approaches are not capable of incorporating socio-economic variables that influence the attainment of the system productivity levels.

3.4 Conceptual framework for the study

3.4.1 The operational definition

In view of the existing lack of a comprehensive definition and measure of sustainability, it is appropriate to provide an operational definition relevant for this study first. In this definition we provide the important components and indicators of sustainability we intend to focus on in this study. This will provide the basis for formulating the conceptual model for the study.

In the context of this study sustainability is defined *as: capability of the land to be productive by avoiding land degradation through **management and conservation of land quality**, and orientation of **technological change** and **institutional policies** in such a way that sufficient productivity and net **economic returns** are attained to enable people to be able to support themselves in the long-term.*

From this definition, land management and conservation of land quality are identified as the means for achieving sustainable agriculture. Productivity and net economic returns are indicators of a sustainable production system. Technological change and institutional policies act as stimuli in the process of attaining sustainable agriculture. The definition suggests that, a sustainable production system depends on the extent to which the society is capable of increasing farm productivity (output and income) by applying appropriate land management and conservation technologies. Emphasis is put on maintaining land productivity and benefits resulting from land management and conservation to support the lives of people over time.

The operational definition has five major components: land degradation, land productivity, net economic returns, technological change and institutional policies. Below is an explanation of how each of these components is linked to sustainability of the agricultural production system and how they are related to each other.

Land degradation in this definition refers to reduced land *quality* in terms of soil nutrients depletion and damaged soil texture and structure through physical changes such as soil erosion, leaching and salinity. Moran (1987) indicated that land degradation can be measured empirically and is closely related to the soil conservation techniques used. Kevin (1994) observes that soil conservation practices are the main controllable variables within a range of determinants of land degradation.

Land Productivity is defined by Altieri (1987) as the process of utilizing land resources to achieve the end product (output) of the production system. Productivity can be expressed in a number of ways, such as: output per unit of land, labour, or income investment. Harwood (1979) recommends that the way productivity is expressed should depend on criteria used by farmers in making production decisions. Productivity is therefore a quantitative measure of the production capacity of land resources and the production system as a whole.

Net Economic Returns refer to income farmers have after all costs have been paid. The net economic returns generated by a sustainable production system are expected to increase over time or at least maintained at a higher level over a long time period. This parameter is discussed further in the next section.

Technological change plays a major role in developing a sustainable agricultural production system. This involves changing or adjusting the production process by utilizing techniques developed through advances in scientific knowledge in such a way that productivity is enhanced or maintained. Technological change in this context includes new innovations or methods which, if incorporated into the production process, could improve or have proved to improve land productivity. This includes the use of improved technologies such as soil conservation techniques, improved seed varieties and other modern production inputs.

Also, the definition observes that farm households operate in an economic world. Therefore, ***economic policies*** such as those related to input and output pricing and credit schemes are considered important in influencing farmers' choice of conservation technologies. In order to attain sustainable productivity, appropriate institutional support and policies should be in place to encourage the use of more productive and sustainable land management technologies.

3.4.2 The conceptual model

This part is intended to present the relationships and linkages between the land degradation problem in the study area, soil conservation and other relevant components of assessing sustainability of the production system in the northeastern mountains. Based on the operational definition presented in the previous section, the conceptual model is developed to explain these relationships. The model is intended to elaborate further on the nature and scope of our research and hence to provide the basis for designing theoretical models.

The conceptual model is presented in Figure 3.1. The model illustrates the complexity of the cause-effect relationships among sustainability components in the study area. We have integrated the land degradation problem with household decision making on adoption of soil conservation technologies (technological change) together with indicators of a sustainable production system (productivity and net farm income) and institutional and policies support and socio-economic variables.

Population pressure is the major factor contributing to land degradation, caused by intensive cultivation and inappropriate farming practices[11], attributed to land pressure. The model identifies two major components of land degradation in the study area: 1) soil erosion caused by inappropriate farming practices, rainfall and land form and 2) declining soil fertility

[11]The practices include deforestation, continuous cultivation and others discussed in chapter 2

caused by nutrient depletion[12]. This leads to a decrease in soil productivity which results in a low output and ultimately reduced farm income.

The model indicates that farm households makes all the decisions related to agricultural production including farming practices and technologies to be used in the production of various farm enterprises. The household theories indicate that farm household decisions are influenced by the goal to maximize utility (profit) subject to resource constraints (labour, land and capital). According to this theory, if improved SWC technologies can prove to be slightly profitable or just "break-even", there would be no difficulties in getting farm households to adopt the appropriate SWC technologies. This assumption ignores the influence of other factors and institutional incentives on farm household behaviour.

In this model it is assumed that household's decision to invest in improved conservation measures is influenced by their perception of the land degradation problem and their interest in enhancing farm output and income or profitability in order to maximize the expected utility. That is, before the household decides on whether or not they should invest in the improved SWC technologies such as bench terraces, they assess the technology in terms of the investment costs involved and the level of household resources, such as labour and implements required by the technology, in relation to their own resource level and what they can acquire from other sources. This assessment will determine how they perceive the returns from improved SWC technologies compared with technologies they are currently using. If the household is convinced that the SWC technology in question is profitable they may decide to adopt it. Furthermore, the model indicates that household's decision on whether or not to invest in a particular soil conservation technology is not only influenced by the level of expected profit/returns but also by sociological factors. Farm household's beliefs have a profound effect on the way they perceive the land degradation problem and their attitudes towards conservation. A farm household that believes in traditional farming, for example, ("this is the way my grandfather and father farmed this land, it was good enough for them, it is good enough for me") can decide not to adopt profitable improved SWC technology because of this belief. The household's beliefs are shaped by sociological factors such as age, education, social status and networks, risk attitude and others which determine their attitude and behaviour towards investment decisions. Households with higher social status such as village leaders or those with higher education, for example, tend to have more knowledge, due to their access to different sources of information through social networks, extension and SWC programmes. This enhances their understanding of the soil degradation problem, therefore influences their beliefs and attitude in favour of using improved SWC technologies.

In addition to sociological factors institutional support is incorporated into the model. Households with access to institutional support, such as extension services and SWC programmes, tend to acquire subsidized inputs, information and better understanding of the land degradation problem and soil conservation practices and hence may perceive SWC to be profitable. Also, households that participate in labour sharing groups and receive additional resources (e.g., implements) through SWC programmes are expected to have more incentives to adopt SWC measures than others. This is due to increased capacity to meet investment costs and resources required by the technology.

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[12]Nutrients removed from the soil by continuous cultivation and soil erosion are either not replaced or replaced at lower rates.

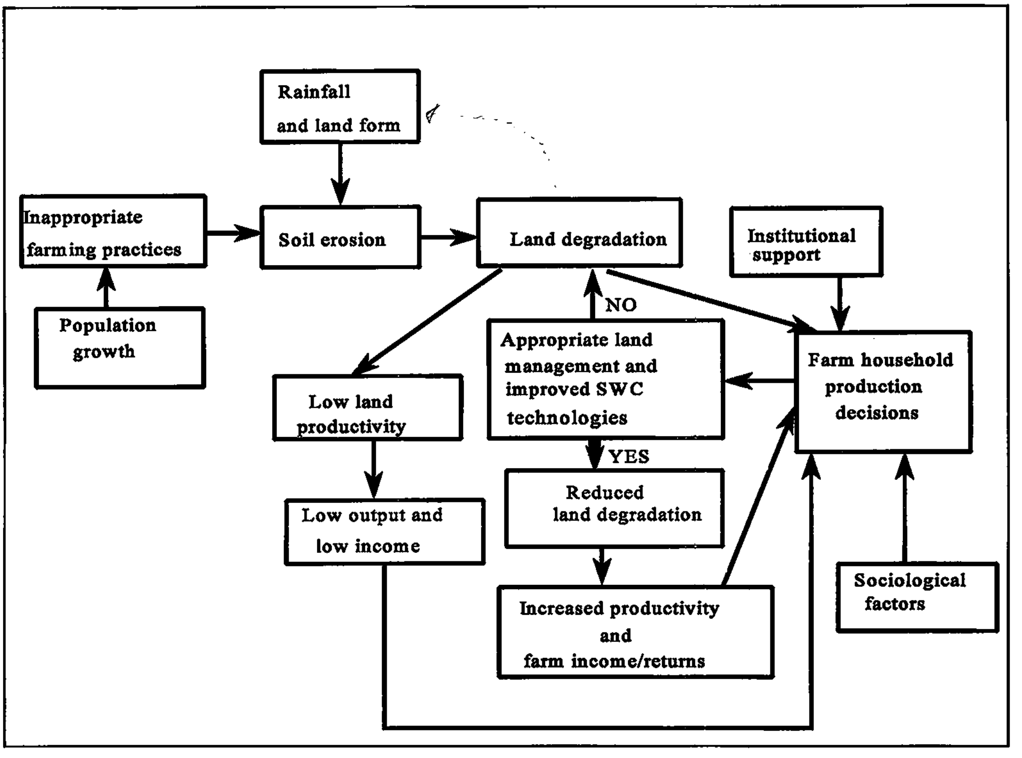

Figure 3.1: Conceptual model: Land degradation on the northeastern mountains

There are many other factors associated with conservation behaviour which could not be explicitly indicated in this model. One of them which is worth mentioning is the time lag between investment in improved SWC technologies and the realization of the impact of conservation on farm output/returns. The productivity response from soil conservation investment is not realized within a short time period like other technologies such as improved seed varieties (Hybrid seeds). Therefore, the household's perception of future benefits from SWC technologies plays a key role in the household adoption decision making process. It is important to note that perception of future SWC benefits is determined by household's personal characteristics such as age and education. Older households tend to have a short planning horizon and therefore may prefer short-run profits rather than distant future profits, while the opposite is true for younger and more educated farm households.

3.5 Theories underlying sustainability components of the study

In this section we discuss some economic theories and concepts related to land degradation (soil erosion) and soil conservation. The discussion is focused on the key components that constitute the operational definition and the conceptual model for the study developed in the previous section.

3.5.1 Population growth → Prakash '99?

The relationship between population growth and environmental damage has been widely documented. The debate on the link between population growth and land degradation dates back to Malthus/Boserup's debate in the 1980s. The Malthusian theory postulates that population growth rate is greater than the power of the earth to produce subsistence for mankind. Therefore population increases at a geometric progression, while the supply of food expands at an arithmetic progression. Malthusian theory has emphasized the role of population growth on environmental degradation in developing countries. The theories identify population growth as a major cause of poor economic and social development and hence poverty. This population pressure hypothesis is supported by several works on land degradation including the World Bank (1984). The authors agree that as population-land ratio increases, the demand for food, building materials and firewood also increases forcing people to new land (extensification process). This results in more removal of the original land cover and expanding agricultural production to marginal and fragile erosion-prone land. Eventually land scarcity occurs and limited land becomes available for agricultural expansion. Further increase in population leads to severe land scarcity and hence farmers begin to intensify their agricultural production on land already in use due to land shortage (intensification process). They attempt to meet their needs on limited land using new cultivation practices, which, in some cases, may have detrimental long-term effects on the land resources. The theories indicate that, in the long-run, as a result of extensification and intensification of agricultural production, land productivity decreases leading to poverty.

The Malthusian assumption has been criticized as it does not consider the possibilities of farmers attempting to reduce land degradation resulting from extensification. The theories are biased towards the negative consequences of adopting new farming practices. Boserup (1981) argues that population pressure stimulates technological change especially in the agricultural sector. She attributes the changes in agriculture from extensive cultivation to intensive cultivation to increased population pressure, and hence considers population pressure as a necessary condition for agricultural transformation. Boserup regards population as an independent variable in explaining agricultural development, and as a precondition for it to take place. She argues that as land becomes increasingly scarce farmers respond by changing cultivation practices and using improved farm inputs in order to preserve and improve their land productivity. Boserup's main argument is that changes in tools and farming techniques would not have come without population pressure (Boserup, 1965). In her later work on population growth she argues that population growth leads to less soil erosion. As population increases, farmers use less erosive practices as they move towards land intensification. Again, Boserup's theories are biased towards positive impacts of population pressure. She focuses more on technological development, maintaining that population pressure does not involve negative effects on land quality.

Other theories of population pressure focus on the role of the market mechanism. In these theories land scarcity is examined in relation to factor prices. The theories are based on the assumption that over time prices respond to factor scarcity, thus induce factor substitution and introduction of new inputs. That is, as resources are depleted, their prices increase and hence induce the search for substitutes, stimulating technological change (World Bank, 1984). Haswell (in Upton, 1973) argues that once the critical population density is reached, land scarcity occurs and land value (price) increases leading to concern about its conservation. At this point each unit of land has an opportunity cost measured by the value of its marginal product in its most profitable use. Also, the Hayami-Ruttan induced innovation theory demonstrates that factor use changes over time, leading to increased conservation of scarce resources and increased use of abundant resources (Hayami and Rutani, 1971). These theories stress that population growth leads to increased value of land, hence induce adoption of conservation technologies.

3.5.2 Soil erosion

The economic relationships between soil erosion (topsoil depth) and yield, soil conservation and technological change discussed in this section heavily draw on Van Kooten's (1993) models for explaining the economic aspects of soil conservation. Van Kooten indicates that soil erosion can take place without affecting productivity as long as it remains below the rate of natural regeneration or soil formation. Soil loss rates that exceed the rates of regeneration of new topsoil reduces productivity, leading to declining output in the long run. Studies on soil regeneration show that in most tropical areas, soil loss rates exceed soil regeneration. High rates of soil loss observed in these areas are attributed to erosive farming, which enhances soil erosion by water and wind. It is assumed that in these areas there is linear relationship between soil loss due to erosion and output loss, leading to user costs (Carlson et al., 1993).

The user cost of soil erosion is the impact of soil loss on future profits via declining soil productivity. That is, it is the present value of future revenues that are lost if we incur a unit of soil loss today. Van Kooten (1993) illustrates the user costs by first assuming that production can occur without any erosion (Figure 3.2). Suppose that P_0 represents the discounted value of the path of net returns from growing a crop on a field where topsoil depth is maintained at the existing level, and that P_1 represents the discounted returns from an alternative cropping strategy such as continuous cropping without fallowing. Using the same planning horizon[13] the user cost of soil erosion is given by the difference in net returns, $P_0 - P_1$. However, Van Kooten argues that farmers do not make decision based on total user costs. Since farmers are able to switch from more erosive to less erosive cropping systems at any point in their planning horizon, they consider marginal user costs or opportunity cost.

[13] Returns end at the same dashed line indicating that an identical planning horizon is used.

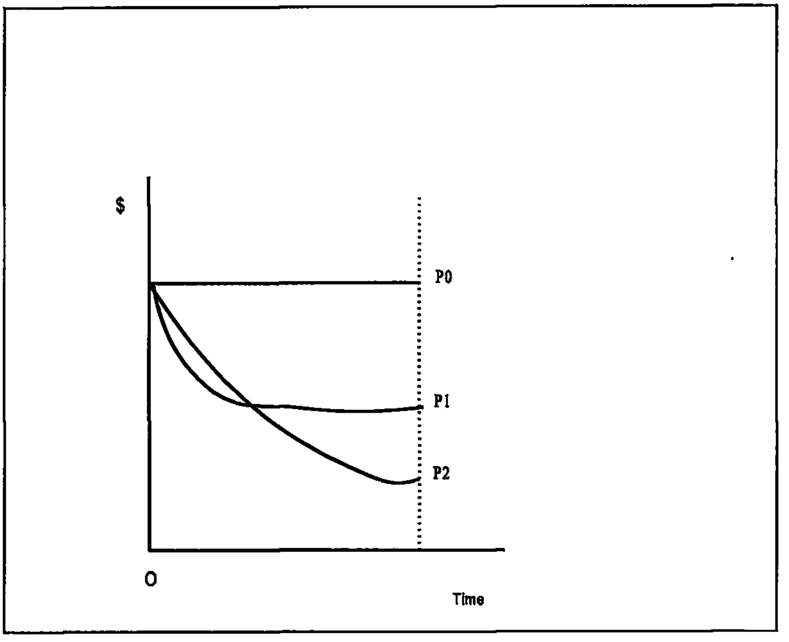

Figure 3.2: User cost and opportunity cost of soil conservation
Source: Van Kooten, 1993

The correct measure of on-farm opportunity cost of soil erosion is determined by comparing the erosive practice P_1 with the best available soil conserving practice P_2 Here, $P_1$and P_2 are the respective discounted values of net returns from the two practices. The difference between P_1 and P_2 is the on-farm opportunity cost of soil erosion. If the difference, P_1-P_2 is less than zero, then there is an on-farm cost for applying erosive practice, and if this is greater than zero, then the recommended soil conserving practice, P_2 is worse than erosive practice, P_1, and farmers who choose to use the erosive technique are behaving rationally. Lal (1977) observes that a thorough analysis of alternative soil conservation is required in order to be able to get a realistic impression of the long-run benefits to be drawn from various conservation practices. This needs proper consideration of economic factors associated with these practices. De Graaf (1993) notes that a judgement based on total yield alone is often misleading, if the costs and benefits accrued to the practices are ignored. Also variability in annual returns is an important aspect to be considered, since it provides information on the risk attached to the adoption of various conservation practices. Farmers who are risk averse will refrain from adopting soil conservation measures in a situation where there is high variability in annual returns attributed to external factors such as price and weather variations as well as other institutional supports and policies like marketing facilities. In order to enhance the use of appropriate soil conservation measures, variations in annual net returns accrued to farmers have to be stabilized by instituting appropriate policies and institutional support such as price support programmes, timely marketing system and infrastructure.

Biological relationships between yield and topsoil depth indicate that as the topsoil depth increases, increase in yield from additional topsoil declines (Figure 3.3)[14]. The reason for this is that, once the depth of soil exceeds the rooting zone, additional soil is not required for crop growth. Figure 3.3 also indicates that there is a limited yield level that can be attained. At higher levels of the topsoil depth, the curve is flat, indicating that a significant decrease in topsoil depth will not have a large impact on yield i.e., the marginal product of topsoil is very small. At lower levels of topsoil depth the curve is steep. In this case, a small reduction in topsoil depth will result in substantial yield loss, and the marginal product of soil depth is high. The implication of the yield-topsoil depth relationship for soil conservation can be explained by using the marginal

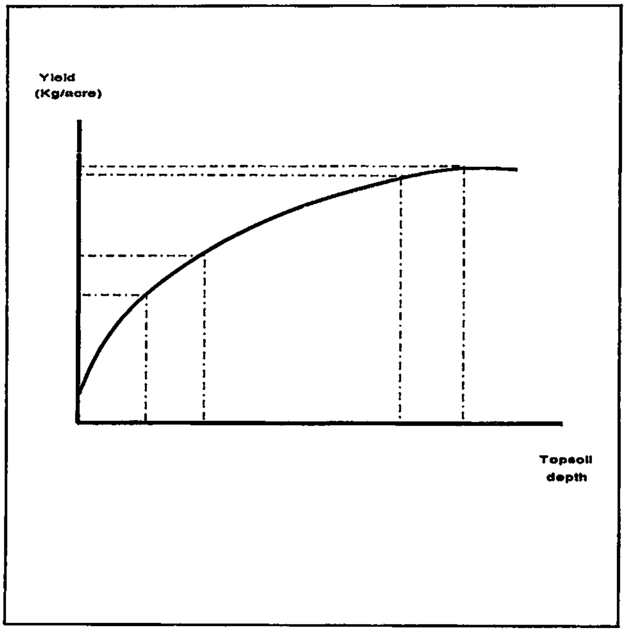

Figure 3.3: Relationship between yield and topsoil depth
Source: Van Kooten, 1993

[14] The positive intercept on the yield axis indicates that it is possible to achieve some crop growth, even if topsoil depth is completely removed.

user cost of soil erosion. As the land is cultivated, soil loss increases and farmers sees a decrease in yield down the yield-topsoil depth curve. Additional losses in soil result in greater yield losses and the marginal user cost of soil erosion increases and hence the incentive for farmers to use soil conservation practices increases. Losses from erosion become large enough to justify expenditures to reverse the situation. As long as farmers are operating at the top of the yield-topsoil depth curve (flat part), they have little incentive to prevent soil loss, as their is little benefit from soil conservation. On the other hand, when production occurs at the lower ranges of the curve, the benefits to soil conservation increase (Van Kooten, 1993). This explains why in most empirical research it has been found that farmers are unwilling to adopt soil conservation technologies when topsoil depths are adequate[15]. They tend to use soil conservation techniques only if topsoil depth declines to very low levels.

Miranowski (1984) illustrates the relationship between intertemporal productivity and soil loss by using the framework developed by McConnell (1983). He concludes that efficiency is achieved when soil loss occurs at the level where the average output loss associated with additional soil loss equals the average cost of using the soil. For the upward sloping part of the curve, if the farmer places a higher value (i.e., large yield foregone) on a unit of output per topsoil, he will make greater efforts to reduce soil loss and save the topsoil. Second, if agricultural output prices are increasing over time, more soil conservation technologies are adopted. If farmers expect this upward trend to continue in the future the incentive to use soil erosion control measures may increase over time. Finally, Miranowski indicates that lower discount rates increase the net present value of soil erosion control measures, especially those with greater benefits in the distant future. Higher discount rates will reduce the efforts to prevent soil loss. Montanez (1985) analysed the main obstacles to adoption of soil conservation in the subtropical mountainous watershed in Las Cuevas, Dominican Republic. Using a damage function, he showed that in addition to the relationship between topsoil depth and crop yield the profitability of soil conservation adoption is very much related to farmers' planning horizon, technological level and conservation costs. Similarly, Ervin and Washburn (1981) and Walker (1982) found that farmers will not respond to impacts of low topsoil depth due to soil erosion by adopting conservation practices unless they have low discount rates and long planning horizons. Cárcamo et. al (1994) argues that for farmers in the developing countries planning horizons are likely to be short and discount rates higher because farmers operate at subsistence level.

3.5.3 Technical change

Technical change that relates to soil erosion can be either endogenous or exogenous. Exogenous technical change in this context involves the use of production technologies which are not intended for reducing soil erosion. Such technologies include among other things fertilizer application and improved seed varieties. Endogenous technological change refers to technical change that takes place to remedy erosion (erosion-induced technical change). With exogenous technical change, yield can be increased despite soil erosion. This can convince the farmers that erosion damage is insignificant and that there is little need to adopt soil conservation

[15] Top soil depths are at a level at which the marginal user costs of soil erosion are insufficient to justify adoption of soil conservation practices.

practices. Fertilizer use and improved crop varieties have increased absolute yields despite decreasing topsoil depth. The yield loss due to erosion, that is the loss farmer should be using in their conservation decisions, is the difference between the potential yield they could have if they had used soil conservation techniques and actual yields (Van Kooten, 1993).

Technological change in the context of this study refers to improvements of methods of production which reduce soil erosion (endogenous technical change) and ultimately increase soil productivity. Production function is often used to analyse improvements of methods of production (technological change). These improvements change the relationships between outputs and inputs over time, and hence shift the production function upwards. The relationship between technological change and soil erosion is illustrated in Figure 3.4. The farmer is assumed to be operating at the production function *F1*, and is producing at point *A*. The production function *F2* represents production at some time in the future. With this production function the farmer is operating at point *A'* and is able to obtain more yields *Y'2* for every level of topsoil depth attributed to technological improvement. Without technical change, a reduction in topsoil depth from *Do* to *D1* would decrease yields from *Yo* kg/ha (point *A*) to *Y1* kg/ha (point *B*). Technological change has reduced the impact of soil loss, (in the form of the yield decrease) from *Yo* (point *A)* to *Y2* (point *B'*). Therefore, erosion damage off-set by erosion-induced technological change is *Y2-Yo* kg/ha. This conclusion is wrong unless the respective technical change is induced by concern about soil erosion (endogenous). If technological change is exogenous, the correct measure of soil erosion damage is obtained by comparing yield levels at points *A'* and *B'*.

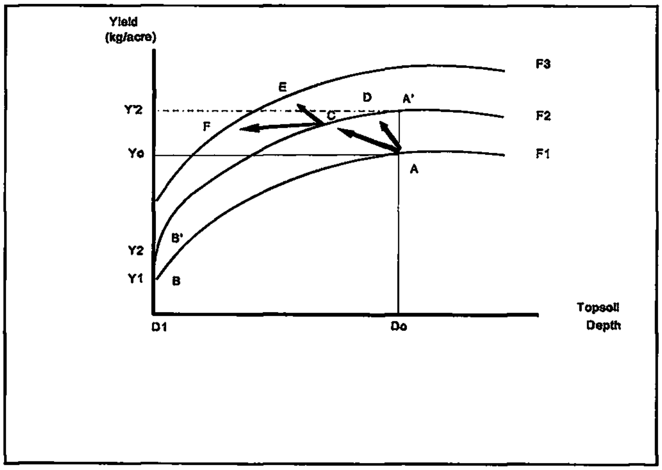

Figure 3.4: Soil erosion with technical change
Source: Van Kooten, 1993

However, with exogenous technical change it is, again, not appropriate to conclude that technological progress has partly offset erosion damage. It is expected that farmers will continue to use erosive agronomic practices in the false belief that this will continue to offset erosion damage. In early years farmers will move along path *A* to *C*. With conservation practices they would move along *A* to *D*. After some time the exogenous technical change will shift the production function to *F3*. With continued use of erosive practices this will cause movement along path *C* to *F*, instead of *C* to *E* with conservation practices. In this case the potential yield declines in spite of technological improvements.

The above illustration implies that government support which encourages the use of fertilizers and improved crop varieties (e.g., input subsidies) to improve land productivity, reduces the adoption rate of soil conservation technologies. This hypothesis indicates that with the use of fertilizers and improved seed varieties productivity losses from soil erosion are delayed. Bilthy and Kirby (1985) have observed that fertilizer subsidy hinders the adoption of management and production practices suitable for reducing land degradation. This argument holds only when the subsidy level is high enough to give farmers incentives to use enough fertilizer and improved seed varieties to attain substantial yield increases.

3.6 Summary

Although there is no consensus on a specific comprehensive definition of agricultural sustainability, it is obvious that quite a lot of effort has been put into identifying components, criteria and indicators for expressing the concept of agricultural sustainability. One important point of agreement in these definitions is that agricultural sustainability requires that the current agricultural production process is managed in such a way that the current land productivity is maintained over time to meet the long-term (future) needs of the farm households and society as a whole. Resource conservation including soil conservation is mentioned by several authors as an important means for achieving sustainability of the agricultural production system.

Economic and bio-economic methods and approaches have been developed for measuring sustainability of production systems. Economic approaches such as Linear Programming (LP) and Cost Benefit Analysis are built upon the utility maximization assumption, hence pay attention to attainment of higher monetary returns over time. On the other hand, bio-economic approaches focus on the biological response (yield, nutrient levels) of the system to changes in conservation methods. In general, the approaches for measuring sustainability reviewed evaluate the potential performance of the production system in terms of economic returns and output levels with respect to conservation technologies used by farmers or which could be used by farmers. Little attention is paid to the willingness and ability of farmers to use the conservation technologies under consideration. That is, factors which influence farmer's choice of alternative conservation practices are not identified and incorporated into these approaches.

It is conceptualized that population growth is the major cause of land degradation in the northeastern mountains. Furthermore, it is illustrated that households in the study area will not adopt soil conservation technologies such as soil erosion control measures unless they perceive the land degradation problem and the long-run conservation gains in the form of increased farm output and income. In other words, the more the households believe in the effectiveness of soil conservation technologies to reduce land degradation and perceive the increasing farm output and income due to conservation, the more they will be willing to invest in soil conservation, leading to a sustainable production system. This will happen as long as appropriate institutional support and incentives and technical information are available. Also, the household's values and beliefs influences attitude towards land degradation and perception of increased farm returns (profit) and hence soil conservation adoption decision. These are influenced by socio-economic factors such as age, social status and networks among others things.

The economic theories of land degradation and soil conservation provide two schools of thought with regard to relationships between population growth and land degradation. A number of authors (Malthusians) maintain that population pressure creates land scarcity and thus triggers land degradation due to extensification and intensification of agricultural production leading to reduced land output. Other authors, like Boserup, believe that population pressure stimulates technological change attributed to land intensification. The Malthusian school of thought is biased towards the negative consequences of population growth, while the Boserupians focus on the positive impacts of population growth. The most important point of agreement is that population growth results in over exploitation of resources and hence in land degradation. Although Boserup and others assume that in the long run land users may circumvent the detrimental consequences of land degradation by changing their farming practices, some of the new practices are not always adequate or appropriate for reversing land degradation. In cases where response includes interventions by the government and development organizations, the impact of these interventions on land degradation depends on the ability and willingness of people to use and maintain them over time. Therefore, population growth can result in technological advances, but the extent to which this happens depends on the attitude, hence behaviour of land users towards changes.

The economic theories of soil erosion have demonstrated that household's decisions on conserving soil are influenced by the opportunity cost of soil erosion determined by the difference between the present values of net returns from traditional and improved technologies, hence long-term benefits. In addition to the benefits, the theories emphasize on the role of institutional and policy support in reducing risks related to output variations, thereby increasing the adoption rate. Again, the assumption here is that a farm household's goal is to maximize expected utility explained in terms of profitability. Furthermore, it is demonstrated that adoption of SWC technologies depends on the impact of topsoil depth loss on yield over time. Farm households will tend to adopt SWC measures only if yield reduction due to topsoil loss is large enough to draw their attention.

In general, these theories indicate that application of soil conservation methods during the production process helps to restore soil quality and hence improve the production capacity of the land over time. Sustainable soil conservation can be attained only if appropriate technologies are developed and successfully adopted by farm households. Again, the behaviour of the households, especially planning horizon and their willingness and ability to adopt soil conservation technologies and to maintain them over time, is emphasized.

CHAPTER 4

ADOPTION THEORIES AND MODELS

4.1 Introduction

In this study adoption of soil conservation technologies has been identified as the most important indicator for assessing sustainability of the production system in the northeastern mountains with respect to land degradation caused by soil erosion. We have seen that population growth influences sustainability of the production system from both demand and supply sides. On the demand side, population growth influences farm household production decisions, due to increased demand for food (consumption) over time. On the supply side, population growth rate influences the rate of soil erosion, which reduces the level of output in the long run, and hence net farm income. In chapter 3, it has been demonstrated that the long-term solutions to soil erosion problem will be found by using soil conservation practices. Adoption of soil conservation measures will help to reduce the impact of soil erosion on output level and farm income, hence improve the long-run output of the agricultural production system.

In this chapter, we first discuss sociological and economic theories and models describing the household innovation adoption process. We also review some empirical studies related to adoption of soil conservation technologies, indicating how various authors have attempted to use sociological and economic theories of innovation adoption to explain the behaviour of farm households towards adoption of soil conservation technologies. This review together with the conceptual model developed in chapter 3 is intended to guide the development of theoretical models and framework for the study.

4.2 Sociological theories of adoption of innovations

In this section we discuss some sociological theories in the literature which explain the process of adoption of innovations. The sociological models and theories discussed in this section intend to shed some light on the adoption process from sociologists' point of view.

4.2.1 Decision-theoretic model of innovation adoption

In this model adoption of innovation is regarded as a learning process. Psychologists advocate that consciously or unconsciously, every person goes through certain mental steps during the learning process about innovation. This process is divided into stages which form a continuum of mental growth concerning the innovation. The process involves four stages: *awareness* stage, *evaluation* stage, *trial* stage and *adoption* stage (Wilkening, 1953; Beal and Bohlen, 1957 ; Rogers and Shoemaker, 1971)[16]. Each stage in the process depends on the preceding stages being completed. Awareness is the stage in which an individual household

[16] The stages are also referred to as *initial knowledge* of innovation, *persuasion* toward the innovation, the *decision on* whether or not to adopt innovation and lastly *confirmation* of the decision. These stages are more or less comparable to these ones.

learns about the new idea or practice. The evaluation stage, also known as persuasion, includes comparison of the expected benefits of the new technology with those of their own practices. The alternative outcomes of the evaluation stage are acceptance or rejection. Mental acceptance is presumed to lead to trial use. That is, if the available information about new technology convinces the household that the technology may be better than his own, he move to a trial stage and decide to try it on his own small plot. During the trial stage, the farm household observes advantages and weaknesses of the new technology and compares it with the old practice. If he is satisfied with the performance of the new technology, he decides to use it on a larger plot, and this is the beginning of the adoption stage. If it continues to do well, he makes the decision to completely adopt the technology (confirmation), otherwise he may decide to discard it.

The duration of the time lag in each stage is directly related to the minimum amount of required information about the technology and is inversely related to the rate at which information is collected. Therefore, collection and evaluation of information play a key role in all three stages. The differences in nature and sources of information collected is the primary characteristic distinguishing each stage from the others. This theory considers two sources of information: off-farm sources and information collected from on-farm sources. Distance to off-farm information and to nearest adopter determines the information availability and reliability (Lindner et al., 1982).

The *awareness* or *discovery* stage involves active information search to discover the existing innovations. During this stage, off-farm information through educational programmes, extension services, neighbours and friends, mass media plays a central role in informing people on the existence of the new technology. If the new technology affects the farm household he may become *interested* in getting more information about its benefits, how it is used and investment involved. This is the beginning of collection of information useful for evaluation of the technology which continues until the decision is reached on whether or not to try the technology.

In *evaluation* stage, the focus shifts to the collection of innovation-specific off-farm information, such as observation of trial by a neighbour, in order to learn about the advantages of the innovation. Lindner, Fischer and Pardey (1979), have demonstrated that everything being equal, the required amount of off-farm information for household's decision maker to decide to use innovation will be inversely related to actual profitability of innovation and directly related to the degree of pessimism of his initial belief about the innovation profitability, and to his conservatism or degree of conviction with which he holds his belief. Furthermore Lindner (1981) treats information collection at this stage as a form of undirected search by assuming that decision makers contact all possible sources of information at random. However, this is not always true since different farm households tend to prefer certain information sources over others. If a decision maker perceives or learns that certain information sources are more likely to contain information about profitable innovations, he develops preferences for these information sources. For example, when the innovations are location-specific, rational decision makers will bias their search within the more proximate sources of information relative to distance sources.

During the *trial* stage, on-farm information generated from the trial plot plays a key role in guiding the decision of the household on the performance of the new technology. The household observes and notes the advantages of the new technology from his own plot before he decide to use it. This information can be collected in one or several seasons. While the collection of off-farm information can continue after the initiation of the trial stage, the time of first use of technology marks the end of extensive use of information from off-farm or external sources.

Together with these stages, three other mental processes take place during these stages, influencing the decision taken by an individual. These are *desire, conviction and satisfaction.* Desire and satisfaction are linked with personal characteristics of an individual, like education level, age, farming orientation, together with economic variables such as wealth and risk aversion. Conviction is influenced by the external forces such as educational programmes, development agencies and institutional support services available to an individual, which play a major role in motivating and persuading farmers to use new ideas and practices (Tylor and Miller, 1978).

4.2.2 Innovativeness and adoption patterns: the adoption curve model

Sociological studies indicate that individual farmers in the same area adopt innovations at different times. Some individuals adopt innovation earlier than others while others do not adopt at all. Technologies or practices spread gradually among families, resulting in various adopter categories over time. The most important cause of innovative behaviour is an underlying willingness to change, to try new ideas, hence to adopt new practices. Innovativeness is treated as a psychological trait, which manifests itself in behaviour including the adoption of new farming practices (Pampel and Van Es, 1977). Personality and individual characteristics such as achievement motivation, risk aversion, entrepreneurship and willingness to change are the primary determinants of early adoption of innovations (Rogers and Svenning, 1969; McClelland and Winter, 1969).

Research has shown that the distribution of the adoption of innovation among farmers over time tends to follow a normal S-shaped curve presented in figure 4.1, known as the adoption

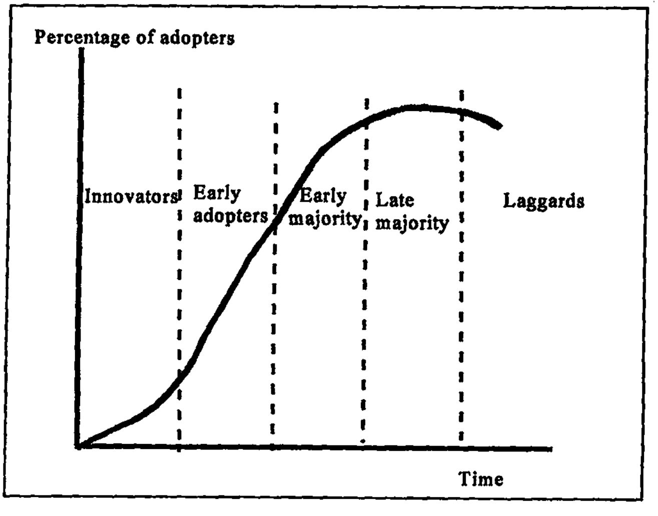

Figure 4.1: Adopters categories over time

curve (Rogers and Shoemaker, 1971). In this curve, population is classified into five adoption categories according to time of adoption. These include: innovators: about 2.5% of adopters, early adopters: who comprise 13.5% of adopters, early majority: 34% of adopters, late majority: 34% and late adopters or laggards (the last to adopt or those who never adopt): about 16% of the adopters (Korsching et al., 1983). These groups tend to vary greatly in terms of their characteristics. *Innovator* is the first group in the community to adopt the new technology. Rogers and Shoemaker (1968) describe innovators as individuals who are venturesome, eager to try new ideas, desiring risk and hazard and willing to accept setbacks. In the society they are individuals with larger than average holdings, greater wealth, and better education. *Early adopters* group is the second to adopt the innovation. Individuals in this group are quick to see the value of new innovations, are less fatalistic, have higher levels of achievement motivation and will try the innovation if they feel it has a fair chance of success. The group includes young and educated individuals. The *early majority* are of an average age, have a higher level of experience and education, highly respected in their community and adopt innovation only after they are convinced of its benefits. The *late majority* group is more conservative, less wealthy and adopt innovation only when it is generally accepted by the community. *Late adopters* (laggards) comprise of older than average individuals, less educated, who seldom take risks. This curve is based on a homogeneous population assumption, with access to information being the only variable factor. Also, it is assumed that the most important cause of innovative behaviour is the underlying willingness to change. The type of innovation is not considered as important as the orientation of individuals towards new ideas.

The application of an S-shaped adoption curve has some limitations which are worth mentioning. First, the S-shaped curve is limited in situations where there are resource constraints associated with the use of a particular innovation. For example, labour or financial resources can limit the use of innovation to only a small group of individuals who have access to and ability to acquire these resources. In this case other potential adopters are eliminated from the adoption continuum, resulting in a non-S-shaped curve. Also, information and support services from extension and development programmes tend to be directed to a certain group of people within a society, mostly innovators. This is attributed to the lack of patience among the development agents (especially externally funded) with slower adopters due to their vested interest to achieve the desirable impacts of innovation within a short time period to justify continued financial assistance from the donor. Under this kind of bias the attainment of an S-shaped curve is either delayed or never achieved. Lump or non-divisible[17] technologies tends to be biased towards larger farmers who in most cases are either innovators or early majority leading to removal of the upper portion of the S-shaped innovation adoption curve.

In addition, different types of innovations will result in different types of adoption patterns. In developing countries, for example, rather than adopting the conventional technological package of divisible[18] technology, farm households adopt such innovations in a stepwise manner. That is, instead of adopting all the components of the technology package at once, they tend to adopt one or two at a time. Byrlee and De Polanco (1986) using on-farm

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[17] Lump or non-divisible technologies refer to technologies that cannot be varied with farm size such as farm machinery, usually involve fixed costs and costs decreases with respect to farm size.

[18] Divisible technologies refer to technologies which involve the use of inputs that can be varied with farm size like hybrid seed, fertilizers and herbicides. They usually involve variable costs.

experimental data from two rainfall zones in Mexico showed that farmers have rationally followed a stepwise process for adopting improved varieties, fertilizers and herbicides for barley, reflecting the relative profitability and riskiness of each component. The adoption of technological components in a sequential fashion results in partial adopters over time. This may not portray the anticipated S-shaped curve, because the delayed full adoption may completely change the shape of the adoption curve. Other aspects not considered in the adoption curve model include the easiness to test and use the innovation. This is related to type of technology, compatibility of the innovation with the production system at individual level and cultural aspects related to the use of innovation. An individual is classified into a certain adoption category based on his behaviour towards the innovation without considering factors influencing such behaviour. An innovative individual can wrongly be labelled a laggard due to late adoption or non-adoption of innovation caused by socio-cultural circumstances. For example, an innovative individual may choose not to adopt new innovation which would interfere with culturally acceptable division of responsibilities between men and women within the household or is incompatible with his personal interests and values.

Though an adoption curve model provides useful information for assessing the aggregate adoption pattern over time, the assumptions underlying this model seem to oversimplify the innovation adoption process.

4.2.3 Group-dynamics model

The group-dynamics theory for adoption takes into consideration the influence of community in the adoption process. These theories are based not only on the wants, desires and wishes of individuals, but also on how the community influences the decision of individuals and how they act and react as groups towards new ideas or practices.

Each person chooses whether to adopt or reject a new idea or farming practice. This choice is the result of an interplay among many forces both within and beyond the individual. His experience, education, traditions, mental capability and many other internal influences affect his decision and choices; but also his decisions and action about the innovation are influenced by behaviour and attitudes of other people in the immediate environment. The development attitude of neighbours, for example, is often an important determinant of whether he chooses to adopt a new technology. From the period between an individual becomes aware of the existence of the technology and the time of accepting or rejecting, he must be convinced that the new technology will either suit his needs or not. Sociologists such as Rogers and Shoemaker (1971) argue that during this period the individual is likely to seek conviction that he is right in his judgement of the technology by means of interpersonal communication channels. The extent to which this happens depends on the degree of interactions and relationships the individual has with others (social networks).

Group-dynamics theory is also important in explaining household adoption behaviour in cases where decisions need group action e.g., flood control techniques and irrigation technologies. The group is made up of individual members, each different from other members. Each member has specific interests, drives, motivations, expectations and hopes, definite values, beliefs and attitudes. Each member also brings to the group certain negative forces such as resistance to and fear of change. He may also have other motives such as personal gains or desires which may or may not fit within the group goals and accepted community standards (Roger, 1971; Beal et al., 1960).

The group-dynamics model emphasizes that each person reacts individually, between each other and within the group or community as a whole during the innovation adoption process. This implies that the dynamics of group behaviour influences the adoption process both at individual level through social interactions with neighbours, friends and relatives, and at community level through joint actions related to common resources.

4.3 Economic theories of adoption of innovations

In this section, the first part outlines some economic theories describing household's decision making behaviour. In the second part theoretical approaches for modelling adoption decisions provided in the literature are discussed. The main objective is to illustrate how some of the economic theories related to household decision making behaviour are used to explain the differences in adoption of agricultural technologies among households in specific time periods and over time. The discussion starts with an outline of some concepts and definitions used in describing the adoption process together with a description of economic variables commonly used to explain household's behaviour with respect to adoption, indicating the role of risk and uncertainty in adoption process. This is followed by a discussion of the farm-household static models of adoption, focusing on both the individual farm household and aggregate levels. This illustrates modelling of decision making on innovations at a certain point during the adoption process. Then, dynamic adoption models are discussed to indicate how the role of time in adoption process is incorporated into economic modelling. The discussion is based on parameters households use in decision making over time.

4.3.1 Assumptions and theories of household behaviour

4.3.1.1 Utility maximization

The economic theories address farm households as decision makers concerned with questions such as what levels of different resources to devote to cultivation of each crop and what technologies to use in crop production. In the process of making such decisions farm households are influenced by their production objectives, which determine their willingness to invest in various production activities including the desired production technologies. Utility maximization theory plays a key role in explaining household's behaviour that influences the decision making towards various choices confronting them. Utility refers to the satisfaction an individual derives from a set of commodities. The meaning of utility maximization in this context is that, given a set of economic and technical constraints, farm households maximize personal and common *welfare*. It is assumed that households have certain preferences concerning production and consumption, expressed in terms of utility they provide. The hypothesis is that a rational farm household will always choose the production and consumption alternatives that maximize utility. In other words, a farm household is considered to have utility maximization as the main production objective.

Utility is assumed to be derived from consumption. Consumption explains the utility or satisfaction the farm household wish to attain from his farm production unit. This implies that farm households work towards income or profit in order to be able to consume the products that money returns can buy. Therefore, farm income and utility through consumption are closely interrelated. An important assumption that can be made from this theory is that a farm household does not derive utility from growing crops or other farm activities; they rather derive utility from commodities and privileges that income from production furnish. Therefore, higher income gives the household more purchasing power of goods and services, resulting in higher utility. The interrelationship between utility, income and consumption is important not only in defining the organization of resources and family activities at a certain time but also in helping to explain uncertainty and risk precautions and other production-consumption decisions.

In explaining farm household behaviour, utility is expressed in terms of expected utility. This notion assumes that a farm household acts in such a way that his decisions maximizes the utility of the expected outcome. This implies that farm households will choose the alternative whose expected outcome will provide them with the highest satisfaction among the alternatives that hey have. Expected utility therefore requires that the individual household has consistent preferences between various alternatives which confront him. In this context household's personal judgement of the preferences in relation to these alternatives plays a key role in the decision-making process.

Labour (farm work or drudgery) is also used to explain utility. The utility maximization model is explained using the *drudgery aversion* theory. In this theory it is assumed that the labour market does not exist and the farm household depends on family labour only. The Lack of a labour market causes the time the household is not working on the farm (leisure) to enter the utility function as a separate goal from income. The theory focuses on subjective decisions made by the farm household with respect to amount of labour to commit to farm production to maximize farm income. This decision involves trade-off between farm work and income required to meet the consumption needs derived from both farm production and other farm household activities. The household has two opposing objectives: income objective which requires work on the farm and leisure (work avoidance) which conflicts with income generation. Leisure in this respect is related to labour available, labour demand and labour allocation within the farm household (Kooreman and Kapteyn, 1987; Wales and Woodland, 1977). The farm household makes a choice between allocating their labour to farm activities or to leisure. They decrease, increase or maintain their total utility by allocating their labour between leisure and farm work, depending on their preferences and priorities. Nakajima (1969) found that utility is maximized when the marginal product of labour is equal to marginal value of leisure. This is when the household is equating the marginal utility gained from one extra hour spent on farm activities to marginal utility derived from the last hour of leisure.

Whereas the drudgery aversion theory is based on assumptions that labour market and other sources of labour supply does not exist, it has been established that there are three main sources of labour supply to farm household: family labour, which is supplied by active people living in the same household, wage or hired labour (casual or permanent) and cooperative or group labour. Hired labour and group labour are used to either supplement the available family labour or to reduce farm work (increase leisure). The amount of labour the farm household is able to hire depends on the wage rate, which in most developing countries is determined by imperfect markets (Boahene, 1995). Therefore, for adoption of innovations besides the prospects of higher income that induces the farm household to adopt innovations, farm households consider the impact of innovation on labour allocation within the farm family and how this translates to leisure prospects. The key element influencing this is the size of the household, and its composition (i.e., working and non-working members) which varies among households. The literature suggests that the larger the family, the higher the supply of labour the household has for farm work (Levi and Havinden 1982). Farm households with large families are therefore expected to draw their utility from investing in labour-intensive technologies. Such investment is expected to increase their income and hence utility. Some empirical studies conducted in Africa provide evidence that households vary in their economic performance according to household size and structure. As the family size increases, the chances of farm households adopting innovations increase. This is attributed to a higher level of labour supply (Levi and Havinden, 1982; Low, 1986). However, family size as an indicator of level of family labour can be misleading. Labour available per household is mainly determined by the number of household members who are available for full-time farm work. Also, availability and accessibility to other sources of labour, such as wage labour are additional determinants of level of household labour.

4.3.1.2 The profit maximization

Another theory that explains the rational behaviour of households is the profit maximization. This is built upon the concept of utility maximization theory. As described earlier, though the household have other production goals they attempts to maximize profit as a means of achieving utility (Debertin, 1992).

Profit is defined as the difference between revenue obtained from what is produced and costs incurred during the production process. The economic efficiency is attained when resources are organized to give maximum profit. Therefore, profit maximization models indicate that in the short run, the farm household will continue to increase the amount of variable input(s) used in the production process as long as the additional revenue exceeds the additional cost. That is, when the value of marginal product (VMP) is greater than the marginal input cost (MIC), it pays to increase the amount of input used in production. The profit is maximized when MVP = MIC. At this point, the value of one unit of input (input price) is equal to the value of one additional unit of output (output price) (Doll, 1984). It is assumed that the farmer would not produce at all if the price of input exceed the maximum average value of product. Therefore, under the assumptions of pure competition the supply curve is the upward-sloping part of the marginal cost curve that lies above the average variable cost curve.

Profit maximization theories describe farm households as economic agents that are efficient in allocating their resources with an objective of maximizing profit. It is assumed that individual farm households use their resources irrationally when they do not maximize profit. The farm household is treated as a farm firm operating in fully formed competitive input and output markets, taking prices as given. This implies that when farm households make an investment decision, the most important question they address is, how much of output to produce and what level of each input should be applied in order to maximize net returns. During the production process, the farm household tries to find the levels of output and input that gives the highest net returns at given input and product price levels. This theory is supported by many neoclassical economists including Shultz (1968), Haswell (1970) and Ellis (1988), who defined the farm household as being both efficient and profit maximizing. Therefore, the prospects of higher income induces households to adopt innovations.

4.3.1.3 Technological change

Technology is a stock of knowledge that can be applied in a production process. Technological change implies changes in this stock (Yotopoulos and Nugent, 1976). Technological change theories are built upon the concept of technical efficiency which is described by several economists including Yotopoulos and Nugent (1976), Yotopoulos (1968), Norman (1974, 1977) and Schultz (1964). Technical efficiency is measured by the magnitude of the physical ratio of output to factor input. The greater the ratio, the greater the degree of technical efficiency. Therefore, *technical efficiency* is defined as "maximum attainable level of output for a given level of production inputs and the range of alternative technologies available to the farm household".

The household theories with respect to technical efficiency are based on the hypothesis that a farm household operates *on* rather than *within* the production function available to them. Therefore, technical efficiency involves movements to a higher point within the production set. A movement of this nature involves a change in production techniques. It involves the use of methods of farm production which have been developed or could be developed with the existing state of scientific knowledge. In neoclassical models, technological change is assumed to shift the production function. The theory of peasant farm household production assumes that output is influenced by the state of technology used by the farm household, the quantities and types of resources used as inputs into the production process, efficiency with which the household uses those resources and scale of production. The theory of technological change suggests that a household obtains different output levels and profits from different types of technologies. This implies that different kinds of technological change have different implications for resource allocation decisions. Doll (1984) indicated that the difference between levels of output and profit obtained when the farm household is using the old technology and that obtained after introducing a new technology is likely to influence household's investment decisions. This implies that household's willingness and ability to make production investment are influenced by the output and profit levels associated with the technology use.

4.3.1.4 Risk and uncertainty

Risk in the production process is regarded as a situation where a farm household conducts the production under conditions of less-than-perfect certainty, but knows both the possible outcomes that could result from the production process and the probability associated with each outcome. For example, if the farmer knows that his crop is likely to fail in one year out of four, then this is a case of risk and the probability of occurring is 0.25. He does not know whether the crop will fail in any particular year, but he knows that over a long period it is likely to fail one year in four on average. Thus, risk exists when the outcome of the process, e.g., yield per hectare, is a random variable with a known probability distribution (Ellis, 1988, Binswanger, 1980).

All farm production activities involve some risk. This is because the household has to make investments in advance of the final output, which may turn out to be more or less than expected. Crop and livestock yield depends on weather, such as rain, which is a random variable. Early or late arrival of rain, too much or too little rain limits the production levels of both crops and livestock. Pests and disease outbreaks can result in complete loss of yield, limiting the realization of the expected output.

Risk is peculiar to the mind of an individual household. Two individual households may view the same event differently. One may consider it to be highly risky, while the other views it as less risky. Risk is characterized by the nature of expectations the individual household formulates as the basis for their plans. Therefore, the degree of risk for a certain event depends on the manner in which the farm household interprets and views the event itself with regard to future expectations. Ellis (1988) argues that, in most decision-making situations, what is relevant is not the knowledge concerning the likelihood of an uncertain event, but rather the decision maker's *personal* degree of belief about the occurrence of events. We can, therefore, concluded that it is the personal view of the individual farm household about the likelihood of an event which determines the course of action they take to cope with the incidence rather than the knowledge about the probability of its occurrence. Therefore, the action or decision an individual takes as to an event depends on their perception of risk and the degree of risk the household attaches to the event (risk aversion).

The treatment of risk as being based on farm household's personal strengths of belief about the occurrence of uncertain events and their personal evaluation of potential consequences originates from the economic concept of personal utility maximization. During the subjective assessment of uncertain events, the individual farm household maximizes expected utility, given their beliefs about events and outcomes and technical and economic constraints. Using the certainty equivalence theory, the individual household compares less and more risky alternatives and places them on a scale of personal preferences. Risk enters the utility function of the household as the preference of production security in the face of subjective risk. In this case utility maximization involves trade-off between greater security and higher income. The attainment of greater security may require that the household minimizes input use to a lower level than is required to maximize profit (avoidance of the loss associated with high input costs) or may use production methods and techniques which do not correspond to highest net returns.

Risk aversion behaviour of the farm household determines the willingness of the individual household to invest in technologies, hence the extent and level the technology is adopted. In making decisions on what to produce and which technology to use, farm households consider the risk involved. Given their food security needs and profit and output maximization goals, they determine the chances of realizing these goals under the uncertainty situation they face. Their decision is influenced by their perception of the likelihood of attaining the expected outcome from using the innovations. Upton (1987) observes that subsistence farm households produce small surpluses of their basic food needs such that any crop failure can jeopardize their survival. For this reason they may be particularly averse to taking risks and therefore prefer more reliable enterprises and production methods.

Ellis (1988) gives the following propositions related to the effect of risk aversion of the farm household on farm efficiency and decision making:

1) Household risk aversion inhibits the diffusion and adoption of innovations which could increase the output and incomes of the farm household families. Ellis relates this to other adoption constraints. He advocates that household skepticism about innovations is related to imperfect knowledge of the innovations and appropriate agronomic practices, and other constraints such as lack of credit and high investment costs.

2) Risk aversion declines as wealth or income rises. Higher income or wealthier farm

households are able to withstand the losses which might result from risky investments. This implies that wealthier farm households are expected to be more efficient and more willing to adopt new innovations. They are also likely to be better informed and have more access to credit and other institutional support services available.

3) Household risk aversion results in cropping patterns and production technologies designed to increase family security rather than maximize profit.

Policies and support programmes intended to enhance adoption of innovations plays a key role in tackling adoption problems associated with risk aversion of the farm household. This refers to risk aversion attributed to external factors other than household's personal characteristics. For example, where risk is attributed to inadequate information the information provision policies and programmes are considered useful. Where risk aversion is related to high investment costs, credit support and input subsidies are suitable mechanisms for overcoming such a barrier.

4.3.2 Economic approaches for modelling adoption of innovations

4.3.2.1 General aspects underlying adoption

In most of the economic literature adoption is defined as a qualitative variable. Adoption is analysed in terms of whether or not the innovation is used by households. This is in some cases expanded to include the extent or intensity of use based on various indicators, such as land area under the technology or the components of technology used. Adoption is also characterized in terms of the level of analysis. Adoption process for innovations can be explained at *individual* households level or at *aggregate* level. The individual household level approach analyses the behaviour of single farm households towards adoption of technologies. The analysis often relates the degree of adoption to factors affecting it. The aggregate adoption approach is based on the assessment of the proportion of households using the technology in a particular area. This is in many cases based on time-series data to identify the trends in the diffusion process. That is, the adoption process is modelled to identify the adoption logistic-shape over time (Besley and Case, 1993). Adoption of innovations have also been modelled using *static* or *dynamic* perspectives. In the case of static analysis the behaviour of an individual farm household or a group of households is determined at a certain point during the adoption process. Dynamic analysis is based on changes in the decision-making parameters over time.

Another important aspect in analysing adoption is types of technologies. Technologies are classified into two categories: *divisible* technologies and *lump* technologies. Divisible technologies refer to those technologies which are scale neutral, and their level of use can be adjusted during the production process. This includes most variable inputs such as hybrid seed, fertilizers and insecticides. Lump or non-divisible technologies are fixed, scale-dependent technologies, such as farm machinery and permanent farm structures such as an irrigation system. Related to type of technology is the aspect of *partial adoption*, whereby households adopt only part of the technology. Often divisible agricultural innovations are introduced as a package containing several complementary components[19] (Mann, 1978). For example, a package of hybrid seed technology would consist of several components, such as specific levels of fertilizers, planting methods and weeding regime. In order for the farm households to attain the expected optimum returns they are required to simultaneously use these components. This is because the potential output is higher if both technologies are adopted. Given the household's perceived risk associated with each technological component, he maximizes the expected utility by making the choice of whether he should adopt the whole package of technology or just part of it. This is followed by a decision on which components to adopt and what amount of resources such as land should be allocated.

The economic assessment of adoption is built upon the assumption that households are motivated to adopt new farming practices due to their desire to maximize utility explained in terms of perceived net returns (profit). Therefore, economic models of adoption have been used to analyse adoption of innovations focusing on economic variables which influence the level of farm returns or profit at a certain point in the adoption process or over time. These variables include farm size, prices, output level, investment level, labour use and markets. It is assumed that given the uncertainty and risk the farm household attaches to new technology they will adopt the new technology only if the perceived future profit is higher than that accrued from the current technology. Uncertainty of the returns from new technology may arise from unavailability of required inputs and vulnerability to weather conditions (objective uncertainty). Also, it may result from farmer's lack of experience with the new technology (subjective uncertainty) (Boahene, 1996).

4.3.2.2 The static household adoption models

These models are used to analyse farm household's decision making about the extent and intensity of use of new technology at each point throughout the adoption process. Most individual farm household studies on adoption of agricultural innovations use static analysis. Adoption is analysed in terms of whether or not (dichotomous choice) the household is using the technology under consideration. In most cases this is extended further to include the extent to which a particular technology is used (adoption intensity). Most of the static farm household adoption models examine the behaviour of farm households towards adoption of one or different types of agricultural innovations. These models incorporate economic factors that explain the observed adoption decisions. In most cases, risk and uncertainty have been incorporated given the role they play in determining the perceived returns.

The static models are specified with the production function, representing a particular technology. This production function depends on land and other resources allocated to that technology and other unobservable factors such as risk and uncertainty. With given output and input prices, the short-run profit from using the technology is expressed as the difference between the total farm returns and variable costs subject to available family land and other resources required by the technology. Moreover, if adoption of new technology involves fixed costs e.g., irrigation structure, then the appropriate criterion for a household may be maximization of total

[19]This refers to a situation whereby combining two innovations, such as hybrid seed and fertilizer, increases the output or profits more than when one innovation is adopted alone.

farm returns minus both variable and fixed costs for each technology used subject to available resources.

Using some explicit assumptions and specifications for the production function, risk and uncertainty, several farm level empirical studies have applied the production function model to analyse factors affecting adoption. The most common specification used in the application of this model is the aspect of production variability which captures the level of risk and uncertainty.

The underlying assumptions of the static farm household technology adoption model are that markets are perfectly competitive and the production and consumption decisions are separable. However, the economic environment in rural households in developing countries (subsistence production) is characterized by imperfect markets resulting in non-separability of the household production and consumption decisions (Feder and Umali, 1991). The inseparability is also explained by the imperfect substitutability of family and hired labour and differences in sales and purchase prices of inputs and outputs. Therefore, the existing imperfect factor and commodity substitution found in developing countries call for adjustment in application of the production function model. Pradhan and Quilkey (1991) apply the individual household model in developing countries to capture farmer technology adoption behaviour taking into consideration the existence of an imperfect factor (e.g., labour) and commodity substitution. The authors assume that the household's production function undergoes changes as a result of the introduction of new technology. The level of farm output is therefore a function of family labour supply and hired labour demand, cash inputs, the proportion of land allocated to the new technology, and other exogenous variables. In this model farm households maximize utility from the consumption of commodities produced, leisure and residual cash endowment used to purchase other consumption commodities, subject to family and hired labour, other cash inputs, land allocated to both traditional and new technology, time endowment and cash endowment constraints.

The static individual models discussed here assume that farm households adopt only one new technology and have to decide whether or not to adopt and to what extent. However, in practice they may have to make decisions involving several technologies or components of the technology.

4.3.2.3 Dynamic adoption models

Several economic models have been developed to explain the dynamic adoption process under risk and uncertainty at both aggregate and individual household levels. These models are based on some of the sociological aspects of the decision making and innovation diffusion process discussed in the previous section. The static models of adoption behaviour provide the basis for dynamic properties of the adoption process. The dynamic adoption models are constructed based on the assumption that the solution to temporal optimization problem at the beginning of each period determines the types of technology the farm household will use in that period, the allocation of land to crops and use of variable inputs. At the end of each period, the actual yield, revenues and profits are realized. This added information about the performance of the technology together with experience accumulated during the period and information about the technology outcomes from other households tends to update the parameters farm household will use in decision making for the next period (Just and Zilberman, 1985).

There are several innovation adoption models that describe the changes in the decision-making parameters over time. Only a few of these models address the adoption of innovations in agriculture. O'mara (1971) was the first to apply the dynamic model of adoption. The model assumes that in addition to cash resource and wealth accumulation at the end of each period as the important parameters households use in decision making for the next period, changes in perceived parameters of production function distributions are also considered. These changes are the result of the learning process that incorporates prior perception and recent information about yields and input uses of households in the region. That is, households improve their prior beliefs on the basis of perceived performance of the technology, and hence are inclined to increase the use of new technology over time. O'mara's work was followed by several models assuming Bayesian learning that uses explicit formulations for perceived distribution of production function parameters over time. Day and Sigh (1977) have developed a dynamic model of adoption characterizing farmer's adoption behaviour as "cautious optimization". In this model the authors assume that with time, farmers' self-imposed constraints, which are due to risk aversion, are gradually eliminated as a result of learning-by-doing effects. Financial constraints are also relaxed due to the effect of building up surplus cash generated by a profitable adoption in previous years. Therefore, adoption increases over time until an upper ceiling is reached. These relations allow more rigorous investigations of the adoption path, and in particular allow analysis of the *evaluation stage* of the adoption process before the household decides to use the technology. Some of these models recognize the role of extension efforts and education differences in changes in perceptions over time.

Another dynamic modelling approach focuses the changes over time on household's effectiveness with new technology. These changes may be the result of learning-by-doing. That is, the farm household may become more proficient with the technology as he accumulates information by using it (Feder and O'mara, 1982). Measures of experience with technology include the length of time the household under consideration and other households in the region have used the technology or the total cumulative amounts of land utilized by farmers in the region over time.

The dynamic adoption modelling efforts also focus in changes on prices over time. In particular these models focus on changes in initial set-up costs associated with new technology. Cost and price changes may result from technological improvements in the production of capital goods or in the marketing network associated with new technology. The argument in these models may be time, other measures of individual and aggregate experience with new technology, measures of extension efforts and the rates of changes in the interest rate.

Uncertainty and risk are also found to be important in analysing adoption of technologies using dynamic perspective. Because a farm household is less familiar with new technology, he may view it as more risky than the traditional technology. However, it is assumed that the perceived risk associated with new technology will decrease over time as a result of learning-by-doing, better dissemination of information and using risk-reducing strategies. As mentioned earlier, in most cases farmers in developing countries adopt only part of the technology package (one or two components in most cases) as a risk reduction strategy. The decision-making process involves the choice of optimal combinations of the complementary components of a technological package over time (Feeder and Umali, 1993). The number and types of the components adopted by an individual farmer are influenced by several economic variables such as the level of resources (labour, farm size and capital), risk aversion, credit and input/output markets and prices. Some farmers may choose to use part of the technology initially as a step towards full adoption, while others may decide to continue with few components of the technology (partial adoption), or in some cases discontinue use after one or two seasons. Partial adopters may use the adopted components of the new technology along with the old technology as part of the evaluation process, to be able to compare the performance of new technology over time. Furthermore, the models assume that the use of complementary components can reduce risk over time. For example, a technology that involves divisible, scale-neutral technology such as hybrid varieties and lump technology, such as irrigation systems, also complement each other. This is because a higher output is realized when the two technologies are simultaneously used. In this case adoption of lump technology (irrigation) is linked with reduced perceived risk associated with adoption of divisible technology (e.g., yield variability due to drought) thus increasing adoption.

Leathers and Smale (1991) have attempted to model sequential adoption of divisible technology in risk-neutral and unconstrained expenditure situations using a dynamic Bayesian model. They assumed that farmers maintain their expected utility (income) which depends on technology adoption decisions. The returns from these technologies are conditional on the validity of the information received about the technology. The model depicts the farmer who is uncertain about the information received and the performance of technology in terms of returns generated. The model demonstrates that in order to learn more about the innovation a farmer may choose to adopt only a component of the package. Later, from their own experience and that of their neighbours uncertainty is reduced and farmers may adopt the whole package. Using this model, Feder (1980) observed that in the initial stages of technology adoption larger farmers adopt both divisible and lump technologies, while small farmers adopt only divisible technologies to a limited extent as a risk reduction strategy. With time as perceived uncertainty is declining, many of them adopt lump technology as well (Feder, 1980).

4.4 Time lag in adoption process

Sociological theories describe adoption as a gradual process which involves sequential stages. Researchers have attempted to use these theories to develop models for evaluating adoption path and the time lag between the initial awareness about technology to actual use of the innovation by an adopter.

Lindner et al. (1979) have developed an expression for explaining the time lag between stages in the adoption process. The authors assume that the farmer is risk neutral and the technology is scale neutral with normally distributed yield and zero start-up cost. The farmer is assumed to collect information about the actual profit received by other farmers from the innovation. This information updates the prior expected profit in a Bayesian fashion. Actual innovation experimentation occurs once the household perceives that the innovation is more profitable than his traditional technology. The authors conclude that the time lag between awareness and adoption is relatively related to the variance of actual profit. Also higher initial perceived profit and lower initial variance are associated with a shorter adoption lag. This model was later expanded by Fischer and Lindner (1980) to incorporate observed difference among farmers in terms of human capital, soil quality, resources level etc. which influences the performance of an individual farm. They assumed that farmers are aware of these factors and account for them when establishing their perceived expected value of mean profit of innovation. From this work the authors conclude that the greater the differences between farmers and the actual information sources, the longer the evaluation period the farmer will need before adopting the technology. This work was further extended by Lindner (1980) to demonstrate that information may account for the tendency of farmers with larger farm to adopt new innovations earlier even when the innovations are scale neutral. The innovation adoption process between the time when the innovation is made available and its use is divided into two sub-periods or lags: discovery lag and evaluation lag. The discovery lag includes the time between the availability to awareness, while the evaluation lag refers to time between awareness to first use of innovation. In this model he assumes that farmers are keen to search and learn about new innovations. The amount of effort devoted to search activities is a function of expected gains from these activities. Larger farmers are expected to put more effort into search activities due to relatively higher expected gains and hence their discovery stage becomes shorter. Taking into consideration the differences among farmers, Lindner demonstrated that larger farmers have shorter evaluation lags because they need less information to convince them that a new innovation has a higher expected profit than the traditional technology. This is due to their ability to test new innovation on-farm, especially lump technologies.

Gibbs et al. (1987) used the time lag model to study the pattern of innovation discovery by South Australian wheat-sheep farmers. A total of 20 innovations were studied. The results show that for most of the innovations studied, lags exceeding one year existed between the time when the first farmer discovered an innovation and the time when 50% of the farmers in the sample had discovered it. Mass media is identified as the most important source of innovation discoveries. More experienced farmers with more resources such as large farms and farmers more active in discovery search tended to discover innovations earlier.

4.5 Empirical studies for adoption of soil conservation technologies

4.5.1 Review of studies

The growing awareness of the impact of agricultural production on land degradation have resulted in introduction of remedial technologies and establishment of institutional support to facilitate the use of new technologies and practices. Priority is being placed on environmental conservation, focusing on technologies that are environmentally friendly. Soil conservation is one of the natural resource management aspects that has received considerable research attention. The USA has played a leading role in the world in developing the science and practices of soil conservation since 1930 (Troeh et al., 1980). The wide awareness of the soil erosion problem among researchers and the USA government has contributed to the increased efforts towards soil conservation research focusing on different tillage and cropping methods. The improved soil conservation measures which have been used in Sub-Saharan Africa essentially originated from the USA in the 1940s (Maher, 1950; Sharman, 1959; Lal, 1988; Stocking, 1988).

In addition to experimental research to determine the effectiveness of various soil conservation practices, attention has been directed to studying determinants of adoption of soil conservation technologies. Over the past 40 years there has been increasing interest in examining conservation methods which have been adopted by farmers and factors influencing adoption of various soil conservation practices. Several models and approaches have been used to study adoption determinants at farm level. Nowak (1993) has identified five general research orientations or perspectives as well as combinations of these perspectives used in examining adoption of natural resource conservation. These research perspectives or models evolved into a discernable historical pattern. They include the diffusionist, rationality, infrastructure, ecological and macro or system perspectives. The empirical research on adoption of soil conservation reviewed below is organized based on these perspectives.

4.5.1.1 Diffusionist perspective

Nowak (1993) notes that initial research on adoption of environmental conservation focused on socio-psychological characteristics of individuals and on how information flows within a local community using some of the sociological theories described in the preceding section. The major thrust of early research was oriented to explaining socio-psychological concept of innovativeness, which manifests itself in adoption behaviour determined by communication, peer pressure, social networks and other social processes discussed in section 4.2. Most sociological research on adoption processes attempts to operationalize the early innovation-adoption process models based on the paradigms developed by Roger and Shoemaker (1971).

Some empirical studies apply the innovation-diffusion and decision-theoretic models to determine factors influencing adoption of environmental practices including soil conservation. These applications are based on various explanations of adoption behaviour: psychological innovativeness and decision-making process, profitability orientation and orientation to farming as a way of life. Types of variables which affect the innovation adoption process are depicted. Using the innovativeness behaviour, Prompel and Van Es (1977) found that orientation of farmers to farming is important in predicting the adoption process of environmental innovations. Tylor and Miller (1978) conclude that an innovation decision process for pollution control technologies is influenced by amount and type of communication which the individual receives about the technology. Formal communication (agency contact) had a positive effect in the discovery or knowledge stage and informal communication had a positive effect in the evaluation or persuasion stage. Lindner et al. (1982) tested the decision-theoretic model of adoption using theoretical evidence on the time taken by early adopters to discover and decide to use this innovation. The results of empirical analysis confirm that distance is a barrier to adoption and that information reliability plays an important role in farmers' adoption decisions. Bultena and Hoiberg (1983) operationalized the adoption curve model and found that early adopters of conservation tillage were closer to farmers who had never adopted than later adopters. The finding refutes the hypothesis that as the distance from adopters decreases, adoption of the technology in question increases. Nowak and Wegener (1981) used the adoption/diffusion model to test the Cancian's thesis for relating social rank to risk behaviour in adoption/diffusion of conservation tillage. They concluded that risk taking orientation associated with early adopters of conservation tillage is influenced by economic rank.

Other studies on adoption of soil conservation operationalized the stages of the innovation-adoption process by assessing factors influencing each individual stage. Ervin and Ervin (1982) modelled adoption of soil conservation as a three-stage process involving perception stage, adoption or use stage and effort stage. They found that perception of the soil erosion problem, number of soil conservation practices adopted and farmer's effort to control soil erosion are influenced by education level of the farmer, perception of the degree of the erosion problem, farming experience, risk aversion, farm income, and governmental support programmes. Gould et al. (1989) treated adoption as a two-stage decision making process, involving: perception of the problem and the adoption or use of soil conservation practices. They found from their farm-level study that the operator's perception of the soil erosion problem is influenced by farm size, slope of farm location, and the operator's characteristics such as education, on-farm training and contact with soil conservation personnel, age of the operator, and operator's future farming plans. They further observed that farm income, age, education, off-farm employment and land tenure influence the adoption of soil conservation practices. Sinden and King (1990) used the approach to analyse the adoption behaviour for soil conservation practices to identify socio-economic factors promoting adoption. The analysis focused on perception of the soil erosion problem and decision to invest in soil conservation practices..

4.5.1.2 Rationality perspective

Concurrently agricultural economists have examined adoption of soil conservation technologies on the basis of economic rationality (profit maximization) from the perspective that an adoption process is based on a cost-benefit judgement, where various forms of constraints determine the outcome of the adoption decision as discussed in section 4.3. According to this viewpoint the primary goal of innovation adoption is to increase profit. This assumption is supported by economists who explain the rate of adoption in terms of profitability, describing innovative farmers as those in the best position to increase profit from the adoption of innovations. Therefore, adoption is treated as the process of profit evaluation (Bose, 1962; Griliches, 1957; Cancian, 1967).

Empirical work on adoption of soil conservation technologies with rationality perspective began in the 1950s. It has been oriented to economic determinants of net farm income. For example, Blase (1960) found that on-farm income and ability to borrow funds are the most important factors in explaining the reduction in the soil loss. These results imply that economic factors play a key role in farmer's decision to use effective soil conservation practices.

Studies conducted after 1960 expanded the range of economic factors and constraints considered important in decisions on using soil conservation practices and some of them incorporated both economic and farmer characteristics such as education level and age. For example, Carlson (1977) found that level of education, age of head of household, farm size, and gross income are related to the number of soil conservation practices the farmer uses. Brown et al. (1978) conducted a study to examine the adoption of recommended conservation practices (no till farming, the use of round bales etc.) in eastern Ohio, USA. The finding showed that levels of adoption were higher among young farmers with a higher level of education, in full-time farming, with a higher level of debt and higher economic status (higher income and acreage). Earle et al. (1979) observed that for Australian farmers increased farm income, education, farm size and perception of the soil erosion problem influence the use of soil conservation practices. Hoover and Wiitala (1980) found that younger farmers and those with a higher level of education in Nebraska, USA were more likely to perceive erosion as a problem and therefore perceive benefits from using conservation practices. Also, Rahm and Huffman (1984) show that farmer's education level influences efficiency of soil conservation adoption decisions. Shortle and Miranowski (1986) found that education among other farmer characteristics and economic variables influences the likelihood of adoption of conservation tillage practices in a small watershed in Iowa, U.S.A.

Carlson et al. (1981) investigated the use of soil erosion control practices among farmers in Idaho, USA. They concluded that farmer's choice of soil erosion control practices is based on the required capital investment. Those farmers with the highest level of education and those with the largest acreage tended to use most erosion control practices. Variable costs such as labour costs have also been found an important determinant of conservation adoption. Eplin and Tice (1986) in their study of farm size and adoption showed that differences in rates of adoption of conservation tillage among farmers occur, because of differences in start-up costs rather than differences in post-adoption costs. Dhanakumar and Perumal (1986) assessed the extent of adoption of dryland technology and the associated conservation practices in India. They found that the majority of farmers were non-adopters, due to labour shortage and higher labour costs.

The influence of risk on household's behaviour towards adoption of innovations is one of the economic factors that has received a lot of empirical attention. Three areas which have received most attention are: differences in risk aversion among households, the impact of risk on farm efficiency, differences in household risk perception and factors influencing household risk aversion. Dillon and Scandizzo (1978) in their study on risk attitudes of subsistence farmers in Northeast Brazil found that most subsistence farmers are risk averse, and that risk aversion is influenced by income level of the farmer and other socio-economic variables including household age. Hamal and Anderson (1982) explored risk attitudes of small-scale rice growers in Nepal, in the context of subjective expected utility maximization model. Farmers were found to be risk averse, and risk aversion was found to diminish as wealth increases both for individuals and in aggregate sense. De Janvry (1972), Hiebert (1974) and Lipton (1979) found that risk creates a barrier to innovation, related to lack of information and to imperfections in credit and land markets and that risk declines as income increases. McSweeney et al. (1983) indicate that farmer's attitude to risk influences their willingness to invest in soil conservation. Risk-averse farmers are less willing to invest in soil conservation practices. Norman (1977) found that farm households meet both food and income security and avoid risk by growing crop mixtures. This implies that the farm household can avoid risk and at the same time maintain economic efficiency. This observation challenges the assumption that risk avoidance involves a trade-off on income and output. Using stochastic simulation model, Setia (1985) examined the influence of revenue uncertainty due to weather, crop yields, crop prices and interest rates on farmer risk attitudes towards adoption of soil conservation practices. The findings indicated that conservation tillage was the most preferred soil erosion control practice, with and without risk consideration.

In addition to assessing household risk behaviour, risk has been incorporated into most of the adoption studies together with other factors. Lopez-Pereira et al. (1994) concluded from their on-farm study in Honduras that risk aversion, availability of crop land and initial cash have no substantial effect on the predicted adoption level of improved soil conservation measures. Cárcamo et al. (1994) obtained conflicting results showing that the adoption of soil erosion control practices by farmers on the steep hillsides of Honduras is influenced by risk aversion, while the costs of constructing soil conservation devices have no significant influence on adoption of these devices. The difference in their results could be attributed to the way risk was measured in the two studies.

Empirical modelling of household risk behaviour in relation to innovation adoption is faced by measurement problems. This is due to the fact that risk as well as risk attitudes are not observable. Different ways of estimating risk have been developed. For example, Binswanger (1980) has measured risk aversion through gambling experiments and used the outcomes as an explanatory variable in a multivariate analysis of fertilizer adoption. Differences in *perceived risk* have been measured by O'Mara. He used interviews in order to elicit a probability distribution of expected yields of a new crop.

4.5.1.3 Infrastructure and macro perspective

The infrastructure perspective refers to the role of development organizations that promote adoption of innovations. Related to the infrastructure perspective, is a macro or system perspective which pays attention to macro-level policies and programmes that encourage adoption of natural resource management practices. This focuses on forces at societal level which determines the micro-level decision process such as institutional arrangements (e.g., land tenure), fiscal and monetary policy components such as prices and interest rates and agricultural programmes.

Farm-level institutional support provided by different development organizations, such as credit schemes, input subsidies and extension services, influences the availability and accessibility of innovations. Macro-level policies determine the environment at which farm-level decisions take place. Access to institutional support and prevailing policy plans plays a key role in enhancing adoption of innovations. These are considered important in developing soil conservation programmes, especially in developing countries. Soil conservation adoption studies that include the infrastructure and macro perspectives show that access to extension services, credit and information (knowledge) is a major determinant of the rate of adoption among the users. For example, Olayde and Falusi (1977) have identified access to credit as an important factor explaining the adoption of soil conservation practices in Nigeria. Veloz (1985) argues that in many developing countries farmers would find soil conservation difficult because of their inability to borrow funds. Chamala et al. (1983) in their study on the attitudes toward information exposure and use of soil conservation found that Australian farmers who had a greater interest in and exposure to soil conservation methods through conservation programmes and extension services often adopted conservation methods. Coughenour and Chamala (1989) concluded from their adoption study conducted in Queensland Australia that adoption behaviour among farmers is influenced by farm conservation policies backed by civil penalties compared to voluntary policy implemented in Kentucky. Producer prices were reported to be positively related with conservation use (Debertin and Sjarkowi, 1989: in Bonnard, 1995). Wollenberg (1991) found that access and allocation of inputs and marketing policy influenced adoption of conservation innovations.

Norris and Batie (1987) found that land tenure has a negative influence on conservation expenditure, while existence of a conservation plan positively influences conservation expenditures. Carlson et al. (1981) found that despite the common belief that non-operator land owners are less concerned about soil erosion than owner-operators, owners did not discourage their renters from using soil conservation practices.

4.5.1.4 Ecological perspective

As researchers recognized the importance of the environment, especially when trying to explain adoption of natural resource management practices, the physical setting of the adoption decision began to receive attention. This emphasizes the applicability of innovations within specific physical settings. Indigenous knowledge systems approach is used to guide an ex-ante assessment of appropriateness of a technology, often using specific user-determined criteria, thereby determining the outcome of adoption decisions. For research related to adoption of soil conservation, the focus has been on the land's physical potential for soil erosion. Often the soil-related variables of the Universal Soil Loss Equation (USLE)[20]: slope, slope length, and soil erodibility are used to explain adoption of soil conservation practices. For example, Saliba and Bromley (1986) tested the Universal Soil Loss Equation (USLE) management factors as a measure of soil erosion control effort. A logit model applied to a farm survey and soils data indicates that topography and soil type (erosion potential) are significantly related to the use of soil erosion control practices. Ashby (1982) conducted a study to examine the interdependence between environment and socio-organizational requirements of technologies. He found different adoption patterns among different types of farms in three micro-climatic zones. Farmers innovative behaviour was found to depend on the suitability of the technology for different types of farms and ecological setting. With regard to the role of physical characteristics in technology adoption, Rahm and Huffman (1984) found that soil type and crop rotation are significant determinants of reduced tillage adoption. Farm location also determine the adoption of certain technologies. Caswell and Zilberman (1985) found that the source of irrigation water in relation to farm location is a significant determinant of adoption of irrigation technology.

4.5.1.5 Integrated approach

As mentioned earlier, research work on adoption of soil conservation began with the rationality and diffusionist perspectives. Gradually, institutional, ecological and macro aspects were incorporated. In the literature there are several studies on adoption of soil conservation practices which integrate the five perspectives. Only selected studies are included in this review.

Some of the empirical studies carried out in the 1980s used more comprehensive frameworks which include a wider range of factors (sociological, economic and physical factors). Ervin (1981) used a decision-making model, which includes physical, personal, economic and institutional factors to identify factors affecting the use of soil conservation practices in Monroe Missouri. His model result shows that personal factors such as perceived profitability of conservation practices and risk aversion are the most important in explaining the number of practices used. He also observed that government funded technical assistance programmes have no significant effect on conservation efforts. Younger farmers were also found to be more receptive of conservation technologies. Bultena and Hoiberg (1983) investigated factors affecting farmers' adoption of conservation tillage for Iowa State farmers in the US. Socio-economic and physical variables examined were: risk orientation, age, education, farm size, tenure, farm income, perceived erosion, perceived attitude of others, perceived adoption by others, and erosion potential based on rainfall and soil erodibility, and steepness of the slope. The results indicate that tenure status did not relate to adoption, while personal attributes of farm household's

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[20]The USLE is expressed as: A = R*K*L*S*C*P
A = Soil loss (tons/ha/year), R = Rainfall erosivity, K = Soil erodibility, L = Slope length, S = Slope, C = Land cover, P = Land management factor (Wischmeier and Smith, 1978).

characteristics and erosion potential of the farm determined adoption. Erosion potential was found to have a positive influence on adoption.

Jamnick and Klindt (1985) conducted research to determine social, economic and physical characteristics influencing the no-till practice decision among the no-till users. Using a logit model, the authors indicated that the probability of adopting no-till soil conservation practice increases with age of farmer, farm size, farmers whose primary occupation is not farming, proportion of land experiencing soil erosion and use of other conservation practices. Nowak (1987) examined adoption of agricultural conservation technologies through analysis of diffusion, economic and ecological factors. The results indicated that economic and diffusion aspects such as awareness, information and knowledge are important in predicting adoption of conservation practices. Hansen et al. (1987) conducted a study in the Dominican Republic to determine if factors shown to explain adoption of soil conservation in the US were predictive of adoption in the Dominican Republic. Sociological and economic factors that influence adoption of soil erosion control practices were tested. Results indicated that unlike in the US, economic factors were poor predictors of adoption of soil erosion control in the Dominican Republic.

Ashby (1985) analysed the soil degradation problem with respect to implementation of soil conservation policy in a Colombian farming system. His analysis focused on how the interactions between institutional and social parameters in agriculture structures farmers' perception and use of natural resources. The results of this analysis indicate that institutional and social parameters facilitate diffusion of soil management practices. Lynne et al. (1988) used an integrated model encompassing attitudinal, social and economic motivations to assess behaviour towards conservation decisions. Using a tobit estimation approach the results indicate that economic, attitudinal and social variables are important determinants of conservation behaviour.

4.5.2 Designs, methodologies and approaches used in empirical work

Most empirical research uses a farm household or a farm operator as unit of observation with information collected from all the land operated by the farm household. Some studies deal with a sample of landowners who may not be the farm operators. Few studies have used land/farm as a unit of observation e.g., Lee (1980) and Lee and Stewart (1983). Most studies cover specific location and time.

Most of the studies, while incorporating a wide range of factors to explain farmer's behaviour of adoption of soil conservation practices, treat adoption as a dichotomous variable, based on whether or not the household adopted soil conservation practices at a particular time (static model approach). Some developments in methodology for analysing the adoption process for soil conservation innovations have attempted to make the assessment of adoption more comprehensive. These methodological efforts have simultaneously integrated the dichotomous approach together with the innovation-diffusion process to capture the dynamic nature of an adoption process. Also, adoption frameworks for examining various stages in the adoption process have been developed. Factors influencing farm household decisions for each stage are identified (Ervin and Ervin, 1982; Gould et al.; 1989).

Featherstone and Goodwin (1993) used a dynamic economic approach to analyse adoption behaviour of the farm households. The approach was used to analyse long-term farmer decisions on conservation investments. Adoption was analysed as both a discrete decision on whether to invest or not, and to examine continuous level of investment. They identified factors influencing long-term conservation investment by farmers as: net farm income, total farm land rented, total crop acres operated by farmer, total current assets, total value of non-farm assets, age of operator and cropping efficiency. The results of their empirical study indicate that older farmers have a lower level of investment in soil conservation. They observed that farmers who are corporately organized are more likely to make long-term conservation investments. They also found that farms receiving government assistance are more likely to make long-term soil conservation investments. Their analysis indicates that in making long-term conservation decisions farmers compare the net present value of the expected benefits with the net present value of expected costs. A dynamic adoption approach has also been empirically applied to examine perception of future benefits from soil conservation, future soil erosion damage and the use of soil conservation technologies. McSeeney and Kramer (1986) used this approach and observed that receptiveness to implementing soil conservation practices depends on farmer's belief about short-term and long-term returns associated with these practices and that the impact of erosion damage also influences adoption of soil control measures. Using the dynamic approach Van Kooten (1993) indicates that in the long-run, the use of fertilizers off-set the damage of productivity loss due to erosion, therefore reduces the adoption rate of soil conservation technologies. Walker (1982) compares future soil loss damage from conventional farming and conservation practice within a dynamic analysis, treating the conservation adoption year as a variable. He found that the long-term soil erosion damage reflected in yield and profitability loss influences farmer's decision to invest in soil conservation practices. Salem (1983) evaluated the economic impact of reduced tillage technology on net farm income over a 40-year planning horizon. MOTAD model was used to examine risk and uncertainty in the farming planning. Saliba (1985) used the dynamic modelling approach to study the linkages between farm management variables, soil loss, crop yields and incentives to practising soil conservation. The author developed an optimal control model with explicit attention to interaction between management choices, soil loss and long-term farm productivity.

4.6 Summary

This chapter was intended to provide some theoretical background to adoption of innovations. The reviews of the theories and models that have been developed for explaining adoption of innovations together with empirical research are presented.

The sociological theories of adoption of innovations are rooted in Rogers' (1968) traditional diffusion model. This model is based on the assumption that an individual goes through four adoption stages: awareness, evaluation, trial and adoption. Access to on-farm and off-farm information is the important determinant of time lag for each stage. Educational programmes, extension services, social interactions with neighbours and friends have been identified as the key sources of information. Individual characteristics also influence the time an individual takes to complete the entire process. An extension to the decision model is the adoption curve model which classifies adopters into adoption categories namely innovators, early adopters, early majority, late majority and laggards. The practical application of this model poses some limitations which may distort the postulated S-curve pattern of adoption. Despite the observed weaknesses, the model has made a great contribution to the research on innovation adoption. Economists and sociologists have used this model to develop analytical frameworks for studying household characteristics and socio-economic factors that influence adoption behaviour.

Sociological theories also capture the role of community actions and peer groups in the adoption process. Group dynamics theory emphasizes the interactions between individuals and others in the society which translates into joint and individual decisions on technology adoption. The theory demonstrates the complex nature of the individual decision-making process and the implications for adoption behaviour.

Economic theories describe individual farm households as rational decision makers who seek to maximize utility from their production activities. Utility is explained as the farm returns or profit farm households accrue from farm production or leisure derived from avoiding farm work. Therefore, during the production process farm households allocate their resources in such a way that they maximize profit and/or leisure. Furthermore, the theories indicate that households obtain different levels of profit from different technologies, implying that the choice of production technologies is influenced by profit prospects. Risk and uncertainty are identified as the most important personal farm household behaviour that shapes their rational production actions related to technology choice and resource allocation.

The economic theories used for explaining adoption of innovation are rooted in the utility maximization theory. Therefore, economic models for assessing farm household decisions for using different types of technologies focus on economic variables and constraints influencing the level of farm returns/profit. Economic theories describing adoption behaviour are numerous and varied. This stems partly from the multitude of definitions that exist for adoption. Major distinctions are individual farm household adoption versus aggregate adoption, analysed as a static (dichotomous choice) or dynamic process. Sometimes distinctions are also made between divisible and lump technologies. Models dealing with aggregate adoption are concerned with the number of farmers adopting single innovation or a package, the total area under new practices and how the innovation spreads through a given geographical area over time. In some cases aggregate adoption takes into consideration the dynamic adoption pattern among different groups in the population based on the sociological adoption curve model. Individual farm-level adoption models assess adoption in terms of the likelihood that farmers with given characteristics will adopt a given technology, often specifying the intensity of adoption. Models based on this approach often use the static dichotomous choice analysis, describing adoption as whether a farmer adopts a complete package of complementary components or a few components. In few cases dynamic models are applied to explain the individual farm level adoption process. Dynamic models assess adoption decision-making over time, taking into consideration changes that influence household's perceived performance of the technology. This includes changes that are influenced by the level of information about the technology the household accumulates over time as a result of learning-by-doing (experience with technology), and those related to changes in risk attitude and prices. Time lag in adoption which is built upon the sociological stages of adoption has also been used to explain the dynamic adoption process at individual level.

From the review of sociological and economic models and theories for assessing adoption of innovations it is evident that there are some overlaps between the two. This is because some of the economic theoretical frameworks for explaining innovation adoption are based on sociological theories. Most of the economic dynamic models discussed above draw a lot upon Rogers' innovation-diffusion theories.

The historical development of the research focus and scope of soil conservation adoption indicate that there has been a gradual expansion of research focus over time. Earlier research focused on either sociological adoption-diffusion models or the economic rationality perspective.

With time other aspects influencing adoption of innovations were incorporated to make the adoption models more comprehensive. Recent studies have integrated economic and sociological factors together with institutional and physical factors to explain differences in adoption behaviour among individual households.

Most of the empirical studies on adoption of soil conservation focus on an individual farm approach employing methods which evaluate the likelihood of a farmer adopting one or a number of practices. Although there is much overlap, studies have tended to focus on the following categories of variables that influence farmer's decision on the adoption of soil conservation practices: farm/physical factors such as ownership, location and land form; household's demographic characteristics such as age and education; sociological factors such as social status, attitudes and beliefs towards degradation and soil conservation; economic/financial factors such as farm income, indebtedness, investment costs, family labour, risk and others and institutional factors like extension services and participation in soil conservation programmes. Despite some contradictions and variations found in the literature about the direction of influence of these variables, some relationships have been repeatedly hypothesized and tested. These relationships are summarized in Table 4.1.

Table 4.1: Summary of factors influencing decision to adopt improved soil conservation Technologies

Factors with positive influence	Factors with negative influence
Education level	Age
Income	Investment costs
Farm size	Risk aversion
Labour	Discount rate
Credit	Farming experience
Soil conservation programmes	Off-farm income
Erosion potential	Other improved practices used
Perception of erosion	Land ownership (Tenure)
Perception of erosion problem	
Social rank and networks	

Empirical studies on adoption of soil conservation technologies have used different approaches to assess adoption. The dichotomous or static approach has been used in most cases. Some studies also use dynamic approach whereby individual adoption behaviour is assessed as a long-term decision-making process. Adoption is also defined as a decision process with stages. Factors or variables influencing behaviour of farm households at each stage are analysed separately.

Adoption of soil conservation technologies has been described based on varied criteria. These include types of conservation practices used, number of conservation practices used and land area under conservation measures. The most important observation is that these variables do not estimate adoption in the same way. Therefore, the most critical issue in addressing soil conservation adoption behaviour is how to define adoption and what should be used as the measure of adoption. The definition and approach chosen in many cases depend on the objective of the study and practical applicability of the criteria chosen.

CHAPTER 5

THE THEORETICAL MODEL

5.1 Introduction

The conceptual model discussed in chapter 3 calls for an approach, which is capable of integrating various factors that influence household's decision-making process towards the use of appropriate soil conservation measures to ensure a sustainable agricultural production system in the northeastern mountains.

In this chapter the approach for analysing the adoption process of the households in the northeastern mountains is described. First we present the analytical framework used in the study. Some empirical evidence underlying this framework is discussed focusing on previous applications. This is followed by a discussion of the adoption decision-making process hypothesized for the analytical framework.

5.2 The framework for analysing adoption of soil conservation technologies in the northeastern mountains

Economic adoption models based on rationality or utility maximization theories provide limited assessment of household's behaviour in adoption of innovations. The models fail to encompass attitudinal and social variables which are very important in explaining the household adoption decision-making process. Utility maximization theory or rationality perspective approach often used by economists to guide the selection of variables to explain household production decisions does not take into account social processes that determine households' resource allocation preferences. Likewise, the innovation adoption/diffusion models used in sociological adoption studies downplay economic variables that determine household's decision behaviour. In order to bridge these gaps, the framework for assessing household decision-making behaviour towards the use of soil conservation technologies needs to be improved by incorporating both sociological aspects such as attitudes, beliefs, perception and intentions and economic factors important in determining household's decisions to invest his resources in soil conservation practices. Our interest is to model household's conservation decisions by merging the profit/utility maximization theory with sociological innovation adoption decision theories. Therefore, in this study a comprehensive interdisciplinary theoretical framework, which links social behavioural processes and household economic behaviour related to household innovation adoption process, is developed.

5.2.1 The analytical framework

The foregoing discussions on economic and sociological models of innovation adoption theories and the review of studies on adoption of soil conservation practices provide the basis for formulating the framework for assessing the factors affecting the adoption behaviour toward soil conservation in the study area. We have seen that most previous research on adoption of soil conservation has analysed adoption only in terms of whether or not households use specific soil conservation technology. In our analytical approach a distinction is made between attitude towards soil erosion and understanding the soil erosion process, adoption or use of soil conservation practices and the level at which soil conservation practices are used. That is, adoption is analysed not only in terms of whether or not the farmer is using soil conservation practices, but as a sequential decision-making process. This approach is based on Ervin and Ervin's (1982) analytical framework for analysing adoption of soil conservation technologies (Figure 5.1). Adoption is modelled as a decision-making process involving three stages:

1) perception stage: attitude towards soil erosion (occurrence/existence) and knowledge about what causes soil erosion.

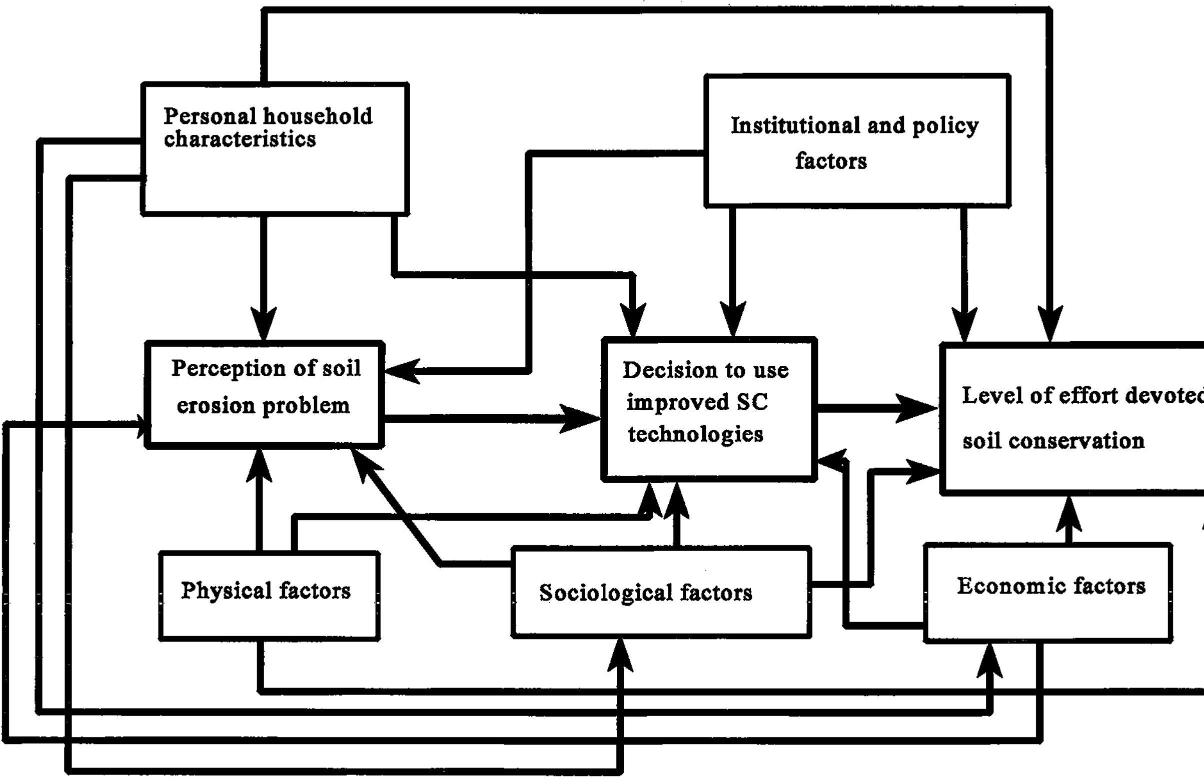
2) use stage: deciding on whether or not to adopt effective (improved) soil conservation technologies, given the recognition of the soil erosion problem.

3) effort stage: deciding on the level of effort to devote to soil conservation having decided to adopt the improved soil conservation technologies.

This approach has been used by a few other researchers such as Tylor and Miller (1978), Hoover and Witaala (1980), Norris and Batie (1987), Gould et al. (1989), Nowak and Korsching (1983) and Lynne et al. (1988), to analyse the adoption process for soil conservation. Many of these studies are partial, usually stopping at the second decision stage (e.g., Taylor and Miller) or including the second and last stage (e.g., Norris and Batie).

The advantage of dividing the adoption process into stages or phases is that we can deal with perception of the soil erosion problem and adoption of soil conservation measures and effort devoted to soil conservation as separate subsequent stages in the adoption process. The three stages are analysed independently indicating factors explaining them. This is important since any discontinuance in the adoption process can be more readily identified and explained. For example, a household may perceive the soil erosion problem and favour soil erosion control, but is not using effective soil conservation measures because he has no access to information about different types of improved soil conservation measures. With a three-stages model such behaviour can be identified and factors or constraints to movement from perception to adoption or use of soil conservation measures be explained.

In this approach it is assumed that perception of the soil erosion problem, decision to use improved soil conservation technologies and the effort devoted to soil conservation are influenced by personal characteristics of the household, such as education level, age and wealth; sociological factors such as social status, attitudes and beliefs; physical factors such as land use and slope; economic factors such as net income, planning horizon and risk; policy and institutional support such as input subsidies, credit, extension services and other educational programmes. Each of these stages is considered a major step towards sustainable use of effective soil conservation technologies. The sociological factors are not explicitly indicated in Ervin and Ervin's model. In their framework these factors are treated as personal characteristics. In our framework sociological factors appear as a separate category. That is, household's beliefs and attitudes towards the soil erosion problem and soil conservation are considered important in the decision-making process. Also, unlike Ervin and Ervin's framework, in our framework we recognize the influence of personal household characteristics on sociological and economic factors. For example, planning horizon and risk aversion, which are here considered economic



ure 5.1: Analytical framework for adoption of improved soil conservation technologies

factors, and sociological factors such as social status and conservation attitudes, are determined by personal characteristics of the household such as age and education. Two other additional adoption decision dimensions not explicitly included in Ervin and Ervin's (1982) approach are introduced in this study. They are *acceptance* of the idea to use soil conservation measures and the implementation *ability*. These are discussed in detail in the next part of this section. Below is a detailed description of each of the three decision stages:

Perception of the soil erosion problem:

The household decision making process in our framework starts with the perception of the soil erosion problem. As mentioned earlier, this refers to household's attitude towards soil erosion and knowledge of what causes soil erosion. There are very few studies which incorporate perceptions of decision makers into the adoption process for agricultural innovations. Wossink et al. (1997) note that only three studies in agricultural economics literature have addressed the aspect of farmer's perception in technology adoption. Similarly, perception analysis for soil erosion problems has been measured empirically in a limited number of studies using different methods. For example, Hover and Witaala (1980) described perception as how farm operators believe the severity of the soil erosion problem to be in relation to the actual level of soil erosion. Ervin and Ervin (1982) described perception as the way households perceive the severity of the soil erosion problem on their farm plots and its impact on short-term returns and land values. Norris and Batie (1987) estimated perception as whether or not farmers believe soil erosion to be a problem on their farm. Other methods, though not used to assess farmer perceptions of the soil erosion problem, include perception scores used by Wossink et al. (1987) to explain farmers' preferences for weed control strategies. Respondents were asked to indicate their degree of agreement or disagreement with various features of each weed control strategy.

In most empirical studies, perception is defined as an attitudinal process explained by the psychological state of an individual which is determined by individual characteristics, socio-economic, institutional and physical factors. That is, the perception of the soil erosion problem depends on household's personal characteristics such as education, age, wealth rank, gender of household (sex) and beliefs, which influence his attitudes and hence awareness or recognition of occurrence of soil erosion and its potential damage. The characteristics of the land the household operates on also determine the degree of physical erosion (erosion potential). This influences perception of the soil erosion problem because the effects of soil erosion on topsoil loss are related to erosion potential. That is, soil loss is more pronounced on land with higher soil erosion potential eg., very steep slopes than vice versa. Institutional support, such as government or donor-supported SWC programmes, can also enhance awareness and recognition of the soil erosion problem through services like farmer training, conservation campaigns and other educational programmes.

Adoption of improved soil conservation technologies:

Once the household perceives the soil erosion problem, he decides *whether or not to* adopt the available soil conservation technologies and *what type*. There are studies which have focused adoption of soil conservation technologies on only one specific technology such as contour farming or type/category of technologies such as physical measures. Others have combined several soil conservation technologies. In order to arrive at meaningful conclusions from this study we need to consider how farmers view different types of technologies. The important question is: Do farmers view different types of technologies differently? If so, what are the appropriate technology categorization criteria that emerge from farmer's point of view.

In order to better capture household's innovativeness with respect to soil conservation in the study area, we put different types of soil conservation measures used in the study area into two categories. These include traditional and improved soil conservation measures (described in chapter 2). Traditional measures include trash lines, grass strips, agroforestry, minimum tillage and zero grazing. Improved soil conservation measures include those technologies introduced by SWC programmes operating in the study area. They are microcontourlines, infiltration ditches, cut-off drain, *fanya juu* terraces and bench terraces. These categories have also been established based on the assumption that traditional soil conservation measures used in the area are insufficient or less effective in reducing soil erosion (see chapter 2). Therefore, we categorize adopters and non-adopters according to the type of soil conservation technology used.

Different factors are modelled to play separate roles in decisions to use improved soil conservation measures. Personal characteristics, such as education and farming experience and age, play an important role in this decision. These not only determine household's belief, understanding and knowledge as to soil erosion but also influence the attitude towards soil conservation activities. Physical factors such as farm location, land form (slope) and rainfall intensity influence the level or degree of soil erosion (erosion potential) and level of erosion damage. These may influence household's decision to use the appropriate type and number of soil conservation measures. Economic factors such as income, labour, risk aversion, and perception of future benefits determine household's interest and acceptance to use effective or improved soil conservation practices. Sociological factors like social status and conservation attitude determine household's decision on using soil conservation measures. Also, as postulated in our framework, household's perception of the soil erosion problem determines the decision to use improved soil conservation measures. Furthermore, support services provided by the government and other development institutions may encourage or discourage the use of improved soil conservation technologies.

perfect
foresight

Soil conservation efforts:

The last stage in the adoption process is the effort households put into soil conservation after having adopted improved SWC technologies. In this stage households decide on the level of resources they prefer to use for soil conservation measure(s) adopted. This decision stage indicates the extent to which farmers are using the technologies and the impact of soil conservation practices on reducing soil erosion. It also gives an indication of the commitment of adopters to maintain/sustain the technologies adopted. The best indicator of effort is the level of investment in soil conservation which translates to level of soil erosion reduction. For example, Norris and Batie (1987) used farmer's actual investment level in soil conservation as an indicator of level of conservation effort. They considered farmer's level of annual expenditure on soil conservation an estimate of ability and commitment to soil conservation. However, many other researchers have defined effort as the reduction of soil erosion achieved by using soil conservation measures compared to level of soil loss that would occur without using soil conservation technologies (eg., Ervin and Ervin, 1982; Lee and Stewart, 1983). Effort in this context is a function of *effectiveness* of the practice used to reduce soil erosion. Others have used the extent of individual technology over household's land *(extensiveness)* and level of *maintenance* over time (Ervin and Ervin, 1982).

It is sometimes difficult to get accurate information on soil loss and soil conservation expenditures. In such situations, other measures have been used to estimate soil conservation effort. These include *the number of technologies* used (e.g., Lynne et al., 1988) and the *amount of land* farmer has put under soil conservation technologies (measured in hectares).

The level of soil erosion control or the level of investment in soil conservation (effort), like perception of the erosion problem and adoption decision, is influenced by personal characteristics, socio-economic, institutional and physical factors. Personal factors, including management ability, which is likely to be determined by level of education, determine the choice of appropriate types of practices to use and level of investment in soil conservation. The way households perceive the nature and severity of the soil erosion problem on their fields/farm plots is an important sociological or personal characteristic which influences level of effort. If a household views soil erosion as a serious problem, he is likely to devote more resources to its prevention than if he does not believe that erosion is posing serious problems to land productivity. Economic factors such as net farm income indicate the amount of financial resources available for erosion control, hence determine level of investment. Finally, erosion potential determines perceived productivity benefits from soil conservation and hence the level of investment in soil conservation.

5.2.2 Decision model of adoption process

For this study our interest was to assess how the attitude towards soil erosion, knowledge and understanding of the causes of soil erosion, decision to use improved soil conservation technologies and the level of resources devoted to soil conservation are influenced by the facets of the complex personal characteristics, socio-cultural, economic and physical factors. Modelling of the adoption decision process in three stages allows us to analyse the decision steps separately to ensure a thorough understanding of the nature and structure of households' soil conservation behaviour in the northeastern mountains.

The sequential process with three stages suggested in our analytical approach is based on the assumption that for a household to reach each of the stages, he goes through a mental decision process which determines his final action. Household's perception of the soil erosion problem is formed from household's knowledge about soil erosion, the values and beliefs about the existence of soil erosion and the impact it has on soil quality and its productivity. The beliefs and values influence household's attitudes towards the soil erosion problem. Attitudes, which in this case shapes the household's perception refer to how the household sees the soil erosion problem and his understanding and knowledge about its existence. The attitude towards the soil erosion problem in turn determines the adoption behaviour of the household. Adoption behaviour is therefore the observed household's reactions to the use of improved soil conservation measures.

Although there is a general recognition that attitudes play a major role in influencing individual's behaviour and ultimately the decisions taken, it is not uncommon for an individual to show behaviour that is not consistent with his attitudes. For example, there are cases where households perceive the existing production problem and may be favourably oriented to the technology but is not using that technology. This suggests that there are factors that intervene between attitude and behaviour which would cause an individual's behaviour to be different from his attitudes (Schafer and Tait, 1990); McGuire, 1976)[21]. Klonglan and Coward (1968) have explained this situation by stating that "......in addition to attitude towards the problem and technology, the adoption unit faces two decisions: to *accept* or *not to accept* the idea or new technology and to use or not to use the technology". They described *acceptance* of technology as symbolic adoption which can be interpreted as *incomplete adoption.* The authors identified two types of symbolic adoption namely constrained adoption and anticipatory adoption. Constrained adoption happens when the adoption unit is unable to use the idea that he has accepted because action or inaction by relevant groups makes innovation unavailable (e.g., lack of required technical information from extension services). Anticipatory adoption is a form of incomplete adoption, in which the adoption unit does not move beyond the acceptance or symbolic adoption, because is facing a situation not possible to use the innovation such as, inadequate resources. In the adoption literature there are other researchers who have viewed adoption process similar to symbolic concept. Coughenour (1968) noted that the adoption decision process involves two stages: decision or choice making and the acquisition of means of using the innovation i.e., implementation. He distinguishes between belief in the innovation and the actual use of an innovation. He uses belief in the innovation to refer to the acceptance that the innovation is useful. Further description of symbolic adoption is provided by Lin et al. (1966). They use the concept of innovation internalization or attitudinal acceptance, which refers to the extent to which the adopter perceives an innovation as relevant and valuable to his situation. These examples show that researchers have assumed that *willingness* or acceptance of the innovation and *ability* to use the innovation are an integral part of the adoption decision process as described in Rogers' decision stages of adoption process discussed in section 4.2. The idea of incorporating *willingness* and *ability* as part of the adoption process provides a systematic interpretation of variations in adoption behaviour.

Nowak (1992) in his assessment of why farmers adopt production technologies indicated that farmers do not adopt production technologies for two basic reasons: they are either *unwilling or unable*. This means that household's behaviour to adopt a particular production technology is formed by his *willingness* and *ability* to use the technology. According to Nowak, farmers can be ***able*** yet ***unwilling***, ***willing*** but ***unable*** and ***both unwilling and unable.*** Unwillingness to adopt new technology implies that the farmer has not been *persuaded* that the technology will work or is appropriate and more profitable than his current technology. Bohlen (1964) described willingness as the *mental acceptance* of a practice or idea (symbolic adoption). Willingness, like perception, is in most cases influenced by household's characteristics, which shape household's attitude and behaviour toward soil conservation. Being unable to adopt a new technique implies the presence of an obstacle or a situation where the decision not to adopt is rational, such as lack of information, technique is too expensive, technique is not compatible with the current production system, or non-adoption is due to household's strong belief in traditional practices. Ability is often determined by the resource level the household has for investment in soil conservation measures (e.g., labour), together with his accessibility to technical information and his level of knowledge, which in many cases is determined by education level.

We use the decision-theoretic model of the adoption process presented in section 4.2, Ervin and Ervin's adoption framework together with Nowak's *willingness and ability*

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[21]This shows that attitudes are not fixed. The determinants of attitudes change continuously depending on the forces or situations an individual encounters.

assumptions and symbolic adoption process to develop the decision model for this study. In Ervin and Ervin's framework, like most of the adoption studies that use the adoption-stage approach, it is assumed that perception is followed almost immediately by use or adoption of the technology. In our decision model we incorporate a time lag between perception of the soil erosion problem and the actual adoption of the technology. The nature of the decision-making process postulated for this study involves a series of steps shown in Figure 5.2. The assumption is that there are two categories of households: those who perceive the soil erosion problem and those who do not. Because of their positive attitude towards the soil erosion problem, households who perceive the soil erosion problem are likely to search for information on effective remedial measures against soil erosion. Once they discover the existence of different types of improved soil conservation technologies, they begin to evaluate these technologies for their effectiveness in reducing soil erosion and improving productivity and farm returns. Two possible outcomes of evaluation are *mental acceptance* (willing) or *rejection* (unwilling). Mental willingness and implementation ability are expected to lead to adoption of more effective improved soil conservation measures such as *fanya juu* and bench terraces. Mental rejection or unwillingness together with lack of implementation ability will lead to non-adoption of improved soil conservation measures. This means that households who perceive the soil erosion problem and are both willing and able to use soil conservation measures are expected to decide to use improved soil conservation measures. Those households who perceive the soil erosion problem but are either unwilling, unable or both, will not adopt improved soil conservation measures. For adopters of improved soil conservation measures, they further decide on the level of resources they want to invest in improved soil conservation measures (conservation effort). High level of investment in soil conservation is expected to lead to a higher soil erosion reduction and less damage to soil productivity, hence a sustainable agricultural production system, and vice versa.

The second category of households constitute those who do not view or perceive soil erosion as a problem of major concern. Although they may be able to use improved soil conservation technologies, their attitude towards the soil erosion problem will make them less interested in reducing soil erosion. They will not put any effort into searching for information on effective measures to control soil erosion and thus will continue to use less effective traditional soil conservation measures or use nothing (non-adopters).

Perception of the soil erosion problem is regarded as an important determinant of interest in searching for information about measures to control soil erosion. Adoption or use of improved soil conservation measures is determined by the outcome of the technology evaluation process by the household. Willingness and ability are conceptualized as possible outcomes of technology evaluation by the household and determinants of the adoption decision. Therefore, acceptance of technology or willingness to use the technology and implementation ability are explicitly included in our adoption decision-making process.

5.3 Factors influencing the decision-making process

In our framework discussed in the previous section we postulate that household's perception of the soil erosion problem, decision to use soil conservation measures and level of investment devoted to soil conservation are influenced by household's personal characteristics, socio-economic, physical and institutional factors. Since most of these factors were discussed in the preceding chapter, in this section only a brief discussion is given for some of the factors which have been incorporated into this study. We focus on the general nature of their influence

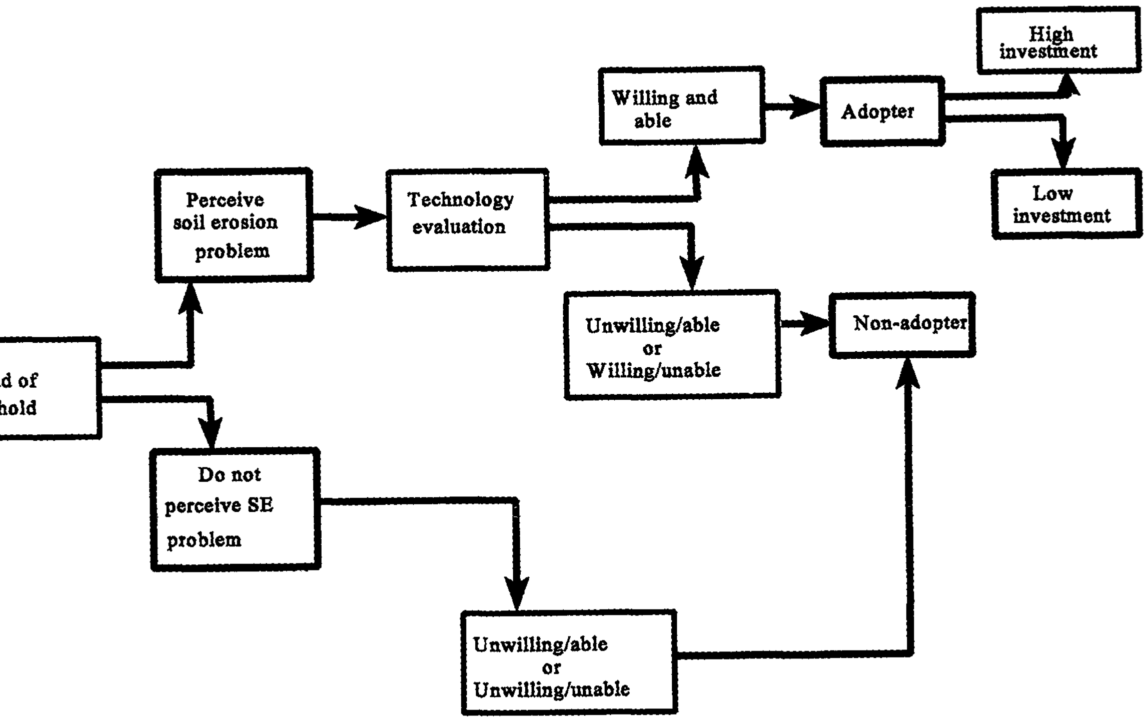

Figure 5.2: The household decision -making pocess

on household's adoption behaviour. The specific hypothesized directions of influence with respect to this study are discussed in chapter 7.

5.3.1 Personal household characteristics

The most common household characteristics that are frequently associated with adoption of soil conservation measures are age of the household and education level. In our study we also consider gender, wealth, marital status and ethnic group of the household.

There is general agreement that education is associated with a greater understanding of soil erosion problem. Higher education also increases farmer's access to information related to benefits and costs of soil erosion. Therefore, educated households are expected to perceive more the soil erosion problem and adopt soil conservation technologies than households with lower levels of education. Positive association between adoption of soil conservation and education have been reported by Carlson et al. (1977) and Earle et al. (1979) among others.

Younger households are expected to have a longer planning horizon (longer payoff period) than older farmers. This results in varied concern about the impact of soil erosion on future productivity between younger and older households. Because of this, younger households are expected to put more effort into searching for technical information about the soil erosion problem, therefore are expected to be more knowledgeable and hence understand and recognize soil erosion problem more easily than older households. Age of household also plays a role in household's decisions to use different types of soil conservation technologies and the level of investment in soil conservation technologies. Older heads of households tend to have a stronger belief in traditional soil conservation measures hence are unlikely to accept new soil conservation measures. Gould et al. (1989) observed that younger farmers are more likely to adopt soil conservation measures than old and more experienced farmers, who might find it difficult to change their way of farming. Also, Hoover and Wiitala (1980) found that soil conservation measures were common among young and educated farmers who have more access to technical information.

Gender of the household determines access to technical information provided by extension agents (most of whom in the study area are male). Due to social barriers male extension agents tend to address male-headed households. Also, female-headed households, who are mainly widows, divorcees and unmarried women, have limited access to production resources such as land. In many cases they depend on borrowed land and to a limited extent on poor-quality purchased land. These situations deprive them of access to information and limit their perception of the soil erosion problem and reduce their ability and willingness to use improved soil conservation measures. Marital status of the household also determines household's access to information and resources and hence perception of the soil erosion problem and adoption. In the study area most single heads of households are female. Therefore, their access to production resources and technical information from extension and other development agents are limited. Wealth level of the household determines his economic position and thus the ability to use improved soil conservation measures.

5.3.2 Sociological factors

Sociological factors that are expected to play a role in the adoption process in this study are related to household's perception of the impact of soil erosion on land quality and productivity, and attitude toward benefits from using improved soil conservation technologies. In our study, we consider the following sociological factors: attitude towards soil erosion, household knowledge about soil erosion, household's ranking of the soil erosion problem, perception of the production trend, attitude towards soil conservation, attitude towards future benefit, and social status. Household's attitude towards soil erosion determines his concern about soil loss and prevention of the soil erosion problem by using appropriate soil conservation measures. Households who know that they have soil erosion on their farms are likely to seek more information about its occurrence and the appropriate measures to reduce its impact on farm production. Also, household's awareness and perception of decreasing productivity over time and his perception of soil quality of his fields located on the slopes influence his perception and understanding of soil erosion problems. Households who feel that productivity and soil quality of their farms located on the slopes have been declining over time are likely to associate this with the soil erosion problem and will look for preventive measures. Therefore, household's concern about conserving the soil quality and his ranking of soil erosion problem are expected to influence his perception of the soil erosion problem, adoption of soil conservation technologies and level of investment in soil conservation.

Perception of future returns from soil erosion control is expected to enhance adoption of technologies. This implies that household's perception of long-term benefits of soil conservation influences the decision to invest in soil erosion control practices and the choice of technologies. The household who does not expect benefits from investing in soil erosion control is likely to postpone the adoption of soil conservation practices.

The social status of households regarded as a source of resources and information is essential for enhancing the innovation adoption. Social status determines the extent of interactions (networks) with friends, neighbours and development agents such as extension agents and soil conservation programmes the individual is capable of establishing. This increases their access to different types of information and resources. Boahene (1995) argues that there is a relationship between the level of informal networks and social status; indicating that people with a higher social status are likely to have stronger interpersonal links. This together with desire to maintain their social status enhances both perception of production problems and adoption of innovations.

5.3.3 Economic factors

Economic factors included in this study are those expected to play a role in determining the willingness and ability to invest in improved soil conservation measures and level of investment. These include family labour, income, off-farm employment, risk attitude and land tenure.

Family labour available for farm work determines the type of soil conservation method selected by the farm household. Households with more labour may decide to use labour-intensive physical soil conservation technologies, while households with less labour due to a smaller family or limited access to hired labour and communal labour may avoid labour-intensive physical technologies and opt for less labour-demanding technologies such as agronomic (biological) or semi-physical technologies. The influence of labour on the decision whether or not to use improved soil conservation technologies can also be viewed in terms of the impact of the respective technology on the labour allocation pattern within the household. This is because some soil conservation practices may lead to changes in household's socio-cultural labour use patterns among the household members which may be desirable or undesirable. For example, the improved technology may interfere with the cultural division of responsibilities between men and women within the household. Therefore, the relationship between adoption and family labour will depend on the types of technologies available. If labour requirements associated with improved technology are thought to be too high relative to capability of the farm household or have undesirable impacts on the household labour organization, then the household will refrain from using the improved technology and vice versa. Available labour (family labour and hired labour) may also influence the level of investment in labour-intensive soil conservation practices.

Off-farm employment reduces household labour available for farming activities, hence reduces the adoption and effort devoted to soil conservation practices. However, Norris and Batie (1987), in their analysis of conservation tillage, found a positive relationship between off-farm employment and level of use of conservation tillage. They concluded that, although off-farm employment reduces labour available for conservation activities, it is a source of income, encouraging investment in soil conservation technologies. Other authors like Gould (1989) concluded that the effect of off-farm employment on conservation effort is unclear. Given this complex relationship it is convenient to focus our analysis on the total labour available for farming activities after taking into account labour allocated to off-farm employment.

High levels of income of the household influence adoption behaviour and ability to investing in soil conservation practices. That is, financial constraints to adoption are determined by household's sources of income and level of farm profits. The ability to put a larger area of land under soil conservation measures or to invest in various combinations of soil conservation technologies depends on household's earnings. Access and level of credit and income from non-farm activities and other sources such as, financial assistance from relatives (children) working in towns (remittances) influence willingness and the financial ability of the household to invest in improved soil conservation technologies and to maintain the conservation technologies adopted. Thampapillai and Anderson (1994) found a positive relationship between adoption and off-farm income and credit. Household's perception of short-term versus long-term returns associated with various soil conservation technologies and what they plan to do with the farm in the future (selling versus giving to children) influences the efforts he devotes to soil conservation practices. Solow (1974) observed that farmer's expectation of future income which depends on the planning horizon influences the implementation pattern of soil conservation practices.

Farmer's attitude towards risk may influence his decision to adopt soil conservation technologies. Risk-averse farmers will avoid to invest in technologies which are costly and take those technologies which involve less investment. Kramer et al. (1983) argues that farmers with a high aversion to risk will follow production practices that are associated with higher income and lower costs. Ervin and Ervin (1982) found that the adoption of soil conservation practices decreases as the level of risk aversion increases.

Land ownership (land tenure) also influences adoption of improved soil conservation technologies. Households who do not own the land/farm they cultivate e.g., borrowed land, have little or no control of the types of technologies they adopt. Conservation measures which involve construction of physical structures such as terraces may need the decision or approval of the land owner. If the land owner is not convinced of the merits of these technologies, then the non-owner household will be unable to adopt or use the technologies. Also, non-owner households may be unwilling to invest in soil conservation due to lack of long-term commitment or responsibility on the land. Therefore, a lower use of soil conservation technologies is expected among the households cultivating borrowed land. The type of land tenure also influences effort devoted to soil erosion control. In a situation where the farm operator is not the owner of the land (borrowers), he may hesitate to devote much effort to soil conservation due to less concern about the long-term quality of the soil. Full ownership of the land increases the sense of responsibility due to a long-term planning horizon and concern about the soil quality of the farm. Also, non-farm-owners are in most cases poor immigrants with limited capability to invest in soil conservation measures. Therefore, more effort is expected from the farm owners than from non-owners. Featherstone and Goodwin (1993) argues that as the percentage of rented land of the farmer increases, the less likely he is to make conservation expenditures.

5.3.4 Institutional factors

Institutional factors in the context of this study include the support provided by various institutions and organizations to enhance the use of improved soil conservation measures. This includes technical support and promotional services provided to farmers to encourage them to use improved soil conservation technologies. The focus is on household participation in different activities organized by the SWC programmes and extension agents, together with their access to technical information and other soil conservation services.

Perception of the soil erosion problem, willingness and ability to use improved soil conservation measures and the level of soil conservation investment depend on whether or not the household participates in soil conservation programmes operative in the area and/or whether or not he has access to extension services and other technical assistance. Support programmes such as educational programmes on soil conservation, and exposure to soil conservation activities through video shows, village tours, participation in village-level resource conservation planning, input subsidies and cost-sharing plans are expected to increase exposure and awareness of soil erosion problems and provide incentives for households to adopt soil conservation practices. Cost sharing plans, input subsidies and participation in labour-sharing groups organized under the SWC programmes lower the costs of soil conservation and therefore influence household's ability and willingness to use improved soil conservation. Since these services vary from one area to another, the areas where the household is located determine the chance that he will participate in such programmes. Households that are located in areas where such a programme exists have higher chances of getting such services compared with households in a non-participating area.

Household's access to information sources is likely to determine his awareness of the existence of the soil erosion problem and understanding its impact on soil productivity. The information from formal and informal sources may therefore influence household's interest and concern about the soil erosion problem. This will in turn enhance adoption of improved soil conservation measures and level of investment in soil conservation.

The use of other technologies which enhance productivity affects the adoption of soil conservation technologies. Government policies such as subsidies on fertilizers or hybrid seeds may encourage the use of these technologies hence off-set the impact of soil erosion on productivity and inhibit investment in soil conservation. Blyth and Kirby (1985) have argued that fertilizer subsidy in Australia has hindered the adoption of management and production practices that reduce land degradation.

5.3.5 Physical factors

As mentioned earlier, physical factors refer to the land characteristics which influence the intensity of soil loss (erosion potential). The erosion potential is determined by the location (slope) of the household's farms and other factors such as, soil type and land use practices. In this study we only focus on location or topography of the farms. Those households who have most of their farms in areas which are more prone to soil erosion, such as steep slopes, are expected to experience more soil erosion and therefore recognize the impact of topsoil soil loss due to erosion more easily than households with most of their farms located on gentle slopes and lowlands. Ervin and Ervin (1982) found that the erosion potential variable was significantly related to perception of the soil erosion problem. Also, households with farms located on steep slopes or those who grow erosive crops, are expected to experience more soil erosion than others. Due to a greater yield reduction they are expected to decide to adopt soil control measures. Gould et al. (1989) argued that those farm households whose farms have the most potential for experiencing severe erosion are more likely not only to recognize the existence of the erosion problem, but also to undertake soil conservation activities. They concluded that soil type, slope and land use will affect the degree of soil erosion experienced. The degree of erosion potential of farmer's field may persuade him to use soil conservation measures of a particular type. For example, because of erosion severity the households may choose to adopt physical soil erosion control measures which are more effective under their topography than biological methods.

The erosion potential of the land is likely to encourage households to put more effort into soil erosion control. Ervin and Ervin (1982) found that erosion potential is associated with higher conservation efforts, implying that greater potential for productivity damage stimulates erosion control. Farmers are expected to put more effort into erosion control to reverse declining productivity.

5.4 Summary

The main objective of this chapter was to develop the theoretical framework for guiding the implementation of this study. The framework has been developed with the quest to have a comprehensive interdisciplinary framework that incorporates sociological and economic theories of innovation adoption process. The three-stage framework developed by Ervin and Ervin (1982) is adapted through some modifications. A detailed household decision-making process was developed using Nowak's adoption decision assumptions derived from the symbolic adoption theory.

In our three-stage adoption framework we assume that household's behaviour/decision to adopt improved soil conservation technologies are determined by household's perception of the soil erosion problem shaped by personal attitudes toward soil erosion. The attitudes are formed from household's beliefs and values about the soil erosion problem and the prevailing socio-economic circumstances which influence technology *acceptance or willingness,* together with situational forces which determine household's technology implementation *ability*. Therefore, we conceptualized the adoption behaviour for soil conservation as a sequential decision-making process which is influenced by personal characteristics of the heads of household, sociological, economic, institutional and physical factors. These factors are considered important in explaining the perceptions of the erosion problem, adoption decision and the level of investment in improved soil conservation technologies among adopters in the study area. This analytical framework links socio-psychological innovation adoption behaviour to economic decisions on soil conservation. This kind of link is necessary for a thorough understanding of household's varied actions with regard to the use of improved soil conservation measures. It is through this understanding that we can design appropriate policies and strategies for enhancing the adoption rate for improved SWC technologies among the households in the northeastern mountains.

The decision model for this study has a stronger ability in clarifying some basic decision-making process and adoption-diffusion ideas: the model may be useful in 1) explicitly identifying important sets of factors for each of the three adoption stages, 2) in identifying and understanding lags in the adoption process and in defining different categories of households based on their adoption behaviour, and 3) in identifying and explaining problems related to rejection and discontinuance of technology use.

CHAPTER 6

DATA COLLECTION

6.1 Introduction

Data collection was divided into two phases. The first phase involved collection of general information about the study area (preliminary survey). This included two activities: 1) review of secondary information from various publications and reports, and 2) informal discussions with key informants[21], individual heads of households and groups of heads of households. The second phase is farm-level data collection from a sample of heads of household. This was carried out by conducting interviews using a structured questionnaire. As indicated earlier, the households in the context of this study are defined as a group of people who live together, and jointly work and depend on the same piece of land, and other production resources, such as family and hired labour. The household members in this context, therefore, have the same production goals and priorities and their decisions with regard to farm production are guided by the same choice criteria.

In this chapter, the procedure used for data collection is discussed, including the preliminary survey, sampling procedure and household interviews.

6.2 The preliminary survey

The main objective of the preliminary survey was to get a better understanding of the study area including the components of the production system, the biophysical and environmental situation and characteristics and existing variations in the four northeastern mountains ranges. Also, the survey was used to capture socio-economic characteristics of the households in the study area, their attitude and perception towards land degradation and soil conservation and factors influencing their decisions. Such an understanding was useful for refining the scope of the research problem, identifying major information gaps, and guiding the sampling process and designing and preparing the farm-level household survey.

6.2.1 Secondary data collection

There is already a wealth of information available about various aspects of the study area. This includes information on socio-economic issues, biological and environmental situation, natural resources management, land degradation and soil conservation aspects. The main objective was to gain an understanding of the prevailing condition in the study area as far as land degradation (soil erosion) and soil conservation are concerned and to establish existing physical and environmental variations in the study area.

Various publications and reports by research, extension and development programmes

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[21] These are individuals with special knowledge of the topic of interest.

working in the study area were reviewed. The review covered technical aspects related to the study, such as soil loss, historical outline of population pressure, land degradation, soil conservation strategies used in the area and the key components of the production system and land use patterns. Institutional aspects such as credit schemes, land tenure system, SWC support programmesand macro-level policies such as environmental policy were also reviewed. Other useful information such as topographic and natural resource maps were examined.

6.2.2 Informal survey

The informal survey was conducted in five representative districts in the northeastern mountain ranges. These were Moshi-rural district in the Kilimanjaro mountains, Arumeru in the Meru mountains, Mwanga in the north Pare mountains, Lushoto and Muheza (Amani) in the Usambara mountains. A total of 24 villages were involved in this survey[22]. Selection of villages was based on the seriousness of the land degradation problem and the extent to which the improved soil conservation technologies were used. It was also important to include villages participating in SWC programmes and non-participating villages located at different altitudes to capture variations. The objective of the survey was to get an understanding of existing variations among the households in the study area. Therefore, the discussions focused on relevant household socio-economic characteristics including their perception and knowledge of the land degradation (soil erosion) problem, their attitude towards land degradation and soil conservation, and their participation in soil and water conservation activities initiated by the SWC support programmes.

The survey involved informal discussions with key informants such as village extension officers, village leaders, representatives of soil conservation programmes, non-governmental organizations (NGO) working in the areas, individual heads of households and household groups (men and women).

A checklist of topics was used to guide the discussions and ensure that all relevant topics on a specific subject were covered. Information collected was summarized (see Appendix I).

6.3 Sampling procedure

Sampling for this study involved three stages: (1) selection of the study districts/mountain ranges (2) selection of the villages and (3) selection of the interview respondents. The most important consideration in selecting districts was the need to have two comparable districts, representative of the study area. The idea was to have a large area of the northeastern mountains which share some historical characteristics with comparable land use systems and socio-economic situations. Also our interest was to have many adopters (at different levels) and non-adopters of improved soil conservation measures. Given these criteria two mountain ranges: the

[22]Field visits included 6 villages in Moshi-rural district, 3 villages in Arumeru district, 8 villages in Mwanga district, 5 villages in Lushoto district and 2 villages in Amani.

north Pare mountains in Mwanga district and the west Usambara mountains in Lushoto district were selected. As mentioned in chapter 2 these areas have similar donor-supported soil and water conservation programmes aiming at improving soil productivity by promoting soil conservation to control soil erosion and ensure sustainable use of natural resources. The support from the Technical Aid of the Republic of Germany (GTZ) has been operative in the west Usambara mountains and the north Pare mountains for the past 16 and 5 years respectively. Another support programme is provided by the Dutch Volunteer Service of the Netherlands (SNV), which started in the two districts 5 years ago. Since our interest was to have many adopters and non-adopters at different levels, the two areas were considered appropriate. Other aspects considered included accessibility and representativeness of the study area.

A total of fifteen villages representing various altitude zones[23] were selected for the study (Table 6.1). It was assumed that households located at different altitudes or agro-ecological zones will have different types and levels of land degradation, caused by different factors, and will most likely use different soil conservation technologies. Selection of villages from different altitudes/agro-ecological zones was expected to provide a mix of degradation levels and conservation strategies, giving assorted farm situations. The selection of villages also considered the intensity of SWC programmes based on the time period the programmes have been active in a particular village and adoption rate of improved soil conservation technologies. Therefore, the selected villages consist of those with active soil conservation activities and villages not participating in SWC programmes.

From each village, 20 farm households were randomly selected from the sampling frame (household list), making a total of 300 households. Where necessary, purposive selection was used to ensure that different categories of households, such as female-headed households were included in the selected list. In each village 10 reserve households were selected for replacements when needed.

6.4 The household interviews

6.4.1 The structure of the questionnaire

In the second phase of data collection, a structured questionnaire and personal observations were used to collect relevant information from sample households in the two study areas. The questionnaire used for household interviews was built upon the objectives of the study. Emphasis was placed on collection of information related to relevant aspects and issues discussed in the theoretical framework of the study and empirical model discussed in chapters 5 and 7 respectively. The information collected during the preliminary survey was used to guide the development of the questionnaire. The original questionnaire was written in English (Appendix II). To ensure that the exact meaning of the question was communicated

[23]Altitude variations are more pronounced in the west Usambara mountains. Three divisions represent different altitudes. Mtae, Mlalo and Soni represent high, medium and low altitudes respectively. In the north Pare mountains the two divisions have more or less the same land form.

Table 6.1: Distribution of villages and households in the study area

Mountain range	Division	Total villages	Selected villages	Total households
North Pare Mountains	Usangi	18	Chomvu	289
			Vuagha	143
			Ndanda	316
	Ugweno	14	Shighatini	386
			Kisanjuni	477
			Mwaniko	505
W. Usambara Mountains	Mtae	14	Tema	382
			Nkelei	278
			Longoi	398
	Mlalo	26	Mlesa	426
			Handei	755
			Zaizo	327
	Soni	16	Kwadoe	390
			Shashui	462
			Mbuzii	655

Source: Tanga and Kilimanjaro Regional population Profile, Population Census, 1988.

to respondents and accurate information collected, the questionnaire was translated into *Kiswahili,* the national language. During the translation it was important to make sure that all the questions were worded to give the same meaning as the original ones. Also, the questions were worded the same way they would be asked to minimize variations in information obtained from different enumerators. Where necessary, local words/terminologies (*kipare* and *kisambaa*) were used to elaborate some scientific/technical terminologies. Also enumerators who spoke the local languages were encouraged to use it to elaborate questions where needed.

The questionnaire contained different types of questions including factual questions intended to elicit facts such as years (age) and quantities (output), subjective/opinion questions seeking respondent's opinion (open-ended questions), pre-coded questions which include pre-determined responses (closed-ended questions). Tabular format was used to organize responses for questions which required collection of information that encompassed several aspects.

In designing the questions consideration was given to the easiness to ask the question, to record responses and flexibility. Most of the questions were pre-coded as these are easy to administer and analyse. The only limitation is that they restrict the respondent to certain responses, therefore may loose information due to lack of flexibility. In addition to this, construction of pre-coded questions needs a thorough understanding and knowledge of the issue being addressed. Open-ended questions were used to collect information on household opinion and experiences.

Before the questionnaire was administered to sample households it was pre-tested in one of the study villages in each of the two areas to evaluate validity of the questions and the structure of the questionnaire and to verify pre-coded responses included in the questionnaire. The interest was in checking clarity, relevance and sequence of the questions and identifying missed items. After the pre-testing, the questions were revised and the questionnaire finalized.

The questions were grouped into eight sections dealing with different types of information. The question sections are as outlined below:

- household characteristics: gender, ethnic group, age, education level, marital status, and wealth rank (house type and assets).

- household composition: family size, family labour and supplementary labour (help).

- conservation attitudes and beliefs: perception of soil quality and productivity, attitude towards occurrence of soil erosion, attitude towards soil conservation, future benefits and risk.

- information on household land: land tenure, plans for land after retirement, farm locations (erosion potential).

- perception of soil erosion: whether the household attribute soil erosion to declining productivity and soil fertility, understanding and knowledge of soil erosion problem and soil erosion experience.

- soil conservation technologies: whether the household use SWC technologies, types of technologies used in various slope, intensity of SWC (plots and area under SWC), decision making and division or responsibilities for soil conservation and use of other technologies.

- institutional support: participation in SWC programmes, support received, participation in training and other SWC activities, sources of information, extension visits and credit support.

- household economic position: livestock ownership including herd size, whether the household has cash crop, farm income, use of hired labour and labour sharing groups, off-farm income, remittances and household expenditure.

6.4.2 *Field work design*

Considerable time was spent on organizing farm-level household interviews. This was very important to ensure a smooth implementation of the task. Prior to conducting the interviews, a familiarizing field visit was made to the study area. The purpose of this visit was to develop a feel for the area and to make initial consultations with relevant individuals such as village leaders, district and village extension officers and SWC programmes (SECAP, TFAP and TIP). These consultations included a brief overview of the intention to work in the area, including the purpose and nature of the study, and seeking permission to work in the area and asking for their cooperation and support during the interviews. Necessary preparations were discussed including availability of the sampling frame (household lists). Also, these consultations provided an opportunity to discuss and clarify issues and questions emerging from secondary information reviews.

6.4.2.1 *Recruitment and training of enumerators*

Enumerators drawn from the district extension office and SWC programmes were recruited to carry out the interviews. It was recognized that enumerators determine the success of the interviews and the quality of data collected. Therefore, enumerator recruitment and training was thoroughly carried out. Key considerations for recruitment of enumerators were personality (friendly, hard-working, open-minded and patient), local knowledge (language and/ or familiar with local farm conditions) and education level (high school or at least diploma in agriculture).

Two days prior to field work were spent on enumerator training. The purposes of training were (1) to provide orientation to the purpose of the research and objectives, the study area and organization of field work, (2) to provide instructions for interview techniques including how to effectively communicate with respondents and how to ask questions, and (3) familiarization with the questionnaire which included elaborations, clarifications and tips on different questions to make sure that enumerators understand all the questions, have clear and consistent views on what information is needed and interpretation of questions i.e., how questions should be asked, and how and where to record the responses. This was carried out by going through all the questions interpreting the intention of each question and the type of answer expected. Enumerators were also asked to comment on the translation of questions.

6.4.2.2 *Structure of interviews*

Each of the sample households were visited and interviewed at their homes. Prior to the interview, appointments were made with the households concerned at their convenience. An average of 12 households were interviewed per day and one interview took about 90 minutes. In male-headed households both husband and wife were encouraged to participate in the interview.

Every day, at the end of interviews the questionnaires were collected from the enumerators and checked for completeness, errors, omissions and irrelevant responses. Identified errors and problems were discussed with the enumerators and where possible corrected immediately. In a few cases respondents had to be re-interviewed. Difficult aspects of the questionnaire were also revisited, discussed and re-emphasized.

Some problems were encountered during the field implementation of household interviews. There were a few occasions where the respondent was not cooperative and/or refused to be interviewed. This happened when the purpose of the interview was not clear to the respondent or when he was just not interested in participating in the interviews. This problem was solved by using the reserve list to replace them. Another problem related to this was a missing respondent. This happened because, either the respondent did not keep the appointment, some emergencies happened such as death in the family and sickness, or when there was confusion about the appointment. In such situations attempts were made to reschedule the interview. In about four occasions the households included in the sample list were not heads of households. In such cases these respondents were replaced with their respective head of household, either right away or an appointment was made at later time. In most households the enumerators spent more time than anticipated because either the respondent had prepared some food to share with the visitor[24] or was interested in discussing other things beyond the interview.

6.4.3 Accuracy and reliability of information from interviews

Successful data collection is determined by the extent to which the information collected is accurate and reliable. The inaccuracy and unreliability of data collected were attributed to the following aspects: (1) collecting inadequate/wrong information, (2) enumeration bias and (3) sampling errors.

There were cases where it was difficult for the respondents to provide accurate information on questions that required him to recall some details such as labour, harvest, income, expenditures and number of extension visits annually. For example, it was difficult for respondents to estimate annual supplemental labour in question B2(b). Also, for questions that needed estimation of farm area in acreage and harvest in weights were difficult for respondents. Given the small scattered plots they own it was hard for them to remember all the plots and give a reliable size of each of them. They also do not measure the amount of crops they harvest. They usually put the harvested crops in traditional granaries and use little by little for food and sale. Others put them in bags and other types of storage containers. Therefore, in such a situation the enumerators had to convert the different local units into required units (kilograms) using the best estimate possible. In this case conversion errors are possible.

Questions that mentioned money were in most cases difficult to register and/or respondents misinterpreted the information provided. This included the question dealing with risk (C6) and the one on future benefit (C5). The responses given to these questions were in some cases influenced by the anticipation that the questions were meant to assess their eligibility for some kind of loan/financial support from the government or donor agency. To avoid this, enumerators were asked to make these questions as clear as possible and explain beforehand that no assistance motives are behind these questions. Therefore, the accuracy of response depended on the enumerator's ability to elaborate/explain the information.

Sensitive information such as that related to income (off-farm income, credit,

[24] It is common in most parts of the study area to give some food to visitors, and refusing is considered disrespectful.

expenditure, remittances), number of livestock brought the fear that such personal information may be disclosed to the public. To reduce wrong information, indirect questions were used to verify information provided and in some cases probing was used to ensure that the respondent was not misleading the enumerator. Related to this, though not encountered often, is the situation where the respondent showed a non-cooperative attitude, was tired, distracted or in a hurry due to having a busy day, lack of interest in the interview or mistrusting the survey objectives, therefore providing doubtful information. Where this situation occurred, effort was made to identify the cause of poor cooperation and rectified. In only two cases the interviews were terminated and the respondents were replaced. Also, enumerators were asked to indicate this kind of behaviour in the last section of the questionnaire. Questionnaires from such respondents were scrutinized and if serious inconsistency in responses was found, a replacement was also sought.

Enumerators' knowledge of local situation including language, interest and motivation influenced the quality of information collected. Inaccuracy in information caused by the enumerator bias includes: enumerator is unable to invoke respondent's interest; asking questions improperly, therefore missing the focus; enumerator expects a particular answer on the basis of earlier response patterns, thus records it without confirmation or enumerator mis-records information in the questionnaire. These problems were minimized through on-job training, close supervision and frequent inspection of the questionnaires by the author.

6.4.4 Data organization

After the field work the next step was to summarize and organize the information collected into a form that can be analysed. This task involved two steps. The first step was translating various questions into variables. The variable formulation process also included formation of sub-variables for some of the pre-coded questions with more than two responses such as social status (A6), type of land ownership (D6) plot location (D5), sources of information (G4), use of other technologies (F10) and others. Each response formed a sub-variable (e.g., the 7 sub-variables for social status). For easiness of analysis these were later consolidated into one meaningful variable. For open-ended questions, such as main problems affecting productivity (C2) and major causes of erosion (E5b) all answers given by the respondents were listed. The most frequent answers were identified and used to derive variables for these questions.

The second step was assigning codes to responses from different descriptive questions and deriving appropriate values for some of the continuous variables such as labour and farm income. For questions with two pre-coded responses such as ethnic group, marital status and sex of head of household, the same questionnaire codes were retained. For variables with sub-variables, like social status, for each sub-variable, a "1" was assigned to responses applicable to the respondent and a "0" to responses not applicable to respondent. For example, we created a sub-variable "SOST1" for "government leader" response-category in question (A6). Respondents who indicated to be one of the village leaders were assigned a "1" for this sub-variable and a "0" otherwise. All the variables/sub-variables together with their respective codes or values for continuous variables were posted into the computer spreadsheet (Lotus) as raw data for further synthesis. Detailed description of variables used in the analysis is provided in chapter 7.

6.5 Summary

This chapter intended to present an overview of the data collection procedure and the design of field work. Data collection was divided into two phases. The preliminary survey which includes secondary data collection and informal or exploratory survey was first carried out, followed by household interviews. The main objective of the informal survey was to provide an understanding of the study area and establishing a good rapport with local people, relevant government authorities and soil conservation programmes working in the area. The survey was also used for collecting information useful for refining the focus of the study, guiding selection of the study area and designing the household interviews.

The informal survey was followed by sampling or selection of the study area. This included selection of representative mountain ranges, study villages and sample households. The main criteria for study area selection were to have a large area representative of the northeastern mountains and an adequate number of adopters and non-adopters of improved soil conservation measures. The north Pare Mountains and west Usambara mountains were selected for the study on the basis that the two areas share some socio-economic and bio-physical features. In addition, the areas receive similar support for soil and water conservation activities. Fifteen villages were selected to represent different altitudes. Twenty households were selected randomly from each village. Purposive selection was used where necessary.

Household interviews were implemented using a structured questionnaire. Questions addressing objectives of the study based on the analytical framework developed in chapter 5 were constructed and administered to a sample of 300 households in the two study areas. The questionnaire was used to collect information on perception of the soil erosion problem, types of soil conservation used by households and the extent different types of soil conservation measures are used. In addition to this, information on household characteristics, socio-economic, institutional and physical factors relevant to explaining the perception of the soil erosion problem, adoption of soil conservation measures and conservation effort was collected.

The farm-level household interviews were preceded by a questionnaire translation, pre-testing and enumerator training. The questionnaire was translated into *Kiswahili*, the national language, to avoid translation discrepancies among the enumerators during the interviews. The pre-testing was carried out to check validity of the structure of the questions in the study villages. Training of the numerators was focused on questionnaire familiarization and interviewing techniques to ensure that the enumerators understood all the questions and adequate and reliable information was collected.

During the interviews various problems were encountered. Different ways to rectify these were looked for as much as possible to reduce data inaccuracy. These include replacing respondents (e.g non-head of households and uncooperative respondents), using probing techniques and indirect questions to clarify doubtful responses and clarifying suspicious thoughts and mis-interpretations emerging from some of the questions. Also, frequent checking of completed questionnaires and on-job training for enumerators are additional strategies used to improve quality of information collected.

Information collected from the household interviews was synthesized and organized into a form that can be utilized to address the study questions. This task involved translating the questions into variables and assigning values to variables created. This was a preliminary step towards further synthesis and data analysis presented in chapter 7.

CHAPTER 7

THE EMPIRICAL FINDINGS

7.1 Introduction

This chapter presents the estimation of the three models based on the three-stage adoption process described in chapter 5, using empirical data collected from the study area. These models are employed to identify the important personal characteristics, socio-economic and institutional factors influencing perception of the soil erosion problem[25], adoption of soil and water conservation technologies and efforts devoted to soil conservation activities. Binomial logit models are used to estimate the effects of model variables on the probability of perceiving the erosion problem and adopting improved soil conservation measures. The Poisson regression model is used to identify factors which determine the household's effort devoted to SWC.

First we describe the structure of empirical models developed for the study. Then descriptive statistics are presented to provide an overview of the characteristics of the sample. Lastly, the model results are presented and discussed.

7.2 The empirical models

7.2.1 Considerations for model choice

As discussed earlier, adoption of improved soil and water conservation measures and effort devoted to soil conservation are assumed to be economic decisions influenced by household's expected utility/profit and perceived risk of using an improved technology, given a set of individual characteristics and socio-economic, institutional and physical factors. Likewise, perception of the soil erosion problem is an attitudinal phenomenon influenced by similar factors.

Identifying the distinctive characteristics of households perceiving the soil erosion problem and those using different soil conservation technologies and predicting the likelihood of a particular household to perceive the soil erosion problem or use improved soil conservation technology is a discrimination or classification process. Given farmers' characteristics, socio-economic, institutional, and physical factors the goal is to identify the discriminants of "perceiving" the soil erosion problem, "adoption" of improved soil conservation technologies, and to identify factors which influence their "effort" devoted to soil conservation. In the former two cases we are considering models where the dependent variable, y is binary, taking only two

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[25]As indicated earlier, perception of the soil erosion problem in the context of this study is defined as household's attitude towards soil erosion and knowledge about the causes of soil erosion.

values, 0 or 1 (dichotomous variable) such that:

$$y = \begin{cases} 1 \text{ if farmer perceives the soil erosion problem} \\ 0 \text{ if farmer does not perceive the soil erosion problem} \end{cases}$$

and

$$y = \begin{cases} 1 \text{ if farmer uses improved soil and water conservation measures} \\ 0 \text{ if farmer does not use improved soil and water conservation measures} \end{cases}$$

We are interested in determining the probability that the farmer perceives the soil erosion problem or adopts improved SWC technologies: $P(y = 1 \mid \mathbf{x})$, where $\mathbf{x}$ is a vector of explanatory variables.

A variety of multivariate statistical techniques can be used to predict a binary dependent variable from a set of independent variables. Multiple regression analysis and discriminant analysis are among the techniques most used. However, modelling a binary dependent variable using multiple linear regression model (LPM) or linear discriminant functions presents some difficulties. In the case of linear probability model (OLS regression), the standard model

$$y_i = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + u_i$$

is estimated. In practice, the LPM includes values outside the 0,1 range. Therefore, the predicted values cannot be interpreted as probabilities. The LPM implies that a unit increase in x_j always changes $p(y = 1 \mid \mathbf{x})$ by the same amount, regardless of the initial value of x_j. This cannot be true because continually increasing x_j would eventually drive $p(y = 1 \mid \mathbf{x})$ to less than zero or greater than unity (Green, 1983a; Maddala, 1983). Another difficulty with LPM is that the assumptions necessary for hypothesis testing in regression analysis are violated when the dependent variable is binary response, making all the standard statistical inferences invalid, even for very large samples[26]. Although a two-step weighted estimator can be applied to correct the heteroskedasticity problem, other problems remain unsolved (Aldrich and Nelson, 1984).

Linear discriminant analysis allows direct prediction of group membership, but for the prediction rule to be optimal requires the fulfilment of assumptions related to multivariate normality of the independent variables as well as equal variance-covariance matrices in the two groups. Unfortunately, in practice the assumption of joint normality of regressors is difficult to attain, and transformations often used do not guarantee equality of covariance matrices (Green, 1990).

In most empirical applications, probit and logit models are used for modelling the relationship between a binary dependent variable and a set of continuous and/or discrete independent variables. These models require fewer assumptions than discriminant analysis and perform better even when the assumptions required for discriminant analysis are satisfied. These functions are easy to use and have proved to be continuous, bounded between 0 and 1,

[26] For example, because the values of dependent variable y_i are not normally distributed, the LPM will not be fully efficient because the distribution of errors is not normal (Maddala, 1992).

monotonically increasing with $\mathbf{x}\beta$. The probit and logit models differ in specification of the distribution of error term. In logistic models the error component follows a cumulative logistic distribution, while for probit models the error term follows the cumulative normal distribution. The cumulative logistic and cumulative normal distributions are very close to each other. The results obtained from the two models are therefore comparable except for very large samples. However, the estimates of coefficients (β_i) differ from each other, although they are related via a transformation (Maddala, 1992). The choice between the two models is usually made on the basis of practical concerns such as personal preferences, experience, availability and flexibility of computer software (Aldrich and Nelson, 1984; Judge et al., 1988).

For perception of the soil erosion problem and adoption of improved SWC technologies we are using logit models. The model has the following framework:

$$y_i^* = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + u_i$$

where y_i^* is not observed (latent variable). What we do observe is a binary variable y_i defined as

$$y_i = \begin{cases} 1 & \text{if } y^* > 0 \\ 0 & \text{otherwise}^{27} \end{cases}$$

The probability is given as

$$Prob(Y_i = 1) = \frac{e^{\beta' X}}{1 + e^{\beta' X}}$$

For the analysis of efforts devoted to soil conservation[28], we could use linear regression model (OLS), but the dependent variable has some discrete characteristic. The observed number of physical soil conservation measures among adopters ranges between 0 and 6. Therefore, to account for this characteristic the *Poisson regression* model[29] is used instead. This model

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[27] The difference between linear probability model and logit model is that in a linear probability model we analyse the dichotomous variables as they are, whereas in *logit* models we assume the existence of underlying latent variable for which we observe a dichotomous realization.

[28] The proxy indicator for effort is the number of physical soil erosion control measures used by the farmer.

[29] This is a nonlinear regression model.

specifies that each y_i is drawn from Poisson distribution with parameter λ_i which is related to regressors $\mathbf{x}_i$ (Green, 1997). The probability $P(Y = y_i)$ is

$$P_y = Pob(Y_i = y_i) = \frac{e^{-\lambda}\lambda_i^y}{y_i} \qquad y_i = 0,\ 1,\ 2\ldots.$$

7.2.2 Model specification

The empirical analysis of household behaviour towards using improved soil conservation technologies is divided into three models based on the three-stage adoption decision process presented in chapter 5. These include perception, adoption or use, and effort models. As mentioned earlier, the household's decision-making process on the adoption of improved soil conservation technologies is influenced by personal characteristics, physical factors of the land, socio-economic and institutional factors.

The construction of empirical variables was carried out using various techniques such as: combining responses, weighting, scoring and ranking. Our interest was to put variables into a form that is compatible with the computer package used, at the same time providing meaningful interpretations. As mentioned earlier, for some of the variables with more than two pre-coded responses we had to narrow them down by either combining the responses or dropping others. Table 7.1 presents variables included in the three models and the hypothesized direction of the relationship between each variable and the dependent variables (perception of the soil erosion problem, adoption of improved soil and water conservation measures and effort devoted to soil conservation). A brief discussion of how the dependent variables and some of the independent variables were constructed is presented below.

The dependent variables:

The dependent variable for the perception model is PERCEPPRO. This is a discrete variable indicating whether or not a household perceives the soil erosion problem. The variable was coded "1" for perceiving the soil erosion problem and "0" for not perceiving the soil erosion problem. The variable was constructed from household's attitude towards soil erosion. This involved combining variables indicating household's attitude towards occurrence/existence of soil erosion (EROATTD) and household's knowledge about what causes soil erosion (EROCAUSE). Households who believe that soil erosion can be avoided (EROATTD = 0) and know what causes soil erosion (EROCAUSE = 1) were assigned a "1"for PERCEPRO variable and a "0" otherwise.

The dependent variable for the adoption model, ADOPTION, is also discrete, indicating whether or not a household uses improved soil conservation measures. This was constructed from question H1 in the questionnaire presented in Appendix II. First the responses were narrowed down by grouping different types of technologies into two categories: improved soil conservation technologies and traditional soil conservation practices/technologies. Improved technologies

: Factors included in the empirical models and hypothesized influence on perception of the soil erosion problem, adop
SWC measures and effort devoted to soil conservation

bles	Description	Measurement	Variable name	Hypothesized direction of influence o		
				Perception	Adoption	Effort
ristics:						
	Age of the head of household	Years	AGE	-	-	-
	Education level of household	Years	EDUC	+	+	+
	Gender of head of household	Female/male: 0/1	HSEX	+	+	+
	Marital status of household	Married/single:0/1	MAST	-	-	-
	Ethnic group of the household	Immigrant/native: 0/1	ETHN	+	+	+
	Wealth category of household	High/Average/Low	WEALTH	+	+	+
:						
le	Attitude towards conservation	Negative/positive:0/1	CONTUDE	+	+	+
	Household attitude towards future benefit	Negative /positive:0/1	BENTUDE	–	+	+
	Attitude towards soil erosion	avoid./unavoid.: 0/1	EROATTD	–	–	–
	If hh. knows causes of soil erosion	No/Yes: 0/1	EROCAUSE	–	–	–
	If hh. knows he has erosion	No/Yes: 0/1	EROKNO	–	+	–
	If hh. ranks SE as priority problem	No/Yes: 0/1	ERORANK	+	+	+
	Perception of production trend	increase/decline:0/1	PRODTRE	+	+	+
	Social obligations for household	# of obligations	SOST	+	+	+
n	If hh. perceives soil erosion problem	perceives/do not:1/0	PERCEPRO	–	+	+
	Household annual farm income	'0000 T. shillings	INCOME	–	+	+
	Household family labour	Full- time Adults	LABOR	–	+	+
	If hh. has other sources of labour	No/yes: 0/1	HELP	–	–	+
	Risk attitude of household	Averse/neutral:0/1	RISK	–	+	+
	Average size of all household plots	Acres	FASZ	–	+	+
	If hh. Has off-farm sources of income	No/yes: 0/1	OFINC	–	-/+	-/+
	If receive financial support from relatives	No/yes: 0/1	REMIT	–	+	+
	If household cultivates cash crop	No/yes:0/1	CASHCRO	–	+	+
:						
mme	If hh. participates in SC programmes	No/yes: 0/1	CONPROG	+	+	+
isits	# of visits by extension staff per yr.	Number	EXVIST	+	+	+
p	Participation in labour-sharing groups	No/yes: 0/1	LABSHA	–	+	+
	Level of access to information	Number of sources	INFSO	+	+	+
	District where houdehold is located	Mwanga/Lushoto: 0/1	DIST	+	+	+
	SE potential based on location of plot	Low/medium/High	EROPOT	+	+	+

not included in the respective model; -/+= Direction of influence is indeterminate and hh. = household (head of household) included *fanya juu* and bench terraces, infiltration ditch, cut-off drain and macrocontour lines (MCL). Traditional technologies are grass strips, trash lines, agroforestry, zero-grazing, minimum tillage and others. A "1" was assigned to households using at least one of the improved soil conservation technology (adopters) and a "0" to households either using traditional measures only or not using any soil conservation method (non-adopters)[30].

The dependent variable for effort model, EFFORT, stands for level of commitment or investment devoted to soil conservation. Because of lack of reliable information on the actual household's expenditure for soil conservation (investment level), extent of erosion reduction, and the acreage under conservation, types of soil conservation measures (physical, semi-physical and biological) were used instead. The level of investment devoted to soil conservation by households was established by first categorizing types of technologies into physical measures (*fanya juu* and bench terraces, infiltration ditch, cut-off and cut-off drain), semi-physical measures (macrocontour lines, grass strips and trash lines), biological measures (agroforestry, zero-grazing and minimum tillage). We assumed that households using physical measures such as *fanya juu* and bench terraces commit more resources (labour and capital) to soil conservation than households using semi-physical structures and biological measures. Therefore, the number of physical technologies used by a household served as a proxy for level of investment/commitment to soil conservation and hence the amount of effort. Since it is uncommon for farmers to use more than one type of physical soil conservation technology on the same plot, we assume that the number of physical measures as opposed to whether or not households use physical measures will capture the extensiveness of soil conservation in terms of number of plots under conservation.

The independent variables:

Since the meaning, measurements and hypothesized direction of influence for most of the independent variables included in the three models are fairly clear, only a few of them are discussed.

The variable education level (EDUC) is included as a proxy for the capacity of head of household to understand technical aspects related to soil erosion and soil conservation. Higher education levels are hypothesized to be associated with more access to information on the soil erosion problem and improved soil conservation measures, hence a positive relationship with perception, adoption and effort. Age of the household (AGE) is hypothesized to have a negative influence on perception of the soil erosion problem, adoption of improved soil conservation measures and investment level to improved soil conservation measures. Older heads of households are expected to have shorter planning horizons than younger ones. Given the fact that benefits from soil conservation are not realized within a short time period, older heads of households are likely to refrain from making soil conservation investments. In addition to this, due to a lower level of education, older heads of households tend to be less knowledgeable about

[30]As explained in chapter 2, the traditional soil conservation practices have proved to be less effective in reducing soil erosion in the study area. Since our interest is in assessing application of effective soil conservation measures in order to attain sustainable production, we categorize households who are not using erosion control measures and those using traditional practices as non-adopters. We recognize the fact that households who are not using any soil erosion control practice may be experiencing more soil erosion than households using traditional practices, but from the sustainability point of view the two cannot ensure a sustainable production system.

the causes and occurrence of soil erosion and its impact on productivity, ie., less perception of the soil erosion problem. The variable ETHN (ethnic group) is coded "1" for native households and "0" for immigrants. Native refers to *Wapare* and *Wasambaa* for the north Pare and west Usambara mountains respectively. This includes those heads of households whose ancestors are original inhabitants of the area. It is hypothesized that immigrants are less likely to adopt soil conservation measures and are expected to make a lower conservation investment compared with native households. The variable WEALTH represents the economic rank of the household. Three wealth categories were established: *"high, average* and *low"* coded as "1", "2" and "3" respectively. Compared with average and low wealth categories, households in a high wealth category are more likely to perceive the soil erosion problem, use improved soil conservation technologies and devote more effort to soil conservation. The assumption is that more affluent households are able to adopt innovations in proportion to their wealth. This is because they have a higher level of resources and ability to acquire information on improved soil conservation technologies.

The conservation attitude variable, CONTUDE, refers to whether or not the head of household agrees that he has the responsibility to protect the soil quality for future generations. The variable is coded "1" if he agreed and " 0" if he did not. The hypothesized positive direction of influence on the three dependent variables is based on the assumption that heads of households who believe that they have the responsibility to protect the soil quality are likely to perceive the soil erosion problem, see the need to control soil erosion (use improved soil conservation technologies) and form favourable attitude towards investment in effective soil conservation technologies. The variable BENTUDE is coded " 1" for households who accept future benefits and a " 0" for those who do not. This is a proxy for household's willingness to invest in improved soil conservation technologies despite benefits not being realized within a short period. This variable is hypothesized to have no influence on the perception of the soil erosion problem, but have a positive influence on both adoption of improved soil conservation technologies and effort devoted to soil conservation. It is expected that households with a positive attitude towards future benefits are likely to use improved soil conservation measures and put more effort into soil conservation than households with a negative attitude towards future benefits. The inclusion of a variable for household's social status (SOST) in this study was intended to capture the household's level of interactions and social links within the society. The indicator used for this variable was the number of formal and informal obligations such as leadership the head of household had in the society. It is assumed that heads of household with a lot of leadership obligations in the society possesses a higher social status and hence some distinctiveness. This gives them more opportunities than others to interact with development agents, such as soil conservation programmes, extension agents and people in other villages/areas. Therefore, heads of households with a higher social status are likely to have more access to reliable information on soil conservation, hence a better knowledge about soil erosion and conservation than others. The knowledge together with the aspiration to maintain their distinctiveness, heads of households with a higher social status tend to be innovators compared with heads of households with a lower social status. It is therefore hypothesized that the number of social obligations will be positively related to perception, adoption and effort.

Perception of the soil erosion problem is also an independent variable in both adoption and effort models. This is intended to capture the sequential decision-making process on adoption of soil conservation technologies. It is presumed that household's perception of the soil erosion problem will in turn determine adoption of improved soil conservation technologies and effort devoted to soil conservation. A positive influence of perception of the soil erosion problem on both adoption of soil conservation technologies and level of investment is hypothesized.

The variable INCOME refers to the level of household's annual net farm income. This is the income obtained from crops and livestock sales less variable costs. A positive relationship is expected between the level of farm income and adoption as well as the level of conservation investment (effort). The variable RISK was measured using the individual's choice between two investments: one which has a higher chance of success but is less profitable and another with a lower chance of success but more profitable. The responses were coded "1" for households who chose the second investment (risk neutral) and "0" for households who chose the first investment (risk averse). A positive direction of influence is hypothesized for adoption and effort variables. Compared with a risk-averse household, we expect that a risk-neutral head of household is likely to adopt improved soil conservation measures and devote a higher level of resources to soil conservation. The variable OFINC represents income earned from non-farm activities, mainly off-farm employment and businesses such as small shops, known as *duka*. The direction of influence for this variable on adoption and effort is indeterminate. We expect a positive influence on the assumption that off-farm income would increase household's ability to use hired labour for conservation activities. A negative influence is also possible. Since farming may not be their main or priority income earning activity, off-farm income earners are likely to decide not to invest their financial resources in soil conservation. In other words, households with off-farm income are likely to be less concerned about farming profits since they do not make their total living from the land. Also, such households are likely to face labour shortage due to competition between farming and off-farm activities, reducing their ability to install physical soil conservation structures.

The variable participation in soil conservation programmes (CONPROG) indicates whether or not the head of household participated in promotional activities provided by soil conservation programmes (SECAP/TFAP and TIP). These include educational and awareness enhancing activities such as training on soil conservation measures, video shows, village tours, farmers' field days and support services such as cost-sharing, input subsidies and technical assistance. Participation in these activities depend on whether or not the village where the head of household resides is under SWC programmes and on household's access to the promotional activities and support services. Accessibility refers to whether the household in a village with SWC programme is nominated or had an opportunity to participate in the conservation activities/events. In most cases nomination of heads of households to participate in soil conservation promotional activities or events such as training and village tours is based on various criteria such as position in village (e.g., village leader), member of village land use planning committee, using soil conservation measures and others. A "1" was assigned to heads of households participated in at least one of the programmes' activities and/or received soil conservation support. It is hypothesized that, heads of household who participated in SWC promotional or awareness enhancing activities and/or received support from the programmes are likely to perceive the soil erosion problem, adopt improved soil conservation measures and devote more effort into soil conservation.

The variable DIST is included as an indicator for the difference in number of years the SWC programmes have been operating in the two districts. This is a proxy for level of exposure to and experience in improved soil conservation activities. A code "0" is assigned to households located in the north Pare mountains and a "1" to those located in the west Usambara mountains.

A positive direction of influence is hypothesized for perception, adoption and effort. This is because, due to a longer exposure to soil conservation activities, households located in the west Usambara mountains are more likely to perceive the soil erosion problem and adopt improved soil conservation measures than households in the north Pare mountains (Mwanga district). Adopters of improved soil conservation technologies in the west Usambara mountains are also expected to make higher investments in soil conservation than those in the north Pare mountains, for the same reason.

7.3 Model results and interpretations

The Maximum Likelihood Method (MLE) was used to estimate the specifications for the three models (perception of the soil erosion problem, adoption of improved soil conservation technologies and the effort or level of investment in conservation). To avoid the problem of multicollinearity, the backward stepwise procedure was used to select variables to be included in the models. In addition to stepwise selection, theoretical relevance was used to determine the inclusion and exclusion of variables in the models.

Since only a sub-sample of adopters was used to estimate the effort model, Mill's ratio (λ) for sample selection was included in the model as an additional regressor to correct for sample selection bias. This ratio was estimated from the parameters of the logit model for adoption (i.e., the model that determines sample selection)[31]. That is, the estimates from the adoption model were used to estimate λ for each observation selected for Poisson regression model for effort.

After the models were estimated they were examined for adequacy in terms of how the model fits the data. The estimated models were assessed for goodness-of-fit. The chi-square statistics (χ^2) was used to test the null hypothesis that the regressors simultaneously have no impact on the probability of the dependent variable. In addition to chi-square, the perception and adoption models were assessed using classification tables. The table is provided by LIMDEP to indicate how well the model classifies the sample cases into observed categories (perception and adoption categories). The predicted and observed outcomes are compared and the number of cases that are correctly and incorrectly classified are determined[32].

The variables in the models were also examined based on their sign and statistical significance of their effect on the dependent variables. The statistical significance was based on test results of the null hypothesis that the effect of an individual explanatory variable on the dependent variable is not different from zero, using t-statistics.

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[31]Only observations with adoption = 1 were selected for model estimation, i.e., 162 cases (adopters).

[32]For example, in the case of adoption model, the comparison is based on whether or not the estimated probability that the household used improved SWC is greater or less than 0.5. If the probability of a particular household is more than 0.5 he is classified as adopter of improved SWC technologies.

7.3 1 Sample characteristics

As mentioned earlier, the study sample consisted 300 heads of households drawn from 15 villages in the two study areas. Table 7.2 and 7.3 present a summary of sample characteristics for variables hypothesized as determinants of household's perception of the soil erosion problem, adoption of improved soil conservation technologies and effort devoted to soil conservation. The sample had 162 (54%) adopters and 138 (46%) non-adopters with an average age of about 52 and 54 years respectively (Table 7.2). Also, out of the 300 heads of households, about 68% perceived the soil erosion problem while 32% did not (Table 7.3).

It is indicated that among adopters 63% were male heads of households and 37% were females. The female-headed households included two categories of women: single women (unmarried, divorcees and widows) and married women, whose husbands worked and lived in towns. For those households who were using improved soil conservation technologies (Adopters), 57% perceived the soil erosion problem, while among the non-adopters only 39% perceived the soil erosion problem. Most of the non-adopters and those who did not perceive the soil erosion problem were in low social status category.

On average, adopters of soil conservation appeared to have more family labour and higher income than non-adopters. Compared with non-adopters the majority of adopters participated in promotional activities/services organized by soil conservation programmes operating in the study area and most of them were members of labour-sharing groups. Also, it is evident that most adopters of soil conservation technologies had contact with extension compared with non-adopters. In addition, adopters had on average more annual extension visits than non-adopters. This implies that adopters had more access to technical information and conservation related support services available in the study area than non-adopters.

Those heads of households who perceived the soil erosion problem had on average relatively higher education level than those who did not perceive the problem. There was a fair distribution of households who perceived the soil erosion problem between the west Usambara and the north Pare mountains (51.7% and 48.3% respectively). On the other hand, the west Usambara mountains had a larger proportion of households who did not perceive the soil erosion problem (77%). Majority of heads of households (57%) who perceived the soil erosion problem indicated that soil erosion was their priority problem in agricultural production, while only 42% of those who did not perceive the soil erosion problem, ranked soil erosion as a priority problem. Most heads of households who perceived the soil erosion problem and those who did not, felt that soil productivity of their plots located in the mountains was declining. More than 50% of heads of households who perceived the soil erosion problem participated in promotional conservation activities organized by SWC programmes such as video shows, village tours, seminars and others. In both groups the majority of heads of households have had contact with extension. On average, those heads of households who perceived the soil erosion problem had more information sources than households heads who did not perceive the soil erosion problem.

Table 7.2: Sample characteristics for adopters and non-adopters

Variable	Description	Adopters n = 162 (54%)	Non-adopters n = 138 (46%)
Hh characteristics:			
AGE	Average age of head of household	52.31	53.76
EDUC	Education (av.school yrs) (%)	4.25	3.54
HSEX	Gender of head of households		
Male	% Male	63.0	58.0
Female	% Female	37.0	42.0
ETHN	Ethnic group (% immigrant)	18.0	14.5
WEALTH	Wealth category of hh (%):		
High	Proportion in high category	20.0	16.0
Average	Proportion in average category	41.0	40.0
Low	Proportion in low category	40.0	44.0
MAST	Marital status of head of hh.		
Single	% Single	12.3	18.1
Married	% Married	87.6	81.8
FSIZE	Average family size	5.91	5.19
Economic factors:			
INCOME	Annual average income ('000Tsh)	206.2	162.4
LABOR	Average family labour	3.95	3.43
RISK	Risk averse (%)	85.0	83.0
FASZ	Average farm size (acres)	5.64	4.42
OFINC	Has Off-farm income (%)	72.2	25.0
TENURE	Owns all land (%)	87.7	87.7
REMIT	Receives remittances (%)	59.9	25.0
CASHCRO	Cultivates cash crop (%)	84.0	66.0
EFFORT	Average physical cons. measures	1.50	0.00
Sociological factors:			
BENTUDE	Prefers future benefit (%)	35.0	9.00
CONTUDE	Positive conservation attitude (%)	95.0	93.0
EROKNO	Hh knows has soil erosion (%)	86.0	76.0
ERORANK	Soil erosion priority problem (%)	59.0	43.5
PRODTRE	Soil productivity is declining (%)	72.8	82.6
PERCEPRO	Perceives soil erosion problem (%)	57.0	39.0
SOST	Social status (%)		
High	Proportion with high status	23.5	10.1
Average	Proportion with average status	32.7	16.7
Low	Proportion with low status	43.8	73.2
Institutional factors			
EXCON	Has contact with extension (%)	67.3	50.0
EXVIST	Average # of extension visits	15.4	8.00
CONPROG	Participate in SWC prog. (%)	70.4	23.9
LABSHA	In labour-sharing groups (%)	50.0	3.9
INFSO	Average # of information sources		
Physical factors:			
EROPOT	High soil erosion potential (%)	27.0	12.0

Table 7.3: Sample characteristics for perception of soil erosion problem

Variable	Description	Perception n=203 (67.7%)	No perception n=97 (32%)
Hh characteristics:			
AGE	Average age of head of household	53.04	53.04
EDUC	Education (Average school years)	4.13	3.49
HSEX	Sex of head of household		
Male	% Male	60.6	60.8
Female	% Female	39.4	39.2
MAST	Marital status of head of household		
Single	% Single	18.2	8.2
Married	% Married	81.8	91.7
Sociological:			
CONTUDE	Positive conservation attitude (%)	94.5	93.7
ERORANK	Soil erosion s priority problem (%)	56.7	42.3
PRODTRE	Soil productivity is declining (%)	74.9	82.5
SOST	Social Status (%)		
High	Proportion in high status	18.7	14.4
Average	Proportion in av. status	25.6	24.7
Low	Proportion in low status	55.7	60.8
Institutional:			
CONPROG	Participate in SWC progr. (%)	57.8	32.4
EXCON	Has contact with extension (%)	59.1	59.8
INFSO	Average # of information sources	3.58	2.30
DIST	District (%)		
North Pare	Proportion in the north Pare	48.3	22.7
West Usambara	Proportion in the west Usambara	51.7	77.3
Physical:			
EROPOT	High soil erosion potential (%)	17.8	21.6

Table 7.4 presents the sample distribution of the three categories of types of soil conservation technologies used at the two mountain ranges: physical, semi-physical and biological measures. On average, households in the west Usambara mountains used more semi-physical measures and biological measures. The difference in average number of physical measures used in the two mountain areas is relatively smaller. The difference in the total number of measures for the three categories between the two areas may be attributed to the difference in number of households in the study sample.

TABLE 7.4: Types of soil conservation measures used in study area

Types of SWC measures	Usambara mountains (Lushoto district)			North Pare mountains (Mwanga district)		
	Mean	Standard deviation	Total	Mean	Standard deviation	Total
Physical	1.77	0.84	165 (93)	1.90	1.00	120 (63)
Semi-physical	2.56	1.28	340 (133)	2.47	0.99	158 (64)
Biological	3.78	1.93	548 (145)	2.10	1.19	132 (63)

Note: 1) Figures in bracket show total number of households using the respective type of technology in the area.
2) Total refers to the total number of respective type of technology in the whole area.

7.3.2 Factors influencing the perception of the soil erosion problem in the northeastern mountains

The variables representing households' characteristics, socio-economic, institutional and physical factors presented in Table 7.1 were used for estimating the binomial logit model for perception of the soil erosion problem. The model estimates for perception are presented in Table 7.5.

Variables entered the perception model are sex of the head of household (HSEX), household participation in activities of soil conservation programmes (CONPROG), marital status of the head of household (MAST) and district or mountain area the household resides (DIST) which, as indicated earlier, represent the level of exposure to or experience in improved soil conservation activities. The coefficient for sex of head of household (HSEX), has as expected a positive sign, indicating that the probability of perceiving the soil erosion problem is higher for male-headed households than female-headed households. The reason behind this is probably due the difference in accessibility to the main information sources: extension services and SWC support programmes, which are often directed to male-headed households. The results show that sex of head of household (HSEX) increases the probability of perception of the soil erosion problem by about 10%. Similarly, the coefficient for household's participation in awareness enhancing activities organized by soil conservation programmes (CONPROG) as hypothesized, has a positive influence on the likelihood of perceiving the soil erosion problem. This imply that households who participated in various activities organized by SWC programmes

Table 7.5: Binomial logit model results for perception of the soil erosion problem in the northeastern mountains

Variables (X_i)	Estimated coefficient (β)	Marginal effect (δ)	Standard error (SE)	P[|Z|=z] (Significance)
Variables in the model				
HSEX	0.4125	0.0976	0.0616	0.15479
CONPROG	0.3294	0.0670	0.0562	0.21361
MAST	-0.8366	-0.1777*	0.0966	0.04596
DIST	-1.1940	-0.2536**	0.0615	0.00004
Constant	1.8343	0.3896	0.0828	0.00000
Log likelihood:			-176.47	
Model chi-square:			24.68	0.00005
Correct predictions (%):				
Perceive erosion problem (n=96):			77.88	
Do not perceive erosion problem (n=201):			64.37	
Overall (N= 297):			86.34	

**: Significant at 0.01 level ($P \leq 0.01$)
*: Significant at 0.05 level ($P \leq 0.05$)

such as village-level conservation planning, video shows, study tours etc. are expected to have more interest in learning and understanding the nature and occurrence of the soil erosion problem. The results indicate that household participation in activities of SWC programmes increases the probability of perceiving the soil erosion problem by 7%. Marital status of the head of household (MAST) and the district the household resides (DIST) have a negative influence on the probability of the household to perceive the soil erosion problem. As expected, compared with married heads of household, single heads of household are less likely to perceive the soil erosion problem. Again, this may be attributed to unequal access to technical information from extension and SWC programmes. The results show that marital status decreases the perception of the soil erosion problem by about 18%. The negative sign for district indicates that as we move from the north Pare mountains to the west Usambara mountains the probability of perception of the soil erosion problem among households declines. As we move from the north Pare to the west Usambara mountains the probability for the heads of households to perceive the soil erosion problem declines by 25%. This is contrary to what was expected. Given the fact that farm households in the west Usambara mountains have had longer interactions with SWC programmes, one would expect a higher probability of perception of the soil erosion problem.

Among the model variables only location of the household (DIST) and marital status of head of household have significant marginal effects at 0.01 and 0.05 levels respectively. Sex of head of household (HSEX) and participation in activities of SWC programmes (CONPROG) are not significant at 0.10 level.

The model failed to include several variables, expected to have influence on the perception of the soil erosion problem. This includes age of the household (AGE), social status (SOST), education level (EDUC), erosion potential (EROPOT), perception of production trend (PRODTRE), and intensity of extension visits (EXVIST). This could be attributed to measurement problems for perception to be discussed later. Although the model failed to include these regressors, its goodness of fit is fairly acceptable. The model has a very significant chi-square and high percentage of correct predictions. The model correctly classified about 78% of farm households, who actually perceive the soil erosion problem and 64% of those who do not. Overall, 86% of farm households were correctly classified into their actual perception categories.

7.3.3 Factors determining adoption of improved soil conservation technologies in the northeastern mountains:

Estimation of the adoption model included different explanatory variables (regressors) presented in Table 7.1. Again, the Maximum Likelihood Method was used for estimating the variable coefficients and marginal effects of regressors on the probability of adoption of improved soil conservation technologies. The results of the binomial logit model for adoption are presented in Table 7.6. Variables in the model include whether or not a household cultivates cash crop (CASHCRO), participates in activities of SWC programmes (CONPROG), whether or not a household knows that soil erosion exists in at least one of his plots (EROKNO), the way a household ranks the soil erosion problem (ERORANK), farm size (FASZ), participation in labour-sharing groups (LABSHA) and off-farm income (OFINC). All variables included in the model possesses the hypothesized direction of influence on the probability for farm household to use improved soil conservation technologies. Except off-farm income (OFINC) all variables have a positive influence on the probability that farm household adopts improved soil conservation measures.

Households with cash crops (coffee and tea) are more likely to adopt improved soil conservation measures than households who do not grow at least one cash crop. The results show that, as we move from not growing cash crop to growing, the probability for a household to adopt

Table 7.6: Binomial logit model results for adoption of improved soil conservation technologies in the northeastern mountains

Variables (X_i)	Estimated coefficient (β)	Marginal effect (δ)	Standard error (SE)	P[|Z|=z] (Significance)
Variables in the model				
CASHCRO	0.8047	0.1984**	0.08214	0.01573
CONPROG	1.8032	0.4445**	0.07058	0.00000
EROKNO	0.5939	0.1464	0.09016	0.10435
ERORANK	0.7535	0.1858**	0.07040	0.00832
FASZ	0.0959	0.0236*	0.01121	0.03410
LABSHA	0.4890	0.1077 *	0.02018	0.04532
OFINC	-0.5249	-0.1294	0.08110	0.11451
Constant	-2.8022	-0.6908	0.12727	0.00000
Log likelihood:			-158.24	
Model chi-square:			97.49	0.00000
Correct prediction (%):				
Adopters (n=162):			72.84	
Non-adopters (n=136):			69.12	
Overall:			71.14	

**: Significant at 0.01 level (P≤ 0.01)
*: Significant at 0.05 level (P≤ 0.05)

improved soil conservation measures increases by about 20%. Households who cultivate cash crops are assumed to have a higher farm income, therefore have more financial ability to invest in soil conservation. Participation in various promotional activities of SWC programmes (CONPROG) increases the probability for the household to use improved soil conservation measures. This is because participating in SECAP/TFAP or TIP activities such as training, village tours, soil conservation planning committee, water user groups, etc. increases household's access to technical information and support services, hence ability and willingness to adopt improved conservation measures. The results indicate that participation of households in promotional activities of SWC programmes (CONPROG) increases the probability to use improved soil conservation measures by about 44%.

Knowledge about the existence of soil erosion in household's plots (EROKNO) is also an important determinant of adoption of improved soil erosion control measures. Those farm households who know that they have soil erosion problem in at least one of their fields located on slopes have a higher chance of adopting improved soil conservation measures. This indicates that awareness about the existence of the soil erosion problem influences household's concern about the problem, hence willingness to use improved soil erosion control measures. Also, farm households who rank soil erosion as one of their priority problem (ERORANK) are more likely to use improved soil conservation measures in their plots located on the slopes. That is, households who see soil erosion as a problem of major concern are willing to use improved soil conservation measures to reduce the adverse impacts of soil erosion on soil productivity. The results indicate that knowledge about the existence of soil erosion and ranking of soil erosion as a priority problem increases the probability that the farm household will use improved soil conservation measures by about 15% and 18% respectively.

The results indicate that the larger the farm size, the more likely the farm household is able and willing to use improved soil conservation techniques to reduce soil erosion in plots located on the slopes. This is because farm income may be higher for households with a large farm size. Higher farm income increases their ability to use improved soil conservation measures. The results show that farm size (FASZ) increases the likelihood of adopting improved soil conservation measures by only 2%. This is a rather small effect and could be due to relatively small sizes and low variability in farm size among the households in the sample. Labour-sharing groups *(kiwili/ vikwa)*, LABSHA, play a role in determining adoption of improved soil conservation measures. Households who are members of labour-sharing groups are more likely to adopt improved soil conservation measures than those who are not. This is because they have a higher resource ability (labour) for establishment of labour-intensive improved soil conservation measures. Joining *kiwili/vikwa* labour groups increases the probability of using improved soil conservation measures by 11%.

The results reveal that off-farm income (OFINC) has a negative effect on the use of improved soil conservation measures. That is, households with other sources of income such as permanent or seasonal employment and small businesses and trading such as small shops *(duka)* are less likely to use improved soil conservation measures. As mentioned earlier, this may be due to labour competition between farming and off-farm activities, which reduces their ability to establish labour-intensive improved soil conservation measures, or they are unwilling to use improved soil conservation measures because farming is not their priority income earning activity. It is indicated that OFINC decreases the probability of using improved soil conservation measures by 13%.

The variables CONPROG, CASHCRO and ERORANK have the most significant effects on adoption of improved soil conservation measures. These variables are significant at 0.01 level. Households participation in promotional activities organized by soil conservation programmes (CONPROG) is the strongest determinant of adoption of improved soil conservation measures. This variable has the highest and most significant effect on adoption of improved soil conservation measures. This is followed by cultivating cash crop (CASHCRO) and farm household ranking of the soil erosion problem (ERORANK), which also have very significant effects on the adoption of improved soil conservation measures. The variables FASZ and LABSHA are significant at 0.05 level. Household's awareness of the soil erosion problem in his plots (EROKNO) and off-farm income (OFINC) have the least significant effects on adoption of improved soil conservation measures. These variables are significant at approximately 0.10 level.

Surprisingly, family labour (LABOR) has no effect on adoption of improved soil conservation measures. Given that most of the improved soil conservation measures are labour- intensive we expected that households with a higher level of family labour would be more able to meet the high labour demand needed for construction of soil conservation structures than households with lower levels of family labour. The results indicate that family labour does not influence the decision to establish improved soil conservation structures, hence is not a binding constraint. This implies that the main source of labour required for construction or establishment of improved soil conservation structures is labour groups. Family labour may be important for routine maintenance of the improved conservation structures.

The model has a reasonable goodness of fit with very significant chi-square. About 73% of adopters and 69% non-adopters were correctly classified. Overall, the model classified 71% of sample cases correctly.

7.3.4 Factors determining efforts devoted to soil conservation in the northeastern mountains

The effort model was estimated based on a sub-sample of adopters (162 households). As mentioned earlier, the Poisson regression procedure with correction for sample selection bias was used to determine factors influencing effort devoted to soil conservation. Number of physical measures was used as a proxy for the level of investment in soil conservation technologies (effort). The effort model results are presented in Table 7.7. Different factors influence the effort devoted to soil conservation among adopters.

The number of physical measures the household is capable of constructing increases with household's ranking of the soil erosion problem (ERORANK), level of extension visits (EXVIST), education level of head of household (EDUC), participation in activities of soil conservation programmes (CONPROG), family labour (LABOR) and participation in labour-sharing groups (LABSHA). On the other hand, like for adoption of improved soil conservation measures, the number of physical soil conservation measures among adopters decreases as we move from the north Pare mountains to the west Usambara mountains (DIST). Also, adopters with off-farm income (OFINC) have a lower level of investment in soil conservation measures than those without off-farm income.

The results show that households who consider soil erosion a priority problem in agricultural production (ERORANK) use 28% more physical soil conservation measures than households who do not. This is because those households who feel that soil erosion is a major problem in agricultural production are expected to devote more effort to reducing soil erosion. As mentioned earlier, adopters with a higher education level are likely to have more knowledge about the soil erosion problem. This leads to more commitment to soil conservation activities.

Table 7.7: Effort model of improved soil conservation for adopters

Variables (X_i)	Estimated coefficient (β_i)	Marginal effect (δ_i)	Standard error (SE)	Significance
---------- Variables in the model ----------				
ERORANK	0.3374	0.2815**	0.1066	0.0083
DIST	-0.2366	-0.1974	0.1442	0.1711
EXVIST	0.0044	0.0037	0.0021	0.0893
EDUC	0.3424	0.2857	0.2432	0.1502
CONPROG	0.5412	0.4516**	0.1264	0.0004
LABOR	0.1029	0.0916**	0.0287	0.0028
LABSHA	0.1860	0.1552	0.1286	0.1873
OFINC	-0.2927	-0.2442*	0.1239	0.0488
Constant	1.3830	0.0319	0.0442	0.0607
Lambda	0.0354	0.0732	2.7612	0.9788
Model chi-square		73.03		0.0000
Adjusted R-square		0.17		

**: Significant at 0.01 level ($P \leq 0.01$)
*: Significant at 0.05 level ($P \leq 0.05$)

The results show that the education level of heads of households (EDUC) who use improved soil conservation technologies increases the number of physical measures used by 28%. The number of extension visits (EXVIST) has very minimal effects on the number of physical measures used. For each extra extension visit the number of physical measures among adopters increases by only 0.4%. This could be attributed to low variability in the number of extension visits among adopters. Like in the case of adoption, households who have participated in activities of SWC programmes (CONPROG) tend to install more physical soil conservation than non-participants. Participation of household in SWC promotional activities increases soil conservation effort by 45%.

Given the fact that physical soil conservation measures are labour-intensive, a higher level of family labour increases the ability of adopters to invest in physical soil conservation measures. Model results indicate that one extra adult equivalent (LABOR) in a household increases the number of physical measures by 9%. The labour-sharing groups (LABSHA) like in the case of adoption also influences efforts adopters put into soil conservation. Adopters who are members of *kiwili/vikwa* labour sharing groups have more labour capacity, hence a higher level of investment in soil conservation. Adopters participating in labour sharing groups have 15% more physical measures than non-members. Off-farm income (OFINC) has a negative impact on number of physical measures used. Adopters with off-farm income have 24% less physical soil conservation measures than those without off-farm income. This indicates that those adopters of soil conservation measures with additional sources of income tend to invest less in soil conservation. As explained earlier, this may be due to competition for resources especially labour between off-farm activities and farm work. Also, Compared to the north Pare mountains the level of conservation effort in Usambara mountains is less by 19%.

Household ranking of soil erosion problem (ERORANK), participation in soil conservation activities and support services (CONPROG) and family labour (LABOR) have the most significant effects on the level of conservation efforts. These variables are significant at 0.01 level. Off-farm income (OFINC) also is an important determinant of the level of effort devoted to conservation activities among adopters (significant at 0.05 level). Other variables, though some of them have substantial positive effects on adopter's conservation effort they are not as significant. The effects of location of adopter (DIST), extension visits (EXVIST), education level (EDUC) and labour-sharing groups (LABSHA) are not significant at 0.05 level.

Despite that the model's goodness of fit being poor (low adjusted R-square), the model chi-square is highly significant indicating that all variables included in the model are jointly different from zero. This confirms that there is a relationship between the dependent variable and explanatory variables included in the model.

7.4 Summary

In this chapter factors determining perception of the soil erosion problem, adoption of improved soil conservation technologies and effort devoted to conservation activities have been identified, examined and results discussed. The binomial logit models were applied to identify the socio-economic determinants of perception of the soil erosion problem and adoption of improved soil conservation technologies in the study area. The Poisson regression model, accounting for sample selection bias was used to determine factors influencing soil conservation effort among adopters of improved soil conservation technologies.

The results of descriptive statistics have been presented to indicate the sample distribution between the adoption and perception categories of households with respect to the explanatory variables included in the model. Also, the distribution of different types of soil conservation measures used in the study area has been presented. The results indicate that the sample contained 54% adopters and 68% households who perceive soil erosion problem. Furthermore, the results show that about 57% of adopters perceive the soil erosion problem.

The logistic estimation for perception of the soil erosion problem shows that only the mountain area where the household is located, the proxy for level of exposure to improved soil conservation technologies and household's marital status have a significant effect on the perception of the soil erosion problem. The probability that a household perceives the soil erosion problem declines as we move towards the west Usambara mountains. The probability of perception of the soil erosion problem is lower for single heads of households compared with married households. The sex of heads of households and participation in soil conservation programmes also influence perception of the soil erosion problem, but their effects have not been identified to be very significant. The results indicate that, the likelihood of perceiving the soil erosion problem is higher for male heads of households than female heads of households. Also, participation in activities provided by SWC programmes such as conservation meetings, seminars and other educational activities, cost-sharing plans and other support services increases the probability of perception of the soil erosion problem among the heads of households.

A number of variables hypothesized to have influence on perception of the soil erosion problem did not enter the model. These include household characteristics such as age of household and household's education level; sociological variables such as social status and perception of production trend in plots located on the slopes; institutional variables such as extension visits and information sources and physical factors such as erosion potential.

The adoption model shows that cash crop cultivation, participation in various soil conservation promotional activities and labour-sharing groups, household ranking of the soil erosion problem and farm size have the most significant effects on household's decisions to use improved soil conservation technologies. Other determinants of adoption of improved soil conservation technologies are knowledge about erosion and off-farm income. However, the effect of these variables on adoption of improved soil conservation technologies is not significant.

The model excludes a number of variables hypothesized to influence adoption of improved soil conservation technologies. None of the hypothesized household characteristic variables entered the model. Age and education level of the heads of households which seem to be key determinants of adoption of soil conservation practices elsewhere do not feature in the case of the northeastern mountains. Also, economic factors such as family labour, income and risk; sociological factors such as social status and perception of the soil erosion problem; institutional factors like extension visits and physical factors such as erosion potential and district are not important factors for explaining household behaviour towards adoption of improved soil conservation technologies in the northeastern mountains.

It is interesting to note that in the study area, whether or not head of household perceives the soil erosion problem does not always determine his adoption decision. As postulated in our decision-making model, heads of household who perceive the soil erosion problem may decide not to use improved soil conservation measures due to situational constraints such as inadequate resources and lack of technical information, which reduces their *ability* to use improved soil conservation measures or because he is *unwilling* and hence does not accept the idea of using improved soil conservation technologies, despite the fact that he perceives the problem. Also, contrary to our decision model postulated for this study, there are heads of households who decide to use soil conservation measures even though they do not perceive the soil erosion problem. That is, there are heads of household who do not perceive the soil erosion problem, but are *willing* and *able* to use improved soil conservation measures. Therefore, our results confirm our hypothesis that in practice, perception of the soil erosion problem by heads of households does not guarantee the use of improved soil conservation measures and at the same time demonstrate that non-perception of the soil erosion problem in the study area does not always translates to household being unwilling and/or unable to use improved soil conservation measures. This is because of the influence of promotional activities and support services provided by soil conservation programmes, which interferes with the hypothesized household adoption behaviour. Promotional support services from SECAP/TFAP and TIP programmes in the study area intervenes between the household's attitude towards the soil erosion problem and his adoption behaviour, making the adoption decision for soil conservation inconsistent with his attitude towards the soil erosion problem. For example, the head of household may decide to install improved soil conservation structures in his fields, not because he perceives the need for soil erosion control, but because he wants to receive the services and support provided by the SWC programmes. That is, the incentives to use improved soil conservation technologies may be rooted in the anticipated benefits from SWC programmes, such as subsidized inputs, free farm implements, cost-sharing plans and irrigation water from *ndiva* and not necessarily from a voluntary decision associated with perception of the soil erosion problem. Even though the subsidies and cost-sharing plans provided by the programmes are very small, their impact on households' decisions on using the improved soil conservation measures may be enormous.

The Poisson regression results of effort model reveal that among adopters of improved soil conservation measures in the northeastern mountains, the level of effort devoted to soil conservation activities is explained by the adopters' ranking of the soil erosion problem, participation in promotional activities organized by soil conservation programmes, family labour and off-farm income. These factors were found to have a significant effect on the number of physical measures the adopters have constructed in their fields. The area a household is located, number of extension visits, education level of head of household and participation in labour-sharing groups are less important determinants of soil erosion control efforts in the study area. Most of the heads of household's characteristics and physical factors such as erosion potential hypothesized as key determinants of household's conservation efforts did not enter the model. Also, like in the adoption model, most of the sociological factors including perception of soil the erosion problem do not influence soil conservation efforts among adopters. This indicates that in the northeastern mountains economic and institutional factors are key determinants of efforts adopters of improved soil conservation technologies devote to soil erosion control. As mentioned earlier, this is partly attributed to the influence of soil conservation programmes operating in the two study areas.

In general, the results show that participation in promotional activities of SWC programmes by heads of households in the northeastern mountains influences the adoption decision process in all three stages conceptualized for this study. Participation of heads of households in activities organized by SWC programmes influences perception of the soil erosion problem and plays a significant role in determining decision to adopt improved soil conservation measures and level of effort in terms of investment committed to soil conservation activities. The results also indicate that ranking of soil erosion as the priority problem in agricultural production, participation in labour-sharing groups and having off-farm income influence the *willingness and ability* to use improved soil conservation technologies (adoption stage) and the level of soil conservation effort (effort stage). Also, the mountain area where the head of household is located determines household's perception of the soil erosion problem and to a limited extent influences the level of effort devoted to soil conservation.

The findings do support our contention that different factors are responsible for determining households' perception of the soil erosion problem, adoption of improved soil conservation measures and level of investment in conservation among adopters in the northeastern mountains. However, the results refute the hypothesized sequential decision-making process that household's characteristics, socio-economic, institutional and physical factors determine household's perception of the soil erosion problem, and those perceptions in turn determine the adoption decisions and investment level for improved soil conservation technologies. As mentioned earlier, this inconsistence in adoption behaviour could be attributed to among other things, the incentives provided by SWC programmes to stimulate adoption. If the study was conducted in an area where adoption of soil conservation measures was "*incentive-free*" more reliable evidence would have been established.

CHAPTER 8

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This chapter presents a summary of the study together with the main conclusions and recommendations that emerged from the study. First we provide an outline of this study and the main conclusions from the empirical findings. Then we discuss the implications of the findings of the study to support services from government extension services and donor-funded SWC programmes operating in the northeastern mountains. Also, we highlight some limitations of this study and offer suggestions for further research.

8.2 Summary of the study

The aim of this study was to explain household adoption behaviour towards the use of improved soil conservation measures to reduce land degradation (soil erosion) and reverse declining soil productivity and to attain agricultural sustainability in the northeastern mountains of Tanzania, with reference to the north Pare and the west Usambara mountains. In addition, this study was intended to outline implications and recommendations for policy and institutional support for improving soil conservation in the study area. The assumption was that adoption of soil conservation measures and the level of investment in soil conservation by households were the means for achieving a sustainable production system in the northeastern mountains. In this context, the operational definition of sustainability together with a conceptual model were developed to indicate the interrelationships between the farm household's adoption decisions and sustainable use of soil conservation measures.

An interdisciplinary approach which incorporates both sociological and economic approaches for analysing households' decision behaviour was used for modelling household adoption of improved soil conservation measures. Therefore, various sociological and economic theories and models of the innovation adoption process were discussed indicating how economists and sociologists have used household decision theories to describe the adoption process. Also, a review of empirical studies on adoption of soil conservation measures was included to show different approaches and the scope of previous research on adoption of soil conservation. From this review an analytical framework and adoption decision model were developed for the study. Our analytical framework is based on Ervin and Ervin's (1982) approach for analysing adoption of soil conservation practices. In our model three components of the adoption decision process are linked: the perception of the soil erosion problem, the decision to use improved soil conservation measures and the level of investment or effort devoted to soil conservation among adopters.

We postulated that perception of the soil erosion problem leads to adoption of effective soil conservation measures. Furthermore, we assumed that household's adoption decisions are determined by his *willingness* and *ability* to use improved soil conservation measures. Once the household adopts improved soil conservation measures, he decides on the level of investment or effort to commit to soil conservation. Those households who do not perceive the soil erosion problem are not expected to be willing to adopt soil conservation measures due to lack of interest in reducing soil erosion.

A study designed to address the objectives of the study was carried out in the west Usambara mountains (Lushoto district) and the north Pare mountains (Mwanga district) in 1995/1996. Data collection was divided into two phases. The first phase involved collection of general information about the study area (preliminary survey). This included: 1) review of secondary information from various publications and reports, and 2) informal discussions with key informants, individual heads of households and groups of heads of households. The second phase included farm-level data collection from a sample of heads of households. This was carried out by conducting interviews using a structured questionnaire. The interviews focused on households' characteristics, socio-economic aspects of the soil erosion problem, soil conservation measures used, beliefs and attitude towards soil erosion and conservation, participation in soil conservation support programmes and extension services and economic attributes such as income, farm size, labour, livestock herd size, and wealth rank.

Three empirical models: perception of the soil erosion problem, adoption of improved soil conservation and conservation effort models were developed for the study. These models incorporated several socio-economic, institutional and physical factors as independent variables. The empirical analysis was carried out using binomial logit models to estimate the effects of the independent variables on the probability of the heads of households to perceive the soil erosion problem and to adopt improved soil conservation measures. The Poisson regression model was used to identify the determinants of effort (level of investment) the household is willing to devote to soil conservation.

The results from this study indicate that in the study area different types of soil conservation measures are used to reduce soil erosion. Although the majority of households use biological techniques (agronomical practices) such as agroforestry and trash lines, physical and semi-physical measures are also common. There are also households who are not applying any soil conservation measure. Also, the results reveal that a large proportion of households perceive the soil erosion problem and more than half use improved soil conservation measures.

Personal characteristics of the heads of households (gender/sex and marital status), participation in activities of SWC programmes and the mountain area where the household is located were identified to be the determinants of perception of the soil erosion problem in the study area. Marital status and household location have a negative influence on perception of the soil erosion problem. The results show that the probability of perception of the soil erosion problem is lower among single heads of households. This could be due to difference in access to information and level of exposure between single and married heads of households. Also, perception of the soil erosion problem is lower among households in the west Usambara mountains than households residing in the north Pare mountains. Participation in promotional activities of SWC programmes and sex of heads of households have a positive influence on perception of the soil erosion problem. The participation in promotional activities of SWC programmes increases the level of exposure to the soil erosion problem, hence perception of the soil erosion problem. Also, the results indicate that the probability of perceiving the soil erosion problem is higher for male heads of households than for female heads of households.

The decision on whether or not to use improved soil conservation measures is determined by economic rank of the household indicated by whether he has cash crop or not and farm size. In addition to economic rank, participation in activities of SWC programmes and in labour-sharing groups (*kiwili/vikwa*) are among the most important incentives to using improved soil conservation measures in the study area. Ranking of the soil erosion problem also plays a major role in enhancing adoption of improved soil conservation technologies. The results also indicate that household's knowledge or recognition of soil erosion increases the likelihood of adoption of improved soil conservation measures. Furthermore, households with off-farm income are less likely to use improved soil conservation measures. Possible explanations are that off-farm income earning activities reduces the time available for farm work and that off-farm income earners may have little concern about land quality due to their orientation towards off-farm earnings.

It is evident from this study that socio-economic and institutional factors influence the level of investment households commit to soil conservation. Institutional support from SWC programmes especially educational activities such as village-level training, village tours, information from mass media and participation in conservation planning enhance the level of investment in soil conservation significantly. The level of family labour, off-farm income earnings and the way households rank the soil erosion problem are also strong determinants of the level of resources devoted to soil conservation among adopters. Other determinants of level of effort among adopters are level of extension visits, household's education level, participation in labour-sharing groups and area the household is located.

8.3 Major conclusions

From this study we observe that households' characteristics and institutional factors, especially promotional activities conducted by SWC programmes and the level of exposure of household to conservation activities are key determinants of households' perception of the soil erosion problem. The study also demonstrates that the decision to use improved soil conservation technologies and the level of investment in soil conservation (effort) are separate decisions. The two decisions, however, share some identical explanatory variables and are both influenced by sociological, economic and institutional factors. Despite of these commonalities we observe that economic and institutional factors plays more important role in determining the decision to use improved soil conservation while institutional factors are more important in determining the level of resources committed to soil conservation.

The empirical findings fail to support the general sequential decision process postulated for adoption of improved soil conservation technologies. The perception of the soil erosion problem is not a necessary condition for using effective soil and water conservation measures as anticipated. Neither does the perception of the soil erosion problem determines the level of conservation investments among adopters. The results confirm that not all heads of households who perceive the soil erosion problem decide in favour of improved soil conservation technologies. However, contrary to our model, not all households who do not perceive the soil erosion problem decide not to use improved SWC technologies. This is thought to be due to the influence of different promotional activities and support services offered by soil conservation programmes working in the area. These services motivate people to use improved soil conservation technologies despite of their negative attitude towards the occurrence of soil erosion and lack of understanding of the causes of soil erosion and the need for erosion control. The question that comes in mind is whether this kind of adoption is sustainable. On the one hand, the answer is "yes" as long as these incentives are made available for a time long enough for adopters who do not perceive the soil erosion problem to recognize the impact of soil loss on soil productivity and understand the role of soil conservation in reducing soil erosion and improving soil productivity. On the other hand, the answer is "no" if the anticipated incentives are withdrawn too early.

8.4 Implications and recommendations for improving soil conservation activities

This section presents the implications of the findings for policy and institutional support with respect to improving soil conservation activities in the northeastern mountains. Also, the limitations of the study are discussed and suggestions for further research are put forward.

8.4.1 Implications for policy and institutional support

From the empirical findings we learn that encouraging adoption through institutional support is necessary in the west Usambara and Pare mountains together with other areas in the northeastern mountains. Therefore, government resource commitment is required to strengthen, expand and support long-term soil conservation programmes in the area. This also includes support for soil conservation research and extension services to facilitate soil and water conservation technology generation and dissemination. To ensure sustainability of activities initiated with donor-funded assistance the government should institutionalize these efforts by incorporating these activities into the existing government-supported national agricultural extension and research system, and design strategies and mechanisms e.g., budgetary commitment to ensure continuity after support is ceased.

We note that institutional efforts are not successful if there is no thorough understanding of factors influencing decisions to use soil conservation measures and make long-term investments in soil conservation. Understanding these factors is necessary in identification of possible constraints to adoption and hence provides a guide for designing appropriate plans and strategies for accelerating adoption of effective soil conservation measures. In addition to this, knowledge about constraints to adoption of appropriate soil conservation measures could guide the development of appropriate technologies.

There are two important issues that we need to consider in relation to adoption of soil conservation measures: 1) what policy and additional institutional support are needed to encourage adoption of soil and water conservation in the west Usambara and north Pare mountains, and other areas in the northeastern mountains and 2) what other strategies and mechanisms should be designed to ensure sustainable use of soil and water conservation technologies in the study area.

To encourage adoption of improved soil conservation technologies the soil conservation policies and institutional support programmes should be focused on enhancing the ability and willingness of farm households to use improved soil and water conservation measures. From the empirical results we can divide households in the study area into different categories based on their adoption behaviour:

1) households who perceive the soil erosion problem, and are *willing* and *able* to use improved soil and water conservation measures.

2) households who perceive the soil erosion problem, and are *willing* but *unable* to use improved soil and water conservation measures.

3) households who perceive the soil erosion problem, and are *able* but *unwilling* to use improved soil conservation measures.

4) households who do not perceive the soil erosion problem, but are *willing and able* to use improved soil conservation measures.

5) households who do not perceive the soil erosion problem, are *willing* but *unable* to use improved soil conservation measures.

6) households who do not perceive the soil erosion problem, are *able* but *unwilling* to use improved soil consecration measures.

Among households who perceive the soil erosion problem and those who do not there are households who are *unwilling and unable* to adopt soil conservation measures.

For any household to adopt improved soil and water conservation technologies he has to be both able and willing. Therefore, adopters of soil conservation measures can be found in categories 1 and 4, while non-adopters are likely to be in the rest of categories.

The available financial, technical, and educational services are destined to fail if no effort is put into understanding different groups of households these services are intended for. In order to increase adoption of effective soil and water conservation measures in the study area, understanding why some households fail to adopt improved conservation technologies is crucial. For the SWC programmes to attain their aspired goals of reducing soil erosion and improve land productivity, deliberate effort should be devoted to: 1) identifying the existing categories of non-adopters with respect to their ability and willingness to use improved soil conservation practices 2) establishing the reasons why these households are unable or unwilling to adopt improved soil conservation measures and 3) designing suitable strategies that can be used to promote *willingness and ability* to use improved soil and water conservation measures for different categories, taking into consideration their attitude and behaviour towards the soil erosion problem. This process of trying to understand the complex reasons why different households are unable or unwilling to adopt improved soil conservation measures may consume a lot of time but is worth the effort. This approach is necessary for targeting the support services to different needs of various groups of households. This implies that household grouping will enable SWC programmes to provide specific types of support or assistance compatible with the needs of specific group of households. For example, willingness among non-adopters who are able but unwilling can be promoted through educational programmes such as mass media (video shows, radio and others), on-farm demonstrations and field days. Adoption obstacles for those lacking ability to use soil conservation technologies can be eased by strengthening and expanding cost-sharing plans, input subsidies, cooperative labour and increasing accessibility to technical information. The proportion of each category in the study area will determine the types of strategies and level of resources that should be used to promote adoption among different *unwilling and/or unable* categories. For households who are both *unwilling and unable* to adopt improved soil conservation measures, dual purpose strategies, designed to both persuade them and eliminate different constraints to their ability to invest in soil conservation technologies, are needed. Targeting of effort will not only ensure an accelerated rate of adoption but will also make the programmes more cost-effective.

The second issue mentioned above addresses the evidence drawn from this study that there are households who use improved soil and water conservation measures but do not perceive the soil erosion problem. Among other things, sustainable use of improved soil conservation measures depend on the extent to which the technology users understand and feel the need for controlling soil erosion. Therefore, those adopters who do not perceive the soil erosion problem, are likely to abandon these measures if the circumstances which triggered their adoption change. This implies that for successful implementation of soil and water conservation activities the institutions concerned need to realize that, in addition to farmers being able and willing to solve the soil erosion problem, they also need to be knowledgeable about the problem itself. The knowledge and understanding of the problem will ensure sustainable use of soil conservation measures adopted, hence the sustainability of the production system. In view of this, SWC programmes operating in the northeastern mountains should provide long-term support and incentives to adopters to ensure that adopters who do not perceive the soil erosion problem maintain the adopted conservation measures. This should go hand in hand with efforts to promote knowledge about the soil erosion problem through training, mass media and other methods. This will facilitate learning through time and sustainable implementation of soil conservation activities.

The major role of labour-sharing groups in promoting adoption and level of investment is apparent. Only few people are currently involved in the *kiwili/vikwa* labour-sharing groups. Therefore, SWC programmes need to encourage more people to participate in these groups. The current voluntary participation in labour groups exclude non-adopters of improved SWC due to their lack of awareness or interest in controlling soil erosion. Appropriate strategies are needed to encourage non-adopters to join labour groups. This could enhance their willingness and ability to use improved soil conservation measures.

Given the role of women in agriculture and the fact that female-headed households tend to be poor due to their limited control of resources especially land they should be encouraged to participate in activities of soil conservation programmes. This will improve their economic position and welfare.

8.4.2 Limitations of the study and implications for further research

Before we provide some suggestions for further research it is important to give some drawbacks or limitations of this research and how these should be dealt with in the future.

The estimations of perception of the soil erosion problem and household beliefs and attitudes towards soil erosion and conservation would have been better if adequate data had been available or alternative methods had been used to collect this information. More meaningful estimates of household perception would be established if information about the actual severity of soil erosion for each household on a specific plot was available. Household's perception could be determined by comparing household's belief about the severity of soil erosion in his fields and the actual erosion level. Although information on household's belief on the severity of soil erosion problem was collected, this information was not adequate and reliable for estimating perception. Also, given the sample size and the fact that farmers own several scattered plots, it was not possible to come up with an estimate of the actual level of soil erosion for each individual household. Therefore, attitude of heads households towards soil erosion and knowledge about the causes of soil erosion were used as indicators of perception of the soil erosion problem instead. Furthermore, households' beliefs and attitudes towards both the soil erosion problem and soil conservation were difficult to capture with the kind of methodology used in the study. Appropriate informal anthropological and sociological approaches would generate more reliable information on these aspects together with information on how households see the severity of the soil erosion problem in their own plots.

The total number of physical measures is used as an indicator of level of investment in improved soil conservation technologies (effort). It was not possible to gather reliable information on actual expenditure for different soil conservation measures. This is because most heads of households do not keep records of resources spent on different farming activities including soil conservation measures. The proportion of total land area under conservation would be an alternative measure to actual expenditure. This is because using number of physical measures does not indicate the extent of resources a household has invested in soil conservation in relation to his total land area. The head of household using only one practice for all his five acres is putting more effort into soil conservation than the one who is using five practices in only one third of his total land area (assuming same land size). Again, reliable land area under soil conservation measures could not be estimated due to small scattered plots owned by different households. Furthermore, due to data limitation, the indicator of effort used in this study (number of physical measures) does not take into consideration the practical/technical need for alternative measures.

The two areas used for this study are not that homogeneous in terms of soil conservation measures used. The two major SWC programmes operating in the two study areas (SECAP and TFAP) started at different times with different emphasis in terms of types of technologies. The SECAP has been active in the west Usambara mountains for a much longer period than TFAP in the north Pare mountains. Limiting our research to one mountain range could have reduced the level of variability attributed to differences in exposure to soil conservation activities among the sample households.

Furthermore, this study is based on only two mountain ranges of the northeastern mountains. This may limit the applicability of the results in other mountain ranges not included in the study. That is, we do not know to what extent the results obtained from the two mountain ranges are applicable in the Kilimanjaro and Meru mountains. Also, this study is based on cross-sectional data (static decision process), but we know that household's decision making on adoption is dynamic, influenced by changing socio-economic and institutional factors. Therefore, we cannot predict how stable the results are over time and thus we do not know how long the results obtained from this study will be valid.

This study focused on household's decision-making side of the soil degradation problem as the basis for assessing sustainability of the production system. It is assumed that understanding the extent to which soil conservation measures are adopted and factors determining farmer's adoption decisions will provide a guide for improving sustainability of the the production system. In this regard we suggest some research activities that would complement or extend this study.

First, for further understanding of household adoption behaviour a comprehensive analysis focusing on erosion damage is required. Research based on the actual level of soil erosion reduction among adopters will provide the basis for estimating future productivity of the production system and thus the actual level of sustainability. This kind of research will require a lot of physical and agronomic data such as soil properties, rainfall intensity, vegetation cover, steepness and length of slope and crop management strategies to allow the use of the USLE (Universal Soil Loss Equation) approach[33].

Second, as indicated earlier, there are different categories of households in the study area, based on their varied attitude and behaviour on the use of improved soil conservation measures. Research effort to identify these categories and their needs will help in targeting technical support and information required to promote adoption of soil conservation measures and allow for design of better strategies for dealing with the soil erosion problem in the northeastern mountains.

Third, research using dynamic optimization models that link farmer's dynamic decision behaviour with soil productivity in relation to soil conservation measures, resource and soil loss constraints and policy options would provide a more comprehensive assessment of the sustainability of the production system in the northeastern mountains. However, a lot of information is needed to be able to carry out this analysis.

Fourth, though the level of farm income did not feature as an important determinant of adoption of improved soil conservation measures and effort a household devotes to soil conservation, its influence is indirectly explained by the growing of cash crop and farm size. An interesting study stemming from this would be to assess adoption behaviour in relation to farm returns/income or economic profitability of soil conservation technologies. The Cost Benefit Analysis (CBA) approach focusing on different types of soil conservation measures could provide useful information for designing appropriate soil conservation measures. Traditional measures could be used as a reference for comparison.

Lastly, it would be interesting to conduct a detailed farm-level study to examine household's perception of the soil erosion problem. Appropriate sociological/anthropological approaches could be used to collect information on household's belief about the severity of soil erosion and identify the disparity between households' beliefs and actual severity. The results from this study could be used for guiding the development of this kind of research.

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[33]The USLE is described in chapter 4

Despite the limitations and weaknesses outlined above, the information generated from this study is useful in refining and guiding the development of policies, soil and water conservation support programmes and research and extension activities for the northeastern mountains.

APPENDIX I

INFORMAL SURVEY REPORT

1. INTRODUCTION

The informal survey was carried to collect general information about the study area. Four districts in the northeastern mountains were visited. These are Moshi in the Kilimanjaro mountains, Arumeru in the Meru mountains, Mwanga in the north Pare mountains and Lushoto district in the west Usambara mountains and Muheza (Amani) in the east Usambara mountains. The survey included collection of relevant secondary information related to land degradation, soil conservation and other aspects and discussions with farmers and key informants.

Field visits included eight villages in the Mwanga district (Vuchama-Ndambwe, Mamba, shighatini and Msangeni in Ugweno division, Vuagha and Chomvu in Usangi division and Ngujini and Kirongaya in Lembeni division); five villages in the Lushoto district (Shashui, Malindi, Lukozi, Kibaoni Longoi and Kwalei); one village in Muheza district, (Mlesa); six villages in Moshi (Marangu West, Tema, Rauia, Kondeni, Makuyuni Kiriche, Makuyuni Masaini) and three villages in the Arumeru district (Maroroni, Loita-Nkwamara and Sakila). Selection of these villages was based on the seriousness of the land degradation problem and the extent to which soil and water conservation techniques are used. It was also important to include villages participating in donor-funded soil conservation programmes and non-participating villages to capture variations. It was also interesting to have villages at various altitudes.

Informal discussions were held with individual farmers and farmer groups (e.g., village-level land use planning committees). Both men and women farmers were involved in the discussions. Additional information was gathered from village leaders, district and village extension agents and soil and water conservation programmes operative in the study area. The discussions focused on various socio-economic aspects, the soil erosion problem, use of soil conservation measures, attitude towards land degradation and soil conservation and institutional support services available.

This report summarizes the information collected from reports and various publications, discussions with farmers and key informants in the study area. This summary is focused on three representative areas, namely the Kilimanjaro mountains (Moshi district), the north Pare mountains (Mwanga district) and the west Usambara mountains (Lushoto district).

2. GENERAL INFORMATION ON THE STUDY AREA

2.1 Physical environment

The northeastern mountains comprise steep slopes located at high altitudes. The slopes of the Kilimanjaro mountains have an altitude ranging between 800m and to above 3000m. The highest point is found at the snow-capped Kibo peak of mountain Kilimanjaro which is at 5,895 metres above sea level. The north Pare mountains comprise steep dissected slopes, bordered by sharp escarpments. The Usambara mountain slopes are extensive highland plateaux, separated by steep slopes from the surrounding plains and they have altitudes ranging from 800m to more than 2200m (Land Resource Development Centre, 1987).

The soils of the Kilimanjaro slopes are volcanic, formed from lava erupted from the Kilimanjaro mountains. These soils are shallow, acidic and stony. They are classified as high-altitude ferruginous tropical soils (Anderson, 1982; Conyers, 1970). The topsoil colour varies from dark-brown to red-brown, and the subsoils are dark-red brown. In most parts soils are rich in potassium, calcium and magnesium. The soils in Usambara are deep, dark reddish brown clay loams. They are mainly humic ferralitic and feralsols of high altitude. (Conyers, 1970; Lundgren, 1978; SECAP, 1987). In the Pare mountains soils are deep, dark reddish-brown clay loams and dark-red loams, except on the steep hill tops.

In most parts of the three mountain ranges, soils are highly erodible, especially those at long-steep slopes (Kocher, 1976).

2.2 Population

The northeastern mountain slopes are among the most densely populated parts of Tanzania. Total population in the three mountain ranges is about 1,545,631 people (Tanga and Kilimanjaro 1988 Regional Census Profile). The Kilimanjaro mountain slopes have the highest population with an average population density of 148 people per km^2. Population in the zone between 1,000 - 1,800 metres above sea level are as high as 700 people per km^2 (Kilimanjaro 1988 census profile). Average population density in the west and east Usambara mountains is 102 people per km^2 and 48 people per km^2 respectively. In some areas of the west Usambaras population density reaches 200 person per km^2 (SECAP, 1987). Population in the north Pare mountains is estimated to be 150-200 people per km^2 in the highlands (TFAP, 1992).

In the three areas population varies with altitude and is unevenly distributed. Population density is directly related to agro-ecological potential and accessibility of the area. Most people live at high altitudes and cultivate land in the uplands as well as in the lowlands.

2.3 Settlement patterns

In the Kilimanjaro and Pare mountains people live at high elevations in villages consisting of scattered homesteads. Each homestead is surrounded by a banana/coffee field (homegarden). Unlike the Kilimanjaro and Pare slopes, people in the Usambara slopes live in villages consisting of clusters of homesteads with about 60-80 households. In each cluster of homesteads the fields run downhill from the homesteads.

3. SPECIFIC INFORMATION ON STUDY AREAS

3.1 Kilimanjaro mountains: Moshi district

Moshi district is one of the five districts of the Kilimanjaro region. The district is divided into four divisions: Vunjo East, Vunjo West, Hai East and Kibosho. The district covers the southern and western slopes of the Kilimanjaro mountains. The total area of the Moshi district is 1,529 km^2, but most of it is uninhabited or only sparsely inhabited (Kocher, 1976). The densely settled portion of the Moshi district is on the southern slopes of the Kilimanjaro mountain at elevations of 1,000 - 1850m. Higher elevations above (1,850 m) are not inhabited by people. The western slopes and the plains have a lower annual rainfall and are sparsely populated.

General information

Topography: Hilly, steep mountainous slopes dissected by narrow valley bottoms
Rainfall: 600 - 1600 mm, per annum, bimodal (October-December and March-April)
Temperature: 22.4-31.7°C
Average farm size: 0.5 - 3.5 ha
Population: 342,553
Population density: 750 persons/km^2
Population growth rate: 2.1%
Total area: 1,529 km^2,
Divisions: 4
Total villages: 148
Total households: 62,673
Average household size: 5.5
Available average workforce/household: 1.8
Ethnic groups: Wachaga
Soils: volcanic, high altitude ferrugirious tropical soils

3.1.1 Land use and cropping systems

The intensity and type of land use on the slopes of the Moshi district are mainly influenced by climate, altitude, socio-economic factors and population density. The slopes are intensively cultivated with arabica coffee, bananas and other shade trees, maize, beans and vegetables. Intercropping is a common farming practice in the area. Dairy cattle is an important enterprise. Cattle are permanently housed and fed on crop residues and pastures. The average farm size is less than 1 ha.

Three distinct cropping zones have been identified. The upland zone (1500m - 2200m) consists of a coffee-banana belt (homegarden) and stall-fed livestock. Other crops include cocoyams, fruit trees and vegetables. The midland zone (1000m - 1200m) consists of a bean maize-banana system. The lowland zone (700m - 800 m) has maize intercropped with beans, cassava, vegetables, rice, sunflower and finger millet (Nkonya,1990; ICRA,1992). Coffee and bananas are generally cultivated in all areas above 850m. Farmers in the uplands and midlands also own some land in the lowlands/plains. The slopes above 2200m are under forest reserve.

Coffee is the main cash crop in the area. Production of vegetable and flower seeds has become an important cash earning enterprise among smallholder in parts of the district.

3.1.2 Socio-economic aspects

Land tenure

People in the Kilimanjaro mountains have a very strong attachment to their land due to the existing land shortage. Land is considered a very important possession among Wachaga. There are two types of agricultural land: *kihamba* (homegarden) and *shamba* or *pori*. Kihamba is the traditional clan land located in the upland zone. The occupant of this land has permanent freehold rights through inheritance (father to son). This is the land where the occupant establishes his residence and grows permanent crops, mostly bananas and coffee. *Kihamba* land is usually small, due to continuous fragmentation among the household's sons. The average size is 0.4 to 1.0 ha.

Shamba land is located at lower slopes and is used for growing maize and beans. *Shamba* land used to be allocated to individuals by the chiefs on a yearly basis. Nowadays the ownership is obtained from government authorities through village committees. This is applicable only in the sparsely-populated lowlands.

Because of land shortage especially among young generations, land purchasing, borrowing and share-cropping are common in *shamba* land (ICRA, 1992). Some of the farmers interviewed indicated that their farm sizes have reached the point where they cannot be divided anymore. One farmer in Rauia village said:

> *"I have two boys who are still going to school. When they grow up the younger son will inherit this land but the other one will have to purchase land in the lowland or somewhere else. I cannot divide this small land (about 1.5 ha) anymore".*

Women do not inherit *kihamba* land. However, in some cases when they are not married or divorced, fathers or elder brothers may decide to allocate some land to their daughters/sisters. Widows are allowed to continue to use their husband's land and eventually pass it on to their sons.

Indigenous knowledge

In response to increased land scarcity, people at the Kilimanjaro mountain slopes adopted various resource management and land use strategies. These include furrow construction; soil conservation measures such as terracing, mulching and tree planting; diversification and intensification of agricultural production and intercropping (ICRA, 1992; Maimu,1993; Lema, 1993).

Furrow construction was an indigenous engineering skill, developed by people at the mountain slopes over many years. This is a technique of leading water from deep river valleys over long distances. Before tap water was introduced, furrow water was used for domestic purposes and to irrigating annual and perennial crops. The furrows were managed and controlled by "community users." People of one clan or several clans with a common interest formed a "community of water users". The head of this community was chosen and was responsible for organizing cleaning, repairing of furrows and distribution of water among the users.

Soil conservation measures have been aimed at reducing soil erosion and moisture retention. Farmers developed techniques such as contour ridges, trash lines, grass strips and minimum tillage techniques to reduce soil erosion. The terracing technique was also introduced by the British colonial government under the Land Usage Scheme. This technique was not readily accepted by the people, therefore spread very slowly. Tree planting (agroforestry) has been practised in the area for many years. In the homegardens and annual crop plots various tree species have been incorporated to provide shade for coffee trees, firewood, fruits and building materials.

Before land became scarce due to increased population, farmers also practised shifting cultivation and land fallowing to maintain soil fertility of their fields. With increasing pressure on land farmers started to use farm yard manure especially in the *kihamba* and fields located close to homesteads. Mulching is also used to retain soil moisture especially in the coffee-banana plots (homegardens). Crop rotation is sometimes used in shamba fields but intercropping is the most common practice used as a strategy for maintaining soil fertility to overcome land and labour shortages.

In one of the villages, farmers use various organic farming techniques. These include compost manure and pest and disease control techniques. *Mama* Helen Mcharo of Tema village explained that she was using cow urine to control cut-worm and aphids, solution made from pepper and washing soap bar to control various pests. Wood ash is also applied around the plants to control cut-worms and supply nutrients to the plant. Most farmers interviewed also have knowledge of crop varieties, soil types and quality.

Household structure

A traditional household consists of husband with one or two wives, their children and in some cases relatives. In polygamous households wives live in separate houses with their children and the husband allocates land to each of them. There are a few cases where because of land scarcity, the husband migrate with one of the wives, (usually the younger wife) to the lowlands where he purchases land and establishes a home. One such case was encountered in Makuyuni-Masaini village. *Mzee* Amos gave the following information concerning his household structure:

> *" I moved to this place with my younger wife five years ago. I bought this land (about 7 hectares). I cleared it and established this farm. My older wife lives in the upland. She is working and managing my clan land (kihamba) independently. I visit her once or twice a month. She contacts me in case of any problem that needs my attention or any issue that need my decision. You know, in the Wachaga society there are certain decisions that only a man can make. For example, women are not allowed to make decisions on disposal of livestock except their chicken".*

Female-headed households also exist as a result of husband's death, divorce and unmarried women.

Gender roles

Male-headed households :

There is a division of responsibilities among members of the household. Like most societies in Tanzania, women are responsible for all domestic chores. Most farming activities in male-headed households are shared between men and women. The rearing of dairy cattle is the responsibility of women, but men assist when necessary. In male-headed households coffee trees, livestock and land are controlled by men, who are responsible for making decisions on their use, income generated and their disposal.

Decisions on types of crops and varieties, timing of farm operations, types of production technologies are made by both men and women. Decisions which involve major investments such as input purchases and physical soil conservation structures are usually made by men. For polygamous households, women control and make all the decisions related to farming activities independently. The husband controls land, livestock, coffee trees for each wife. One of the women participated in the discussions explained her situation as follows:

> *"My husband has two wives. Each of us has a separate house and fields. I work on this land and make all the production decisions independently, but this land, coffee trees and the cows I have, will always remain the property of my husband. He is also responsible for selling coffee and he controls the money he gets. I however have the responsibility of selling milk and I am allowed to keep and use the money independently."*

Female-headed households:

Female-headed households are responsible for managing and controlling all production activities. If land is obtained from the father, she may have no control of the trees or is required to consult the father when she wants to make major investments for the land.

Sources of labour

The main source of labour is from the household members. Hired labour is used by some households at labour peak periods, which occur in December and January. Due to financial constraints there are very few households who are able to hire labour. Cooperative labour is sometimes used, and is organized among clan members or relatives.

Sources of income

Households obtain most of their income from cash crops, especially coffee. Vegetable, milk sale and food crops (maize, beans, bananas) are the additional income earning enterprises. Some of the households obtain cash from hiring out their labour, selling local brew and from other petty business carried out off-season or together with agricultural activities. Households with children working in urban areas also receive remittances from them. For some households the husbands have either seasonal or permanent off-farm employment such as being a school teacher, parish worker or civil servants.

Wealth indicators

The indicators of wealth in the Wachaga society include the size of the coffee/banana plot, house type, number of dairy cattle owned by the household, possession of a consumer durable, e.g., motorcycle, car and bicycle and agricultural machinery, such as a tractor and cheese-maker.

3.1.3 Soil erosion

There are two types of soil erosion at the Kilimanjaro mountain slopes: water erosion and wind erosion. Wind erosion is difficult to notice and is less important in most areas of the district. Water erosion is the most serious problem in the area. There are three types of water soil erosion: sheet, rill and gully erosion. The degree and type of erosion vary with land slope, farming practices, land use system, soil type and rainfall intensity (ICRA, 1992).

The areas affected most by water erosion are the steep slopes of the uplands and midlands in bean/maize fields (sheet, gully). Soil erosion is very little in banana/coffee plots in the upland. Wind erosion also occurs during the dry seasons, especially in the lowlands.

Farmers interviewed indicated that yield from their farms located on very steep slopes have been declining due to removal of top soil by runoff water. They indicated that this problem has been increasing. Farmers who are using soil conservation measures such as terracing indicated that they are either not experiencing soil erosion or experience limited soil loss.

3.1.4 Soil conservation measures used in the area

The most common practices used to control soil erosion at the upland and midland slopes are grass strips (guatemala, elephant and setaria) and trash lines. Farmers indicated that these measures are not very effective. Some farmers use contour ridges and bench terraces introduced during the British colonial rule. They indicated that if these are maintained well, they are very effective in reducing soil erosion. Through extension advice farmers tend to cultivate and plant their fields against the slope. Few farmers leave their plots to fallow in alternate seasons to improve soil fertility. Mulching is widely used in coffee/banana plots to conserve moisture and reduce erosion. Zero-grazing and agroforestry are practised in the upland and midland intensive systems.

In areas with soil and water conservation programmes improved soil conservation measures are used. They include bench and *fanya juu* terraces[1], infiltration ditches and cut-off drains.

3.1.5 Institutional support

Extension services

Most villages in the Moshi district have access to the Village Extension Officer (VEO).

Marketing services

Farmers sell coffee to the Kilimanjaro Native Cooperative Union (KNCU) through primary societies located in the villages. Food crops are sold to private traders and local markets within the villages or in Moshi town. Vegetables and milk are sold within the villages to neighbours and local cheese makers.

Inputs such as seeds, fertilizers, insecticides and pesticides, farm implements are obtained from government networks and private traders and agencies. These include Tanzania Fertilizer Company (TFC), Tanzania Farmers Association (TFA) and KNCU.

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[1] *Fanya juu* ("through up hill" in *Kiswahili*) is a terracing process whereby a trench is excavated to form an embarkment on the upper side by throwing the excavated soil uphill.

Development programmes

There are several agricultural development programmes and non-governmental organizations working in Kilimanjaro mountains. Land degradation is one of the areas which has attracted support from the government, donors and development organizations. In the Moshi district there are three major projects dealing with soil conservation aspects. They are as follows:

Himo tree nurseries and small farm development project:

This project started in 1990 under the cooperation between Tanzania Environment Society (TESO) and German Agro Action (GAA). The project is implemented by the Community Development Trust Fund (CDTF). The project covers the three cropping zones presented above (600 - 1,500 m). The project area is Vunjo East division involving 10 villages in 5 wards. The main objectives of the project are:

- to protect natural resources (soils, water and vegetation)
- to increase income of small farmers.

The project started as a tree nursery project supporting individual farmers and groups to establish tree nurseries for their use to protect the environment and generate income. In 1993 the project activities were expanded to include additional components namely:

- soil and water conservation (terraces, water harvest pits)
- efficient firewood utilization (reduce firewood consumption using improved stoves)
- improvement of rain-fed agriculture
- improvement of traditional furrow irrigation.

Project contribution includes provision of basic tools, seeds and polythene bags for tree nursery establishment and marketing support for the seedlings. Water user groups have been formed with the help from the project support. Water user groups are trained in appropriate soil and water conservation techniques. The condition for irrigation support is that farmers should be registered water users and willing to implement appropriate soil and water conservation measures.

Activities carried out by the project are regular extension visits to provide on-site technical advice to participating farmers; on-site training in soil and water conservation techniques, furrow improvement and crop production; participatory planning and evaluation of various production recommendations. Village technicians have been trained to promote and implement the project recommendations.

Marangu Community Development Association (MACDA):

This is a non-governmental organization supporting rural development activities in Marangu area. The programme was started in 1991 with the following components:

- Dairy programme - improving zero-grazing and pasture establishment
- Water improvement - improvement of water intake
- Afforestation

The project established tree nurseries in schools for planting in eroded areas, gullies, at steep slopes and around the farms.

Tanzania Tree Planting Foundation (TTPF, Olimo branch):

This is a non-governmental organization supported by the Japanese NGO called Defence of Green Earth Foundation. The organization started in 1989 as a people's initiative. Emphasis has been on environmental protection through tree planting. Other soil conservation measures being promoted are bench terracing and organic farming. More than 3,000 farmers are participating in project activities.

Support provided under the project includes farmer training in soil conservation, tree planting, zero-grazing and organic farming.

3.2 Pare mountains:Mwanga district

The Pare mountain ranges comprises the north Pare mountains in Mwanga district, and the south Pare mountains in Same district. The north Pare and the south Pare mountain blocks are separated by a wide valley running from east to west. Mwanga district has a land area of 2,170 km^2 and is divided into four divisions: Usangi, Ugweno, Lembeni and Mwanga. The north Pare mountains can be found in Usangi and Ugweno divisions with a population of 54,374 (1988 census) and a total area of 808 km^2. The altitude ranges from 800 - 2,200 metres above sea level. The landscape is dominated by steep slopes with a gradient in some places exceeding 40%. The soils are poor with low organic matter, nitrogen and phosphorous. The soils are also acidic (Fungameza, 1992).

General information

Rainfall: 800 - 1300 mm, bimodal (November and May) - erratic
Temperature: 14 - 28 °C
Average farm size: 2 ha (1950), less than 1 ha (1994)
Average farm size per person: 0.5 acre
Population: 97,004 people, including lowlands
Population density: mountain area 200 people/km^2 in mountains and 22 people/km^2 in lowlands
Total households: 17,487, 25% of which are female headed
Average household size: 6 people
Available average workforce/household: 1.9 adults
Ethnic groups: Wapare, Wachaga, Wagweno
Soils: Nitrosols and cambisols with low-medium fertility, high erodibility, stoniness and shallow topsoil depth.

3.2.1 Land use/farming systems

The farming system in the north Pare mountains is characterized by homegardens around the homestead (0.1 - 1.5 ha) and distant fields including the lowlands located up to one hour walking distance. The homegardens consist of a mixture of coffee, bananas, some annual food crops, multipurpose shrubs and trees. Distant fields, including the ones in the lowlands, are used for cultivation of annual food crops such as maize, beans and rice. Farmers also own woodlot to meet their firewood needs and building materials (timber and poles).

Food crops in the area include bananas, maize, beans, sweet potatoes, yams and vegetables (tomatoes, onions, spinach, cabbage) grown in plateaus and around the homegardens. The main cash crop is coffee. Surplus food crops and vegetables are also sold (Fungameza, 1992). The majority of farmers (80%) keep stall-fed cattle of local and mixed breeds.

3.2.2 Socio-economic aspects

Land tenure

The following types of land tenure can be identified in the north Pare mountains:

Clan land:

This is land owned and controlled by clans through customary law. It is inherited from father to son for building and cultivation[2]. This implies that the owner or the user of land acquired in this way is only the custodian and therefore not allowed to transfer it to someone else (Mvungi, 1992). By this law women cannot own land, but can acquire land either through purchasing or through their husbands, in the case of widows.

Mbuta land:

This is land obtained from a relative or a friend by giving him a traditional gift known as "*mbuta*" (a potful of traditional beer, "*dengelua*"). This land is usually used for establishing a residence and a homegarden plot (*nkonde*). Once acquired, the land remains the property of the owner (buyer) and can be passed on to his sons who may be required to renew the gift (*mbuta*). This arrangement can continue for generations as long as the individual continues to use it (Glukert, 1994; Mvungi, 1994). If the individual decides to move, he is required to give it back to the original owner or his family. He is not allowed to sell it or rent it out.

Rented land:

This is land acquired through renting whereby a farmer rents land from another for cultivation of annual food crops. However this is not very common in the highlands, given the existing land scarcity problem in the area. Renting can be in cash or in terms of share-cropping, where the tenant gives part of the harvest to the landlord.

Borrowed land:

This is land borrowed from farmers who either have excess land or who cannot use in all his plots due to old age or health problems. This is given for free, and can be for one or several seasons.

Government allocated land:

The village government committee allocates public or communal unused land to

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[2]Note that due to land shortages the land passed on to children is progressively becoming too small for further fragmentation.

individuals for their use. This is practised in the lowlands, where there is no land pressure.

Communal land:

This includes community land, which is available to the general public mainly for grazing purposes. This is mainly found in the lowlands where land is abundant. Other types of communal lands are the government controlled lands which include protected areas such as forest reserves, hilltops, very steep slopes and water catchment areas and clan controlled/protected forests, *mpungi* and *mshitu* used for performing traditional rituals (Mvungi, 1992; Mshana, 1994).

It is important to note that the amount of land owned by individuals depends on which clan or ethnic group one belongs to. People with larger land areas are those from former ruling clans, which were responsible for land distribution (Mvungi,1992). Immigrants seem to own smaller land areas.

Indigenous knowledge

Traditionally people in the north Pare mountains have been using farm yard manure, known as *"kitonto"* and mulching in their homegardens and the nearby food crop plots to improve soil fertility. Some soil conservation techniques such as grass strips, trash lines, intercropping and crop rotation have been used by farmers for many years to improve soil fertility and minimize soil erosion. Minimum tillage or no-till methods, traditionally known as *"kitang'ang'a"* have been used to maintain soil cover, thus reducing soil erosion and retaining moisture. When land was abundant, farmers also fallowed their land as a soil fertility improvement strategy. Socio-economic surveys conducted in the area indicated that farmers have some knowledge of land degradation and conservation techniques. They are aware of the soil erosion problem, soil erosion control and the need to plant trees (Mvungi, 1992, Maghimbi, 1991).

Gender roles

In male-headed households women handle all the domestic chores and most of the farming activities for annual food crops. Sometimes children, especially girls, help their mothers after school. They mostly help with domestic chores, fodder cutting, feeding animals and stall cleaning, livestock grazing, collection of firewood and carrying produce to the market.
Usually men are responsible for coffee (spraying and pruning) and for working off-farm. They make most of the major household's decisions including those pertaining to cash crop, coffee, livestock and trees. Men also control income generated from coffee, trees and livestock sales. Women are the principal decision makers for annual food crops and control the proceeds accrued from these crops, together with milk sales (Fungameza, 1992; Mvungi, 1992; Glucket, 1994). Decisions on the use of soil and water conservation measures vary among households. This situation applies to both monogamous and polygamous households. In cases where the husband works and stays in the urban area the wife takes care of cash crops and makes most of the household decisions, except those involving major investments or pertaining to disposal of land, trees and livestock. The urban-residing men still control income generated from sales of trees, livestock and coffee.

Sources of income

Farmers get most of their income from selling coffee and surplus food crops (bananas, maize, beans and rice from the lowlands), livestock products and trees. Other income earning activities are selling local beer *(dengelua)* and honey (especially in Ugweno division), running a local business and trading, including small shops (*duka*). Some farmers receive remittances from children and relatives (mainly husbands) employed in urban areas. Some households sell their labour to supplement their agricultural income. Women in Usangi division obtain additional income from pottery and other handicraft activities. In some male-headed households men have seasonal or permanent off-farm employment.

Sources of labour

Family labour:

Most labour used for agricultural activities come from family/household members. These include people who work full-time and those who work part-time due to engagement to other activities. Children (7-15 years) help their parents with various farming activities.

Hired labour:

The use of hired labour is not very common in the area. Hired labour is sometimes used for cultivation, planting and harvesting in lowland fields. Hired labour is often used by farmers with off-farm employment/activities. In villages where improved soil conservation measures have been introduced a few farmers use hired labour to construct physical structures such as bench terraces.

Cooperative labour (vikwa):

These are traditional labour groups revived by the soil conservation programmes, TFAP/TIP. They are used mainly for construction of bench terraces. A voluntarily formed group of 5-10 households work in turns in each other's fields once or twice a week. In most cases the plot/field owner prepares food for the group. Some of these groups carry out other activities such as planting, weeding and harvesting jointly. These groups are either mixed i.e., consist of both men and women or men/women only. In Usangi division most of the groups consist of women only. Group composition is determined by many social and cultural factors. Most group members are either relatives, friends or those who share a common social status. For example, in Kisangara, discussion with a women group revealed that all women in that group were single (unmarried or divorced). They decided to form their own group because they were in the same social situation. During the discussion they gave the following explanation for forming the group:

> *"We are a very happy group. For us it is more than just working together. We have a lot of common experiences and social encounters to share. As single mothers, we have a difficult life. We have a lot of problems. Meeting once a week gives us an opportunity to exchange ideas and advice on various issues and problems. Also, most groups in this area are men-dominated. Joining such groups would not be socially and culturally acceptable, given how our society views single women".*

3.2.3 Soil erosion

Soil erosion is one of the most serious problems at the slopes of the north Pare mountains. In most parts top soil has been washed away leaving behind poor unproductive soils. There are three types of erosion: sheet, rill and gully erosion. Farmers showed an understanding of this problem and could explain the process and identify the eroded areas. One farmer, Mr. Guraidi of Vuagha village explained the soil erosion problem as follows:

> *" Movement of topsoil downhill by rain water. This soil is deposited in the plains and valley bottoms. As the topsoil disappears the fields become less productive and the soil colour changes from dark-brown to red with lots of stones and small rills".*

Benedicta Lucas, a single head of household (divorced) gave the following explanation for the soil erosion problem:

> *"My father died some years ago when I was still married. I was given part of this land by my brother after I was divorced seven years ago. It was fallow land (for more than ten years). When I cleared it the soil looked very fertile with black colour. In the first season, I had a very good harvest. Thereafter, yield started to decline and the soil became poorer and poorer. The rain washed all the topsoil downhill."*

3.2.4 Soil conservation measures used in the area

Some of the soil conservation measures especially those related to soil erosion control were introduced by the colonial government. Most of the techniques used to date are built upon farmers' indigenous knowledge and experience. The traditional soil conservation methods in the area are: application of farm yard manure, tree planting, grass strips (elephant grass), trash lines and woodlot intercropped with fodder grass. Also, there are remnants of bench terraces, introduced during the colonial period.

In the villages surveyed some farmers use soil conservation techniques introduced by donor-funded programmes (TFAP and TIP) while others still use traditional grass strips and trash lines or none. Those farmers who are using soil and water conservation technologies especially bench terraces and *fanya juu,* seem to have a good understanding of future benefits from these technologies. Mzee Selestine Peter of Kirongaya village stated that:

> *"...we have the responsibility of making our land more productive. It is better to spend three months to construct these labourious bench terraces for higher production later. Although I may not live long to see this, my grandchildren will inherit a better land."*

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The number and types of soil conservation techniques used vary among farmers. The type of soil erosion techniques used depends on the slope gradient, e.g., bench terraces are appropriate in very steep slopes. In Ugweno division both men and women participate in the establishment of soil conservation structures (Gluckert, 1994; TFAP, no year). However, in Usangi women do most of the work as men are either working in the urban areas or do not participate in farm work. Most of these farmers learned about these technologies from video shows, meetings and seminars organized by the soil conservation programmes, while others learned about them from neighbours and friends. Very few farmers indicated that they use hired labour for construction of physical soil conservation structures. From discussions with some of the labour groups, we learned that it takes one full day to construct a *fanya juu* terrace of 15-20m by a group of 5-10 people, depending on soil type.

Farmers who do not use soil conservation measures gave the following reasons:

- too much labour required to construct SWC structures: 6 farmers interviewed in Ugweno division indicated this reason
- plots too small, SWC technologies takes some land out of production
- do not foresee benefits
- it is not necessary to change way of farming
- lack of technical information
- do not believe in future benefits

One farmer explained his non-adoption of improved soil conservation measures as follows:

> *"Look at me, I am an old man. The soil conservation measures we are told to establish require a lot of work. Only strong, young people can manage to build the terraces, not me. I have very few years to live, therefore, I would not like to spend the little energy I have on "makingamaji" (physical SWC technologies). Once my sons take over my land they will use the modern soil conservation measures if they wish".*

3.2.5 Institutional support

Extension services

The area is provided with government village extension officers (VEO) responsible for providing on-site technical advice to farmers on crop and livestock production. The district is also under the National Extension Programme (NALERP) using the Training and Visit Approach (T&V). The villages also have access to divisional veterinary and forest officers. The SWC programme participating villages also receive technical information related to soil and water conservation from TFAP and TIP staff.

Marketing

Coffee is sold to primary cooperative societies and private coffee marketing agents. Food crops(bananas, maize, beans, sweet potatoes) are sold at weekly village markets, held twice or once a week in various places. Farmers obtain their agricultural inputs from the Tanganyika Farmer's Association (TFA) shop located in Mwanga town, about 30 km from Ugweno and Usangi divisions.

Donor-funded development programmes

There are two donor-funded programmes dealing with soil and water conservation issues. They are Tanzania Forestry Action Plan (TFAP) supported by German Agency for Cooperation (GTZ) and the Traditional Irrigation project (TIP) funded by the Netherlands government under the Dutch Volunteer Service (SNV).

The Tanzania Forestry Action Plan (TFAP):

The objective of the TFAP programme is to encourage sustainable use of natural resources through the following components:

- soil fertility management
- water management
- site-specific crop and tree management
- buffer zone management

The above components include activities such as low external input agriculture, agroforestry, soil and water conservation, afforestation of catchment areas and protection of river banks.

The project operates through Village Land Use Planning Committees (VLUPC) formed under the project to link the project with the village government and farmers on the issues related to utilization of land resources. The committee also plays a key role in enhancing the adoption of SWC technologies in their villages and development of soil and water conservation guidelines for their villages. Each participating village has a facilitator who provides day to day technical assistance for soil conservation to farmers. This mainly concerns the layout of physical SWC measures.

The traditional irrigation improvement programme (TIP):

The Traditional Irrigation Programme was initiated in 1989. The project is supporting improvement of traditional furrow irrigation networks. Activities under this project include rehabilitation of traditional water reservoirs (*ndiva*) and improving management and organization of irrigation water user groups. The project has three technical components, namely:

- Soil and water conservation to avoid erosion during irrigation
- Catchment afforestation to improve water sources
- Irrigation structure construction - to improve local irrigation structures

TIP has imposed the condition that, in order for the farmer to qualify for irrigation water supply through the programme the respective field must be terraced.

The two projects conduct seminars, training courses and awareness meetings to increase farmer participation in the project activities. The projects emphasize farmer participation in planning and execution of various activities. Some of the villagers have been trained as soil conservation facilitators responsible for advising farmers on soil and water conservation techniques. As indicated earlier, the projects have also revived the traditional labour-sharing groups known as "*vikwa*", used in constructing of soil and water conservation structures. The two programmes provide participants with implements such as forked hoes, hammers, sprinklers to enhance their use of soil conservation measures, materials and technical assistance required for rehabilitation of irrigation structures (cost-sharing) and subsidized improved seed varieties for bananas and other crops.

3.3 Usambara mountains: Lushoto district

The Usambara mountains are bordered by the Pare mountains in the northwest and Masai steppe in the south. The mountains are divided into two mountain blocks known as the west and the eastern Usambaras. These blocks are separated by the Lwengera valley. The western Usambaras constitute the main block of metamorphosed volcanic rocks bordering the south Pare mountain block. They rise from the surrounding plains at approximately 600 metres above sea level with irregular upper plateaux of altitudes of 1,300 - 1900 m. The highest point of this block is 2300 metres above sea level. The eastern Usambara block is situated at a lower altitude of about 1200 m (Mwihomeke, 1987; Kajembe, 1994).

The eastern Usambara mountains occupy 90% of the total area of Lushoto district. The district covers an area of 3500 km^2 in the northeastern part of Tanga region.

General information

Rainfall: 600-1300 mm per year, bimodal (November and May)
Temperature: 16 - 22 °C
Average farm size: 1.5 ha
Average farm size per household: 2.5 ha
Population: 357,531
Population density: 102 people/km^2
Total households: 65,268
Average household size: 5.5
Available average workforce/household: 5-6 people
Ethnic groups: Wasambaa, Wapare, Wambungu
Soils: Wetter SE parts: humic ferralitic soils of high altitudes; in drier and cooler parts: humic ferrisols of high altitude

3.3.1 Land use patterns/farming systems

In the Usambara mountains a fragmented land use pattern dominates. Each household has scattered plots (more than 5) located at an average of 20 minutes walking distance from the homestead. Cropping patterns are to a large extent influenced by subsistence requirements. The oldest land use patters are traditional irrigation, intercropping and livestock keeping. With increased demand for cash, there has been a decline in traditional subsistence production and increasing commercial production especially of horticultural crops.

The dominant crop production system in Lushoto district is smallholder, rainfed, low input cultivation. Crops grown in the area include maize, beans, round potatoes, cassava, sugar cane, tea, coffee, bananas, taro, yams, vegetables (tomatoes, onions, cabbages) and temperate fruits (pears, apples, plum, and apricots). Vegetables, sugarcanes and fruits are the main cash crops, sold to markets in Dar es Salaam and Tanga towns. Maize and beans are major food crops.

Cassava, round potatoes, sugarcanes and fruit trees are intercropped with annual food crops (maize and beans) at steep and gentle slopes. Vegetables, round potatoes and taro are grown in the valley bottoms. Inorganic fertilizers, manure and irrigation are used in vegetables and potato plots. Tea is grown in the southeastern part of the district in both large scale commercial plantations (estates) and by small farmers. Egger et al. (1980) identified the following land use patterns in the western Usambara mountains:

- diversified natural forest, *ocotea* forests and forest plantations
- traditional farming with bananas, trees and field crops in multi-storey system
- tea and coffee plantations as permanent crops
- traditional intercropping and fallow system with crops such as maize, beans, sweet potatoes, trees and bananas.
- intensive cultivation of maize in pure stand, developed from traditional intercropping system through adoption of modern farming
- valley bottoms with fertile soils and possibility for irrigation with maize, beans and vegetables
- degraded bush land, semi-natural shrub vegetation with a high diversity of woody plants and climbers on abandoned or communal land

About 70% of total agricultural land in the Usambara mountains is cropped. About 10% of this area is on the hilltops, 20% in the valley bottoms and 70% on slopes (Pffeifer, 1990).

Agro-ecological zones:

Three agro-ecological zones can be identified in the west Usambara mountains:

- Humid-warm zone: occupying the south, southeast, and western and central parts at altitudes of 1000 - 1300m, with an annual rainfall of 800 -1700 mm, and three continuous dry months. Food crops are maize, bananas, beans and cassava. Cash crops include tea, coffee, cardamon, vegetables and sugarcanes.

- Dry-warm zone: northeast area between 1200-1800 m, rainfall 500-800 mm with a four-month dry period. The zone is characterized by a high degree of subsistence farming, overgrazed communal grassland and heavy erosion. Food crops include: maize, beans and cassava. Cash crops are irrigated vegetables and round potatoes.
- Dry-cold zone: northwest area between 1700-2100 m, rainfall 500 - 800 mm, with a four-month dry period and slight frosts in valley bottoms. In this zone, large forest reserves and timber production is found. Food crops are mainly maize and beans, with little banana and cassava. Cash crops are temperate fruits, vegetables and round potatoes.

Livestock is an important enterprise in all three zones. On average farmers keep 1-3 cattle and several goats and sheep. Small-scale beekeeping is also practised in the forests (Lundgren, 1978; Scheinmann, 1986; LRDC, 1987; Pfeiffer, 1990; Kajembe, 1994).

3.3.2 Socio-economic aspects

Land tenure

Like in the north Pare mountains, land in the west Usambara is obtained mainly through inheritance of clan land. Sons receive piece of land from their fathers once they get married. They also inherit their fathers' land when he dies or retires He shares this land with his wife or wives, which may lead to further subdivisions. Unmarried daughters sometimes get access to clan land, but given the current land shortages, this does not happen often. Divorced women cannot claim their husband's land. If young widows decide to stay with the in-laws or are inherited by one of the younger brothers, They are allowed to maintain control of the husband's land until her sons grow up (Mitzlaff, 1988). If she goes back to her parents, she may get land from her father or brothers.

In some cases, farmers also own purchased land. Migrant farmers have purchased all the land they own. This does not happen often nowadays due to increased attachment to land among farmers attributed to land scarcity. Women rarely buy land as most of them lack capital together with the existing traditional barrier of selling land to women (Metzlaff, 1988, informal discussion with farmers, 1995). Other forms of acquiring land which are now disappearing include share-cropping and land borrowing. The former involves an arrangement where a farmer gives his land to a friend, relative or neighbour to cultivate for a specific time period, and receives part of the produce as agreed. Usually the land owner provides seed and other inputs. Like in the north Pare mountains, land borrowing arrangement does not involve any payment.

There is also land obtained through government allocation. In 1962 up to 36,000 ha of the natural forests were allocated to people in surrounding areas for settlement and cultivation.

Indigenous knowledge

Traditionally, people of the Usambara mountains adapted their agricultural practices to the mountainous environment to meet their multiple needs (Pfeiffer, 1990). Intercropping with different crops has been used as a risk reduction strategy. Farmers own several scattered plots in different locations with varied altitudes and agro-climatic conditions to spread the risks of crop failures. Also, this was used as a strategy for constant food supply and favourable labour distribution. Furrow irrigation has been developed in some parts to supplement rainfall water (Woytek et al., 1987; Kaswamila, 1995).

People have used both traditional and improved soil conservation measures to reduce soil erosion and improve fertility. These include trash lines, grass strips, mulching and terraces. Multi-storey agroforestry system, mixed cropping, shifting cultivation, crop rotation and green manuring are used to improve soil fertility.

Gender roles

A typical *Wasambaa* household comprises members of different ages. There is division of labour according to gender, age ad status (Mitzlaff, 1988). Normally men are responsible for cultivating cash crops (vegetables) in valley bottoms. They also undertake major farming tasks such as land clearing, tillage and harvesting. Women are responsible for domestic chores, collection of firewood and marketing. They are also responsible for cultivation of food crops. They make all the production decisions but sometimes seek advice and/or approval from men. They keep most output to meet the family food supply need and sell only a small proportion to meet their money needs. Like in the north Pare mountains men make all the decisions pertaining to cultivation of cash crops (vegetables, coffee, tea), livestock and trees.

For most polygamous households each wife has her own house and plots in the same village or sometimes in other villages. They make production decisions (on food and cash crops) independently. The husband is consulted only when it is necessary. Other arrangements are used to suit various situations. For example, wives may stay in the same house and work jointly or separately under control of their husband (own interview, Longoi village). Children are also assigned various domestic and farm tasks depending on age and sex. Girls help their mothers with domestic chores, while boys look after livestock. The construction of terraces and other soil conservation measures is performed by both men and women.

The household structure

Traditionally men are the heads of households in the *Wasambaa* society. There are very few female-headed households as a result of divorces, unmarried women, widows and women whose husbands have permanent employment in urban areas. In such a situation a woman may be regarded as head of the household. She manages all the household activities independently, and makes most of the production decisions (Mitzlaff, 1988).

Sources of labour

Family labour:

The main source of labour within the household is from family/household members. This constitutes all the people who live and contributes labour to a particular household. This includes people who devote all their time to farm activities (full-time), and those who work part-time on-farm.

Hired labour:

During peak periods some households use wage labour to supplement their own labour. Wage labour is used for various farm tasks and crops. Poor households sell their labour in addition to working in their own plots. This sometimes contributes to low crop yields from their plots.

Cooperative labour:

Traditionally there are different kinds or labour-sharing among the Wasambaa. This arrangement is used during the peak periods for farm activities and house construction. One form of cooperative labour is when through a social network the head of a household organizes a working party (*ngemo*) for friends, neighbours and relatives to work in his field and thereafter provides them with a special meal and local beer, *muwa*. Men or women of the same age or social status may form a labour-sharing group known as "*kiwili*". Like *vikwa* in the north Pare mountains, they take turns to work in each other's fields (Zongolo, no year). Women interviewed in Shashui village, Soni district indicated that they have labour-sharing groups (*kiwili*) consisting of 2-3 women for various farm operations e.g., weeding, tillage, planting and mostly in constructing of terraces.

Sources of income

Interviews with farmers in the area indicated that the main source of income is from crop sales. A few farmers (2 out of 6) indicated that they had other sources of income. They obtain income from off-farm business such as selling local beer and from part-time employment and remittances from children working in urban areas.

Wealth indicators

Social status and wealth of individuals in the *Wasambaa* society depend on the amount of land and livestock one possesses and type of house. Possession of consumer durables is an added wealth indicator.

3.3.3 Soil erosion

Soil erosion caused by rainwater is dominant in the west Usambara mountains. This has resulted in serious loss of fertile topsoil, leading to a reduction of productivity on the slopes and sedimentation of rivers and streams downhill. The types of water erosion found in this area include: sheet, rill and gully erosion.

Average topsoil loss on arable land in the west Usambara mountains is estimated to be 0.6-1.0 cm/year, amounting to 100 tons/ha annually. This results in 370 kg of nitrogen loss per hectare per year (Kaswamila, 1995).

Soil research conducted in the area revealed that the intensity of soil erosion is to a large extent influenced by the slope of the land, farming practices, soil type, rainfall intensity, slope gradient, slope length and slope shape. These influence water velocity and volume down the hill (Kaswamila, 1995). Scheinman (1986) categorized the west Usambara mountains into the following slope classes:

Class I: Gentle slope (0 - 25%)
Class II: Medium slope (26 - 45%)
Class III: Steep slope (45% or more)

According to the Erosion Inventory Map, the west Usambara mountains have two major erosion areas:

1. The area south of the imaginary east-west borderline (Lushoto-Baga-Masumbai, with small isolated spots of erosion.
2. The area north of Lushoto (northern and northwestern Usambara mountains) with heavy and large-scale erosion (Woytek et al., 1987)

Like in the north Pare and Kilimanjaro mountains, most farmers interviewed showed an understanding of the soil erosion problem and the need to protect their fields from soil erosion.

3.3.4 Soil and water conservation measures used in the area

Like in other study areas, soil and water conservation techniques were introduced in the west Usambara mountains by the British colonial government in the 1950s. The techniques introduced include the construction of bench terraces aimed at controlling soil erosion. Indigenous or traditional biological measures include techniques such as trash lines, grass strips (nippier and guatemala), agroforestry, farm yard manure, mulching using crop residues and straws, hedge trees and woodlot.

The Soil Erosion Control and Agroforestry Programme (SECAP), supported by technical aid of Germany (GTZ), has introduced various improved soil erosion control measures such as multipurpose crop strips (macrocontour lines), bench and fanya juu terraces, infiltration ditches and cut-off drains. The traditional irrigation improvement project (TIP) supported by the Netherlands volunteer service (SNV), like in the north Pare mountains is assisting farmers in improving traditional irrigation systems and constructing bench terraces.

Pfeiffer (1990) observed that in the west Usambara mountains soil erosion of 17.1 mm/year is recorded in fields without improved soil conservation measures compared with 12.6 mm/year in fields with soil conservation measures.

3.3.5 Institutional support

Extension services

Most village are served by villages extension officer(s) who visit farmers to advise them on various issues of agricultural production. Some of the villages also have access to forestry officers and community development workers. The donor-funded projects in the district (SECAP and TIP) have posted an extension officer in all participating villages. Some of the young villagers have received training in extension techniques and various conservation aspects, e.g., layout of contours so that they can assist and advise others.

Rural development programmes

Soil erosion control and agroforestry programme (SECAP):

In 1979/80, the Government of Tanzania in collaboration with the Regional Integrated Rural Development Programme (TRIDEP) supported by technical aid of the Republic of Germany (GTZ), initiated an integrated soil control and agroforestry project (SECAP) to study and promote erosion control measures throughout the western Usambara mountains (Lushoto district). The project is focused on two main aspects: 1) reducing environmental destruction and 2) restoring the ecological balance in the target areas in the west Usambara mountains. The project is aiming at achieving a sustainable land use system in the west Usambara mountains by applying soil and water conservation measures and agroforestry systems so as to increase land productivity (Shelukindo, 1993). These measures were based on farmers' practices. SECAP's activities are as follows:

Macrocontour lines: SECAP developed a package known as Macrocontour lines (MCL). The MCL is defined as a permanent horizontal hedge planted densely with perennial crops along the contour lines of the hill, 5 -15 m apart; depending on the steepness of the slope. These reduce the speed of run-off water and traps soil particles (Scheinman, 1986). They consist of various components such as: fodder grass and legumes (guatemala, desmodium and leucaena), trees, bananas and pineapple. The components of the MCL depend on what a particular farmer grows in his plot, other enterprises he has (e.g., cattle), his needs, preferences and priorities. The strips between the MCL are planted with food crops referred to as macrocontour lines. This package is intended to meet farmers' multiple needs: fodder for cattle, firewood for fuel, food and cash (e.g., from sugar cane, pineapple and fruits) and to control soil erosion. Based on the experience gained, SECAP is introducing physical soil conservation measures such as bench terraces, cut-off drains and infiltration ditches where necessary to supplement MCL.

Catchment afforestation: Together with the MCL, SECAP has launched a Catchment Forestry

Programme (CFP). This programme intends to reafforest catchment areas by planting trees to further control erosion and improve water retention. This is implemented through community involvement. People in the area are involved in drawing up the tree planting plan, planting, protecting and managing the areas planted with trees.

Agroforestry: The programme promotes agroforestry practices at individual farm-level. The programme provides farmers with trees seedlings, fruit tree species to plant on their crop fields and along the macrocontour lines and border lines to reduce erosion, provide firewood and fodder for livestock.

Zero-grazing: The project introduced a livestock programme aimed at promoting zero-grazing. The project assisted farmers to establish zero-grazing dairy unit and to acquire the upgraded in-calf heifer. The animals are fed on fodder grown on macrocontour lines. The programme also established village bull centres. Farmers are encouraged to use farm yard manure on their contoured food crop plots on the slopes to improve soil productivity. However, experience has shown that most farm yard manure is used for production of cash crops in the valley bottoms (Shelukindo, 1993). It is important to note that in order for a farmer to qualify for improved cows from SECAP he had to establish macrocontour lines and plant trees first.

Organic farming: The project is also promoting practices such as green manuring, mulching and crop rotations. Farmers are provided with on-site training in compost making using crop residues.

SECAP promotional approaches: SECAP uses various extension instruments to enhance farmer's participation in the project activities. These include the following:

- Campaign meetings before the onset of rains
- Village committees to link farmers with the project
- Farmers field days for demonstration of new techniques
- Macrocontour line campaigns to enhance establishment of macrocontour lines at individual level
- Individual follow-up visits to provide on-site advice to farmers participating in the programme.

Traditional irrigation programme (TIP):

This programme was introduced in Lushoto district in 1990. The main focus of this programme is to improve the traditional irrigation systems, using farmer's participatory approaches. Given the topography of the area the project incorporates soil conservation aspects. In order for the farmer to be eligible for irrigation assistance under the project, he is required to control soil erosion using bench terraces. The project also provides inputs and implements for construction works. With the assistance of the project and SECAP, farmers have organized themselves in cooperative labour groups (*kiwili*) for construction of bench terraces (see Mwanga district).

The project activities are confined to areas with traditional irrigation schemes. These comprise areas on gentle slopes up to a gradient of 12%.

Marketing services

Farmers have access to local markets which are held twice a week in a specific place. At these markets farmers sell various farm products, mainly food crops. Private traders and middlemen purchase fruits and vegetables directly from farmers for selling them at town/city markets, such as Tanga and Dar es Salaam markets. Tea is sold to tea factories within the villages and to private traders.

4. CONCLUSIONS

From the above review, it is clear that in the study area there is variation in physical environment, which influences the cropping practices, cropping systems and cropping patterns within the study areas and between them. These variations are influenced by various factors such as altitude, rainfall intensity and land form. Population density and settlement patterns also vary among the three areas resulting in different rates of land degradation.

Despite the above-mentioned variations, the three areas experience the same problems related to land degradation. They include:

- land pressure due to increasing population
- poor soil fertility and low crop productivity
- poor soil cover
- accelerated soil erosion
- intensive cultivation and diversified agriculture

The three areas also share common socio-economic characteristics including land tenure, indigenous knowledge and experience in soil conservation, gender role, sources of income and labour and perception and attitudes towards land degradation. They also have the same types of institutional support from the government network and donor agencies. There are however, variations in the level of such support and the time they were introduced. The north Pare and west Usambara show more commonalities in this respect.

Given the above similarities, more or less the same soil conservation measures have been introduced in these areas to reverse land degradation. It is expected that the adoption variations among the households within the study site are determined by individual household's socio-economic characteristics and behaviour towards soil conservation.

APPENDIX II

THE HOUSEHOLD QUESTIONNAIRE
West Usambara and North Pare Mountains

DATE........... FARMER NO...........

DISTRICT............DIVISION.............VILLAGE.............
ENUMERATOR...............

SECTION A: HOUSEHOLD CHARACTERISTICS:

A1. Sex of the head of the household:
1. Male
2. Female

A2. Ethnic group:
1. Msambaa
2. Mpare/Mgweno
3. Mchaga
4. Mmbugu
5. Other (specify)

A3. Age of the head of the household_______

A4. Years spent in formal school__________

A5. Marital status:
1. Single
2. Married
3. Divorcee
4. Widow

(b) If married, how many wives do you have_________

A6. Social status:
1. Village government leader (chairman, secretary, ten-cell leader)
2. Village government committee member
3. Religious leader
4. Retired civil servant
5. Member of Village land Use Planning Committee (VLUPC)
6. Chairman of water user group
7. Member of any socio-cultural group
8. Other (specify)

A7. House type:

1. Very good: iron sheet/tile roof, concrete wall, cement floor.
2. Good: iron sheet roof, mud wall, cement floor.
3. Average: iron sheet roof, mud wall, non-cementfloor.
4. Poor: tined roof, mud wall, non-cement floor
5. Very poor: thatched roof, mud walls, non-cement floor.

A8. Do you own any of the following assets/services:

1. Car
2. Motorcycle
3. Bicycle
4. Television set
5. Tractor
6. Telephone
7. Electricity
8. House for renting

SECTION B: HOUSEHOLD COMPOSITION:

B1. How many people are living with you (including yourself):

Age	Total	How many work full time in the farm	how many work part time in the farm	How many have full time off-farm activities
16-35 years				
36-60 years				
over 60 years				
children (7-15 years)				
TOTAL				

B2. (a) Do you have friends relatives or any other people who often help you with agricultural activities whenever you need their help ?

1. Yes
2. No

(b) If YES, on average how many people help you annually and for how long: ....people ....days

SECTION C: CONSERVATION ATTITUDES AND BELIEFS

C1. (a) Do you think the productivity (quality) of your soil (in terms of its production capacity) is important in agricultural production:
1. Yes
2. No

(b) If Yes, in your experience, what has made you think so:____________________

C2. From you experience, what are the main five problems that have been affecting the productivity of you soil/land (mention in order of priority)
1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

C3. Farmers have responsibility towards future generations to use soil in such a way not to cause erosion:
1. Agree
2. Disagree
3. Unceratin

4. Receiving a certificate for outstanding soil conservation farm of year is worth a lot and can lower profits:
1. Agree
2. Disagee
3. Uncertain

C5. Receiving Tsh. 10,000/= now is worth a lot than waiting to receive Tsh. 500,000/= in five years
1. Agree
2. Disagree
3. Uncertain

C6. Suppose you had Tsh. 100,000/= for investment in two different farm business with the following feasibility report:

1. In the FIRST business you have 90% chance to recover it plus 10% profit.

2. In the SECOND business you have 30% chance to recover it plus 50% profit.

Which business would you choose to invest on:
1. First
2. Second
3. None

SECTION D: LAND INFORMATION:

D1. Do you own (through inheritance or purchase) all the land you are currently using:
1. Yes
2. No

D2. If you **do not own some** of the land how did you acquire it:
1. renting
2. share cropping
3. free temporary use
4. Other (specify)____________________

D3. What plans do you have for your land (purchased or inherited) after retirement/death:
1. Sell
2. pass on to children
3. lease
4. other (specify)__________________________

D4. How many plots/fields do you have (in total) _________

D5. How many of your plots are located:
1. In very steep slopes ______

2. In gentle slopes ______

3. In the valley bottoms ______

4. In the low lands ______

SECTION E: PERCEPTION OF SOIL EROSION

E1. Describe the soil productivity (quality) of your plots located in:

Very steep slopes:
1. Good
2. Average
3. Poor

In gentle slopes:
1. Good
2. Average
3. Poor

In lowlands/valleys:
1. Good
2. Average
3. Poor

E2. How would you describe the productivity (yield) of your plots located in slopes, now compared to some years back:

1. declining
2. same
3. better
4. uncertain

E3.(a) If **declining**, what could be the reasons:

1. soil washed away (soil erosion)
2. soil dries quickly after rain
3. poor rainfall
4. insects and diseases
5. poor fertility
6. Other (specify)

(b) If one of the reasons is declining fertility what do you think is the causes of this:

____

E4. Do you experience soil erosion from your of your plots

1. Yes
2. No

E5. (a) Soil erosion is a natural process that cannot be avoided:

1. Agree
2. Disagree

(b) If **disagree**, what do you think are major causes of soil erosion:

____

____

____

E6. How would you describe soil erosion problem in your plots located in:

Very steep slopes: 1. not existing
2. little
3. moderate
4. severe

Gentle slopes: 1. not existing
2. little
3. moderate
4. severe

Lowlands/valleys: 1. not existing
2. little
3. moderate
4. severe

SECTION F: SOIL CONSERVATION TECHNOLOGIES:

F1. (a) Are you using any soil and water conservation technologies in any of your plots:
1. Yes
2. No

Note for enumerator: If he/she is not using any soil conservation techniques go to question F8

F2. (a) If yes how many techniques are you currently using ___________

(b) Which of the following techniques are you currently using in various locations of your plots:

TYPE	steep slopes	gentle slopes	Low lands
Fanya juu terraces			
Bench terraces			
Infiltration ditch			
Cut-off drain			
Grass strips			
Macrocontourlines			
Trash lines			
Agroforestry			
Zero grazing			
Minimum tillage/weeding			
Mulching			
Others (specify)			

F3. (a) How many of your plots are under various soil conservation technologies_____________

(b) Give the size (in acres) of your plots with various soil conservation techniques and indicate the slope type (steep, gentle, lowlands/valley):

Name of the plot	Size (Acres)	Slope

F4. (a) How many of your plots with soil conservation techniques have these techniques in:

The whole plot_____
Quarter of the plot_____
Half of the plot_____
Three quarter of the plot_____
Very small part of the plot_____

(b) If in any of your plots you are not using soil conservation techniques in the whole plot, what is the reason:

1. Inadequate technical support
2. Did not see the benefits
3. labour shortage
4. Inputs/implement shortages
5. Financial constraints

F5. Who is responsible for construction and maintenance of soil conservation structures:

1. Husband
2. Wife
3. Both (jointly)

F6. Who makes decision on the investment in soil conservation technologies:

1. Husband
2. wife
3. Both (jointly)

F7 (a). Are you carrying out routine maintenance on physical soil conservation structures you have constructed:

1. Yes
2. No

(b) If **No**, why____

F8. If you are not currently using soil conservation techniques, have you used them before and decided to stop:

1. Yes
2. No

If **Yes**, why did you stop:

1. Project support ended
2. No benefits realized
3. labour shortage
4. lack of inputs and implements
5. Other (specify)

F9. (a) If **you are not** currently using soil conservation technologies, what are the reasons:

1. Not aware of the technologies
2. too expensive
3. financial constraints
4. too much labour
5. do not foresee benefit
6. other (specify)

F10. What other measures are using to improve soil productivity:

1. Improved seed variety
2. Inorganic fertilizers
3. Farm Yard Manure
4. Green manure
5. Compost
6. Crop residue/weed mulching
7. Other (specify)

SECTION G: INSTITUTIONAL SUPPORT:

G1. Have you participated in **any** of the following soil conservation activities/events organized by SWC programmes (SECAP/TFAP, TIP and others):

1. Developing village conservation programme
2. Conservation training programme
3. Construction of village land use planning model
4. Demonstration for soil conservation measures
5. Farmers' field day
6. Soilconservation tour in another village
7. Soil conservation video show

G2. Have you received any of the following **support** from SWC programme(s):

1. Technical information/assistance
2. Cost sharing/financial assistance for soil conservation
3. Inputs/implements
4. Casual labour for construction of conservation structures
5. Other (specify)

G3. What are your **sources** of information on soil conservation:

1. radio and village films
2. newsletters, pamphlets and leaflets
3. donor projects
4. extension
5. relatives
6. friends
7. neighbours
8. cooperatives
9. village land use planning committee/village leaders
10. other (specify)

G5. (a) Are you visited by village extension officer:

1. Yes
2. No

(b) If Yes, how many times are you visited annually_______

G6. (a) Do you have access to any credit sources:

1. Yes
2. No

G7. If **Yes,** What are your main sources of credit:

1. cooperative society
2. banks
3. community development projects
4. neighbour, friends and relatives
5. Other (specify)

G8. How many times have you received credit from each source for the past five years and for what purpose. Also, indicate total amount received:

SOURCE	TIMES	PURPOSE	AMOUNT (Tsh.)

SECTION H: HOUSEHOLD ECONOMIC POSITION:

H1.(a) Do you keep livestock:

1. Yes
2. No

(b) If YES, indicate types and number where applicable:

TYPES	NUMBER
Cross breed (diary)	
Cross breed (diary bull)	
Local breed (Zebu)	
Goats	
Sheep	
Oxen	
Other (specify)	

H2. What crops do you grow in your various plots. Also indicate acreage and average yield in the past 5 years, uses and income from crop sales :

CROPS	SIZE (Acres)	Average yield last season (bags/Kg)	Use:food or cash) (gunia/Kg)	Income (Tsh.)

H3. (a) Do you use hired labour for farming activities:

1. Yes
2. No

(b) If **Yes**, which activities do you usually use hired labour, how many people per season and at what rate (average):

ACTIVITY	No. OF PEOPLE	No. OF DAYS	WAGE RATE (Tsh.)

H4. Are you involved in labour sharing (cooperative labour) arrangement for farming activities:
1. Yes
2. No

H5. If **Yes** which activities do you usually use cooperative labour:
1. ______________
2. ______________
3. ______________

H6. What are your other sources of income:

INCOME SOURCE	AMOUNT/YEAR (Tsh.)

H8. Do you obtain remittances (cash assistance) from relatives/children working in urban areas:
1. Yes
2. No

SECTION I: FARMER OPINION:

I1. Do you have comments, questions or anything that you would like to discuss concerning this interview or agricultural development in general.

____

____

I2. Enumerator's remarks (doubtful answers, any useful information)

____

References

Aldrich, J. And F. Nelson (1984). *Linear probability, logit and probit models*. Beverly Hills: Sage Publications.

Allegretti, M.H. (1990). Extractive reserves: An alternative for reconciling development and environmental conservation in amazon. In: *A.B. Anderson (eds.). Alternative to deforestation: steps towards sustainable use of amazon rain forest:* New York: Columbia University Press.

Altieri, M.A. (1987). Agroecology: The scientific basis of alternative agriculture. *Westview special studies in agriculture science and policy.* Westview Press (Boulder), IT Publications (London).

Anderson, G.D. 1982. A survey of soils and land use potential of southern and eastern slopes of Kilimanjaro, Tanzania. University of Dar es Salaam, Institute of Resource Assessment, Tanzania and Clark University. *Environmental training and management in Africa with south-east consortium for international development.* Worcester, Massachusetts.

Ashby, J.A. (1982). Technology and ecology: implications for innovation research in peasant Agriculture, *Rural Sociology,* 47(2): 234-250.

Ashby, J.A. (1985). The social ecology of soil erosion in Colombian farming system. *Rural Sociology,* 50(3): 377-396.

Aune, J.B. (1994). Prediction of soil degradation in Tanzania - A system analysis approach. *Centre for environment and development studies,* Agricultural University of Norway.

Aune J.B. and R. Lal (1995). The tropical soil productivity calculator: *a model for assessing effects of soil management on productivity.* In: Lal, 1995.

Attaviroj, P. (1990). Soil erosion and land degradation in the northern Thai- uplands. In: Dixon J.A., James D.E.,and P.B. Sherman (eds). Dry land management*: economic case studies.* Earthscan Publications Ltd, London.

Bank of Tanzania (1996). *Economic and operations report for the year ended 30 June, 1995,* Dar es Salaam.

Barbier, B. Edward (1987). The concept of sustainable economic development. *Environmental conservation.* 14(2).

Beal, G.M., J.M. Bohlen and J.N. Raudabaugh (1960). Leadership and dynamic group action. Iowa State University Press, Ames, Iowa.

Berry, E. (1977). Land use in Tanzania by districts. *University of Dar es Salaam, Institute of Resource Assessment,* research notes No. 6.

Besley, T. And Anne Case (1993). Modelling technology adoption in developing countries. *American Economic Review,* 83: 396402.

Blyth, M.J. and M.G. Kirby (1985). The impact of government policy on land degradation in rural sector. In: Thampapillai, D.J. and J.R. Anderson. A review of the Socio-economic analysis of soil degradation problems for developed and Developing countries. *Review of Marketing and Agricultural Economics*, Vol. 62, No. 3, December, 1994.

Binswanger, H.P. (1980). Attitudes towards risk: experimental measurement in rural India. *American Journal of Agricultural Economics*, Vol. 62.

Blase, M. G. (1960). Soil erosion control in western Iowa: Progress and problems. Unpublished Ph.D dissertation, Iowa State University, Ames. In: Nowak, P.J. Dhanakumar, V.G. and M.M., Zinnah (1983). *Annotated Bibliography of studies related to the adoption and diffusion of natural resource management practices.* Department of Rural Sociology. University of Wisconsin-Madison, Madison, Wisconsin.

Boahene K. (1995). *Innovation adoption as a socio-economic process: the case of Ghanaian cocoa industry.* Thesis Publishers, Amsterdam.

Bohlen, J.M. (1964). The adoption and diffusion of ideas in agriculture. In: Copp, J.H. (Eds.). *Our changing rural society:* Perspectives and Trends, pp. 265-287. Ames, Iowa State University Press.

Bojö, J. (1990). Benefit-Cost Analysis of the farm improvement with soil conservation Project in Maphtseng, Mohale's Hoek District, Lesotho. In: Dixon, A. J., James, D.E., and P. B. Sherman (eds.), (1990). *Dryland management economic case studies.* Earthscan. Publications Ltd., London.

Bonnard, P. J. (1995). *Land tenure, land titling and adoption of improved soil management practices in Honduras.* Unpublished PhD Dissertation. Michigan State University.

Bose, S.P. (1962). Peasant values and innovations in India. *American Journal of Sociology,* 67:552-6.

Boserup, E. (1965). *The conditions for agricultural growth.* Allen and Unwin, London.

Boserup, E. (1981). *Population and technological change: a study of long-term trends.* Chicago University Press, Chicago.

Brown, M.A., Maxon, G.E. and L.A. Brown (1978). Diffusion agency strategies and innovation diffusion: a case of the eastern Ohio Resource Development Center. *A study in the diffusion of innovations*: Discussion paper No. 25, Department of Geography, Ohio State University.

Bultena, G.L. and E.O. Hoiberg (1983). Factors affecting farmers' adoption of conservation tillage. *Journal of soil and water conservation* (May-June): 281-285.

Bultena, G.L. and E.O. Hoiberg (1988). Preventing topsoil: a study of US farmers' commitment to resource conservation. *Society and Natural Resource*, 1: 159-165.

Bureau of statistics (1990). *National accounts of Tanzania*, 1976-1989. Planning Commission, Dar es Salaam.

Bureau of Statistics (1993). *Population census, 1988: regional statistical abstracts Tanga region.* Planning Commission, Dar es Salaam.

Bureau of Statistics (1993). *Population census, 1988: regional statistical abstracts Kilimanjaro region.* Planning Commission, Dar es Salaam.

Byerlee, D. And H. de Planco (1986). Farmers stepwise adoption of technological Packages: evidence from Mexico Altiplano. *American Journal of Agricultural Economics*, (August): 519-527.

Cancian, F. (1967). Stratification and risk taking: A theory tested on agricultural innovations. *American Sociological Review* 32: 912-27.

Cárcamo, J.A. Alwang, J. and G. W. Norton (1994). On-site economic evaluation of soil conservation practices in Honduras. *Agricultural Economics, 11: 257-269,* Elsevier B. V.

Carlson, J.E., Dillman, D.A. and W.R. Lassey (1981). The farmer and erosion: factors influencing the use of erosion control practices. University of Idaho, *Agricultural Experiment Station, Bulletin,* No. 601.

Carlson, J.E. and D.A. Dillon (1988). The influence of farmers' mechanical skills on the development and adoption of new agricultural practices. *Rural Sociology,* 53 (2): 235-245.

Carlson, G.A., Zilberman, D. and J.A. Miranowski (1993). *Agricultural and environmental resource economics.* Oxford University Press.

Caswell, M. F., and Ziberman, D. (1985). The effects of well depth quality on the choice of irrigation Technology. *American Journal of Agricultural Economics* 68, 798-811.

CGIAR (Consultative Group on International Agricultural Research (1989). Sustainable agricultural production: implications for international agricultural research. *FAO res. Tchnol. paper* 4, Rome.

Chamala, S. And M.C. Coughenour (1989). Constraints and incentives to stable mulching among Queensland grain growers. *Journal of Soil Conservation,* 42: 92-97.

Chambers, R.G. (1988). Applied production Analysis: *A dual approach.* Cambridge University Press.

Ciriary-Wantrup, S.V. (1968). Resource conservation economics and policies, 3rd edition. Division of agricultural sciences, University of California Berkeley, CA.

Cole, H.S.D. et al. (1973). *Models of doom: a critique of the limits to growth.* Universe books, New York.

Conway, G. R. (1985). Agroecosystem analysis. *Agricultural administration,* 20: 31-55.

Conway, G.R. (1987). Properties of agroecosystem. *Agricultural systems,* vol. 24, pp. 95-117.

Conway, G.R. and E.B. Barbier (1990). *After green revolution: Sustainable Agriculture for Development.* Earthscan Publications Ltd., London.

Conyers, D., Kasulambemba, F., Mbwana, A., Mosha, F. and P. Nnko (1970). Agro-economic zones of northeastern Tanzania. University of Dar es Salaam. *BRALUP Research Report,* No.13.

Coughenour, C.M. (1968). Some present problems in diffusion from the perspective of theory of social action. In diffusion research needs, Missouri Agricultural Experimentation Station, Columbia. *North Central Regional Research Bulletin,* 186: pp. 5-14.

Coughneour, C.M. and S. Chamala (1989). Voluntary and mandated institutional control on soil conservation behaviour of U.S. and Australian farmers. *Society and Natural Resources,* 2: 37-51

Day, R.H., and Singh, I. (1977). *Economic development as an adaptive process: The green revolution in Indian Punjab.* New York: Cambridge University Press.

Debertin, D.L. (1992). *Agricultural production economics.* 2nd edition, privately published, 1992.

de Graaf, J. (1993). *Soil conservation and sustainable land use: an economic approach. development oriented research in agriculture.* Royal Tropical Institute, Amsterdam.

de Groot, J.P. (1994) Policies for soil conservation. *Paper presented at workshop on policies for Sustainable land use in Costa Rica, Heredia, Costa Rica.* In: Kuiper, M.H (1987). The impact of land degradation on agricultural productivity: a multi-period economic land use model with economics.

de Janvry, A. (1979). *Comment in economics and the design of small farmer technology.* In: Aberto Valdez, Grant Scobie and John Dillon (eds.). Ames Iowa State University Press.

Dhanakumar, V.G. and G. Perumal (1986) Constraints and technological gap in adoption of conservation technology in dryland areas of Kovilpatti in India. *Rural Development Journal* 1-2: 437-440.

Dillon, J.L. and P.L. Scandizzo (1978). Risk attitudes of subsistence farmers of northeast Brazil: a sampling approach. *American Journal of Agricultural Economics*, Vol. 60.

Doll, J. P. and F. Orazem (1984). *Production economics: theory with applications*, 2nd ed. New York: Wiley.

Dumanski, J. (1987). Evaluating the sustainability of agricultural system. In: *Africa land development and management of acidic soils in Africa II.* International Board for soil Research and Management, IBSRAM Proc. 7. Bangkok Thailand.

Dumsday, R.G. and D.A. Oram. (1990). Economics of dryland salinity in Murray river basin, Northern victoria, Australia. In: Dixon J.A., James, D.E. and Sherman, P.B (eds.). *Dryland management economic case studies*. Earthscan Publications Ltd, London.

Dykstra, D. P. (1984). *Mathematical programming for natural resource management*. McGraw Hill Company, New York.

East Africa Metrological Department (EAMD) (1975).*Tanganyika and Zanzibar.* Nairobi, Kenya.

Earle, T.R., Rose, C.W. and A.A. Brownlea (1979). Socio-economic predictors of intention toward soil conservation and their implications in environmental management. *Journal of Environmental Management,* 9: 225-236.

Ehui, S.K. and D. S. C. Spencer (1993). Measuring sustainability and economic viability of tropical farming system: a model from Sub-Saharan Africa. *Agricultural economics,* 9 279-296. Elsevier Science Publishers B. V. Amsterdam

Ellis, F. (1988). *Peasants economics*. Cambridge University Press, Cambridge.

Epplin, F.M. and T.F. Tice (1986). Influence of crop and farm size on adoption of soil conservation tillage. *Soil and Water Conservation,* 41(6): 424-427.

Ervin, C.A. (1981). Factors affecting the use of soil conservation practices: an analysis of farmers in Monroe County, Missouri.

Ervin, D. E. and R. A. Washburn (1981). Profitability and soil conservation in Missouri. *Journal of soil Water Conservation,* 36:107-111.

Ervin, C.A. and D.E. Ervin (1982). Factors affecting the use of soil conservation practices: hypotheses, evidence and policy implications. *Land Economics*, Vol. 58, no. 3: 277-292.

Ezaza, W.P. (1992). An assessment of sociological impacts on East African mountains and highland environments: A case study from Tanzania. *Mountain research and development,* Vol. 12, no. 4 pp. 401-408.

FAO (1980). *Perspective study of agricultural development for Tanzania: Cental Paper.*

FAO (1983). *Keeping the land alive - causes and cures.* By Kelly, H.W. (consultant), FAO/GTZ, Rome Italy.

FAO (1990). *The conservation and rehabilitation of African lands. Towards sustainable agriculture.* An international scheme. Food and Agriculture Organization of the United Nations. Rome, Italy.

FAO (1991). Issues and perspectives in sustainable agriculture and rural development: *Main document no. 1.* FAO/Netherlands conference on agriculture and environment. Hertogenbosch, The Netherlands, 15-19 April, 1991, FAO, Rome.

Featherstone, A.M. and Goodwin B.K. (1993). Factors influencing farmer's decision to invest in long-term conservation improvements. *Land Economics,* 69(1): 67-81.

Feder, G., and Umali, D.L. (1993). The adoption of agricultural innovations: A review. *Technological Forecasting and Social Change,* 43(21): 5-239.

Feder, G., Just, R.E., and Zilberman, D., (1985) Adoption of agricultural innovations in developing countries: A survey. *Economic development and cultural change,* 33: 255-298.

Feder, G. and T. O'mara, G. (1982). On information and innovation diffusion: a Bayesian approach. *American Journal of Agricultural Economics,* 64: 145-147.

Feder, G. (1980). Farm size risk aversion and the adoption of new technology. *Oxford Economic Papers,* 32: 273-283.

Feierman, S. (1984). *Defending the promise of subsistence: population growth and agriculture in West Usambara mountains, 1920-1980.* University of Wisconsin Press, Madison, USA.

Fresco, L.O. and S.B. Kroonenberg (1992). Time and spatial scales in ecological sustainability. *Land use policy,* July, 1992.

Fungameza, D. (1992). *Study on the indigenous land use systems in north Pare mountains with special reference to wagweno and wasangi ethnic.* An Appraisal conducted for GTZ/TFAP, North Pare.

Fungameza, D. and Frischenich, G. (1992). *Village based land use planning: from conflict to partnership in management of natural resources by local communities in Mwanga district, Tanzania.* The GTZ-TFAP, north Pare project.

Gibbs, M., R.K. and A.J. Fischer (1987). The discovery of innovations by farmers. *The Journal of Australian Institute of Agricultural Sciences,* 53(4).

Gould, B.W., Saupe, W.E. and R.M. Klemme (1989). The role of farm and operator characteristics and the perception of soil erosion. *Land Economics* Vol. 65(2): 167-182.

Green, W. (1983a). Estimation of limited dependent variable models by ordinary least squares and method of moments. *Journal of Economics,* 21: 195-212.

Green, W. (1990). *Econometric Analysis, 1st ed.* New York: Macmillan publishing company.

Griliches, Z. (1957). Hybrid corn: An exploration in economics of technological change. *Econometrica,* 25: 501-22

Glückert, W.M. (1994). *A report on socio-economic survey.* GTZ/TFAP, North Pare.

Hamal, K.B. and J.R. Anderson (1982). A note on decreasing absolute risk aversion among farmers in Nepal. *Australian Journal of Agricultural Economics*, Vol. 26, (3): 220-225.

Hansen, D. O, Erbaugh, and Napier, T. (1987). Factors related to adoption of soil conservation practices in Dominican Republic. *Journal of soil and water conservation,* 42 (5): 367-369.

Harwood, R.R. and E.C. Price (1976). Multiple cropping in tropical Asia. In: Papendick, R.I.; P.A. Sanchez and G.B. Triplett (eds). *Multiple cropping.* Wisconsin.

Haswell, M. (1970). *The economics of subsistence agriculture. 4th ed.* London: Tropical agriculture series.

Hayami, Y. And V.W. Ruttan (1971). Actors prices and technical change in agricultural development. *Journal of Political Economics,* 78, 1115-1141.

Hiebert, D. (1974) Risk, learning and the adoption of fertilizer responsive seed varieties. *American Journal of Agricultural economics,* 56, 764-68.

Hoover, H., and Wiitala, M. (1980). Soil erosion and sediment control: some obstacles and remedies. *Natural resource economics division, economics, statistics and cooperative service, U.S. department of agriculture,* Washington D.C.

ICRA (International Centre for development oriented research in Agriculture) (1992). Coming down the Mountain: A study of Agriculture on the slopes of Mount Kilimanjaro, Tanzania : *working document series* 21, Tanzania.

IFAD, (1992). *Soil and water conservation in sub-Saharan Africa: towards sustainable production by rural poor.* Amsterdam, The Netherlands.

IUCN (International Union for the Conservation of Nature and Natural Resources) (1980). World conservation strategy: living resource conservation for sustainable development. IUCN-UNEP-WWF, Gland, Switzerland.

Judge, G., C. Hill, W. Griffith, and T. Lee (1985). *Theory and practice of econometrics.* New York: John Wiley and Sons.

Just R.E and Zilberman D. (1985). *Adoption of agricultural innovations in Developing Countries: a survey.* The University of Chicago.

Jamnick, S.F. and T.H. Klindt (1985). An analysis of no tillage practice decisions. *Bulletin of Agricultural Experiment Station,* University of Tennessee, (635).

Kajembe, G.C. (1994). Indigenous management systems as a basis for community forestry in Tanzania. A case study of Dodoma Urban and Lushoto districts. *Tropical resource management paper no. 6, Wageningen Agricultural University,* Wageningen.

Kayombo, B. and G.C. Mrema (1994). Soil conservation, mechanization and sustainability of agricultural systems in Africa: A critical review. *NAMA Newsletter,* Vol. 2, No. 1&2, Review Essay No. 4.

Kevin, P.A. (1994). Socioeconomic modelling of agricultural land degradation. In: *System-oriented research in agriculture and rural development,* pp 376-380.

Kimambo, I.N. (1991). *Penetration and protest in Tanzania. The impact of world economy in Pare, 1860-1960.* James Currey, London.

Klennert, K. (1986). Rural development and careful utilization of natural resources, case of Pakistan and Sudan. *Agriculture ecosystem and environment,* 48 (1): 134-149.

Klonglan, G.E. and E. Coward, Jr. (1970). *The concept of symbolic adoption: a suggested interpretation.* Rural Sociology Research unit, Department of Sociology and Anthropology, Ames, Iowa State University.

Kocher, J.E. (1976). Social, economic and demographic characteristics of some rural areas in Lushoto and Moshi districts. University of Dar es Salaam, *BRALUP, Research Report* no. 44.

Kooreman,P. And A. Kapteyn (1987). A desegregated analysis of the allocation of time within the household, *Journal of Political Economy*, 95: 223-249.

Korsching, P.F. and P.J. Nowak (1983) Soil erosion awareness and use of conservation tillage for water quality control. *Water Resource Bulletin,* 19 (3): 459-462.

Korsching, P.F. (1984) Farm structural characteristics, institutional support and the use of soil and water conservation technologies. *Paper prepared for presentation at 1984 annual meeting of southern association of agricultural scientists,* Nashville, Tennessee, 6-9 February, 1984.

Kramer, R.A., McSweeny, W.T., and R.W. Stavros (1983). Soil conservation with uncertain revenues and input supplies. *American Agricultural Journal of Agricultural Economics, 65: 694-702.*

Kruseman G., Hengstdijk, H. and R. Reuben (1993). Disentangling the concept of sustainability: conceptual definitions, analytical framework and operational techniques in sustainable land use. DLV Report no. 2 DLO/Department of Development Economics-WAU, Wageningen.

Kuiper, M. (1997). The impact of land degradation on agricultural productivity: a multi-period economic land use model with a case study of the Naguev settlement, Costa Rica. A thesis in development and environmental economics.

Lal, R. (1985). Soil Erosion and sediment transport research in tropical Africa. *Hydrological Sciences Journal- Des Sciences Hydroligiques, Vol. 30.*

Lal, R. And Singh, B. R. (1994). Research priorities in Soil Management for Sustainable land Use. *Norwegian Journal of Agricultural Sciences*. Supplement No. 21

Lal, (1977). Soil Conserving versus Soil degrading crops and soil management for erosion control. In: Greenland, D.J. and R. Lal (eds.). *Soil conservation and management in the humid tropics.* John Willey and sons, Chichester, Newyory..

Lal, R. (1987). Managing the soils of Sub-Saharan Africa, *Science,* 236: 1069-1076.

Land Resource Development Centre (1987). Tanzania profile of agricultural potential. *Overseas Development Administration,* Tolworth tower, Surbiton, Surrey KT6 &DY, England.

Leathers, H.D., and Smale, M.A. (1991). Bayesian approach to explaining sequential adoption of components of a technological package, *American Journal of Agricultural Economics* 68, 519- 527.

Lee, L.K. (1980). The impact of land ownership factors on soil conservation. *American Journal Agricultural Economics*, 63:1070-1076

Lee, L.K. and W.H. Stewart (1983). Land ownership and adoption of minimum tillage. *American Journal of Agricultural Economics*, 65 (2), 256-264.

Lema, A.J. (1993). Exemplar land use and natural resource management practices of the Chagga farmers on the slopes of Mt. Kilimanjaro, N. E Tanzania. *Report prepared for the Centre for international Development of world resources institute*, Washington D. C. , USA

Leon-Verlade, Carlos, U., Muñoz, Hector, Davis, Peter, Quiroz, Arce, Blanca (1994). *Systems Oriented Research in Agriculture and Rural Development.*

Lin, N., Leu, D.J., Rogers, E.M. and D.F. Schwartz (1966). The diffusion of innovation: institution building though change. East Lansing Institute of International Studies in Education and Department of Communication, Michigan State University.

Lindner, R.K., Fischer, A.J. and P. Pardey (1979). The time to Adoption. *Economic letters*, No. 2: 187-90.

Lindner, R.K. (1980). Farm size and the time lag to adoption of a scale neutral innovation. *Mimeographed.* Adelaide: University of Adelaide.

Lindner, R. K., and Ficher, A.J. (1981). Risk aversion, information quality and the innovation adoption time lag. *Economics Department Working Paper,* 81-17, University of Adelaide.

Lindner, R.K., Pardey, P.G. and Jarrett F.G. (1982). Distance to innovation source and the time lag to early adoption of trace elements fertilizer. *Australian Journal of Agricultural Economics,* Aug.: 98-113.

Lipton, M. (1976). Agricultural finance and rural credit in poor countries. *World Development,* 4: 543-54.

Lockeretz, W. (1990). What have we learned about who conserves soil? *Journal of Soil and Water Conservation* (Sept-Oct.): 517-524.

Lopez-Pereira, M. A., Sanders, J. H. Baker, G. T. and Preckel P. V. (1994). Economics of erosion control and seed fertilizer technologies for hillside farming in Honduras. *Agricultural Economics,* 11: 271-288, Elsevier B. V.

Low, A.R.C. (1986). Decision making under uncertainty: A linear programming model of peasant farmer behaviour, *Journal of agricultural economics,* 25: 311-22.

Lundgren, B. (1978). Soil conditions and nutrient recycling under natural and plant forests in Tanzanian highlands. *Swedish university of Agricultural sciences, reports of forest ecology and forest soils.* Department of forest soils, SUAS, No. 31.

Lutz, E. Pagiola, S. and C. Rieche (1994). Lessons from economic and institutional analyses of soil conservation projects in central America and Caribbean. *Economic and institutional analyses of soil conservation projects in central America and Caribbean.* Washington D.C.: The World Bank.

Lynam, J.K. and R.W. Herdit (1989). Sense and sustainability: sustainability as an objective in international agricultural research. *Agricultural Economics, Vol 3:* 381-398.

Lynne, G.D. Shonkwiler, J.S. and L. Rola (1988). Attitudes and farmer conservation behaviour. *American Journal of Agricultural Economics,* 70 (1): 12-19.

Maddala, G. (1983). *Limited Dependent and Qualitative Variables in Econometrics.* New York: Cambridge University Press.

Maddala, G. (1992). *Introduction to econometrics, 2nd ed.* New York: Macmillan.

Maher, C. (1950). Soil Conservation in Kenya colony, Part I: factors affecting erosion, soil characteristics and methods of conservation; Part II: Soil conservation practice: organization and legislation, present position and outlook. *In the empire Journal of Experimental Agriculture:* Vol. XVIII (1950): No. 71, 137-149; No. 72, 233-248.

Maimu, Z. (1993). *The Impact of Agricultural modernization on ecological sustainability and position of female farmers on the slopes of Mount Kilimanjaro, Tanzania.* A research report in partial fulfilment of MSc. degree in ecological agriculture at Wageningen Agricultural University, Department of Gender studies and Department of Ecological Agriculture.

Mann, C.K. (1978). Packages of practices: a step at a time with clusters. *Studies in Development,* 21, pp. 73-81.

Mayawalla, A.E.J. (1994) Structural adjustment policies and mange of soil and forest resources in Tanzania. *Norwegian Journal of Agricultural Sciences.* Supplementary No. 21: 45-46.

McConell, K. (1983). An economic model of soil conservation. *American Journal of Agricultural economics, 65: 83-89.*

McClelland, D.C., and D.G. Winter (1969). *Motivating economic achievement.* New York: Free Press.

McGuire W.J. (1976). The concepts of attitudes and their relations to behaviours. In: Sinairo, H.W. and Broedling, L.A. (eds). *Perspectives on attitude assessment: Surveys and their alternatives.* Champagne, Illinois.

McSweeny, W.T. and Kramer, R.A. (1986). Soil conservation with uncertain revenue and input supplies: Reply, *American Journal of Agricultural Economics,* 71: 361-362.

Meadows, D.H. et al. (1972). *The limits to growth.* Universe books, New York.

Mills B. and J. Kagwanja (1994). *Agricultural research priority setting to ensure sustainable agricultural production in Kenya.* Kenya Agricultural Research Institute.

Ministry of Tourism, Natural Resources and Environment (MTNRE) (1994). *Tanzania National Environment Action Plan: a first step,* June, 1994.

Miranowski, J.A. (1984). Impacts of productivity loss on crop production and management in a dynamic economic model. *American Journal of Agricultural Economics, February: 61-71.*

Mitzlaff, B. (1988). *Women farmers or farmers wives.* A consultancy report for GTZ/SECAP.

Montanez, G. (1985). *Land use, soil erosion, and farmers' attitudes towards conservation: basis for land management policies in Las Cuevas watershed, Dominican Republic.* Unpublished doctoral dissertation, University of Florida.

Moran, E.F. (1987). *Monitoring fertility degradation of agricultural land in lowland tropics.* In: Little, P.D, Horowitz, M.M. and A.E. Nyerges (eds), pp. 69-91. Lands at risk in the third world, (eds). Boulder, CO: Westview.

Morgan, R.P.C. (1986). *Soil erosion and conservation.* Longmans, Essex, UK., 298 pp.

Mshana, R.R. (1992). *Insisting upon peoples' knowledge to resist developmentalism: peasant communities as producers of knowledge for social transformation in Tanzania.* Zulg.: Frankfurt (Main), university diss..

Mwihomeke, s. (1986). Performance of various tree species planted in Lushoto district to test their suitability for agroforestry. GTZ/SECAP.

Mvungi, A.A.K. (1992). Scio-cultural analysis of North Pare mountains: the Wagweno and Wasangi. *Final Report submitted to GTZ/TFAP*, Mwanga.

Nakajima, C. (1969). Subsistence and Commercial Family Farms: Some theoretical models of subjective equilibrium, pp. 165-85. In: C.R. Wharton (eds). *Subsistence agriculture and economic development.* Aldine, Chicago.

Napier, T.L., Napier, A.S. and Tucker, M.A. (1991). The social economic and institutional factors affecting adoption and continued use of soil conservation practices: the Asian experience. *Soil and Tillage Research*, 20: 365-382.

Ninez, V.K. (1984). Household gardens: theoretical considerations on an old survival strategy. Lima: CIP report. *Potatoes in food systems research*, No. 1.

Nkonya, E.M. et al. (1991). Arumeru district diagnostic survey. *Final Report presented to National FSR Coordinating Committee Meeting*, SUA Morogoro.

Nkonya, E.M., Schroeder, T. And D. Norman (1995). *Factors affecting adoption of improved maize seed and fertilizer in northern Tanzania.* Department of agricultural economics. Kansas State University.

Norris, P.E. and Batie, S.S. (1987). Virginia farmers' soil conservation decisions: an application of tobit analysis. *Southern Journal of Agricultural Economics*, 19: 79-90.

Norman, D.W. (1974). Rationalizing mixed cropping under indigenous conditions: the example of Northern Nigeria. *Journal of development studies*, Vol. 11.

Norman, D.W. (1977). Economic rationality of traditional Hausa dryland farmers in the North of Nigeria. In: Steven, R.D. (eds). *Tradition and dynamics in small-farm agriculture.* Ames: Iowa State University Press.

Nowak, P.J. and P.F. Korsching (1982). Social and institutional factors affecting the adoption and maintenance of agricultural BMPs. In: Shaller, F. And Bailey, G. (eds.) *(1983). Agricultural management and water quality.* Iowa soil and water conservation society.

Nowak, P.J., and Wagener, D. (1981). Risk and social position in explaining the adoption of soil conservation practices: an application of cancian's thesis. *A paper presented at annual meeting of American Agricultural Economist Association,* Clemson, S.C., July, 1981. Journal paper No. J-10355 of the Iowa Agriculture and Home Economics Experiment station, Ames, Iowa.

Nowak, P.J. (1992).Why farmers adopt production technology: *Journal of soil and water conservation,* 47, 14-16.

Nowak, P.J. (1993). The adoption of agricultural natural resource management practices: A critical review. *Discussion paper prepared for the soil and water conservation society task force on socio-economic research,* Minneapolis, April 29-30, 1993.

Oldeman, L. R. (1992). Global Extent of Land Degradation. Bi-annual Report: ISRC, Wageningen, The Netherlands.

O'mara, G. (1971). *A decision-theoretic view of technique diffusion in a developing country.* Ph.D dissertation, Stanford University.

Pampel, F. Jr. and J.C. Van Es (1977). Environmental quality and issues of adoption research. *Rural Sociology,* 42 (1): 57-71

Pradhan, J., and Quilkey, J., (1991). Modelling adoption of HYV in developing economies: Theory and empirics. *Paper presented at the Conference on Mechanisms of Socio-Economic change in Rural areas,* 25-27, 1991, Australian National University, Canberra, Australia.

Pearce, D.E., Barbier and A. Markandya (1989). *Sustainable Development: Economics and the environment in the third world.* Earthscan Publications, London.

Pezzey, J. (1989). Economic analysis of sustainable growth development. *World Bank Environment Department*, Working Paper No. 15.

Pfeiffer, R. (1990). *Sustainable Agriculture in practice*: the production potential and environmental effects of macrocontourlines in west Usambara Mountains, Tanzania.

Pike, (1965). In: Lema, A.J. (1993). Exemplar land use and natural resource management practices of the Chagga farmers on the slopes of Mt. Kilimanjaro, N. E Tanzania. *Report prepared for the Centre for international Development of world resources Institute*, Washington D. C. , USA.

Pimentel, D., Havey C. Resosudamo, P. Sinclair, K., Kurz, D. McNair, M., Crist, S., Shpritz, L. Fitton, L., Saffouri, R. And R. Blair (1995). Environmental and economic costs of soil erosion and conservation benefits. *Science,* Vol. 267, No. 5201, February 24: 1117-1123.

Rahm, M.R. and Huffman, W.E. (1984). The adoption of reduced tillage: the role of human capital and other variables. *American Journal of Agricultural Economics,* 66 (4): 405-413.

Rogers, E.M. and F.F Shoemaker (1968). *Communication of innovations*. New York: Free Press.

Rogers E.M. and L. Svenning (1969). *Modernization among peasants*. New York: Holt, Rinehart and Winston.

Rogers, E.M. and F.F. Shoemaker (1971). *Communication of innovations*. New York: Free Press.

Royal Tropical Institute (KIT) (1992). *Agriculture economics and sustainability in the Sahel. Papers presented at the third Sahel Seminar.* Heerink, N., Kuvenhoven, A., Tilburg, A. van (eds). KIT, May, 1992.

Ruthernberg, H. (1964). *Coffee-Banana Farms at Mt. Kilimanjaro. the Evolution of integrated farming system*, Ifo-Inst.Nr 2, Berlin-Heidelberg-New York.

Salem, M.A. (1983). Economics of reduced tillage technology on soil conservation and risk analysis of eastern Oklahoma farmers. Unpublished doctoral dissertation, Oklahoma State University, Stillwater, Oklahoma. In: Nowak, P.J. Dhanakumar, V.G. and M.M., Zinnah (1983). *Annotated Bibliography of studies related to the adoption and diffusion of natural resource management practices,* Department of Rural Sociology. University of Wisconsin-Madison, Madison, Wisconsin.

Saliba, B.C. (1985). Soil productivity and farmers' erosion control incentives: a dynamic modelling approach. *Western Journal of Agricultural economics,* 10(2), 354-364.

Saliba, B.C. and D.W. Bombley (1986). Soil management decision: How should they be compared and what variables influence them? *North Central Journal of Agricultural Economics,* 8(2): 305-317.

Schafer, B., and Tait, J.L. (1990). *A guide for understanding attitude and attitude change*. Iowa Cooperative Service, Ames: Iowa State University.

Scheinmann, D. (1986). *Caring for land of Usambara. A guide to preserving the environment through agriculture, agroforestry, and zero grazing*. SECAP, Lushoto, Tanzania. Published by GTZ, Enschborn, West Germany.

Schipper, R.A. Jansen, D.M. and J.J. Stoorvogel (1995). Sub-regional linear programming models in land use analysis: a case study of the Neguev Settlement, Costa Rica. *Draft paper*. Department of Development Economics, Wageningen Agricultural University.

Schultz, T.W. (1968). *Economic growth and agriculture*. New York, McGraw-Hill.

Shultz T.W. (1964). *Transforming traditional agriculture*. New Haven; Conn.: Yale University Press.

Scott, J.C. (1973). *The moral economy of the peasant*. New Heaven: Yale University Press.

SECAP, (1987). *Soil erosion control and agroforestry in the west Usambara mountains: evaluation of an extension approach*. By: Wotek, R., Bähring, A., Dersch, D., Habermehl, J., Kaufmann, P., Könemund, G. and M. Weitz. Centre for advanced training in Agricultural Development, Technical University of Berlin.

Setia, P.P (1985). *Simulating the adoption of soil conservation management systems under the conditions of uncertainty*, University of Illinois at Urbana-Champaign.

Sharman, C. (1959). Conservation comment from Umvukwes ICA: *Rhodesia Agricultural Journal*, 56, No. 4: 153-154.

Shelukindo, H. and K. Gaudens (1993). Development, experience and reorientation of soil erosion control and agroforestry activities in the West Usambara mountains, Tanzania. *Paper presented in the Workshop on National Agroforestry and Environment, SUA,* Morogoro-Tanzania 12-13 October, 1993.

Shelukindo, H. (eds.)(1995). Technical recommendations for soil and water conservation mesures and agroforestry systems: Biological and physical soil and water conservation measures. *Prepared by Technical Committee SECAP/TIP*, Lushoto.

Shenkalwa, E.M. (1989). *Evaluation of erosion control in Tanzania by soil physio-Chemical Analysis*. A thesis submitted to the State University of Ghent in partial fulfilment of the requirements for the degree of master of soil science. International training centre for post graduate soil scientists.

Sianga, C.W. (1994). Land has come back: lessons from soil conservation project in Dodoma region of Tanzania. *Norwegian Journal of Agricultural Sciences. Supplement No. 21.* Ås Science Park, Ltd., Norway.

Sjarkowi, F. (1986). *Soil erosion and yield uncertainty in the soil conservation decision*. Doctoral dissertation, University of Kentucky.

Shortle J.S. and J.A Miranowski (1986). Effects of risk perceptions and other characteristics of farmer and farm operators on the adoption of soil conservation tillage practices. *Applied Agricultural Research,* 1(2): 85-90.

Shortle, J.S. and J.A. Miranowski (1992). A dynamic analysis of cropland erosion control policy. *Washington DC: Resources for the Future Disc. Pap.* D-90, Feb. 1992.

Sinden, J.A and D.A. King (1990). Adoption of soil conservation measures in Manilla Shire, New South Wales. *Review of Marketing and Agricultural Economics*, 58: 180-192.

Stocking, M.A. (1988). Assessing vegetative cover and management effects. In: Lal, R. (Eds.). *Soil erosion research methods*. International society of soil science: Wageningen pp. 163-186.

Stomp, T.J. and L.O. Fresco (1991). *Describing agricultural land use: a proposal for procedures, data base and user's manual*. Draft report, FAO Rome, ITC Enschede, WAU, Wageningen.

Stoorvogel, J.J. and E.M.A. Smalling (1990). *Assessment of soil nutrient depletion in sub-Saharan Africa: 1983-2000*. Vol. I, main report. The Winand Staring Center, Wageningen, The Netherlands, report No. 28.

Svein, I. (1991). *The Usambara mountains in Tanzania: History, vegetation and conservation*. TIRDEP, Tanga.

Thampapillai, D.J. and J.R. Anderson (1994). A review of the socio-economic analysis of soil degradation problems for developed and developing countries. *Review of Marketing and Agricultural Economics*, Vol. 62, No. 3, Australian Agricultural Economics Society.

Thomas, D.B. (1991). Choosing conservation measures for cropland on smallholdings in Kenya. Department of Agricultural Engineering, University of Nairobi. *Paper prepared for the International Workshop on soil and water management for sustainable smallholder development*. Nyeri, Kenya and Arusha, Tanzania

Thomas, J.F. (1989). Regional land use planning: the Murray river catchment of western Australia. In: Dixon, A.J., James, D.E. and P.B. Sherman (eds.). *Dryland Management, Economic Case Studies*. Earthscah Publications Ltd, London.

Tisdell, C. (1995). *Economic indicators to assess the sustainability of conservation farming projects*. Department of Economics, discussion paper No. 167. University of Queensland, Australia.

Troeh, F.R., Hobbs, J.A., and R.L. Donahue (1980). *Soil and water conservation for productivity and environmental protection*. Printice Hall, New Jersey.

Tylor, D.L., and W.L. Miller (1978). The adoption process and environmental innovations: a case study of government project. *Rural Sociology*, 43(4), pp. 634-648.

Upton, M. (1987). *African Farm Management*. Department of Agricultural Economics and Farm Management, University of Reading, Cambridge University Press, New York

Upton, M. (1973). *Farm management in Africa: the principles of production and Planning*. London, Oxford University Press.

van Kooten, G.C. (1993). *Land resource economics and sustainable development: Economic policies and the common good*. UBC Press, Vancouver.

Veloz, A. Southgate, D. Hitzhusen, F. and MacGregor R. (1985). The economics of erosion control in a subtropical watershed: A Dominican case. *Land Economics*, 61(2): 145-155.

Wales, T.J. and A.D. Woodland (1977). Estimation of the allocation of time for work, leisure and housework. Econometrica, 45:115-132.

Walker, D.J. (1982). A damage function to evaluate erosion control economics. *American Journal of Agricultural Economics, 64:690-698.*

Walker, D.J. and Young, D.L. (1986). The effect of technological progress on erosion damage and economic incentives for soil conservation. *Land Economics, 72*: 104-113.

WCED (The World Commission on Environment and Development) (1987). *Our common Future.* "The Brundtland report", Oxford University press, Oxford.

Wilkening, E. A., and D. Johnson (1961). Goals in farm decision making as related to practice *adoption. Wisconsin Agricultural Experimentation Station, Research Bulletin,* No. 225.Madison, Wisconsin.

Wollenberg, E.K. (1992). Urban markets and rural resource productivity. In: Bonnard, P.J. (1995). *Land Tenure, Land titling and Adoption of Improved Soil Management Practices in Honduras.* Unpublished PhD Dissertation. Michigan State University.

Wossink G.A.A., de Buck, A.J., van Niejenhuis, H.J., and H.C.M. Haverkamp (1987). Farmer perception of weed control techniques in sugarbeet. *Journal of Agricultural Systems,* Autumn, 1987.

World Bank (1984). The world development report. World Bank, Wshington, D.C.

World Bank (1987). Environment, growth and development. *Development Committee Pamphlet,* 14, World Bank, Washington D.C.

World Bank (1992). The *World Bank atlas*. The World Bank, Washington DC.

World Bank, (1969-1995). *World tables (various issues)*. John Hopkins Press.

Yotopoulos, P.A. (1968). On efficiency of resource utilization in subsistence agriculture. *Food Research Institute Studies,* Vol. 8, No. 2.

Yotopoulos, P.A. and J.B. Nugent (1976). *Economics of development*: *empirical investigations*. New York: Harper& Row, Chapter 9.

Inleiding

Het noordoostelijk gebergte van Tanzania, bestaande uit vier regio's (Kilimanjaro, Meru, Pare en Umbara) vormt het belangrijkste deel van het totale landbouwareaal. Dit gebied heeft een snelle bevolkingsgroei gekend die tot een stijgende vraag naar voedsel, brandhout en landbouwgrond leidde. In de meeste delen van de hellingen is als gevolg van de continue bebeouwing en andere faktoren sprake van een dalende bodemvruchtbaarheid en ernstige erosie. De agragrische produktiviteit is daardoor teruggelopen, met ernstige voedseltekorten als resultaat.

Het doel van deze studie is om het gedrag van huishoudens ten aanzien van het gebruik van verbeterde bodem conserveringsmaatregelen om zo de bodemerosie en de dalende bodemproductiviteit tegen te gaan. Het doel is een duurzame landbouw te creëren in de noordoostelijke bergstreek van Tanzania, daarbij gebruik makend van onze bevindingen in de noordelijke Pare en westelijke Usambara bergstreek. Daarnaast is deze studie opgezet om meer inzicht te krijgen in de beleidsimplicaties en de beleidsaanbevelingen met het oog op een duurzame landbouw in het betreffende gebied. Meer in het bij zonder ging het daarbij om de volgende vragen:

1) Wat beïnvloedt de perceptie van de huishoudens ten aanzien van het probleem van de bodemerosie?

2) Welke factoren spelen een rol bij de beslissingen die huishoudens nemen als het gaat om de keuze voor verschillende bodemconserveringstechnieken en maatregelen?

3) Wat bepaalt de inspanningen gericht op de bestrijding van erosie en het behoud van water van de adopters?

4) Hoe kunnen beleid en institutionele arrangementen worden ingezet om een duurzaam gebruik van bodem en water te garanderen?

De veronderstelling is dat de adoptie van bodembesparende maatregelen en het investeringsniveau in duurzame teelttechnieken de middelen vormen om een duurzame landbouw in het betreffende gebied te creeren.

Theorie

Om de adoptie van verbeterde (i.t.t. de traditionele vaak weinig effectieve) bodemconserveringstechnieken te verklaren wordt een interdisciplinaire benadering gevolgd, gebaseerd op zowel sociologische als faktoren. Met het oog daarop worden verschillende sociologische en economische innovatietheorieën en modellen besproken. Daarnaast wordt een overzicht gegeven van empirische studies om de verschillende benaderingen te illustreren en om te laten zien wat de 'state of the art' op dit moment is. Vervolgens wordt op basis van the theorieverkenning en het literatuuroverzicht een analysekader en een besluitvormingsmodel voor de adoptie van verbeterde bodemconserveringstechnieken ontworpen. Het analytisch framework is gebaseerd op de benadering van Ervin en Ervin (1982). Drie componenten van het adoptiebeslissingsproces worden daarin met elkaar in verband gebracht: de perceptie van het erosieprobleem, de beslissing om verbeterde bodemconserveringstechnieken toe te passen en het niveau van de investeringen, ofwel de inspanning gericht op bodemconservering door de adopters.

Gesteld wordt dat de perceptie van het bodemerosieprobleem leidt tot de adoptie van bodemconserverende technieken. Bovendien wordt verondersteld dat de adoptiebeslissingen van de huishoudens worden bepaald door de bereidheid en mogelijkheid om bodemconserverende maatregelen te treffen. Wanneer een huishouden eenmaal besloten heeft tot adoptie van bodemconserverende maatregelen, wordt vervolgens besloten hoeveel er zal worden geinvesteerd in bodembesparende maatregelen. Huishoudens die de bodemersosie niet als een probleem ervaren, zullen, vanwege hun geringe belangstelling ervoor, niet overgaan tot adoptie van bodemconserverende technieken.

Empirisch model

In de periode 1995-1996 is een onderzoek uitgevoerd in de westelijke Usambara bergstreek (het Lushoto district) en de noordelijke Pare bergstreek (het Mwanga district).

De dataverzameling vond plaats in twee fasen. De eerste fase bestond uit de verzameling van algemene informatie uit het studiegebeid (verkennende enquete). De onderdelen van deze fase waren: 1) een overzicht van de secundaire informatie afkomstig uit verschillende publicaties en rapporten; 2) informele gesprekken met sleutelfiguren, hoofden van huishoudens en groepen van hoofden van huishoudens. De tweede fase omvatte de verzameling van bedrijfsgegevens door middel van een steekproef uit de verzameling van hoofden van huishoudens. Deze gegevens werden verkregen via interviews waarin gebruik werd gemaakt van een gestructureerde vragenlijst. De interviews spitsten zich toe op de karakteristieken van de huishouding, de sociaal-economische aspecten van het erosieprobleem, de gebruikte bodemconserveringsmaatregelen, visie en attitude ten aanzien van de bodemerosie en bodemconservering voorlichtingsvoorzieningen, participatie in bodemconserveringsprogramma's en economische karakteristieken zoals inkomen, bedrijfsomvang, arbeid, aantal dieren en vermogenspositie.

Voor de studie zijn drie empirische modellen ontwikkeld, te weten het perceptiemodel voor de perceptie van het bodemerosieprobleem, een model voor de adoptie van bodemconserverings maatregelen en een model dat de inspanning ten aanzien van bodemconservering verklaart. Verschillende sociaal-economische, intitutionele en fysieke factoren fungeerden als afhankelijk variabelen in deze modellen. Teneinde de de effecten van de onafhankelijke variabelen op de kans dat een hoofd van een huishouden erosie als een probleem ervaart en besluit tot de adoptie bodemconserveringstechnieken te bepalen werden in de empirische analyse binomiale logit modelen geschat. Met behulp van een Poisson regressiemodel werd achterhaald welke factoren de inspanningsintensiteit (investeringsniveau gericht op bodemconservering) van de huishoudens bepalen.

Empirische resultaten

De uitkomsten van de studie maken duidelijk dat een groot deel van de huishoudens in het onderzochte gebied bodemerosie als een probleem ervaren en dat meer dan de helft ervan verbeterde bodemconserveringstechnieken gebruiken. Wat eveneens duidelijk wordt is dat er verschillende type conserveringsmaatregelen worden genomen om de erosie tegen te gaan. Hoewel de meerderheid van de huishoudens traditionele conserveringstechnieken zoals combinatie van houtwallen en landbouw en afscheidingen van dicht gras (de zogenaamde trash lines)gebruiken, zijn fysische (terrassen) en semi-fysische maatregelen ook niet ongebruikelijk.

Persoonlijkheidskarakteristieken van de hoofden van de huishoudens (het geslacht, de burgerlijke status), deelname in activiteiten van *Soil and Water Conservation* (SWC) programma's en de bergstreek waar men gevestigd was beleken bepalend te zijn voor de perceptie van het bodemerosieprobleem in het onderzochte gebied. Burgerlijke status en de locatie van het huishouden bleken een bnegatieve invloed op de perceptie van het erosieprobleem te hebben. Alleenstaande hoofden van huishoudens bleken bodemerosie minder als een probleem te ervaren. Dit kan worden veroorzaakt door het verschil in de toegang tot informatie en de mate van blootstelling tussen alleenstaande en getrouwde gezinshoofden. Verder blijkt men in de westelijke Usambara bergen bodemersoei minder als een probleem te ervaren dan on de noordelijke Pare bergen. Deelname in de promotieactiviteiten van SWC-programma's en het geslacht van de gezinshoofden bleek een positieve invloed op de perceptie van het ersoeiprobleem te hebben. Participatie in promotieactiviteiten stimuleert de bewustwording van het erosieprobleem en beïnvloedt daarmee ook de perceptie van het erosieprobleem. Daarnaast bleek uit de gevonden resultaten dat de kans dat erosie als een probleem wordt gezien voor mannelijke gezinshoofden hoger is dan voor vrouwelijke.

De beslissing om al dan niet bodemconserveringstechnieken toe te passen wordt bepaald door de economische positie van de huishouding, in het bijzonder door de aanwezigheid van cash crops en de bedrijfsgrootte. Daarnaast blijken institutionele steun via de SWC-programma's en de deelname aan (zelfgeorganiseerde) arbeidspools (kiwili/ vikwa)van belang te zijn als prikkels om bodemconseveringstechnieken in te zetten. De ranking van het bodemersoieprobleem blijkt ook een belangrijk factor te zijn om er toe over te gaan conserveringsmaatregelen te nemen. Verder laten de resultaten zien dat de mate van kennis die huishoudens ten aanzien van het erosieprobleem hebben de waarschijnlijkheid van adoptie van conserveringsmaatregelen beinvloedt. Mogelijke verklaringen zijn dat inkomensgenererende activiteiten buiten het eigen bedrijf de tijd verminderen die beschikbaar is om op het eigen bedrijf te werken en dat zij die inkomsten van buiten het eigen bedrijf genieten minder geinteresserd zijn in de bodemkwaliteit, juist vanwege die overige inkomsten.

Het is op basis van dit onderzoek evident dat sociaal economische en institutionele faktoren het investeringsniveau met betrekking tot bodemconservering beinvloeden. Van significante betekenis is de support via de SWC programma's, in het bijzonder de opleidingsactiviteiten zoals trainingen op dorpsniveau, dorpsexcursies, en informatie via de media en de deelname in conserveringsplanning. Daarnaast zijn het niveau van de gezinsarbeid, van de inkomsten van buiten het bedrijf en de wijze waarop de huishouding het bodemerosieprobleem beoordeelt sterke bepalende faktoren terverklaring van het investeringsniveau in conserveringsmaatregelen. Overige determinanten zijn het aantal voorlichtingsbezoeken, het opleidingsniveau van de huishouding, de deelname aan arbeidspools en de inkomsten van buiten het agrarisch bedrijf.

Belangrijkste conclusies en aanbevelingen

Het onderzoek maakt duidelijk dat de beslissing om verbeterde bodemconserveringstechnieken toe te passen en de mate waarin deze worden ingezet twee gescheiden beslissingen zijn. Beide beslissingen worden echter beïnvloed door een aantal gemeenschappelijke variabelen. Beide blijken af te hangen van sociologische, economische en institutionele faktoren. Ondanks deze overeenkomsten valt op dat economische en institutionele faktoren een relatief dominante rol spelen bij de beslissing om al dan niet bodemconserverende technieken te gebruiken, terwijl de institutionele faktoren dominat zijn als het gaat om de verklaring van de mate waarin deze technieken worden ingezet (investeringsniveau). Ook bleek dat huishoudkarakteristieken en institutionele factore, in het bijzonder de promotieactiviteiten van SWC-programma's en de mate waarin huishoudens met conserveringsactiviteiten in aanraking kwamen een sleutelrol te spelen in de perceptie van het ersosieprobleem.

Het was op basis van de empirische resultaten niet mogelijk om het algemene volgtijdelijke componenten in het keuzeproces (perceptie, adoptie, investeringen) ten aanzien van de adoptie van verbeterde bodemconserveringstechniken te achterhalen. Zo blijkt de perceptie van het erosieprobleem geen noodzakelijke voorwaarde te zijn voor het gebruik van effectieve bodem- en waterconserverende maatregelen. Ook blijkt de perceptie van het erosieprobleem niet bepalend voor het niveau van de investeringen in conserveringstechnieken door de adopters. Zoals blijkt uit de resultaten gevonden op basis van het gepostuleerde beslissingsmodel is het niet zo dat huishoudens die de erosie als een probleem ervaren dus ook ten gunste van verbeterde boedmconserveringstechnieken beslissen. Echter, niet alle huishoudens die de erosie niet als een probleem blijken te ervaren besluiten om vervolgens ook geen verbeterde SWC technieken in te zetten. Vermoedelijk wordt dit veroorzaakt door de beïnvloeding die van de verschillende promotieactiviteiten van in het gebied draaiende bodemconserveringsprogramma's uitgaat. Deze diensten motiveren mensen om bodemconserverende technieken te gebruiken ondanks hun gebrek aan inzicht in het bodemconserveringsprobleem. De vraag dringt zich op of een dergelijk type adoptie duur-zaam is. Enerzijds kan het antwoord daarop 'ja' zijn voorzover deze prikkels lang genoeg aanwezig blijven zodat dergelijke adopters de voldoende tijd krijgen om hun attitude en perceptie van het erosieprobleem aan te passen en in te zien dat er een negatieve relatie bestaat tussen bodemerosie en grondproduktiviteit. Anderzijds moet het antwoord 'nee' zijn voor zover de prikkels waarop wordt geanticipeerd ophouden voordat het beslissiende inzicht is doorgebroken.

Vanuit dit onderzoekresulteren de volgende aanbevelingen voor het beleid en de institutionele arrangementen nodig voor bodemconservering in het bestudeerde gebied:

1) Het is noodzakelijk dat de overheid zich inzet voor lange termijn bodemconserveringsprogramma's in dit gebied en deze ook probeert verder te versterken.

2) Het beleid en de institutionele support dienen, teneinde de adoptie van verbeterde bodemconserveringstechnieken aan te moedigen, er op gericht te zijn de bereidheid en mogelijkheden van de agrarische huishoudens om conserverende technieken te gebruiken te stimuleren c.q. te verruimen.

3) Om het aantal adopters te laten toenemen is het cruciaal inzicht te verkrijgen waarom sommige huishoudens (non-adopters) er niet to overgaan bodemconserverende technieken te gebruiken.

4) Bodem-en waterconserverinsgprogramma's draaiend in het noordoostelijk berggebied moeten lange termijn ondersteuning en prikkels bieden aan adopters om ervan verzekerd te zijn dat adopters die bodemerosie vooralsnog niet als problematisch ervaren toch de conserverende technieken blijven gebruiken. Dit beleid moet dan hand in hand gaan met inspanningen gericht op een verdere verspreiding van de kennis over het bodemerosieprobleem door training, het gebruik van de media en andere methoden.

In verband met toekomstig onderzoek ten aanzien van de bodemerosieproblematiek worden nog enkele beperkingen van deze studie aangegeven en worden er suggesties gedaan hoe bodemconservering als onderdeel van een duurzame landbouw verder kan worden aangepakt. Daarbij gaat het onder andere om een omvattende analyse van het werkelijke niveau van de reductie van erosieschade bij de adopters, te gebruiken als basis voor schattingen van de produktiviteit in de toekomst. En verder om onderzoek gericht op de identificatie van huishoudadoptiecategorieen met als doel om tot een betere 'targeting' van de institutionele ondersteuning van bodemconservering te komen en om onderzoek dat gebruik maakt van dynamische optimaliseringsmodellen waarin de beslissingen ten aanzien van conserveringstechnieken van de agrariers in samenhang worden bezien met de bodemprodctiviteit, de bodemconservering en beperkingen bij de produktie en beleidskeuzes.

About the author

Zainab Mbaga-Semgalawe was born in Usangi, Mwanga,Tanzania. In 1984 she obtained a bachelor's degree in Agriculture (Bsc. Agric.) with agricultural economics major (Rural Economy), at Sokoine University of Agriculture, Morogoro, Tanzania. In 1986 she graduated with a masters degree (Msc.) in agricultural economics at University of Missouri, Columbia, USA. From 1987-1989 she worked for the Tanzania Agricultural Research Organization (TARO) as Agricultural Research Officer for Farming Systems Research (FSR). Thereafter, she joined the Ministry of Agriculture in the department of Research and Training. As a researcher, in addition to carrying out socio-economic research she participated in coordinating farming systems research programme in the country to ensure that the technology development process is focused on problems and needs of farmers through farmer involvement in technology development process. Other duties included providing technical support to zonal FSR teams, planning, monitoring and evaluation of programme's activities and development of national and zonal FSR strategies.

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