ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

IMPACT OF ADOPTION OF SOIL BUND ON GRAIN PRODUCTION: THE CASE OF KILIE WATERSHED AREA, LUME WOREDA, ETHIOPIA

By

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This work is dedicated to my wife Meseret Meshesha and my adorable son Kidus.

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LIST OF ABBREVIATION

ADLI	Agricultural Development Led Industrialization
AGDP	Annual Gross Domestic Product
ANOVA	Analysis of Variance
BoA&RD	Bureau of Agriculture and Rural Development
CSA	Central Statistics Authority
CVM	Contingent Valuation Method
EHRS	Ethiopian Highland Reclamation Study
FAO	Food and Agriculture Organization
FFW	Food-For-Work
FKA	Farmers' Kebele Administration
GPS	Global Positioning System
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
ILCA	International Livestock Center for Africa
LUPRD	Land Use Planning and Regulatory Department
M.a.s.l	Meter Above Sea Level
ML	Maximum Likelihood
OLS	Ordinary Least Square
PADETS	Participatory Agricultural Demonstration and Training Extension System
PRA	Participatory Rural Appraisal
RTP	Rates of Time Preference
SPSS	Statistical Package for Social Science
SSA	Sub Saharan Africa
SWC	Soil and Water Conservation
Stata	Statistical Data Analysis Soft Ware Program
TLU	Tropical Livestock Unit
UNDP	United Nation Development Program

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ABSTRACT

This study is undertaken in Kilie watershed area found in Lume woreda, Oromia Regional State. The paper focused on analyzing the factors that influence the adoption of soil bund on grain production using cross-sectional data collected in 2007 on randomly selected 141 households having 520 plots. The data included in the analysis comprises both socio-economic factors at household level and biophysical variables at farm plot level.

Probit and impact evaluation econometric models were used to determine the factors affecting the adoption decision behavior of the farm household and the impact of adoption on grain production respectively. The result of the probit model showed that sex of the household head, farming experience, training on soil and water conservation practices, land size, plot slope, labour-land ratio, size of livestock, person-land ratio and distance of plot from residence found to be significant. In the second model, the regression analysis was run by classifying the crops grown by the farmers into three categories: for the whole crops, for the main crop (teff) and other crops (excluding teff). The result indicated that in all of the three cases the impact of adoption of soil bund on crop production has positive sign, however, it was significant (at 5% level of significance) only for teff. In the case of whole crops and other crops, the variable soil and water conservation practice is not significantly different from zero. The other variables that have significant influence on the value of crop production include: sex of the household's head and the major factors of production (fertilizer, land size, family labour and draught power).

Two main policy implications can be emerged from the study. To expand the adoption of the conservation practice the government should strengthen the program in the area. To encourage the probability of adoption and intensity of use, research on improved soil and water conservation techniques should play attention to the provision of tangible short term benefits. The second is to stimulate the adoption of soil and water conservation practices farmers should be provided with short term training. The training will help them to use the technology effectively and in sustainable way.

CHAPTER ONE

INTRODUCTION

1.1. Background

Degradation of resources, especially of soil and vegetations has been rampant and on the increase in most parts of the world (Oldeman *et. al.*, 1990). Its severity is higher in developing countries where there is poor farming practice, population pressure, intensive/extensive crop production, and absence of strong environmental policy.

The human population in hilly mountainous regions of developing countries is growing rapidly. As a result agricultural lands in these areas are degraded at an alarming rate due to the use and/or misuse of the land beyond its carrying capacity. Land degradation is the most serious problem in Sub Saharan Africa (SSA) and particularly in the densely populated areas of East Africa requiring prompt attention (Grepperud 1996).

In Ethiopia all physical and economic evidence shows that land degradation is important problem notably in the highlands where human and livestock pressure are the highest. The highlands of Ethiopia occupy 44% of the total area of the country and are inhabited by more than 90% of the population with about 93% of the cultivated land and 75% of the countries livestock population. These areas are cultivated for centuries and at present they are suffering from serious forms of degradation. The process of land degradation is enhanced by multiple interacting forces such as steady population growth, clearing of wood land for expanding agricultural land, overgrazing, and methods of cereal production that induces soil erosion and the use of dung and crop residues for fuel (Berry, 2003).

The recorded soil erosion in Ethiopia ranges from 16 to 300 tons/ha/yr depending mainly on slope, land cover, and rainfall intensity. The loss of soil by erosion on cultivated lands was estimated to be 42 tons per hectare per year (Hurni, 1993 cited by Berry, 2003) Besides, soil nutrient depletion is greater than 30kg/ha of nitrogen (N) and 15 - 20 kg/ha potassium (K) and phosphorous (P) (UNDP 2002). The higher rate of nutrient depletion is attributed to erosive cropping, low use of inorganic and organic fertilizer and other poor land management practices.

For example in terms of nutrients, the average rate of inorganic fertilizer application is 78kg per ha (CSA, 2006).

Agricultural practices leading to soil depletion and land degradation in steeply sloppy arable land constitute a significant draw down of stocks of natural resources wealth. According to the study made by the World Bank, the rate of annual on-site soil losses from soil degradation is estimated to be about 5% of the Annual Gross Domestic Product (AGDP) (Bojö and Cassells, 1995 Cited in Yesuf *et al.*, 2005). In general, in Ethiopia degradation of agricultural land continues to pose a series threat to the livelihood of the peasant household leading to low and declining agricultural productivity, poverty and food insecurity.

In agricultural based poor rural economy like Ethiopia, the main link between the economy and the environment go through the agricultural production activities performed by the farm households. The farm household being an economic unit, made their land use decisions taking in to account their own objectives, production possibilities and constraints. Due to this natural resources will be depleted thereby causing land degradation unless compensating investment in conservation of soil structure and fertility are made. The farmers settled in the study area also experienced declining land productivity as a result of soil erosion and declining soil fertility. The major causes responsible for the problem include over cultivation, overgrazing, slope of the farm land and poor land management practices.

Therefore, this study by analyzing the factors that affect the small farm holder's decision behavior to adopt soil and water conservation practices and the impact of the conservation practice on crop productivity aimed at producing baseline information for policy makers that will help them envisage appropriate strategies and policies to address the problem of land degradation at farm level.

1.2. Statements of the Problem

The productivity of smallholder farming in many parts of Ethiopia is mainly constrained by interlinking and reinforcing problems of resource degradation and poverty. The situation is further aggravated by high population growth, erratic climatic condition, top-down planning system, lack of appropriate and /or poor implementation of policies and strategies, limited use of sustainable land management practices, limited capacity of planners, researchers, land users as well as frequent organizational restructuring (Zeleke *et al.*, 2006).

In most of the highlands, land degradation is considered as a sever problem. It is estimated that every year almost 1.9 billions tons of top soil has been washed away from the highland parts of the country (Zeleke *et al.*, 2006 citing LUPRD/UNDP/FAO, 1986). According to Ethiopian Highland Reclamation Study (EHRS) in mid 1980's 27 million hectares (50%) of the highland was significantly eroded, 14 million hectares severely eroded and over 2 million hectares beyond reclamation. Land degradation contributes to low agricultural productivity which is reflected both on crop and livestock production. The costs of land degradation include direct cost (loss of soil nutrient, crop production, forest removal and decline in livestock carrying capacity) and the indirect cost (loss of environmental service, silting of dams and river beds, increasing irregularities of streams and reduced ground water capacity). The direct cost of land degradation on agricultural production was estimated to be within a range of 2 to 6.75% of AGDP per annum [Yesuf *et al.*, 2005, citing FAO (1986), Hunri (1988), Sutcliffe (1993), Bojo and Casselles (1995) and Sonneveld (2002)].

As a result of the direct and indirect effects of land degradation agricultural production is deteriorating. In the last three decades food output growth per capita has been declining and lags behind the rates of population growth. Every year nearly 5 to 7 million people are expecting external assistance for their survival and more than 45% of the population are below the absolute line of poverty (Zeleke *et al.*, 2006). Yet, economic growth and development in the country, is primarily dependent on the agriculture sector which accounts for about 50% of the GDP and 85% of total export. Increasingly, many farmers are incapable of producing enough food to satisfy household consumption and rural poverty has become a chronic problem.

The causes of land degradation are a complex phenomenon that stems from interplay of both natural and socio economic factors. In Ethiopia three major factors were identified to have significant impact on the vicious cycle of resources degradation and ultimately in the reduction of soil productivity, and hence crop production. These are: (i) the reliance of 85% of the population on an exploitive subsistence rain fed production system which prevailed for centuries using simple and traditional tools together with poor agricultural practices; (ii) deforestation to expand crop land and satisfy the energy demand of the household; (iii) livestock pressure and their poor management which mainly depend on free grazing system and (iv) the use of crop residues and cow dung as a sources of feed for livestock and fuel respectively which resulted in a subsequent loss of humus and soil nutrients (Berry, 2003 and Zeleke *et, al.*, 2006).

The most challenging issue that Ethiopia has faced is, to meet food security by implementing appropriate land productivity enhancing technologies and at the same time reversing the trend in agricultural land degradation to maintain sustainable agricultural production in the future. In response to the frequent food deficit and accelerating degradation of agricultural land, considerable public resources have been invested since mid 1970's on improved land management practices and soil and water conservation technologies with the underlying expectation of activating private initiative. However, this effort hadn't recompensed the anticipated result and the adoption of soil and water conservation technologies remained limited. Most surprisingly, in some places adopted conservation measures were either partially or fully removed (Shiferaw and Holden, 1998). Thus, soil degradation remained to be a persistent problem in the country. This failure is attributed to the costly and labor intensive nature of the introduced technologies; poverty, perception of farm land degradation, negligence to incorporate indigenous soil and water techniques, tenure insecurity and household characteristics. More generally the adoptions of soil and water conservation practices are influenced by biophysical, social, economic and institutional factors.

Hence, by considering the personal, physical, institutional, attitudinal and economic factors, this study attempts to identify the key determinant factors that influence farmer's decision to invest on soil bund and its impact on the productivity of grain in the study area.

1.3. Research Questions

The research questions of the study were: -

i) What are the biophysical and socio-economic factors affecting the households' decision to adopt soil bund soil and water conservation technology?
ii) What is the contribution of soil bund conservation technology on the grain productivity performance of the household?

1.4. Objective of the Study

The general objective of the research is to assess on farm adoption of soil bund and its impact on crop production in Kilie Watershed area found in Lume woreda, at the central part of Oromia Regional state.

The specific objectives are:-

i) To analyze the factors that influence farmer's adoption decision of soil bund soil and water conservation technology.
ii) To analyze the impact of the soil bund on crop production in the study area.
iii) To draw policy conclusions that will help policy makers to design appropriate soil and water conservation measures that will be acceptable by the land users.

1.5. Scope and Limitation of the Study

This research based on household and plot level data assessed the determinant factors that influence the farmers' decision to adopt soil and water conservation practices and the impact of adoption on the crop production performance of the farm household in Kilie Watershed area found in Lume woreda, Oromia Regional State. In the study both adopters and non adopters are grouped using a binary variable. But, the intensity of adoption of soil bund is not considered.

The finding of the research is very specific in terms of its location as well as the type of technology. Hence, it cannot be considered as a typical generalization to the wider part of the country. However, with some possible adjustments it can be used to draw recommendations to other areas that have similar agro-ecological and socio-economic settings.

1.6. Significance of the Study

Agriculture is the base of Ethiopian economy. This is clearly seen on the policy it follows; Agricultural Development Led Industrialization (ADLI). However, the success of this policy and strategy is challenged by the current trend of land degradation. Therefore, there is an urgent need to arrest and/or reverse this menace in order to achieve sustainable land resources management practices.

In this regard, this study will contribute to the existing studies by analyzing the determinant factors that influences farm household's decision to adopt soil and water conservation practices and the impact of adoption on the productivity performance of the farmer. Identification of the factors that lead farmers to soil and water conservation investment will help policy makers to design appropriate extension approach and farm land conservation strategies to enhance soil fertility and food security.

1.7. Organization of the Thesis

The thesis has five chapters. The introductory part, chapter one, is followed by literature review which deals with the review of land degradation, concepts and approaches to land degradation and empirical studies on the adoption and impact of adoption on productivity. In chapter three methods of data collection, descriptive statistics and econometric models employed in the analysis and the definition of the explanatory variables are presented. Results of both the descriptive and econometric analysis are presented in chapter four. Chapter five which is the last part of the thesis deals with the summary, conclusion and policy recommendation of the research's finding.

CHAPTER TWO

LITERATURE REVIEW

2.1. Causes of Land Degradation

Land degradation is defined as the reduction in soils ability to contribute to crop production (Blaikie 1985); and a change to land that makes it less useful for human beings. Other literatures also define land degradation as a temporary or permanent decline in the productive capacity of the land. In this definition, the word land emphasizes a wider focus to include natural resources, such as climate, water, land forms and vegetation. Degradation process can be caused without the interference of human being. But accelerated land degradation is most commonly caused as a result of human intervention in the environment. The effects of these interventions are determined by the natural landscapes.

There are multiple interacting forces that have resulted land degradation in Ethiopia. In order to lay out policies and strategies that will address the problem of land degradation appropriately, the root causes and their underlying factors should be identified.

2.1.1. Proximate Causes of Land Degradation

The proximate causes of land degradation reviewed here include clearing of deforestation, unsustainable farming practices, the use of dung and crop residues for fuel and overstocking of grazing lands.

Deforestation

In developing regions deforestation is one of the major sources of human induced land degradation. The clearing of forests to expand crop land has been a long historical process in Ethiopia. This is confirmed by a number of empirical studies conducted in different parts of the country. It has been reported that an increase in the cultivated land at the expense of natural vegetation cover occurred between 1957 and 1995 in the Derkolli, south west Wello; in Dembecha, east Gojam; Kalu north Wello; Mafud escarpment, around Debre Sina (Belay, 2002; Gete and Hunuri, and Kibrom and Hedlund, 2000 cited in Bewket and Sterk 2002). In Ethiopia the current rate of deforestation is (conservatively) estimated at a rate of 62,000 ha per year. The original extent of forest which was estimated to cover 65% of the total area has now declined to 2.2 %. The forest lands which are mostly converted into cropland have greatly reduced vegetative cover that leads to accelerated soil erosion. Usually the soil erosion is exasperated in steeper slope land. Also importantly the change in land use can change the hydrological pattern of run off, reducing infiltration and increasing stream flow during and after rain (Berry, 2003).

Unsustainable Land Management Practices

In most parts of the country, particularly in the highlands, the farming system is dominated by cereal production (teff, wheat, and barley) which accounts for about 73% of the total cultivable land (Markos Ezra, 1997 cited in Zeleke *et al.*, 2006). All these crops leave little ground cover during the main rainy season and through their growing period exposing the soil to erosion. This situation together with poor land management practices and the consistent push of cultivation towards increasingly marginal areas, greatly contributes to the current level of land degradation and to a significant reduction in agricultural production.

Use of Dung and Crop Residues for Fuel

As rural population has grown and woodland is converted to cultivation, the use of dung as a source of energy has become a common practice in high and low potential cereal crop producer zones. Moreover, scarcity of grazing land and shortage of livestock feed has forced extensive use of crop residues as a source of livestock feed. Traditionally cow dung and crop residues were used as fertilizer, however, Jabbar *et al.*, (2002) on their research in the highlands of Ethiopia found out a breakage on the traditional nutrient cycling in the crop-livestock system that leads to reduced soil fertility and erosion. Therefore, there is a substantial ground to argue that the diversion of cow dung and crop residues for uses other than land management directly contribute to land degradation.

Overgrazing Of Pasturelands

Ethiopia has a high number of livestock population including 35.3 million cattle. Only 25% of the livestock population grazes in the rangelands which cover about 57.7 million sq km of the countries land area. The remaining 75% of the cattle graze in the highlands creating series overgrazing problems. It has been also estimated that 20 percent of total soil erosion is from pasturelands (Melese, 1992 cited by Berry, 2003). The data on the density of livestock show that current stocking rates are well above optimum rates. However, in some areas for example Tigray improvements have occurred (Berry, 2003).

2.1.2. Underlying Factors of Land Degradation

The underlying factors of land degradation reviewed include: natural conditions, population pressure, poverty, and access to market and public services.

Natural Conditions

The basic physical conditions that have positive impact on land degradation include rainfall variability from year to year and place to place, particularly in the drier parts of the highlands. The sequence of drier years with reduced vegetation cover followed by wetter years with heavy rainfall is conducive to high levels of soil loss. Additionally, the physical make up of the Ethiopian Highlands with gorges and other topographic barriers restricts the development of effective internal marketing systems in some areas (Berry, 2003).

Population Pressure

Population growth especially in rural areas increases the pressure on land resulting in the continuous cultivation and a shift to marginal lands for the purpose of expanding crop land to compensate for reduced land size rather than adopting intensification techniques. This situation most likely contributes to the reduction of soil fertility as well as increasing soil erosion. This view is conformed by Grepperud (1996) whose research result indicates that population pressure is contributing significantly to land degradation in the highlands of Ethiopia. Shiferaw and Holden (1998) also reported a decline in land productivity with population pressure. Conversely, evidences of empirical studies from other parts of the world also show negative impacts consistent to the original idea of Boserup (1965), i.e. with increased population pressure; farmers may intensify and improve their land management practices (Tiffen *et al.*, 1994; Tempelton and Scherr, 1999 and Pender 2001 cited in Nkonya *et al.*, 2004).

Poverty

Poverty is both the cause and consequence of land degradation. Poverty is generally assumed to impose short time horizons. Efforts to increase production and improve food security and well being, through intensification and new technology have in some cases resulted in negative environmental impacts. Theoretically this results from the poor having high rates of pure time preference which lowers the ability to forego consumption today. The implications of a high subjective discount rate are rapid resource extraction to meet present income or consumption needs and low investment in natural resources to improve future returns. Similarly, farmers are less likely to make natural resource investments where returns are expected after a number of years. In Ethiopia it is observed that poorer households had less ability to invest on soil and water conservation practices, implying that poverty contributes to land degradation (Holden and Shiferaw, 2002 cited by Nkonya *et al.*, 2004).

Access to Markets and Public Services

An important part of moving to sustainable land management is the development of an appropriate rural infrastructure to encourage alternative livelihoods and to develop local and regional markets. The nature and development of markets for factors of production (i.e. input and output) and the availability of well-functioning rural financial service can play important role in determining the land use pattern as well as the land management practices. In rural areas where markets are well developed farmers are more likely to receive higher prices for their output and pay lower prices for inputs of production. The availability of adequate credit service also helps farmers to acquire the ability to purchase input needed for sustainable agricultural development. Therefore, the existence of perfect input-output and financial market is paramount importance for implementing appropriate and sustainable land management practices. This proposition is inconformity with Pender *et al.*, (2001) who found out that the existence of better access to market, credit and technical assistance programs were associated with improvement (less decline) in land quality, wealth and food security. However, observed results from Holden *et al.*, (2002) indicated that improved access to markets for credit and off-farm employment reduces farm households' incentives to invest in land conservation practices which lead to more overall soil erosion and more rapid land degradation.

Education plays important role in improving the crop production performance of the farmer by increasing the farmers' awareness on the presence of the problem (such as land degradation) as well as the ability to adopt new technology. Educated farmers are more likely to use improved land management practices than the non-educated farmers (Shiferaw and Holden 1998). On the other hand, Benin *et al.*, (1996) in Ethiopia and Nkonya *et al.*, (2004) in Uganda observed that educated persons are less likely to invest on improved land management practices and productivity enhancing technologies such as the use of manure and inorganic fertilizer. Therefore, the impact of market access and public services on land degradations seems to have mixed effect.

2.2. Approaches to Land Degradation

In the course of dealing with the problems of land degradation three approaches were identified by Biot *et al.*, (1989): the classical (technical), populist revolution (that has been underway over the past two decades and shares some characteristics with neo Marxist or world systems diagnoses of land degradation problem) and neo liberal counter revolution. The characteristics of the three approaches are presented on table 2.1.

These approaches were neither strictly sequential in their historical development, nor mutually exclusive. For example, the issue of population pressure on natural resource was a prominent theme in the classical approach to soil and water conservation, but has re-emerged strongly as part of the counter revolution too. Also, the present emphasis on poverty as a major cause and effect of environmental degradation is shared by both populist and counter revolutionary approaches. There is a dilemma, however, which is that, while a synthesis of these existing position appears to have been reached and policies, which should be successfully identified, in practice there is a widespread disillusion with the application of these approaches.

The ***classical approach*** assumes that the extent of and solutions to the problem of land degradation are well known, but the problem is to get people to implement them. According to this approach the major causes of land degradation are: mismanagement of the environment by the users, over population and subsistence fundamentalism. This approach identified three-step approach to mitigate the problem. The major steps proposed were, indicating the need of implementing soil and water conservation practice requiring the cooperation and participation of the community. However, the classical approach intervention was failed due to technical failures such as misapplied research; lack of fit between techniques and local farming system and livelihood strategies; inappropriate land tenure condition; lack of participation by land users in designing and implementing conservation technologies; and inadequacies of state bureaucracies charged with soil conservation strategies.

Table 2.1: Characteristics of main approaches to land degradation

Variable	Classical	Populist	Neo-Liberal
Peasant behavior	ignorant, irrational, traditional	virtuous, rational community-minded	rational, egocentric
Diagnosis of environmental problem	environmental solution	Socio-political solution	Economic solution
Immediate causes of environmental problems	mis-management by users	Mis-management by state, capitalists, TNCs, big business	Poor government policies and bureaucratic rules and regulations
Structural causes of land degradation	Over-population, backwardness, lack of foresight, ignorance	Resource distribution, inappropriate technologies	Inappropriate property rights, institutions, prices and rapid population growth
Institutional prescription	top-down centralized decision making	Bottom-up participation	"market" policies, property rights, resource pricing, self targeting safety nets
Academic discipline; profession	Science, bureaucratic	Sociology, activist, NGOs	Economics; development professionals
Gender orientation	Gender blind	virtuous but victimized women	Gender myopia
Research framework	Systematic empiricism	Rapid/participant rural appraisal, community as a unit of analysis	Methodological individualism
Orientation to market	Not considered	Exploitation	Pareto optimality & externalities
Models of peasant society	Conservative, paternalistic	Egalitarian	Democratic/liberal
Views of collective action	Deficient	Essential and unproblematic	Conditional rationality/political entrepreneurs
Technology	Soil conservation works, particularly terracing	Agronomic techniques of conservation	Not specified

Source: Rethinking research on Land Degradation in Developing Countries, Biot *et al.*, 1989.

Contrary to the classical approach, ***the populist approach*** assume that the nature and extent of land degradation is imperfectly understood, that local people often reject conservation technologies for good reason and, in fact, adopt their own individual and collective approaches that have in the past resulted in sustainable livelihood practices. The idea of this approach is people centered and bottom up approach. This approach requires site specific participatory study and design using a multidisciplinary approach by teams of specially trained and oriented natural and social scientists in combination with local farmers and organizations.

The ***neo-liberal approach*** asserts that suitable technologies presently exist or can readily come into existence; the problem is to understand the present structure of incentives that prevents land users from adopting them, and to design incentives that will induce adoption. This approach derives partly from a reasoned response to the naivety of extreme populist ideas, partly from extreme populist idea, from an understanding of the realistic constraints to change of the real-world bureaucracies and state-citizen relationships and from the classical position. However, the various strands of this position are not theoretically integrated, and derive from previous approaches. The first is the central role of population growth in exacerbating pressure on natural resources, which is very prominent in contemporary policy statements. The second is the link between land degradation and poverty. This involves the careful construction of explanations of land degradation into land users' production strategies and the serious constraints under which they are formulated. The third strand from the classical approach re-establishes the certainty that technologies for soil and water conservation exist, problem definition is relatively unproblematic, and that it is a matter of getting farmers to adopt these technologies through extension and appropriate incentives.

In developing countries including Ethiopia several soil and water conservation projects are influenced by the above three approaches (Tesfaye, 2003). More specifically, the populist approach becomes central to many development agencies. Presently, many rural development projects such as sustainable agriculture, health, welfare and education projects are directed by this approach. This study is related to the neo-liberal approach in that it tries to use the technology that the surrounding farmers are practicing, and it makes use of the existing extension system to reach the farmers. It also provides incentives such as hand tools to encourage the farmers to implement the conservation practice.

2.3. Efforts on Soil and Water Conservation

The conventional approach of rehabilitation of degraded lands as a major component to mitigate the impact of soil degradation in many parts of the country was started through Food For Work (FFW relief assistance following the 1974-1975 famine. The approach has focused on soil and water conservation; construction of terraces, check dams, cut-offs drains and micro-basins; and afforestation and re-vegetation of fragile and hill side areas. Between 1976 and 1988, conservation and afforestation undertaken by the Ethiopian farmers, under the FFW program, amounted to some 800,000 km of soil and stone bund on crop lands, 600,000 km of hillside terraces for afforestation of steep slope, 100,000 hectares of closed areas for natural regeneration, 500,000,000 tree seedlings were planted, and many activities of land rehabilitation were performed (Hunri, 1988, 1989 cited in Wegayehu, 2003).

This conventional soil and water conservation effort has resulted in many ecological benefits such as restoring farmlands, increasing soil depth, water holding capacity and improved woodlot and pasture land. Even though the importance of conservation practices is well recognized by the farmers, the rate of its adoption was generally poor.

2.4. Model for Analyzing the Adoption Process

In the economic model of adoption behavior, the farmers decision to adopt, i.e., invest on certain technology (in our case soil and water conservation practices) is heavily affected by the complex interplay of biophysical, institutional, economic and socio economic factors. Virtually according to the economic theory, farmers make utility maximizing farm land degradation controlling practices decision based on estimates of costs of investment versus the costs of losing soil to erosion.

Farmer's choice to decide between two technologies is based on the comparison of the utility obtainable. If we represent a technology by K, where K = 0 for the old technology, and K= 1 for the new technology, the underlying utility maximizing function that ranks the i^{th} farmer preference for the old and new technology is given by $U(N_{Ki}, Z_{Ki})$, where N_{Ki} represents a vector of the technology's attributes (such as profit, risk, etc); and Z_{Ki} is a vector of farm and household characteristics. This implies that the utility obtainable from the technology depends on the variable vector N and Z. Since utility is unobservable to the researcher, the utility associated with the Kth technology for an individual i can be described through vectors of unobserved technology specific attributes and the farm household heads characteristics. In functional form this relationship can be expressed as follows.

$$U_{Ki} = \alpha_K F_i(N_{Ki}, Z_{Ki}) + \varepsilon_{ki} \quad \text{..........} \quad (2.1)$$

Where, K = 0, 1

$i = 1,2,3,...n$

F = a distribution function (assumes linear or non linear relationship)

ε_{Ki} = random variable

When the ith farmer perceives that the utility derived from the new practice (U_{1i}) is greater than the old practice (U_{0i}) then the farmer will select the technology option K = 1.

If we assume that there is unobservable or latent variable Y^* that generates the observed variable Y, which represents a farmer's decision to adopt a conservation practice then, when $Y^* = U_{1i} - U_{0i} > 0$, the conservation practice will be adopted and $Y = 1$ is observed. Otherwise, the conservation practice is not adopted and $Y = 0$ is observed. Thus, the probability that $Y_i = 1$ is then;

$$P_i = \Pr[Y_i = 1] = \Pr[U_{1i} > U_{0i}]$$

$$= \Pr[\alpha_1 F_i(N_i, Z_i) + \varepsilon_{1i} > \alpha_0 F_i(N_i, Z_i) + \varepsilon_{0i}]$$

$$= \Pr[\varepsilon_{1i} - \varepsilon_{0i} > F_i(N_i, Z_i)(\alpha_1 - \alpha_0)]$$

By letting $\varepsilon_{1i} - \varepsilon_{0i} = \eta$ and $\alpha_1 - \alpha_0 = \beta$ and assuming symmetry, then

$$P_i = \Pr[\eta_i > F_i(N_i, Z_i)\beta]$$

$$= F_i(\beta' X_i) \quad \text{.......} \quad (2.2)$$

Where; X is a matrix of the explanatory variables; β is unknown parameters to be estimated including the intercept; $\Pr[\cdot]$ is a probability function; η_i is the disturbance term and $F_i(\cdot)$ is the cumulative distribution function for the disturbance term. Therefore, the probability of the i^{th} farmer adopting the new technology is that the utility obtained from the new technology is greater than the utility of the old technology. Based on the distribution of $F_i(\cdot)$ which is determined by the distribution of the disturbance term η_i; equation (2.2) will be estimated. According to Amemiya (1981) and Rham and Huffman (1984) usually η_i is expected to be either normally or logistically distributed.

2.5. Concepts on Adoption and Natural Resource Management Practices Impact Evaluation

Farmers change from old to new technologies (or from the conventional practices to new practices) to make their way of production efficient and profitable, or they may perceive a problem and in seeking solutions arrive at a new practice such as soil and water conservation technologies. The problems that motivate farmers to adopt soil and water conservation technologies are soil degradation, soil erosion or declining crop yields due to deteriorating soil fertility.

Adoption refers to the stage of a final decision by farmers to put into use a new idea or innovation linked to a specific channel of communication. Adoption of innovation in agriculture might be the acceptance and use of new crop varieties, management practices, new ideas, methods or techniques which provides a means of achieving a continuous improvement in the level of farm outputs and income. In general, it is defined as a mental decision making steps which an individual go through, i.e. from learning about the idea to the point where he adopts, applies and continues to use it. Therefore, the adoption process is a learning process with two distinct aspects (Abdi Ghadim and Pannel 1999). The first is the collection, integration and evaluation of new information to allow better decisions about the innovation. The second aspect is improvement in landholder's skill in applying the innovation to their situation. Adoption occurs over a period of time and passes through a complex pattern of mental process and activities occurring as a set of series stages described as follows.

Awareness: the person should be made aware of and believe that the agricultural technology or innovation exists. Moreover, he should be convinced to the extent that the technology is potentially of practical relevance.

Information: to make the person interested in the innovation and believes that the technology is possible; he should have access to adequate information. It should be recognized that unless the farmer believes that it might be possible for him, he might not pursue the matter further.

Non-trail evaluation: at this stage in order to make decision about the next step, the farmer using all the information makes mental trial of the innovation without actually committing land labour or money. He raises questions about the cost, input requirement, cost and benefit of the investment, etc, and tries to evaluate it using imagination or waiting the results of the farmers who try the innovation. When the farmer feels that the advantage outweighs the disadvantage he goes to the next step.

Trial evaluation: here the farmer actually make a trial after collecting the required inputs, skills, and money and wait for the outcome.

Adoption: if the farmer feels satisfied with the outcome of the trial, he may decide to continue the use of the technology.

Review and modification: as the scale of use of an innovation increases, the balance of reasons for using the practice shifts from mainly evaluation to mainly beneficial use. Even after adoption peaks, there is a continuous process of review and modification (Pannel *et al.*, 2006).

Non-adoption or dis-adoption: if external information or local trial results are not sufficiently encouraging the farmer will reject the innovation. Rejection of an innovation could possibly occur at any stage in the adoption process or even after adoption. If it is initially adopted but then, say, economic circumstances change or a superior replacement technology or practice becomes available, use of the original innovation may be scaled down and eventually discontinued.

Adoption is theorized to occur as a sigmoid growth curve when graphed as cumulative percentage and which is normally distributed when graphed as frequency over time. This leads to classification categories such as innovator, early adopters, early majority, majority, late majority and laggards (Rogers, 1983). Farmers adopt soil and water conservation practices if they found that yield benefits or profits are attractive. In this situation, a clear financial incentive has induced change in the behavior, as suggested by the classical model of innovation adoption and diffusion. The classical model of adoption is predicted on commercial innovations that apply equally to all farmers for whom the technology is designed. Commercial innovation refers to those innovations that are developed primarily for commercial reasons. Here, adoption was in the farmers self interest, and adoption is expected to occur eventually. However, it is inappropriate to relay on classical model as a basis for promoting in the cases of resource conservation technologies adoption. This is because the adoption and diffusion model is based on voluntarism on the part of the farmer's decision making and the economic gain attached to the new behavior. With agricultural resource conserving innovations, i.e. the use of techniques, methods and approaches to improve land management rather than to increase farm productivity, the costs of adoption are borne by the individual farmer, while the benefits are social.

Ervin and Ervin (1982) described the farmer's decision to adopt soil and water conservation practices as a step wise decision processes. First, the farmer should feel the problem of degradation on his farm land. When the farmer perceives the problem his next step may be to respond towards declining or variability on the productivity of his farm land either by modifying the already existing practices or adopting new ones. If the farmer decided to utilize or adopt the new technology he may depend on information diffused from external sources about the technology. Information is useful to make the farmer aware of the problems and technology choice. The awareness created by the information is often a leading stride to subsequent changes in management including technology adoption. And the next and last step will be the decision which type of the technology and to what extent to adopt it.

Farmers as a rational being decide to invest on the new technology after evaluating the pros and cons of the various factors in the context of physical, social, economic and institutional environment. The most important precondition for widespread adoption of any agricultural technology is its profitability for the farmers. Generally, the major objective of farmers is to maximize returns on investment and particularly for those production factors, which are in short supply but are required by the technology. Therefore, the decision to invest on the technology will be based on the comparison of the net present value of expected benefit with the net present value of the expected costs. Then the decision to invest will be made if the benefits prevail over the costs. There are some distinct features associated with soil and water conservation technology that makes it different from other agricultural technologies such as fertilizer, high yielding variety seeds, etc. Soil and water conservation technology investments have different and longer gestation periods for the benefits to materialize. That is, the payoffs from the investment are cumulative and long run.

The dependency of agricultural production system on natural environment makes farm enterprise vulnerable to frequent disturbances. Yield fluctuations may occur due to erratic rainfall, floods, insect and disease attacks, etc. Thus, the success of the farmer in maintaining his returns depends on the extent of the success of the farmer's capacity in minimizing such risks and uncertainties. Risks and uncertainties affect the farmers' attitude towards innovations and their adoption behavior. Especially poor farmers are often reluctant to adopt technologies because they need stable income especially when returns to adoption are unclear or will only bear fruits in future.

The decision by farmers to adopt soil and water conservation practices also depends on the appropriateness of the conservation technology to satisfy the local needs. The other farm characteristics influencing adoption that are broadly demonstrated in literature include family size, farm size, land tenure, income from crop production, off farm income, age, educational status of farm household, farming experience, plot size, fragmentation, plot slope, distance of plot from residence, etc.

The expectation of the farmer from using new agricultural technology is to gain a change of productivity on his farm land. In its simplest term, productivity is the quantity of a given output of a farmer per unit of input. It shows the ability of the farmer to produce a given output (it may not be maximum possible output) at a given level of input. Different technologies require different time span to bring change in productivity. For example the effect of productivity change on some technologies like fertilizer, high yielding variety seed etc., is visible within short period of time. However, soil and water conservation technologies need a longer period (at least five years) in order to see its effect on land productivity. It is inevitable that land degradation resulted in loss of land productivity and adopting soil conservation will most likely help to curb the trend of land degradation and curtail declining of crop productivity in the long run. Higher productivity and returns will mean that farmers will be convinced of their effort and makes them to afford more investment in soil and water conservation practices.

To evaluate the impact of soil conservation practices on crop productivity two types of techniques are commonly employed by the researchers. One of them is the crop modeling system, which uses several ecosystem factors to evaluate the dynamics of crops and soils process that include soil conservation measures. The other technique uses abstract models such as a production function based on relatively few variables to relate production to soil conservation practices. Regarding the literatures on impact of agricultural technology on crop productivity, large numbers of empirical studies have been focused on modern crop varieties and fertilizer and few examined directly the impact of conservation technology on crop yield using econometric analysis (Byiringiro and Reardon, 1996; Shively, 1998; Kaliba and Rabele 2004, Kassie and Holden, 2005).

2.6. Empirical literature

In this section of the paper the various studies conducted on adoption of soil and water conservation practices and their impact on crop yield productivity are reviewed and summarized. For the sake of convenience they are presented in chronological order.

2.6.1. Adoption and Productivity Studies in Developing Countries

Kerr and Pender (1996) explore the determinants of farmers' investments in indigenous soil and water conservation measures in the semi-arid tropics of India. Many types of indigenous conservation measures are observed in three villages, including investment in terracing, leveling, gully checks, field boundary bunds, grass strips, drainage and other measures. A simple theoretical model is used to develop hypothesis about the determinants of such investments in the context of possibly imperfect factor markets, and these hypothesis are tested using data from the three study villages. Across the three study villages, they found that conservation investment is significantly greater on steep plots, on plots of higher quality, on plots that have incomplete conservation structure, and on plots that are owner-operated. The latter finding confirms that land markets have important impacts on investment incentives. They also found strong evidence that credit and labour market imperfections are affecting conservation investment in one of the study villages, where investment is greater among households having more education and debt, a higher percentage of off-farm income, more adult males, and fewer adult females, who farm less land, or who are of low caste. They interpreted these results as reflecting transaction costs of participation in credit and labour markets, which may be high relative to the small size of investments in the village where these effects are the most notable.

Okoye (1998) using cross-sectional data from a sample of 125 small farmers in highly erosion-prone Anambra State of Nigeria, attempts to identify the major factors influencing farmers' adoption of traditional and recommended soil erosion control practices. Multiple regression results show that income, farm size and risk attitude were the most important factors in the adoption of recommended practices while employment, farm output prices and interest rate influenced the adoption of traditional practices most. A chi-square test also rejects the hypothesis of significant difference between factors determining the adoption of both clusters of practices. It is recommended, among other things, that it is these implicated variables that should be focused on in erosion control practice adoption programmes.

Semgalawe (1998) using three empirical models: perception of the soil erosion problem model, adoption of improved soil conservation model and conservation effort model analyzed households' improved soil conservation measures adoption decision behavior. These models incorporate 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 head of household to perceive the soil erosion problem and to adopt soil conservation measures. Poisson regression model was used to identify the determinants of effort (level of investment) the household is willing to devote into soil conservation. The results from this study indicate that personal characteristics of the heads of households (gender/sex and marital status), participation in activities of Soil and Water Conservation (SWC) programmes and the mountain area where the household is located are the determinants of perception of the soil erosion problem in the study area. Marital status and household location have 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. The 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 soil erosion problem, hence perception of the soil erosion problem. Also, the results indicate that the probability of perceiving soil erosion problem is higher for male-headed households than female-headed households. The decision on whether or not to use improved soil conservation measures is determined by the economic rank of the household indicated by whether he has cash crop or not and farm size. In addition to economic rank, institutional support from SWC programmes and participating in labour sharing groups are among the most important incentives to using improved soil conservation measures in the study area. Ranking of soil erosion problem also play a major role in enhancing adoption of improved soil conservation technologies. The results also indicate that household's knowledge about 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. 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 earning and the way household rank 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, participating in labour sharing groups and off-farm income.

Baidu-Forson (1999) using Tobit model attempted to identify factors that motivate the level and intensity of adoption of specific soil and water management technologies in the Illela region of Niger using the data obtained from 114 farmers. The result shows that higher percentage of degraded farmland, extension education, lower risk aversion, and the availability of short term profits are important for increasing the adoption and intensity of use of improved "tassa" and half-crescent shaped mounds. Age and attitudes to differential gains between farm and non-farm income showed no influence on adoption. Three main policy implications emerge from these findings. First, technologies should be targeted to locations that have large percentages of degraded farmlands. The probability of adoption and intensity of use are likely to be high at such locations. Second, there is the need to provide extension education that demonstrates risk reduction capacities of conservation techniques. This will make available information capable of stimulating adoption of land enhancing technologies. Finally, policy makers should not seek to target innovations to younger farmers because age has no relationship to adoption of the improved "tassa" and half-crescent shaped mounds.

Tengen *et al.*, (2001) conducted a research in order to determine the social and economic factors that influence adoption of SWC measures in the West Usambara highlands, Tanzania. For this research a household survey, group discussions and transect walks were undertaken. A total of 104 households were interviewed and several fields were visited during the transect walks. Data was analyzed with the use of cross-tabulation, cluster analysis, factor analysis and chi-squared methods. The results obtained indicate that involvement in off-farm activities, insecure land tenure, location of fields and a lack of short-term benefits from SWC are among the major factors that negatively influence adoption of SWC measures. Membership in farmer groups, level of education, contacts with extension agents and SWC programmes were found to be positively influencing the adoption of SWC measures. Recommendations to facilitate adoption of different SWC measures include: integration of social and economic factors into SWC plans; the creation of more awareness among farmers of soil-erosion effects and long-term benefits of SWC; the development of flexible SWC measures to cater for different farm patterns and a participatory approach to SWC at catchment's level rather than at individual farmers' fields.

F. Bodnár and J. De Graaff (2003) analyzed five factors that influence farmer adoption of SWC measures were analyzed: land pressure, cotton-growing area, possession of ploughing equipment, possession of a donkey cart and farmer training in SWC. Interviews were carried out with 298 farmers and two to three fields per farmer were visited, in 30 representative villages and 30 villages with high SWC adoption. Correlation, regression and factor analysis led to the following conclusions: (i) Farmers in the high land-pressure area adopt more soil fertility measures. (ii) Farmers in the cotton-growing area adopt less SWC measures. (iii) Farmers with more ploughing equipment adopt more SWC measures. (iv) Farmers with a donkey cart adopt more soil fertility measures. (v) Trained farmers adopt more erosion control measures. There is a strong correlation between the adoption of erosion control measures and soil fertility measures that could not be explained by these five factors only. This suggests that there are additional factors that trigger the adoption of SWC measures.

Kajembe *et al.*, (2005) assessed the impact of the indigenous-based interventions on land conservation. More specifically the study intended to assess farmers' perception of land degradation, the adoption rate of indigenous-based interventions, the impact of those interventions, and lastly the sustainability of those interventions. Data for the study were collected through Participatory Rural Appraisal (PRA) techniques and a questionnaire survey. The Statistical Package for Social Sciences (SPSS) was used to analyze quantitative data and Content and Structural-Functional Analyses were used for qualitative data. The study found that the rate of land degradation was perceived by respondents to be rather severe. The study also revealed that indigenous-based interventions, which require minimal labour and capital, have been highly adopted by many farmers while labour/capital intensive ones have been taken up by fewer farmers. In general, indigenous-based interventions appear to have eased farm operations and contributed towards increased crop yield, improved soil fertility and increased income. Success in some of the indigenous interventions warrants their wider promotion beyond the project area.

Kaliba and Rabele (2005) assessed the impact of adopting soil conservation practices on wheat yield in Lesotho. The study uses input output data collected from 50 small holder farmers in Mafeteng and Masuer districts, the major wheat growing areas in the country. A system of equations was used to estimate factors affecting adoption of soil conservation measures and impact of soil conservation measures on wheat yield. For each farmers wheat yield, based on the soil conservation practices adopted by the farmer, two soil and water conservation variables related to the farmers' soil erosion control methods were constructed. Two Tobit models and modified Cobb-Douglas production function were used to model adoption, and impact of soil and water conservation measures respectively. The adoption of two soil and water conservation measures was modeled as a function of households' demographic characteristics and availability of extension services. The yield equation was modeled as a function of inputs used in production and soil conservation efforts. The results indicate that soil conservation efforts were superior to inorganic fertilizer application in terms of increasing wheat yield. Increase in soil and water conservation efforts, coupled with low inorganic fertilizer use has a potential of increasing wheat production among small holder farmers in the study area.

Okoba and De Graaff (2005) carried out a research to identify the criteria that farmers used to distinguish farm-types and to use these types to evaluate different knowledge levels and perceptions of soil erosion and existing SWC measures in the Central Highlands of Kenya. Community meetings and semi-structured household surveys were carried out in a small catchment's, with 120 households. Results partly support the idea of using farmer-developed criteria to distinguish among land managers with reference to a farm-type classification. Criteria distinguishing three classes of land managers (good, moderate and poor) were significant with regard to the following land husbandry practices: use of hybrid or recycled seed and use of organic and/or inorganic fertilizers. Farmers were aware of on-going soil erosion and of several erosion control measures. Whereas a majority of farmers preferred grass-strips as a SWC measures, they did not recognize agro forestry as a form of SWC measure. Farmers perceived that SWC measures could successfully increase crop yields and soil-water retention, and increase land value. In general, farmers did not perceive that SWC measures successfully prevented erosion phenomena, given the evidence of on-site erosion indicators. They attributed the continued erosion to high rainfall, steep slopes, lack of maintenance and poorly designed SWC measures. They did not consider poor soil-cover, up-down tillage and tall trees to be the causes of erosion. Farmers faced several constraints in adopting SWC measures: lack of labour, tools, capital and know-how to construct the measures.

Kerr and Pender (2005) investigate farmers' perceptions of soil erosion and how it affects crop yields, land values, and private conservation investments in India's semiarid tropics. It is based on three types of data: a survey of farmers in three study villages; a plot survey by a professional soil surveyor in the same villages; and experimental and simulated data from nearby research stations with similar conditions. Farmers' perceptions of erosion are compared to the surveyor's using kappa, a statistical measure of interrater agreement. Perceived erosion-yield relationships are estimated econometrically and compared to experimental and simulated data. Effects on land values and conservation investments are estimated econometrically. Findings suggest that farmers are keenly aware of rill erosion but less aware of sheet erosion; kappa values ranging from 0 to 0·28 suggest low agreement with the soil surveyor. They anticipate annual yield losses of 5·8-11 per cent due to rill erosion; these figures are reasonably consistent with those from nearby research stations. They anticipate yield increases of 3·8-14·5 per cent due to installation of soil conservation bunds, largely because they can harvest soil from up the slope and capture organic matter. Perceived erosion has some effect on land values and soil conservation investments, but other factors such as irrigation and soil type have a much greater effect. These findings suggest that promoting soil conservation requires capitalizing on farmers' interest in short-term gains, such as from water and nutrient management.

2.6.2. Adoption and Productivity Studies in Ethiopia

Shiferaw and Holden (1998) conducted a study of resource degradation and conservation behavior of peasant households in a degraded part of the Ethiopian highlands. In their analysis peasant households' choice of conservation technologies is modeled as a two-stage process: recognition of the erosion problem, and adoption and level of use of control practices. An ordinal logit model is used to explain parcel-level perception of the threat of the erosion problem and the extent of use of conservation practices. Results show the importance of perception of the threat of soil erosion, household, land and farm characteristics; perception of technology-specific attributes, and land quality differentials in shaping conservation decisions of peasants. Furthermore, where poverty is widespread and appropriate support policies are lacking, results indicate that population pressure per se is unable to encourage sustainable land use. The challenge of breaking the poverty-environment trap and initiating sustainable intensification thus require policy incentives and technologies that confer short-term benefits to the poor while conserving the resource base.

Holden *et al.*, (2001) analyzed how market imperfections affect land productivity in a degraded low potential cereal livestock economy in the Ethiopian highlands. The reported result shows that there are significant market imperfections in labor and land markets. These imperfections were found to affect significantly investment on land conservation technologies thereby plot level productivity.

Bewket and Sterk (2002) analyzed the extent of farmers' participation in current SWC activities in the Chemoga Watershed, East Gojjam Zone, Amhara Regional State, Blue Nile basin, Ethiopia. Formal household survey, informal and focus group discussions and field observation were used to generate the data. The results indicate that the majority of the farmers participated in the SWC against their will. The most important factor discouraging them from participating freely was the perceived ineffectiveness of the structures under construction. Awareness about soil erosion as a problem, labour shortage and land tenure insecurity were found to be less important in providing an explanation for the disinterest shown by most of the farmers towards the SWC activities. Therefore, the important factors that need immediate consideration for SWC efforts in the study area or the region at large are: SWC structures have to be carefully designed and constructed taking into account ground realities, and participation of the farmers has to be through their own conviction regarding the effectiveness and efficiency of the technologies. Alternative SWC technologies will have to be considered in this regard.

Gebremedin and Swinton (2002) using a double hurdle statistical analysis of 250 farms in the Tigray region of Ethiopia revealed different causal factors for soil conservation adoption versus intensity of use. Farmers' reasons for adopting soil conservation measures vary sharply between stone terraces and soil bunds. Long-term investments in stone terraces were associated with secure land tenure, labour availability, proximity to the farmstead and learning opportunities via the existence of local FFW projects. By contrast, short-term investments in soil bunds were strongly linked to insecure land tenure and the absence of local FFW projects. Public conservation campaigns on private plots reduced adoption of both stone terraces and soil bunds. Whereas capacity factors largely influenced the adoption decision, expected returns carried more influence for the intensity of stone terrace adoption (measured as meters of terrace per hectare). More stone terracing was built where fertile but erodable silty soils in higher rainfall areas offered valuable yield benefits. Intensity of terracing was also greater in remote villages where limited off-farm employment opportunities reduced construction costs. These results highlight the importance of the right kind of public interventions. Direct public involvement in constructing soil conservation structures on private lands appears to undermine incentives for private conservation investments. When done on public lands, however, public conservation activities may encourage private soil conservation by example. Secure land tenure rights clearly reinforce private incentives to make long-term investments in soil conservation.

Holden *et al.*, (2002) assessed the impact of alternative policies that are envisaged to reduce poverty, increased food security and promote more sustainable land use by employing bio-economic model with market imperfections. The result of the study shows that improved access to markets for credit and of farm employment does not necessarily lead to more sustainable land use. Better access to off farm employment reduces farm household's incentives to invest on land conservation technologies and this leads to more overall soil erosion and more rapid land degradation.

Pender *et al.*, (2002) on their research in Tigray found out that land management practices including stone terraces, reduced burning, reduced tillage and application of manure or compost have positive impact in increasing crop productivity. The rate of return to investment in stone terraces was estimated to be about 25%, and farmers who built terraces on their farm land were found to increase the use of fertilizer.

An observational study was conducted by Daba (2002) to have an insight of the perception of farmers about the danger of gully erosion and their willingness to adopt new improved soil and water conservation measures. The variables studied included literacy, location of farm within the landscape, major land use, the severity of water scarcity, means of traction, perception, type of soil and water conservation measure in use, willingness to adopt new soil and water conservation measures and type of incentives needed for adopting new soil and water conservation measures. The variables studied were coded using dummy variable coding techniques and were subjected to rigorous statistical analysis using canonical correlation, logistic regression and discriminate analysis. Results suggest that perception about the danger of gully erosion is significantly correlated to severity of water scarcity, location of farm within the landscape and literacy of farmers. Willingness to adopt a new or improved soil and water conservation measure is strongly related to fertilizer availability as an incentive and to the literacy of the farmers. It is concluded that under Hararghe Highland conditions, design and implementation of soil and water conservation measures should take into account farmers' priorities such as alleviation of the water scarcity problem. Moreover, successful implementation of an improved or new measure of soil and water conservation measure is contingent upon the availability of incentives, primarily fertilizers.

Deiniger *et al.*, (2003) used a large data set that differentiates tenure security and transferability to explore determinants of different types of land related investment and its possible impact on productivity. The result indicated that not only land rights are highly insecure, but higher land tenure security and transferability significantly enhance investment and agricultural productivity.

Demeke (2003) assessed the important factors that affect the adoption and continued use of introduced soil conservation measures in Farta district, northwestern Ethiopia. The study also explored the constraints faced by farmers in using conservation measures and elicited farmers' opinion for the betterment of future conservation initiatives. Primary data were obtained through a formal survey of 78 farm households, conducted during 2002-03. Results of logistic regression showed that farm size and perceptions of benefit from conservation measures positively and significantly affect farmers' decision to adopt soil conservation measures. Distance of a plot from the homestead, availability of off-farm employment and tenure insecurity were found to negatively and significantly influence farmers' adoption decision.

Gebremedihin *et al.*, (2001) in their survey confirmed that tenure security is an important determinant of farmer's incentive to invest on land and use of improved practices. According to their result, stability of tenure encourages investment in stone terraces, tree plantation and soil bunds. Therefore, improving tenure security is important step that makes help initiate the farmers to invest on soil and water conservation and improved land management practices.

Yesuf (2003) investigated the impacts of market and institutional imperfections on technology adoption in a model that considers fertilizer and soil conservation as a joint decision. The result indicates that a household decision to adopt fertilizer does significantly and negatively depend on whether the same household adopts soil conservation technology. The reverse causality is, however, insignificant. The study also found out that farm technology adoption decision is significantly determined by market imperfection such as limited access to credit, plot size, risk consideration and rates of time preference.

Tessema and Holden (2005) assesses farm households' perceptions of land degradation and determinants of farmers' willingness to invest in soil conservation practices in Gununo highland, southern Ethiopia based on data collected from 140 farm households operating 556 plots. Results from a Contingent Valuation Method (CVM) indicated that majority of the farm households in

Gununo perceive the severity of land degradation in their villages and especially on private farms, in terms of soil erosion and nutrient depletion. The results also show that the amount that the farm households are willing to pay or contribute is affected by various factors such as perception of erosion, poverty in terms of resource endowment (labor, land and oxen) and cash (income), tenure security, level of education, and plot characteristics.

Yesuf (2005) measured farmers attitudes towards Rates of Time Preference and risk (RTP) using an experimental approach. The estimated RTP is found to be very high and most of the farm households were found to be intermediate to extreme risk averse implying that they are less likely to engage in land investment activity. The result confirmed to be consistent with economic theory which postulates that, in the absence of credit and insurance markets, poor farm household tend to have high RTP and highly risk averse and become more reluctant to participate in many of farm investment activities that entail short term costs but long run benefits and/or more risky. The study also suggested that in poor rural economy like Ethiopia, addressing the issue of tenure security alone might not be a sufficient tool for sustainable resource management and food security.

Kassie and Holden (2005) using both parametric and non parametric econometric models analyzed the impact of soil conservation on yield in high rainfall areas of Ethiopian highlands. The result from parametric and non parametric econometric analysis indicated that yields on conserved plots were statistically lower than yields on plots without conservation. Risk analysis using regression analysis and normalized second order stochastic dominance analysis did not support the hypothesis that conservation reduced risk compared to the situation of without conservation. Endowment difference between plots with conservation and without conservation and opportunity cost of conservation (area occupied by conservation structure) may contribute to this result. Result from productivity decomposition showed that plots with and without conservation barley differ in their endowment of soil fertility and soil depth; it was the returns to this variables that matter for productivity difference. The simulation results indicated that there are possibilities to make conservation more productive. The implication of the result is that farmers that are resistance to adopt the technology may be associated with lower yield from conservation practices. Thus the result suggests the need for designing and implementing appropriate soil conservation strategies that enhance productivity and better adapt to local conditions in order to increase the rates of adoption.

Anley *et al.*, (2006) employing a Tobit model tried to identify the main factors influencing farmers' decision to adopt and intensify the use of improved and indigenous SWC measures. The analysis was undertaken based on responses from a sample of 101 households which operate on 204 plots in Dedo district, Western Ethiopia, interviewed in 2003 cropping year. The results suggest that area of cultivated land, land/labour ratio, age and education level of household head and distance of the plot from home and slope of the plot provided statistically adequate predictive power on the use and intensity of SWC measures.

Hagos and Holden (2006) examined the role of tenure security, resource poverty, risk and time preferences and community led conservation investment on differentiated patterns of household investment in land conservation by small holder farmers in the northern part of Ethiopia by controlling for biophysical, household characteristics, market access conditions and village level factors. Investments in soil bunds and stone terraces are specifically studied so as to capture the link between these various factors and the durability of conservation investments. The researchers also introduced the distinction between the determinants of the decision to invest and how much to invest in conservation. The regression result pointed out that publicly led conservation programs seems to significantly stimulate private investment on land conservation. The public program initiated households to solve the land degradation problem on their private land by drawing perhaps on technical assistance and labor mobilization. It is also conceivable to think that public led conservation programs gave a sort of kick-off effect on individual initiative by lowering the significance of household level constraints in resources such as labour, inputs and capital. It also indicated that at household level, the decision to invest on soil and water conservation practices depend on the improvement of land quality and crop yield. The evidence on the significance of households' attitudes toward risk aversion suggests the important role of risk and the households' risk-bearing capacity in the decision towards in the decision to intensify conservation measures. At the same time, tenure security indicators and households' resource endowments (resource poverty) had weaker effects in increasing willingness to invest and the level of investment made. The policy implication of these results necessitates the importance of agricultural research and extension efforts that target technologies which reduce household risk and poverty while enabling sustainable investments in conservation measures by individual households.

CHAPTER THREE

DATA SOURCES AND METHODOLOGY

This section of the paper gives description about sources of the sample data, the method employed in selecting the sample population, procedures followed in the process of data collections and methods of data analysis.

3.1. Sources and Methods of Data Collection

3.1.1. Sample Size Determination

The total number of households (n) to be included in the survey was determined using the formula

$$n = \frac{N}{1 + N(e)^2} \quad \text{.. (3.1)}$$

Where n is the sample size, N is the total number of households in the area and e is the desired margin error. The sample size of the households for the survey was computed taking 7% (0.07) of margin error. Based on the above formula, the minimum sample size requirement was 121 respondents, but this study was conducted on 141 farm households.

3.1.2. Source of Data and Sampling Design

The data used in this study were collected from Kilie Watershed Site which comprises Bole and Goljie Farmers Kebele Administration (FKA). The number of sample farmers from each FKA was determined based on the proportion of the households residing in the bounded catchment's area. Accordingly, a total of 141 sample farmers were selected out of which 85 are from Goljie and 56 are from Bole FKA. The detail sample size from each FKA is presented on table 3.1.

Then the farmers from each FKA were selected using random sampling method from the list of the household heads which was obtained from Lume Woreda Bureau of Agriculture and Rural Development (BoA&RD), Soil and Water Conservation Team.

Table 3.1: Household, sample size and number of enumerators

№	FKA	Number of households	Sample size	Number of adopters	Number of enumerators
1	Goljie	180	85	72	2
2	Bola	120	56	33	2
	Total	300	141	105	4

Source: Lume Woreda BoA&RD, 2007.

3.1.3. Method of Data Collection

Before conducting the actual data collection, a preliminary pilot survey on five households was conducted to asses the workability of the prepared questioner. Then little modification was made based up on the lesson learned. To handle the collection of the data two Development Agent and two 12th grades completed students were employed and the data collection was conducted for ten consecutive days.

The questioner (See Annex 4) used for the interview was designed to seek the following information:

i) General farm land information: farm size, number of plots and their size, walking distance of the plot from residence, slope type, number of years since the farm operator owned the land, erosion status as perceived by the farmer, fertility status, etc.
ii) Farm household characteristics: age, sex, education of the household head and family size
iii) Total asset values of farm tools and number of livestock
iv) Variable inputs:
    a. Labour input: head count of family labour
    b. Quantity of fertilizer applied
v) Output and income: yield of crops and off-farm income.
vi) Market and credit information: main market and access of credit for agricultural activities.
vii) Farmers' knowledge of and experience in soil and water conservation technologies and activities.

viii) Soil conservation information: practices employed by the farmers to maintain the fertility of their farm land and motivation and behavior of farmers with regard to soil conservations.

3.2. Method of Data Analysis

In this study, to analyze the sample data both descriptive and econometric methods were employed

3.2.1. Descriptive Statistics

In the descriptive statistics section the data analysis techniques used to compare the two groups (adopter and non-adopter) included independent t-test, chi-square (χ^2), and one-way Analysis of Variance (ANOVA) F-test. The analysis also employed the computation of frequency, means and percentages for different variables.

3.2.2. Econometric Model

In order to analyze the soil and water conservation behavior and its impact on production, two equations system was constructed. The first equation specifies the farmers' soil bund adoption decision behavior and the second equation measures the impact of adoption of the technology on grain production.

i) Adoption Model (Probit Equation)

Following the works of Rham and Huffman (1984), to determine the factors influencing the adoption behavior of soil bund a random utility approach was used. We assumed that there is unobservable or latent variable, A_j^* which generates the observed variable A . Then we modeled the latent variable as follows:

$$A_j^* = X_j{}' \beta + \mu_j \qquad (j = 1, \ldots N) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Where,

A_j^* is the adoption variable

X_j is a vector of farmer and farm characteristics;

β is a coefficient to be estimated;

μ_j is a random disturbance which is normally distributed with mean zero and constant variance.

If we represent A_j as the observed dependent variable, then A_j^* is linked to A_j as follows

$$A_j = 1 \text{ if } A_j^* > 0 \text{ and}$$

$$A_j = 0 \text{ if } A_j^* \leq 0 \text{ .... (3.2.1)}$$

Farmer j adopts the conservation practice if $A_j^* > 0$. The probability that $A_j = 1$ is then:

$$\Pr\lfloor A_j = 1 \rfloor = \Pr\lfloor A_j^* > 0 \rfloor$$

$$= \Pr\lfloor X_j \beta + \mu_j > 0 \rfloor$$

$$= 1 - F\left(-X_j{}' \beta\right)$$

$$= F\left(X_j{}' \beta\right) \text{ .... (3.2.3)}$$

Where,

$\Pr[\cdot]$ is the probability function, and

$F(\cdot)$ is the cumulative distribution

a. Estimation Method

Estimation of Binary choice model is usually based on the method of maximum likelihood (ML). The relevant probability can be written as

$$\Pr\left(A_j = 1 / X\right) = \Pr ob\left(A_j^* > 0 / X\right)$$

$$= \Pr ob\left(X_j{}' \beta + \mu_j > 0 / X \right)$$

$$= \Pr ob\left(\mu_j > -X_j{}' \beta + \mu_j / X \right)$$

Assuming a symmetric, mean zero pdf for μ_j, we have

$$\Pr ob\left(\mu_j > -X_j{}' \beta + \mu_j / X \right) = \Pr ob\left(\mu_j < X_j{}' \beta / X \right)$$

It will be convenient to standardize μ_j, which gives

$$\Pr ob\left(\frac{\mu_j}{\sigma} < X'\left(\frac{\beta}{\sigma}\right) / X \right) = \Phi\left(X_j{}'\left(\frac{\beta}{\sigma}\right)\right) \qquad (3.2.4)$$

Where, $\Phi(\cdot)$ and σ are the cdf and standard deviation of μ_j, respectively. Therefore, the parameters are only identifiable up to a scalar σ, which is commonly set to unity (i.e. $\mu_j = 1$). The likelihood function is given by

$$L = \prod_j^n \left[\Phi_j^{A_j} \{1 - \Phi\}^{1-A_j} \right] \qquad (3.2.5)$$

And the log-likelihood function is given by

$$\ln L(\beta) = \sum_i^n \{ A_j \ln(\Phi) + (1 - A_j) \ln(1 - \Phi_j) \} \qquad (3.2.6)$$

Maximization of (3.2.6) will require non linear optimization methods such as Newton's algorithm.

b. Marginal Effects

Consider the mean effect on changing one particular continuous covariate X_j, $j = 1 \ldots \mathrm{K}$ by small amount, on the outcome probability. Under the normalization $\sigma = 1$, this effect will be given by

$$\partial\left[\Pr ob\left(\frac{A_j = 1/X_j}{\partial X_j}\right)\right] = \partial E\left[\frac{A_j / X_j}{\partial X_j}\right]$$

$$= \partial\left[\frac{\Phi(X'_j\beta)}{\partial X_j}\right]$$

$$= \phi\left(X'_j\beta\right)\beta_k \qquad j = 1,...k \quad .... (3.2.7)$$

ϕ is standard normal function.

Since these values varies with the values of X, while interpreting the estimated models the values should be calculated at the means of the repressor or other pertinent values. For computing marginal effects, one can evaluate the expression at the sample means of the data or evaluate the marginal effects at every observation and use the sample average of the individual marginal effects.

The predicted probabilities and the estimated marginal effects are non linear functions of the parameter estimates. To compute the standard errors we can use the linear approximation called "Delta method" (see Green, 2003) which uses a first order Taylor-series expansion to calculate the covariance matrix in the case of non linear function of random variables. For the estimated marginal effects,

$$Asy.Var\left[\Phi\left(X'_j\hat{\beta}\right)\hat{B}_k\right] = Asy.Var[\hat{\gamma}] = \left[\frac{\partial\hat{\gamma}}{\partial\hat{\beta}}\right]V\left[\frac{\partial\hat{\gamma}}{\partial\hat{\beta}}\right] \quad .... (3.2.8)$$

Where, V is the covariance Variance matrix.

c. *Measuring Goodness of Fit*

In binary choice models, the standard R^2 measure of goodness of fit does not have the same interpretation as the conventional regression, i.e. percentage change of variation in Y explained by the variation in X. Many alternatives have been suggested for qualitative regression (QR) models, of which a few are:

McFadden's likelihood ratio index (pseudo R^2)

$$R^2 = 1 - \frac{LnL_U}{LnL_R} \quad \text{..........} \quad (3.2.9)$$

This measure is bounded by zero and one but is difficult to interpret between the limit. It is not uncommon to see low R^2 values (e.g. less than 0.25) for models that explain the data well.

d. Likelihood Ratio Statistics

$$LR = -2(\ln L_R - \ln L_u) \quad \text{..........} \quad (3.2.10)$$

The standard likelihood Ratio statistics is asymptotically distributed chi-squared (χ^2).

Then, the adoption probit model for our study is specified as follows:

$$\Pr ob(A_j^* = 1) = f\begin{pmatrix} Gender, perception, landsize, Education, plotslope, \\ far\min g\exp eriance, Dis\tan ceofplotfromresidence, Dependencyratio, \\ TLU, Extension, Training, Labolanduratio, pesonlandratio \end{pmatrix}$$

ii) Model for Measuring Impact of Adoption on Grain Production

The model for measuring the impact of adoption on grain production is adapted from Madala (1983). It is often used to evaluate the benefits of development programs. The basic setup for estimating the impact of adopting soil bund on grain production assumes that the value of grain production per farm household Y_j is a linear function of a vector of explanatory variables Z_j (variable Z_j can be a subset of X_j that influences the adoption decision of the farmer in equation 3.2) and a binary dummy variable A_j whether the plot has soil bund $(A_j = 1)$ or it doesn't $(A_j = 0)$. Then the linear regression equation can be specified as:

$$Y_j = Z_j'\gamma + \delta A_j + \varepsilon_j \quad \text{..........} \quad (3.3)$$

Where, ε_j is a random disturbance which is independently and normally distributed with mean zero and constant variance.

Estimation of equation (3.3) using Ordinary Least Squares (OLS) may suffer from the following misspecification problem. 1st adoption of soil bund A_j might be endogenous to the impact evaluation equation if there is correlation between adoption A_j^* and the error term ε_j. On the other hand, the farmers decision whether to adopt soil bund conservation technology or not depend on the characteristics of the farm and the farmer himself. So the decision of the farmer to adopt soil bund is based on each farmers self selection. In this case the selection process may face a random selection bias problem. Self selection problem can arise due to the correlation between ε_j and μ_j i.e. $\left[E(\varepsilon_j \mu_j) \neq 0\right]$. Therefore, estimation of equation (3.3) by OLS with out taking into account for the self selection problem will result in biased estimates of γ.

The conceptual model structure employed in this study is the conventional endogenous treatment model, focusing on the full sample instead of only the adopter in the second equation. To estimate the two equation system the joint distribution of errors (ε_j, μ_j) were assumed to follow a bivariate normal distribution, and then apply the standard sample selection approach but with full sample. In this approach, two-stage estimation is applied following the Heckman type of two-stage estimation framework (1979).

Therefore, estimation of the second equation followed the following procedure. In the first stage, univariate probit analysis was used on model (3.2) to get estimates of β. Then, these parameter estimates were used to compute the inverse mills ratio[1] (IMR) and the predicted probabilities of adopting soil bund land conservation practice $(\hat{P}soilbund)$ of each observation which are going to be used to correct for the self selection and simultaneity problem of the second equation. Then, the second step is to apply Ordinary Least Squares (OLS) method of estimation using IMR

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[1] $IMR = \phi(X'_j\hat{\beta}) / \Phi(X'_j\hat{\beta})$ for posetive observations $(A_j = 1)$

$IMR = \phi(X'_j\hat{\beta}) / (1 - \Phi(X'_j\hat{\beta}))$ for the zero observations $A_j = 0$

Where, ϕ and Φ are the standard normal density and cumulative probability functions respectively.

and $\hat{P}soilbund$ as an additional explanatory variable. For the empirical analysis we applied a log- log linear functional form. Therefore, the impact measuring equation is specified as follows:

$$LnY_j = \gamma_0 + \gamma_i LnZ_j + \delta \hat{P}soilbund_j + vIMR + \varepsilon_j \ldots\ldots\ldots\ldots\ldots \quad (3.3.1)$$

Where,

Y_j^* is the value of crop in monetary terms in its natural logarithmic form

Z_j is a vector of explanatory variables (all the factors of production, farming experience and person-land ratio are in their natural logarithmic form)

$\hat{P}soilbund_j$ is the predicted probability of adoption variable estimated from probit model

IMR_j is the inverse mills ratio of each observation

γ_i, δ and v are parameters to be estimated

ε_j is a random disturbance with mean zero and constant variance.

3.2.3. Definition of Variables Used in the Analysis

i) Variables Used in the Adoption Equation

Gender: Adoption of physical soil and water conservation technology requires a considerable amount of human labour power that can be used to build and maintain the structure. However, female households are usually lack of such resources than male headed households (Bekele and Holden, 2001). Therefore, since male headed households are expected to have more resources, it is hypothesized that they are more likely to invest on soil and water conservation than female headed households.

Perception: the degree of soil erosion as perceived by the farm household. If the farmer perceives the presence of soil erosion, then he will be ready to invest on soil and water conservation practices (Ervin and Ervin, 1982 and Shiferaw and Holden 1998). Therefore, it is hypothesized that adoption of soil bund and perception are positively related.

Table 3.2: Variables included in the model, expected signs, definitions and values

Table 3.2.1: Variables included in Adoption Equation

Variable	Definition	Value	Expected sign	Type of measure
Dependent variable				
Soil Bund	Soil conservation practice	0 = non adopter 1 = adopter		Dummy
Independent variables				
Gender	Sex of the farm house hold	0 = female headed 1 = Male headed	+	Dummy
Perception	Degree of erosion as perceived by the farm household	1 = low 2 = moderate 3 = high	+	Categorical
Land size	Size of the farm plot	hectare	+	Continuous
Education	Educational status of the farm household head	0 = illiterate 1 = read and write 2 = grade 1 to 4 3 = grade 5 to 8 4 = grade 9 to 10/12	+	Categorical
Plot slope	Degree of slope of the plot as perceived by the respondent	0 = plain 1 = moderate 2 = Sloppy	+	Categorical
Farming experience	Experience of the farmer since started operating his own farm	Number in years	+/-	Continuous
Distance of plot from residence	Distance of plot from residence	Distance in walking minutes	-	Continuous
Dependency ratio	The number of dependants relative to economically active family members	Number of persons	-	Continuous
Size of livestock holding	Total livestock holding of the household	Tropical Livestock Unit (TLU)	+	Continuous
Extension	Participation in extension program	0 = No 1 = Yes	+	Dummy
Training	Participation in training program	0 = No 1 = Yes	+	Dummy
Labour-land ratio	Available labour force relative to land size	Man equivalent (ME)	+	Continuous
Person-land ratio	Population density per hectare of cultivable land	person per hectare	-/+	Continuous

Land size: the size of the plot is expected to have linear relation ship with adoption of soil and water conservation practices i.e. the level of its adoption increase/decrease with the size of land. Usually the use of soil bund reduces the size of the cultivable land, therefore, farmers with larger size of plots are expected to adopt more than farmers with smaller plot size.

Education: more often it has been concluded that beneficial innovations tend to be adopted more quickly by educated farmers as compared to the uneducated farmers (Bekele and Holden, 1998; Ersado *et al.*, 2001 and Demeke 2003). Education is likely to increase the farmers' exposure to more information and makes them to acquire knowledge and skills on soil and water conservation. It also improves farmers' ability and level of interest to change the existing farming practices. Thus, we posit that the farmers level of education to be correlated positively with adoption.

Plot slope: slope of the plot is considered to play a significant role in the adoption of soil and water conservation practices. A plot with steeper slopes increases the farmers' incentive to adopt soil and water conservation measures (Ervin and Ervin, 1982; Clay *et al.*, 1998 and Bekele and Holden, 1998). In this study we also hypothesized positive relationship between adoption of soil bund and plot slope.

Farming experience: farming experience has two opposing effects on the adoption of physical soil and water conservation measures. Longer farming experience might be associated with a shortened planning horizon over which returns can be captured from investing in the technology (Rahm and Huffman, 1984). On the other hand, experienced farmers have more resources and are more likely to adopt new technologies. Hence, the overall impact of farming experience on adoption is inconclusive.

Distance of plot from residence: it is expected that plots located far away from residence are expected to receive less care than closer plots. Because, the farmers will have less incentive to make land improvements owing to the higher transaction costs associated with longer distances (Clay *et al.*, 1998; Bekele and Holden, 1998 and Wegayehu, 2003). Here, we also posit inverse relationship between adoption of soil bund and distance of plot from residence.

Dependency ratio: it is the number of dependants relative to the economically active persons in the household. The larger the numbers of dependants relative to the economically active members of the household imply lesser labour availability for the household to perform every agricultural activity. Many empirical studies show inverse relationship between dependency ratio and adoption of conservation practices (Bekele and Holden, 1998). Here also, dependency ratio and adoption of soil bunds are expected to be correlated negatively.

Size of livestock: in rural areas, the size of livestock holding reflects the wealth status of the household. Usually, the adoption of an innovation is associated with the wealth status of the farmers. Farmers having large size of livestock are wealthier and are in good position to invest on soil and water conservation practices than those farmers who have small size of livestock (Nyagumbo, 1992 and Wegayehu, 2003). Thus, in this study it is hypothesized that size of livestock is directly related with the adoption of conservation practice.

Extension: extension service programs are positively related to adoption (Kassie and Holden, 2005). It is expected that participation in the extension program creates awareness on the farmers about the significance of land degradation problem, moreover, it improves the farmers' knowledge about the pros and cons of soil and water conservation practices. Thus, it is hypothesized that extension and adoption of soil bund are positively related.

Training: training is expected to stimulate the adoption of soil and water conservation practices by improving the farmer's knowledge about the technology (Semgalawe, 1998). It also increases the ability to construct the structure on their farm land. Hence, it has positive relationship with adoption.

Labour-land ratio: this variable determines the actual farm households' available labour force per unit area. The larger the labour-land ratio, the higher will be the labour force per unit area to accomplish the different agricultural activities. Families with high land-labour ratio are expected to adopt soil and water conservation practices than families having lower labour-land ratio (J. Baidu-Farson, 1999). We also hypothesize direct relationship between adoption and the variable labour-land ratio.

Person-land ratio: household with higher person-land ratio needs larger size of land to fulfill their subsistence food requirement. So with higher person land ratio the use of conservation practice that reduces the land size may have negative impact on adoption. On the other hand, it is also possible to burrow the Boserapeans hypothesis. Therefore, person-land ratio has mixed effect on the adoption of conservation behavior.

ii) Variables Used in Impact Evaluation Equation

PSoilbund: it is the predicted probability of adoption of soil bund obtained from the adoption equation. Like other soil and water conservation practices soil bund also has a capacity to improve the soil structure, texture and nutritional status of the farm plot and have positive impact in increasing the productivity of the farm land (Kabila and Rabele, 2004). So we hypothesize that soil bund will have direct and positive relationship with the value of production.

Gender: male headed households are expected to have better capacity and resources to obtain higher level of crop production as compared to their female headed counterpart. Therefore, gender is expected to have positive relationship with production.

Education: education exposes farmers to various types of information that will help them improve their crop production capacity. Thus, it is hypothesized that an increase in the educational level of the farm household is expected to bring about improvement in productivity performance.

Extension service: contact with extension officer increases the productive performance of the farmer. Hence, we posit the variable extension to have positive association with crop productivity.

Farming experience: the impact of farming experience on crop production performance is mixed. Farmers with longer farming experience have accumulated the resources to improve their productive capacity. On the other hand, more experienced farmers are older; and with age the productive efficiency diminishes. Therefore, the effect of farming experience on crop production is ambiguous.

Plot slope: sloppy plots are more exposed to erosion. Therefore, they are less fertile and less productive. Besides, farmers apply lesser amount of inorganic fertilizer because of its susceptibility to be washed away by runoff which may contribute to its lower productivity. Therefore, the impact of plot slope on productivity is negative.

Table 3.2.2: Variables included in impact evaluation Equation

Variable	Definition	Value	Expected sign	Type of measure
Dependent variable				
Crop value	The value of grain production per household	Birr		Continuous
Independent variables				
PSoil bund	Predicted probability of soil bund	Number	+	Continuous
Gender	Same as adoption equation		+	Dummy
Education	Same as adoption equation		+	Ordinal
Extension	Same as adoption equation		+	Dummy
Farming experience	Same as adoption equation		+	Continuous
Plot slope	Same as adoption equation		-	Ordinal
Distance of plot from residence	Same as adoption equation		-	Continuous
Land size	Same as adoption equation		+	Continuous
Family labour force	Available Family labour force	ME	+	Continuous
Fertilizer	The value of inorganic fertilizer applied per plot	Birr	+	Continuous
Oxen holding	Oxen used for traction purpose	Number	+	Continuous
Off-farm work	Participation in off-farm activities	0 = No 1 = Yes	-	Dummy
Person-land ratio	Same as adoption equation		+/-	Continuous
Inverse mills ratio	Estimates from adoption equation	Number	+/-	Continuous

Distance of plot from residence: as the distance between farm plot and residence increases, it will create inconvenience to manage the farm land properly. Here we expect that as the plot gets far away from homestead less care will be given to the crops cultivated and thus lower productive performance. This implies a negative association between the variables distance of plot from residence and value of crop production.

Land size: is the area of farm land covered with crops measured in hectare. The size of land is expected to have positive relationship with crop production.

Family labour force: labour force can be measured as the number of productive adults (aged 15 to 55) in the household or as person days of labour spent on different agricultural activities such as plowing, weeding and harvesting etc,. An advantage of the first measure is that it allows distinction between different types of labour such as age and sex. An advantage of the second method is that it actually counts the actual time spent on farm activities, rather than just potential effort. For the analysis of this study, the first method is employed. In our study it is hypothesized that labour has positive and direct relationship with crop production.

Fertilizer: it is the value of fertilizer used per plot. It is evident that fertilizer increases the soil nutrient and crop growth; therefore, it is positively related with crop production and hence to crop value.

Oxen holding: it is the number of oxen holding per household. Oxen are the main sources of traction power in crop production. Farmers having oxen can prepare their land adequately and they will be on time for planting. Thus, it is expected to have positive relationship with the dependent variable.

Off-farm work: participation in off-farm activities compete with crop production. It reduces the amount of labour to be invested to accomplish the different agricultural activities implying a negative association. On the other hand, the income earned from the off-farm activities may be invested to purchase on land productivity improving technologies such as inorganic fertilizer which has positive impact on the performance of crop production. Hence the impact of off-farm income on crop production is ambiguous.

Person-land ratio: higher numbers of persons per hectare of cultivable land means higher number of consumers. It means that most of the crops produced by the farm household will be allocated for consumption leaving none or very limited amount of the resources to be invested on land productivity enhancing technologies. Hence, this variable is hypothesized to have negative impact on the productive performance of the farm household.

CHAPTER FOUR

RESULTS AND DISCUSSION

In this chapter, results of the survey were thoroughly discussed. The survey was conducted on 141 households having 520 farm plots. Out of the 520 farm plots, 346 and 174 plots were with and without soil bund respectively. The data included in the analysis were a combination of biophysical characteristics at plot level and farm household characteristics at farm level.

4.1. Descriptive Analysis

This section deals with brief description of the study area and descriptive statistical analysis of the sample household heads and their farm plot. For the sake of convenience the results of the analysis are presented by classifying adopters and non-adopters at the household head level and with and without soil bund of the farm plot into different categories namely demographic characteristics, farm characteristics, attitudinal factors, institutional and economic factors.

In analyzing the sample data, the techniques employed included the independent t-test to identify mean differences between the two groups, the adopters and non-adopters of respondents; the one way ANOVA analysis which was used to find out differences within and between the two groups; and the chi-square (χ^2) test which was conducted to detect if there is any systematic association between the dependent variable – adoption of soil bund – and specific household characteristics. Moreover, descriptive statistics such as frequency, means and percentages were computed for different variables.

4.1.1. The Study Area

The study area, Kilie Watershed is found in Lume Woreda, East Shoa Zone, and Oromia Regional State. The watershed area comprises two FKA namely Bola and Goljie. The Geometric Positioning System (GPS) coordinate demarcates the boundaries of the watershed area at $08^0$34 40.3" - $08^0$36 47.2" North and $039^0$10 33" - $039^0$13 11.8" East. Specifically, it is located about 10 km North East of Modjo town, the capital of the Woreda. The area is bordered with Tede, Kolba Gode and Deka Boara FKA from the North, West and Southern direction respectively and Kechema FKA from East direction (Adama Woreda).

The total area of Kilie Watershed is 921 ha, of which 74% is cultivated land, 2.7% is covered with forest and shrubs, 1.4% is grazing land, 10.76% is occupied by village and the rest 11.2 % is degraded land with big gullies. The topography of the area is undulated gentle slope and it lies on an elevation extending from 1860 to 1980 meter above sea level (m.a.s.l.). Regarding the slope of the land 25% has 4 to 15% slope, 50.3% has gentle and moderate slope and 24.7% has about 16% slope. According to agro climatic zone classification the area belongs to Dry Woyina Dega Zone. The average minimum and maximum temperature is 12 ^{0}C and 30 ^{0}C respectively. The area has bimodal rainfall distribution with a short rainy season from March to May and a long rainy season from June to September. The average annual rainfall varies from 700mm to 950mm.

The watershed contained about 300 households having approximately a total population of 1500 people. The average family size is 5 persons per household. The farmers of the watershed area are mainly engaged in agriculture. The prevailing farming system is mixed farming, crop-livestock production system. Cereal crops comprise the lion share of the cultivable land. The major crops grown by the farmers and their land size in order of their importance are presented on Table 4.1.

Table 4.1: Cropping pattern

Crop type	With soil bund		Without soil bund	
	Size of land (ha)	Number of plots	Size of land (ha)	Number of plots
Teff	118.250	113	37.000	48
Wheat	49.500	92	21.125	44
Beans	23.375	58	14.625	35
Barley	16.500	52	10.250	30
Field peas	4.250	15	3.750	11
Maize	5.125	16	1.375	6
Total	**217.000**	**346**	**88.125**	**174**

Source: Own survey result (2007).

The average yield per hectare for each crop grown by the farmers on farm lands with and with out soil bund was computed from the survey data and presented on table 4.2. From the table it is observed that except barley for other crops the average yield obtained from farm plot with the conservation practice is greater than that of farm land without the conservation practice.

Table 4.2: Average yield per hectare (Qts) with and without soil bund

Crop	With soil bund	Without soil Bund	Both combined
Teff	9.16 (5.93)[a]	8.58 (5.62)	8.99 (9.39)
Wheat	17.59 (2.27)	15.89 (1.88)	17.04 (2.29)
Barley	11.27 (1.67)	11.48 (1.47)	11.35 (1.59)
Maize	15.64 (2.68)	14.80 (2.68)	15.44 (2.73)
Field pea	8.60 (9.1)	8.56 (8.9)	8.64 (8.5)
Beans	9.96 (1.73)	9.13 (2.29)	9.65 (1.99)

Source: Own survey result (2007).

[a]*Values in parenthesis are standard errors.*

As to the utilization of fertilizer, in the area the farmers use both types of fertilizer, i.e. DAP and Urea. Fertilizer is applied only on teff and wheat crops. The average consumption of fertilizer per hectare for farm plots with and without conservation practice is presented on table 4.3. In the area the overall consumption of fertilizer (total area cultivated in hectare divided by total use of fertilizer in kilogram) is 160kg per hectare which is two fold of the national average consumption rate.

Table 4.3: Average fertilizer consumption per hectare (Qts) with and without soil bund

Crop	With soil bund	Without soil Bund	Both combined
Teff	2.26 (0.38)[a]	2.78 (0.57)	2.42 (0.51)
Wheat	1.97 (0.47)	2.24 (0.49)	2.00 (0.49)

Source: Own survey result (2007).

[a]*Values in parenthesis are standard errors.*

Regarding the soil type of the study area, in general it belongs to verti-sol (clay soil). Within this main soil class the farmers locally classified their farm plots soil type in to three groups locally named as Koticha (Black), Gomborie (Brownish/Red) and Bisikie (Clay loam). Table 4.4 shows the crops grown in each soil groups.

Table 4.4: Soil type of the farm plots

Crop type	With soil bund			Without soil bund		
	Clay (Black)	Clay (Brownish/Red)	Clay loam	Clay (Black)	Clay (Brownish/Red)	Clay loam
Teff	87.75 (84)[b]	18.375 (18)	12.125 (11)	29.25 (36)	4.25 (6)	3.5 (6)
Wheat	33 (62)	9.75 (17)	6.75 (13)	12.5 (26)	6.25 (6)	2.375 (6)
Beans	16.375 (39)	3.0 (7)	4.0 (12)	10.75 (24)	2.0 (4)	1.875 (7)
Barley	10.75 (36)	0.75 (3)	5 (13)	5.625 (17)	2.75 (6)	1.875 (7)
Field peas	3.75 (13)	0.25 (1)	0.25 (1)	2 (7)	0.75 (1)	0.75 (3)
Maize	3.875 (12)	0.25 (1)	1.0 (3)	0.375 (2)	0.25 (1)	0.75 (3)
Total	156.5 (246)	34.375 (47)	32.125 (53)	61.5 (112)	18.25 (30)	14.125 (32)

Source: Own Survey result (2007).

[b]*Values in parenthesis are number of farm plots.*

In the area, livestock have diverse function in the production systems. It can provide nutritive food item (meat, milk, eggs, etc.) for home consumption as well as for sale. Moreover, it provides the major source of power for traction purpose. The farmers in the watershed keep cattle, sheep, goats and equine. They use the hillsides as a communal grazing land. The major sources of feed for livestock are crop residues and grasses grown on the soil bund. There is a high feed shortage throughout the year; there is no systematic grazing land management practice.

As to the extension service, the Lume's woreda BoA&RD is the only governmental institution that provides extension services to the surrounding farmers. The existing extension system is called Participatory Agricultural Demonstration and Training Extension System (PADETS). It focuses mainly on crop production. There are three development agents (extension officers) assigned in the area to execute the program.

With respect to the soil and water conservation activities, in the study area the farm households employed different soil and water conservation practices to arrest or reverse the course of land degradation. These are agronomic practices such as crop rotation, contour plowing, manure and compost application, tree planting, water way and physical conservation practice such as soil bund. Practices like crop rotation, contour plowing, tree planting and water way are commonly used by almost all of the farmers and the application of manure and compost is very rare and limited to small number of farmers. Thus, this study focused on soil bund which is the main physical soil and water conservation structure practiced by the surrounding farmers. Soil bund is an embankment made by ridging soil on the lower side of a ditch along a slope contour. In the study area the use of soil bund as a conservation practice has a long history. From 1975-987 the Kilie Watershed area was part of the larger Ejerie-Koka catchments area soil and water conservation project. During that time under the Food For Work (FFW) program assisted by World Food Program (WFP) a lot of conservation structures including soil bund were constructed on most of the farm lands. And recently 17 years later in 2004 a new soil and water conservation project was initiated by Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) in collaboration with the woreda BOA&RD. According to the project agreement GTZ will provide equipments and facilities such as hand tools and transporting facilities and the technical works are handled by the Woreda BOA&RD. The farmers join the program on their free will. The only assistance they receive from the project is hand tools, short-term trainings and technical advice.

As far as, road infrastructure is concerned, there is an all weather road linking the area with Modjo and Adama, the capital of East Shoa Zone. The road linking to Adama has a daily transportation (vehicle) facility. But to travel to Modjo the farmers have to travel 60 to 120 minutes to reach the main highway where vehicles are available.

4.1.2. Demographic Characteristics

i) Gender

In the study area about 84.4% (119) of the household heads were male, and the rest 15.6 % (22) were female. With respect to adoption of soil bund, 10 of the adopters and twelve of the non-adopters were female headed.

Table 4.5 depicts that there is a significant difference between male and female households in the adoption of the soil conservation practice. That means female headed farm households invest less on land conservation activity as compared to the male headed households. This is explained by the fact that female headed households face shortages of the necessary resources such as (male) labour force to perform the conservation activity. Usually the construction of soil bund requires a high amount of both human and animal power.

Table 4.5: Gender composition of the sampled survey

Gender composition		Non - adopters % age	Adopters % age	Total % age	χ^2	*P-Value*
Gender	*Female*	*54.5*	*45.5*	*15.6*	*11.45**	*0.002*
	Male	*20.2*	*79.8*	*84.4*		

Source: Own survey result (2007).

* *imply that the variable is significant at 1% level.*

A chi-square (χ^2) test was conducted to identify whether there was any difference in the adoption of soil and water conservation between adopters and non-adopters with reference to their gender characteristics. The result obtained showed the existence of significant differences ($\chi^2 = 11.45$, p = 0.002). This implied that in the study area male and female household heads had differences in their adoption decision. Concurrence to this study, Semgalawe (1998) in Tanzania and Demeke (2003) on his research in northern part of Ethiopia also observed differences in conservation behavior between female headed and male headed farm households.

ii) Family Size and Age Structure

Family size and its composition greatly determine the amount of labour available to accomplish both on and off-farm activities pursued by the households to sustain their livelihoods. Results of the sampled farm household survey showed that the family size in the study area ranged from 1 to 11 with an average of 6.03 persons per household. The number of children per family ranged between 0 and 9 with an average of 4 children per household. With reference to levels of adoption, the average household size of the adopters was 6.5 persons and that of the non-adopter was 4.67 persons as presented on table 4.6.

Considering the families of economically active groups whose ages were between 15 and 64 years and could contribute labour force to the household, they were on the average about 3.56 economically active members per family. With reference to the mean economically active members of the family for adopters and non-adopters, the values were 4.05 and 2.14 persons respectively. On the other hand the number of dependants per household ranged between 0 and 6 with an average of 2.48 persons per household.

The impact of family size on the adoption and retention of soil and water conservation measures such as physical structures may be either positive or negative as observed by different studies conducted in different parts of the world. Usually households with bigger family size are expected to have enough labour resources to provide the labour that is required for establishing and maintaining conservation structures such as soil bund, and household with smaller family size may face labour shortage which may hinder adoption and sustained use of conservation practices.

The t-test statistical analysis showed a significant ($p = 0.00$) mean difference on the family size of adopters versus non-adopters of soil and water conservation practices. That is, in the area the adoption of soil bund land conservation measure was greater for families with large family members compared to families with low family size, which means that family size has a decisive power in influencing the soil and water conservation investment made by the farm household.

Table 4.6: Demographic variables of the sampled household

No	Characteristics	Non-adopters (N = 36)	Adopters (N = 105)	t-ratio	*P-Value*
2	Family size	4.67 (1.474)[a]	6.50 (2.309)	-5.487*	*0.000*
3	Age of the household head	50.81 (12.649)	54.4 (10.522)	-1.533	*0.131*
4	Economically active group	2.14 (0.683)	4.05 (1.528)	-10.178*	*0.000*
5	Dependants	2.61 (1.293)	2.43 (1.351)	0.722	*0.473*
6	Family labour force	2.73 (1.13)	4.18 (1.533)	-5.994**	*0.000*
7	Dependency ratio	1.36 (0.862)	0.649 (0.418)	4.763**	*0.000*
8	Person-land ratio	3.59 (2.199)	2.88 (1.197)	1.85***	*0.071*
9	Labour-land ratio	1.64 (0.914)	1.84 (0.700)	-2.492**	*0.013*
10	*Farming experience*	*15.78 (11.412)*	*23.07 (9.453)*	*-3.448**	*0.000*

Source: Own survey result (2007).

[a] *values in parentheses are standard deviation*

*, ** and *** *imply that the variable is significant at 1% level, 5% level and 10% level respectively.*

Featherstone and Goodwin (1993) in Kansas and Yesuf (2003) in Ethiopia found out that the likelihood of investing on land conservation is positively influenced by larger family size. However, contrary results were also observed. For instance, the study conducted by Demeke

(2003) in northern part of Ethiopia showed that households with bigger family size didn't adopt those types of soil and water conservation practices that reduced the amount of available cultivable land because of the higher demand for land to meet their subsistence need.

Age would appear to be of particular relevance to the adoption of conservation practices that have long lags between investment and payoffs. If the benefits of conservation practices are not expected with in a short period of time, then older farmers may have less incentive to invest compared to their younger counterparts. The other and different argument on the relationship between age and adoption of land conservation practices relies on the correlation between age and experience. It states that as the age of the farmer increases, he gains more knowledge as well as the resources required to invest on soil and water conservation practices than the younger farmers who lack such resources. Therefore, older farmers are in a better position to invest on land conservation practices.

The review of factors influencing the adoption of conservation practices found both positive and negative relationship between age and adoption. Featherstone and Goodwin (1993) in Kansas; Clay *et al.*, (1998) in Rwanda; and Shiferaw and Holden, (1998); Yesuf (2005) and Deininger *et al.*, (2003) in Ethiopia found negative and significant association between age and adoption of conservation practice. Fitsum and Holden (2006) also found out the age of the farm household to be negatively correlated with the intensity of soil bund. On the other hand, Kaliba and Rabele (2004) in Lesotho found that age has positive influence on the adoption behaviors of the farmer. Moreover, Ersado *et al.*, (2001) obtained that among the other factors that influenced adoption of innovation in Ethiopia, the age of the household head was found to be positively and significantly affecting the probability of sequencing choices-adoption lag.

Regarding the mean ages of non-adopters and adopters, the values were 50.81 and 54.40 years respectively. And the average household head was 53.48 years old. The result of the t-test conducted to measure the mean difference between adopters and non-adopters revealed that there was no significant difference between the two groups (See table 4.6). Thus, age is not found to influence the adoption decision behavior of the farmers' conservation practice in Kilie Watershed area. Similar results were obtained by J. Baidu-Farson (1999) in his research on the factors influencing adoption of land enhancing technology in the Sahil.

iii) Family Labour Force

Own family labour is an indispensable resource of the farm household. It is a crucial determinant factor for every activity undertaken by the farm household such as farming, marketing activities, off-farm works and social obligations, etc. Therefore, analyzing the farm households available labour force should be given due consideration. In this study the farm households' available labour force is measured in Man-equivalent (ME). This type of measurement has great advantage over head count, because it allows taking into account differences of sex and age composition among the family members. The computation of the ME was made following Strock, *et al.*, (1991). According to them, the ME for both sex children less than 10 years of age was taken to be zero; for both sexes between 10 and 14 years of age, it was taken to be 0.35; for adult men between the age of 15 and 50, it was 1; for adult women between the age of 15 and 50 it was 0.8 and for both sexes older than 50 years of age it was taken to be 0.55 (See Annex 2 Table 2.1).

The sampled survey result of this study showed that the average ME per household was 3.8 with the minimum and maximum being 1 and 8.65 respectively. With reference to adoption, the mean value of ME of adopters was 4.18 and that of the non-adopters were 2.73. The t-test showed that there was statistically a significant mean difference (p = 0.000) between the two groups. This means that the amount of available household labour force had definite influence on the adoption of soil and water conservation practices in the study area. A similar result was obtained by Clay *et al.*, (1998) in his study on Sustainable intensification in the highland tropics: Rwandan farmers' investment in land conservation and soil fertility.

iv) Dependency Ratio

Dependency ratio is the number of children below 15 years of age, elders above 64 years of age and disabled household members relative to the number of economically active household members falling between the age of 15 and 64. In the study area the dependency ratio of the sample households ranged between 0 and 4 with an average of 0.83 persons per household. With reference to adoption, the mean value is 1.36 and 0.65 for non-adopters and adopters respectively. Dependency ratio affects adoption of conservation practices negatively. Besides, it increases the food demand of the households since there are many mouths to be fed compared to the less hand available for work. If the number of children and elderly members of the household are high there will be less labour to handle the land conservation activity. Moreover, other available resources such as money will also be channeled to satisfy the basic needs of the family (such as food) rather than investing them on land productivity enhancing technologies.

The result of the sampled survey shows that the Pearson correlation between dependency ratio and the adoption of soil bund conservation technology was negative and significant at 10% level of significance and its value is 28.6%. It was evident that the higher the dependency ratio, the lesser would be the available labour for the household to carry out the construction of physical structures of conservation measures. An independent t-test was also conducted to measure whether there was mean difference between adopters and non-adopters and the result obtained showed that there was a significant difference ($p = 0.000$). This implies that the non-adopters had high dependency ratio which hindered them from adopting the prevailing soil and water conservation practice that required higher amount of labour force. Fitsum and Holden (2006) in their research on the Northern parts of Ethiopia found the variable dependency ratio to influence adoption and intensity of soil bunds both negatively and significantly.

v) Person-Land Ratio

Person-land ratio is taken as a proxy for population pressure (population density per hectare of cultivated land). Population pressure is considered to be one of the most important factors behind the declining use of fallow, increased land fragmentation and continuous cultivation in most rural parts of Ethiopia. Higher population growth increases the pressure on arable land, resulting in lower cultivable land per capita to satisfy the food demand of the household. Therefore, it has negative impact to invest on soil and water conservation practices that reduces the size of arable land such as soil bund conservation technology.

However, evidence of the impact of population pressure on soil and water conservation investment is not clear. Boserup (1965) posits that, under population pressure and increasing constraints to arable land, farmers can protect their land with land improvements such as terraces and soil/stone bunds and sustain soil fertility by use of fertilizer and manure. Evidences that supported Boserup's hypothesis were found by Tiffen, *et al.*, (1994) in Kenya; Templeton and Scherr (1999) and Nkonya, *et al.*, (2004) in Uganda. On the other hand, contrary results were observed. For instance in Ethiopia, Grepperud (1996) indicated that land degradation is positively and significantly influenced by population pressure. Moreover, Shiferaw and Holden (1998) found that higher population pressure created incentives to remove externally introduced physical conservation structures.

In the study area person-land ratio ranged between 0.80 and 12 persons per hectare and the average farm household comprises 3.1 persons per hectare of cultivable land. With reference to the mean person-land ratio of adopters and non-adopters, the values were 2.88 and 3.59 respectively. A t-test was conducted to detect whether there was a mean difference between the two groups and it was found out to have statistically significant mean difference ($p = 0.071$), meaning that population pressure has pronounced influence on land conservation. Moreover, the Pearson correlation statistics indicates that there is a negative and statistically significant association between the variable person-land ratio and adoption of soil bund at 10% level of significance and its value is 20.2%. The result of this study is similar to those study results observed by Grepperud (1996) and Shiferaw and Holden (1998). But contrary to the result of Fitsum and Holden (2006), these researchers in their study on the northern part of Ethiopia found out that the intensity of soil bunds was positively determined by population density.

vi) Labour-Land Ratio

In the area the main sources of human labour for every agricultural activity are family members. Usually larger families are expected to have higher family members, thus own sufficient labour force to handle those agricultural activities. However, family size alone cannot determine the actual available labour force in the family. To show a clear picture of the available labour force, the family's labour force should be weighed against the cultivable land holding. Therefore, labour-land ratio is calculated for the sampled households to obtain the exact available labour force in ME per hectare per household which helps us to make appropriate comparison among the farm households.

The result of the sampled survey data showed that on the average a household has 1.77 ME per hectare available labour force for agricultural activities with the minimum and maximum being 0.5 and 5.9 ME per hectare respectively. With reference to the level of adoption, it was found out that the average value labour-land ratio of adopters was 1.84 ME per hectare and 1.64 ME per hectare for non-adopters as shown in table 4.6.

A t-test analysis revealed a significant mean difference ($p = 0.013$) between adopters and non-adopters. The Pearson correlation was also significant at 1% level of significance and its value is 11.9%. The result of the statistical analysis shows that labour-land ratio has a marked influence in explaining the adoption behavior of the farmers. The study also indicated that adopters of soil bund conservation measure have larger labour force in terms of ME per hectare than the non-adopters. Anley *et al.*, (2006) in their study in the western part of Ethiopia also found similar result.

vii) Farming Experience

Farming experience is measured in the number of years since the farmer began managing his own farm holdings. In the study area, farming experience of the sampled household ranged from 1 to 31 and the average farmer had 21.1 years of experience with standard deviation of 10.45. With regard to the non-adopters and adopters, the value of the average years of farming experience was 15.78 and 23.07 years respectively (See table 4.6).

As it is shown in table 4.7 below, 54.6% of the house hold have more than twenty years of farming experience while the rest 20.6% and 24.8 % have less than 10 and between 10 and 20 years of experience respectively.

Table 4.7: Farming experience of the sampled household

№	Farming experience	Non-adopters % age	Adopters % age	*Total*
1	Less than 10 years	36.0	15.2	*20.6*
2	Between 10 and 20	31.0	22.8	*24.8*
3	*Above 20 years*	*33.0*	*62.0*	*54.6*

Source: Own survey data (2007)

T-test analysis was used to identify whether or not there was mean difference between the two groups. The result showed that there is significant difference ($p = 0.000$) between adopters and non-adopters (See table 4.6). The Pearson correlation between farming experience and adoption was both positive and significant at 10% level of significance and its value is 30.5%. From this it was apparent that more experienced farmers adopted soil bund conservation practices than less experienced farmers. It may also explain the fact that experience increases the likelihood of understanding the benefits of soil conservation measures and equip farmers with resources that enabled them to invest on soil and water conservation practices.

A similar result was obtained by Fitsum and Holden (2006) between adoption of soil bund and experience though the coefficient was not statistically significant. On the other hand, contrary result was obtained by Traore *et al.*, (1998) in Quebec, Canada. According to them experienced farmers tend to become accustomed to environmental degradation problems and see them as part of farming rather than a problem.

viii) Level of Education

Education plays important role in motivating the adoption of soil and water conservation practices. Exposure to education can increase the farmers' management capacity as well as better understanding of the benefits and constraints of soil and water conservation measures. It also improves the capacity and ability of the farmer to obtain and apply relevant information concerning the use of soil conservation practices which is a very important stage of technology adoption.

Table 4.8: Educational status of the sampled household in percentage

№	Educational Status	Non-adopters % age	Adopters % age	Total % age	χ^2 / P–value
1	Illiterate	77.8	40.0	49.6	*11.83** (0.000)
2	Read and Write	11.1	42.9	34.9	
3	Grade 1 to 4	8.3	11.4	10.6	
4	Grade 5 to 8	2.8	2.85	2.8	
	Grade 9 to 10 or 12	*0*	*2.85*	*2.1*	

Source: Own survey result (2007).

* *imply that the variable is significant at 1% level.*

The educational background of the sampled farm households is low (See table 4.8). The total percentage of illiterate comprises almost 50% of the sample household population; and 35% of the households were able only to read and write.

The chi-squared (χ^2) test was conducted to see if there was a systematic association between educational status and adoption of soil bund conservation practices. The result of the analysis showed the presence of significant association ($\chi^2 = 11.83$, sig = 0.000) implying increment in the rate of adoption with an increase in the level of education.

This result is parallel with Ervin and Ervin (1982) at Monroe County, USA; Traore *et al.*, (1998) in Quebec, Canada; Mukabo (2002) at Machakos and Kitu districts in Kenya; Ersado (2001) in the northern part of Ethiopia; Tengen *et al.*, (2001); Demeke (2003) and Deininger *et al.*, (2003). Fitsum and Holden (2006) on their research on Tenure security, resources poverty, public programs and household plot level conservation investment in the highlands of northern Ethiopia revealed the fact that education had significant influence on soil bund conservation investment.

4.1.3. Farm Characteristics

i) Land Size

Land is one of the major constraints in the rural parts of Ethiopia as a whole and in the study area in particular. With continuous growth of population and no alternative employment opportunity in the rural as well as in the urban area, the burden solely rests on land. Each family has to share his holding with his off springs which leads to smaller and more fragmented land holding.

The amount of agricultural production produced by a farm household is largely determined by the size and quality of its land holding. Usually, smaller size of land leads to dissatisfaction and general negative attitude towards adoption soil and water conservation practices. And its effect will be prominent on soil and water conservation practices like soil bund conservation measures that resulted in the reduction of land size. For any technology to bring visibly observable positive outcome, all the necessary inputs should be of optimal quality and quantity. In this regard land size has significant influence in shaping the adoption decision of the technology beneficiaries.

In Kilie Watershed area the size of cultivable land of the sampled household ranged between 0.5 and 3.25 hectares, and the average size of farm land is 2.17 hectares per household. With reference to the average size of land of adopters and non-adopters, the values were 2.35 and 1.64 hectares respectively. The result of the t-test conducted to measure the mean difference between adopters and non-adopters revealed a significant difference (p = 0.000) between the two groups (See table 4.9). This implies that in our study land size influenced the adoption of soil bund significantly.

Table 4.9: Land size, distance of plot from residence and number of plots

No	Land characteristics	Non-adopters (N = 36)	Adopters (N = 105)	t-ratio	*P- Value*
1	Land size	1.64 (0.331)[a]	2.35 (0.454)	-3.446**	*0.039*
	Distance of plot from residence	42.24 (0.409)	29.31 (0.378)	6.162*	*0.000*
2	*Number of Plot per household*	*3.78 (1.456)*	*3.66 (0.949)*	*0.464*	*0.645*

Source: Own survey result (2007).

[a] *values in parentheses are standard deviation*

* *and* ** *imply that the variable is significant at 1% level and 5% level respectively.*

The Pearson correlation between farm size and adoption of soil bund was positive and significant at 10% level of significance and it is 13.3%. This indicated that the farm size of those farm households who adopted soil bund conservation practice was larger than that of the non-adopters. Similar results were also obtained in other different countries. Semgalawe (1998) in his research carried out in Tanzania found that farm size has a determinant impact on the adoption of soil and water conservation practices. According to him investment on soil and water conservation measures are correlated negatively with smaller size of farm holdings. Fitsum and Holden (2006) in their study also found out that the relative farm holding was significant and negative in explaining the intensity of conservation with respect to soil bund pointing to an inverse relationship between farm sizes and conservation intensity. Kassie and Holden (2005) also obtained a linear relationship between adoption probabilities of soil conservation measures with plot size. Okoye (1998) in his study of comparative analysis of factors in the adoption of traditional and recommended soil erosion control practices in Nigeria observed that the adoption of soil erosion controlling practices responded to farm size positively and significantly.

ii) Distance of Plot from Residence

Distance of plots from residence is an important factor in determining the land conservation practices carried out by the farm household. Farm plots found closer to homesteads are more likely to be conserved than distant plots. This is due to the lower transaction cost involved. Moreover, it is easier for the farmers to monitor and maintain the soil and water conservation structures installed on fields closer to home.

In Kilie Watershed area, the distance between farm plots and residence considerably varied from household to household. About 13% of the plots were reported to be found adjacent to the farmers' residence and 13% of the plots are found as far as one hundred twenty minutes walking distance away. The distance between farm fields and home ranged between 5 minutes and 120 minutes and on the average each farm household travels 33.63 minutes walking distance to reach his field. To see the pattern of correlation between adoption and plot distance from residence, Pearson correlation was computed and the result was negative and significant at 10% level of significance and its value is 30.2%.

With regard to adoption, the values of mean distance of the plots from residence between adopters and non-adopters were 29.31 and 42.24 minutes respectively. A t-test was conducted to measure whether there was a mean difference between the two groups, adopters and non-adopters. The statistical result of the survey showed a significant mean difference ($p = 0.000$) between the two groups (see Table 4.9). Therefore, in this study distance of plot from residence has significant power in explaining the adoption decision of the farm households.

Studies on the relationship between distance of plot from residence and adoption of soil and water conservation practice have been found to be either positive or negative. Wegayehu, (2003) and Fitsum and Holden (2006) reported that the variable distance of plot from residence has negative impact on the adoption and intensity of soil bund.

iii) Number of Plots Per Household

The number of plots per household represents farm fragmentation. Usually, it is expected that as fragmentation increases plots are dispersed and reduced in size. This condition creates less incentive for the farmers to make land improvements because of higher transaction costs and the inconvenience it may cause in farming operation in the case of soil bund due to the presence of physical structures.

In the study area, the total number of plots owned by a household ranged between 1 and 7 and the average number of plots per sampled household was 3.7 with a standard deviation of 0.798. With reference to the mean number of plots between adopters and non-adopters, the values were 3.66 and 3.78 plots respectively (See Table 4.9).

A t-test was conducted to measure the mean difference between adopters and non-adopters and the result obtained revealed that there was no statistically significant difference between the two groups. Although it was not statistically significant, the Pearson correlation statistics showed negative correlation between adoption and number of plots. It means adoption of soil bund decreased with increased fragmentation. In general based on these statistical inferences, it can be concluded that in this study, land fragmentation has no influence on the adoption decision of the farm household. This result is in agreement with Fitsum and Holden (2006).

iv) Plot Slope and Degree of Erosion

The nature of the slope of the farm plot is one of the common indicators in determining the degree of soil erosion. Usually plots with steeper slopes are more susceptible to erosion; therefore, it increases the incentive to invest in land conservation measures.

The farmers in the study area were given three grades of slope category, namely Medama (plain), Mekakelnga Dagetama (moderately sloppy) and Dagetama (sloppy) to classify the degree of slope of their farm plots. According to the result of the survey, the respondents had classified 18% of their farm plot as Medama 50% of their farm plot as Mekakelnga Dagetama and the rest 32% of their farm plot as Dagetama (See table 4.10).

Table 4.10: Plot slope and degree of soil erosion

No	Description	Grade	Non-adopters (%)	Adopters (%)	χ^2	*P-Value*
1	Plot slope	Plain	42.5	5.5		
		Moderate	39.1	55.2	74.451*	0.000
		Sloppy	18.4	39.3		
2	*Degree of soil erosion*	*Low*	*70.0*	*39.0*		
		Medium	*28.7*	*53.2*	*38.45**	*0.000*
		High	*2.3*	*7.8*		

Source: Own survey result (2007).

* *imply that the variable is significant at 1% level.*

The result of the Chi-squared (χ^2) test analysis which was used to identify whether there was a mean difference on plot slope characteristics between adopters and non-adopters revealed a significant mean difference (p = 0.000) between the two groups. Moreover, the Pearson correlation between slope and adoption was found to be both positive and significant at 1% level of significance and it is 39.4%. This result implies that the slope nature of the farm land has significant impact on the adoption decision behavior of the farmers. This study also revealed that in the area most of the conservation structures are installed in sloppy parts of the farm land. Similar results were also found by Shiferaw and Holden (1998); Kassie and Holden (2005) and Yesuf (2005) on their research conducted in the different parts of the country.

The degree of erosion of the farm plot is determined by the nature of slope. This implies the positive correlation between slope and degree of erosion. Farmers of the study area were asked to indicate the degree of erosion on their plot (See table 4.10). The survey data shows that about 70% of the non-adopters regarded the degree of soil erosion to be on "low" category compared to 39% for the adopters. On the "medium" category the results were 28.7% for non-adopters and

53.2% for adopters. On the "high" category the results were 2.3% and 7.8% for the non-adopters and adopters respectively.

Chi-squared (χ^2) test was run to see the association between degree of erosion and adoption. The result of the analysis was significant. This means adoption of soil bund increases with an increase in the degree of erosion.

4.1.4. Attitudinal Factors

i) Farmers' Perception of the Severity, Cause and Consequences of Soil Erosion

A decision to adopt soil and water conservation measures depend upon the level of the farmer's perception of soil erosion and recognizing it as a problem (Ervin and Ervin 1982; Gould *et al.*, 1989 and Shiferaw and Holden, 1998). Indeed, the importance of farmers' perception of the technology's attributes in the adoption process is not completely undermined.

Table 4.11: Perception of soil erosion by the sampled farm household

Description	Grade	Non-adopters (%)	Adopters (%)	χ^2	P-Value
Perception of soil erosion	*Low*	*61.1*	*8.6*		
	Medium	*27.8*	*68.6*	*43.193**	*0.000*
	High	*11.1*	*22.9*		

Source: Own survey result (2007).

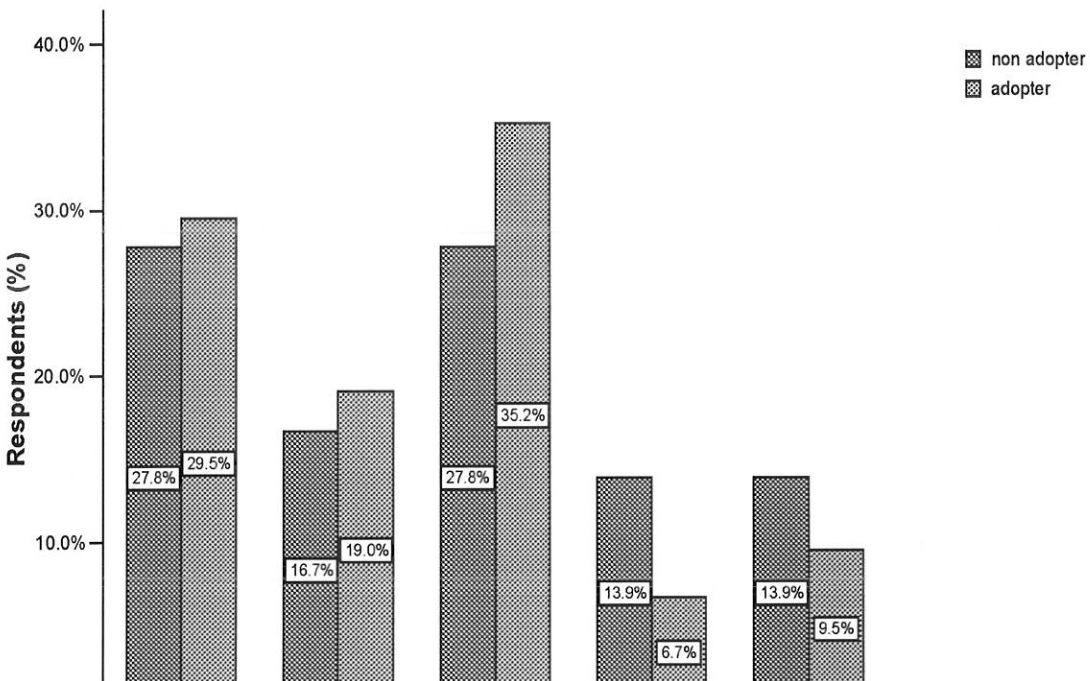
* *imply that the variable is significant at 1% level.*

In the study area, although there is a difference in the perception of the degree of soil erosion severity, all the farmers agreed the presence of soil erosion problem in their farm plots. Table 4.11 shows the respondents degree of perception of soil erosion problem on their farm land with adopter and non-adopter classification. According to the sampled data survey about 11.1% of the non-adopters regarded the severity of soil erosion to be on "high" category compared to 22.9% for the adopters. On the "medium" category the results were 27.8% for non-adopters and 68.6%

for adopters. On the "low" category the results were 61% and 8.6% for the non-adopters and adopters respectively.

The chi-squared (χ^2) test was carried out to identify whether there is a mean difference on the degree of perception of soil erosion between adopters and non-adopters of the soil conservation measure. The result obtained showed significant difference ($\chi^2 = 43.193$; p = 0. 000) between the two groups (See table 4.11). The Pearson correlation between perception of soil erosion and adoption was positive and statistically significant. This implied that the higher the perception of the degree of severity of soil erosion by the farm households, the higher will be its influence on their decision to adopt and maintain the use of soil bund conservation technology.

Figure 4.1: Causes of soil erosion



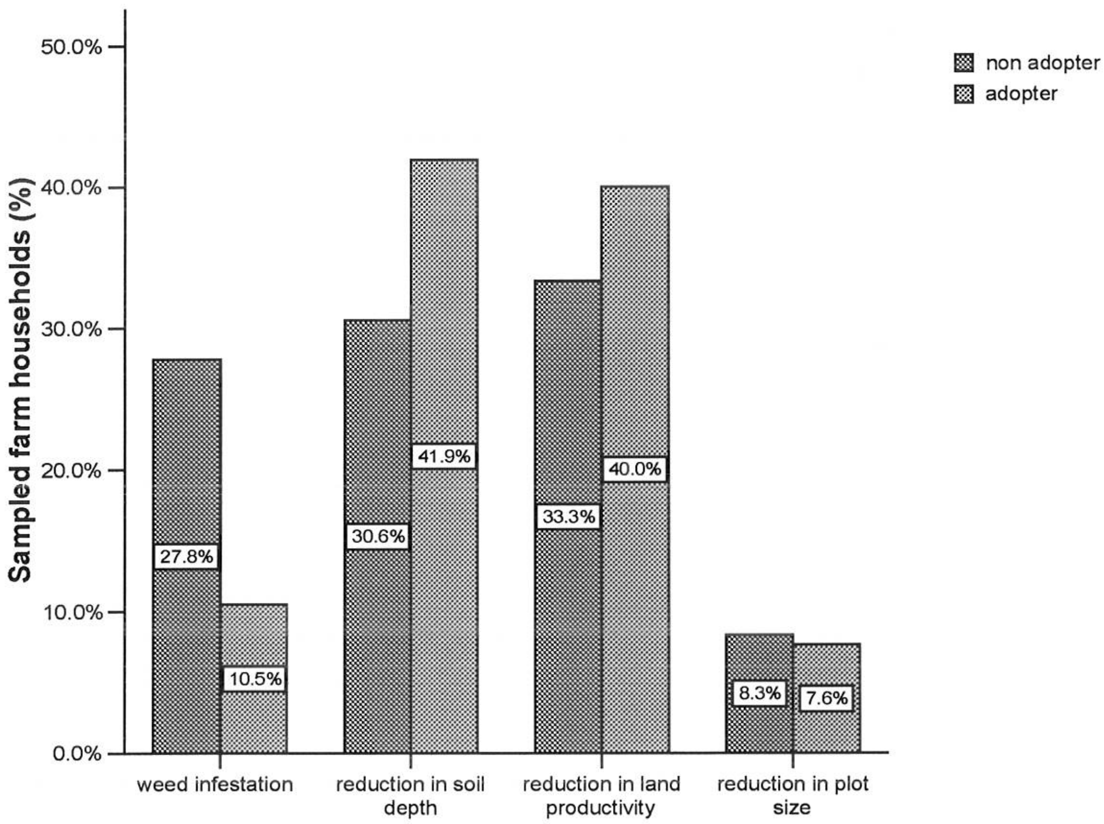
Regarding the cause of soil erosion, the major factors identified by the farmers in order of their importance were poor agricultural practices (32.6%), over-cultivation (29.1%), overgrazing

(10%) and heavy rainfall (8.5%). Figure 4.1 illustrates the cause of soil erosion of the sampled households.

Chi-squared (χ^2) test was carried out to measure whether or not there was a mean difference on the perception of the cause of soil erosion between adopters and non-adopters. The result obtained showed no significant difference between the two groups.

The Chi-squared (χ^2) test was carried out to measure whether there was a mean difference on the perception of the consequences of soil erosion between the two groups'. The result obtained showed no significant difference between adopters versus non-adopters of the soil conservation measure. This means that the two groups' perception level on the consequences of soil erosion is not different.

Figure 4.2: Consequences of soil erosion



ii) Farmers' Perception of Tenure Security

In Ethiopia, the right to ownership of rural and urban land is exclusively vested in the state and the people. And farmers have only user right. FKA which is the lowest level of government's hand is responsible for allocating land among its members. However, FKA is not the only way for the accession of land to the farmers. There are other means of acquiring farm land through informal arrangements such as crop sharing and leasing.

In the study area transferring land through temporary leases, usually for one production season, is a common practice. The price of land varies from Birr 300 to 600 per quarter of a hectare depending on the fertility condition of the land. The implication that the land lease price reflects the land quality has a great impact to encourage farmers to exert more effort in investing on land conservation practices that will improve the productivity of the land.

The perception of the farmer's tenure security as indicated by many researchers has long been considered as a critical factor in determining the adoption and long term maintenance of soil and water conservation structures (Alemu, 1999 and Meredith *et al.*, 2000). To identify the perception of the farmers' tenure security farmers were asked a simple question whether they are expecting land redistribution in the near future that may lead them to the risk of losing their portion of land or not. All of the sampled households responded that they had no such fears and felt secured about the land tenure system. In this respect the recent land policy which allows certified land use right to the land owner seems to bring a change on farmers' attitude towards land tenure security. However, further investigation has to be made to show the attitudinal change reflected with land certification.

4.1.5. Institutional Support

i) Extension Service

For the successful adoption of soil and water conservation practices the existence of a well designed and participatory extension service is of paramount importance. This is especially true for the Ethiopian farming communities where soil and water conservation programs were forced on them in the past. The knowledge and skill capacity of the extension agent and the information transmitting mechanism he uses in diffusing innovations affects the rate of adoption positively or negatively. In the study area, the main source of information about agricultural innovations including soil and water conservation is the government, through BoA&RD agricultural extension program.

To evaluate the adequacy of the extension program, the sampled farm households were asked if they had received extension service with in the last three years. Most of the respondents, 83.7% (118) reported that they have obtained extension service during the last three years. Of the total farm households who made contact with the extension agent 22% were non-adopters and the rest 78% are adopters.

Table 4.12: Percentage of farm household heads who received extension service and training on soil and water conservation practices

Institutional support		Non-adopters (%)	Adopters (%)	Total (%)	χ^2	*P-Value*
Extension service	Yes	72.2	87.6	83.7	4.655*	*0.000*
	No	27.8	12.4	16.3		
Training	*Yes*	*20.0*	*79.0*	*63.1*	*44.81**	*0.000*
	No	*80.0*	*21.0*	*36.9*		

Source: Own survey result (2007).

* *imply that the variable is significant at 1% level.*

The chi-squared (χ^2) test was conducted to measure whether or not there was significant difference between adopters and non-adopters. The statistical analysis showed significant difference ($\chi^2 = 4.655$, sig = 0.000) between the two groups (See table 4.12). This means that extension service has profound influence in the adoption of conservation practices. Similarly, J. Baidu-Farson (1999) in Illela region of Niger and Deininger *et al.*, (2003) on their study on Tenure security and land related investment in Ethiopia found out that access to extension service influenced investment on land improvement significantly with a positive sign. Kassie and

Holden (2005) also obtained positive and significant correlation between the adoption of soil conservation and extension service on their research conducted in the highland parts of Ethiopia.

ii) Training

Training is one of the most important components that bring profound effect in the adoption of farm level soil and water conservation measures. Its significance is high especially on land conservation practices that require basic knowledge and skill in constructing physical structures, like soil bund conservation technology.

In Kilie Watershed area the district BoA&RD supported by GTZ provide technical assistance to the farmers in the implementation of soil and water conservation activities. Short-term and practical training was one of the technical assistance provided to the surrounding farmers to equip them with the required skill to implement the conservation practice. The training focuses on introducing the importance of conservation measures, how to design, implement, etc. Moreover, study tour was arranged for farmers to show best results of well established conservation structures in different parts of the country.

According to the survey result 63% (89) of the respondents participated in the training program. With reference to adoption of the conservation practice, the percentage of the adopters and non-adopters involved in the training program was 79% and 17% respectively (See Table 4.12).

A chi-squared (χ^2) hypothesis test was run to identify if there was any association between participating in training program and adoption of soil and water conservation practices. The result of the analysis showed a statistically significant association between the two variables. A similar result was obtained by Bodnár and De Graaff (2003) in Mali.

4.1.6. Economic Factors

i) Livestock holding

Livestock is an important component of the farming system in Killie watershed area. The size of livestock holding is one of the major indicators of the wealth status of the farm household and the main sources of traction power for traction purpose. The sample household included in the survey owned cattle, sheep and goats, equines and fowls. Usually sheep, goats and fowls are kept to solve the liquidity constraints of the household at times of need.

For the purpose of comparison, the livestock holding of the sampled household was converted in to Tropical Livestock Unit (TLU). According to ILCA (1990) 1 TLU is equivalent to 1 camel, 1.43 cattle, 10 sheep/goats, 1.25 horses/mules and 2 donkeys (See Annex 3 Table 3.1). Table 4.13 shows both the number and types of livestock holding and its TLU equivalent of the farm household.

Table 4.13: Livestock holding of the sampled household

No	Description	Non-adopters (N = 36)	Adopters (N = 105)	t-ratio	*P-Value*
1	Cattle	2.08 (1.730) [a]	4.71 (2.688)	-6.749*	*0.000*
2	Sheep and goat	1.39 (2.333)	1.82 (2.67)	-0.919	*0.361*
3	Equine	0.78 (0.959)	1.29 (0.997)	-2.713**	*0.010*
4	*TLU*	*2.62 (2.043)*	*5.37 (2.718)*	*-6.366**	*0.000*

Source: Own survey result (2007).

[a]*Values in parentheses are standard deviation*

* *and* ** *imply that the variable is significant at 1% level and 5% level respectively.*

The t-test analysis of the sampled survey revealed that there were significant mean differences at 1% and 5% level of significance between adopters and non-adopters predominantly with regard to cattle and equine holdings. Cattle and equine are the most important sources of animal power needed both for traction and transportation purposes. The table also shows a significant mean difference (p = 0.000) of TLU between adopters versus non-adopters.

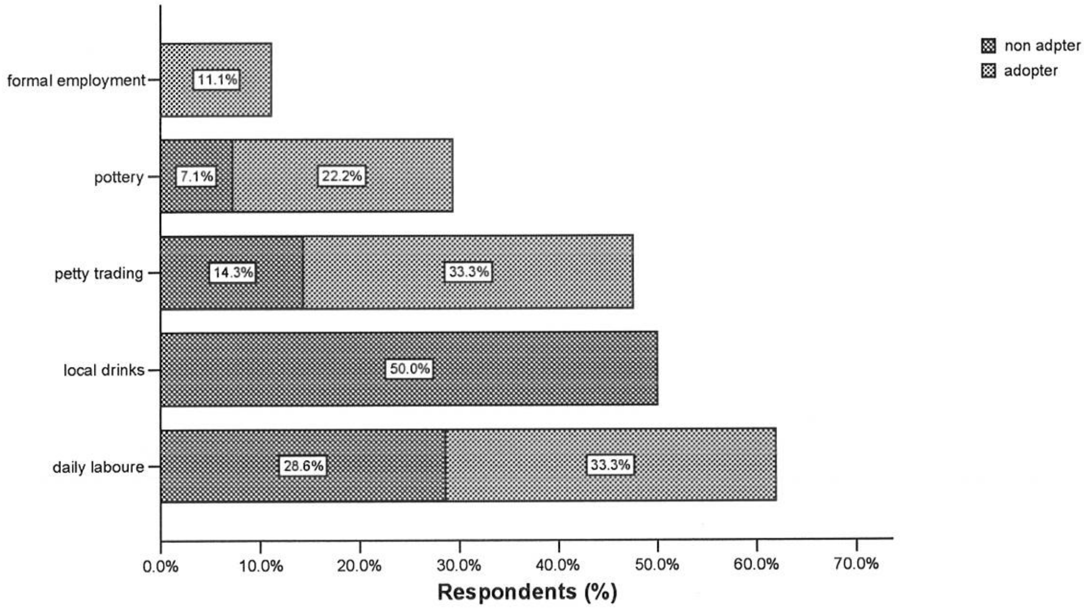
The finding of this survey concur with the study conducted by Nyagumbo (1992) in Zimbabwe which revealed that farmers participating in the development of a conservation tillage technique, no-till ridging, were better resources and owned more draught power than their non-participating counterparts. Moreover, on studies conducted by Deininger *et al.*, (2003) and Kassie and Holden (2005) livestock holding showed positive correlation with investment decision on conservation practices, however, it was insignificant.

ii) Access to off-farm income

Access to off-farm income may affect land use decision, thus investment on land conservation activities. Access to off-farm income may provide resources for farming that remove the liquidity constraint of the household. On the other hand, participation in off-farm activities may take labour away from farming activities. In the study area the major occupational activity and source of income for the sampled farm households was farming. Nevertheless, some of them were involved in off-farm activities such as sale of labour and petty trading. In 2006 G.C about 18% of the sampled farm households, of which 39.9% of the non-adopters and 8.6% of the adopters were engaged in different off-farm activities to supplement their agricultural income. The rest 61.1% of the non-adopters and 91.4% of the adopters had no other source of income other than agriculture. The finding of the survey revealed that non-adopters were more involved than adopters in off-farm activities to earn income, as illustrated on Figure 4.3.

Studies conducted to understand farmers' behavior on the factors influencing the adoption of conservation measures showed both positive and negative results on the relationship between farmers' involvement in off-farm employment and adoption of improved land management practices. Increasing involvement in off-farm activities for income generation seems to significantly and negatively influence the incentive for land conservation (Gould *et al.*, 1989; Okoye, 1998; Clay *et al.*, 1998; Tengen *et al.*, 2001; Demeke 2003 and Fitsum and Holden 2006). On the other hand, Pender and Kerr (1998) on their research works from India obtained that the adoption of indigenous conservation practice was enhanced with increased involvement of the farm household on off-farm employment. Because participation in off-farm activities enabled farmers to overcome cash flow problems required to invest on soil and water conservation practices.

Figure 4.3: Off-farm income source



A t-test conducted revealed a significant ($t = 2.617$, $p = 0.012$) mean difference between adopters and non-adopters in their involvement in off-farm activities. This result implied that off-farm income has a significant influence in the adoption of conservation practices in the area. The Pearson correlation statistics also showed both negative and significant association between adoption and involvement in off-farm works. This means that with increased involvement on off-farm activities the care given to farm land would be reduced.

The Pearson correlation was computed to find out if there was any association between land size and participation in off-farm activities. And the result was found to be negative and significant at 10% level of significance and its value is 49.1%. This implied that with decreased land size the participation of the farmers on off-farm activities has increased. Because, when the farm land gets smaller the income they obtain from agriculture will be too low to sustain their family livelihood. Therefore, this situation forced the farmers to participate in off-farm activities so as to augment their agricultural income. According to the survey data, out of the total farmers involved on off-farm activities about 56% of the farmers owned between 0.5 and 1.5 hectares of land (See table 4.14). This implies that since the size of land holding is barely enough to sustain the family, the farmers shift from farm to non farm activities as a survival strategy which leads them to pay less for land conservation activities. Moreover, usually in most parts of rural Ethiopia including the study area farmers are involved in off-farm activities during slack period, i.e. from January to May just after harvesting the lately matured crop. This period is also considered as a convenient time to perform the construction and maintenance of physical structures of conservation technologies (such as soil and stone bund, terraces, etc). Therefore, participation on income generating off-farm activities forces the farmers to put less effort to maintain the existing as well as the construction of new structures.

Table 4.14: Land size of off-farm work participants

Land size (ha)	% age of off-farm work participants
0.5 – 1.5	56
1.6 – 2.0	20
2.25 – 3.0	24

Source: Own survey result (2007).

Regarding the income distribution, the average off-farm income for the sampled household was Birr 506. With reference to non-adopter and adopter the average value was Birr 941.11 and Birr 356.76 respectively. A one-way ANOVA analysis was conducted to see if there was any significant difference in the mean income between the non-adopters and adopters and within the different off-farm work participants. The result of the analysis revealed a significant mean difference ($F = 6.484$, $p = 0.012$) between and within the groups.

4.1.7. Other land management practices

In Kilie Watershed area soil bund land conservation technology is the one and only physical conservation structure practiced by the surrounding farmers. Together with soil bund there are other common traditional land management practices being utilized by the farmers in order to maintain the soil fertility status of their farm land. Table 4.15 shows the types of the technologies and the percentage of the farmers using them.

Traditionally, farmers use different soil productivity enhancing techniques to maintain the productivity of their farm land. One of the redemption actions employed by the farmers was the use of land fallowing; however, the farmers of the study area abandoned this practice long ago due to the shortage of farm land that was caused by population growth.

Table 4.15: Number of households using different conservation practices

Conservation practice		Non-adopters (N = 36)	Adopters (N = 105)	Total (N = 141)	χ^2	*P-Value*
Crop rotation	Yes	36	105	141	[a]	
	No	0	0	0		
Tree planting	Yes	33	101	134	0.281	*0.372*
	No	3	4	7		
Use of manure	Yes	6	13	19	0.422	*0.574*
	No	30	92	122		
Use of compost	Yes	6	10	16	0.136	*0.240*
	No	30	95	125		
Water way	*Yes*	*19*	*79*	*98*	*6.38***	*0.020*
	No	*17*	*26*	*43*		

Source: Own survey result (2007).

[a] *no statistics are computed because crop rotation is constant.*

** *imply that the variable is significant at 5% level.*

Crop rotation is the other traditional practice utilized by all of the farmers (100%). Usually the most common crop rotation practice used in the area is cereal (such as teff or wheat) followed by pulses (field pea or beans).

Tree planting (it is not actually planting but the farmers let the tree grow on their field) is also a common practice used by the farmers. The indigenous Acacia Abisinica trees are found sparsely scattered on farm land and relatively more in number along the soil bund. The tree serves multi purpose: to maintain soil fertility since it has a nitrogen fixation capacity; to stabilize the soil bund structure; to control soil erosion and as a fuel for domestic use as well as for sale. The presence of these trees to some extent helps those farmers who have large cattle size to use the cattle dung as manure on their farm land.

The use of manure and compost is very small and its use is limited only at homesteads. All the farmers have knowledge that the use of these practices by and large improves the prevailing land productivity declining problem but they are not using it due to the bulky nature of the material which needs a means of transportation to transport it to their distant farm plot.

4.1.8. Access to market

Lack of well developed infrastructure particularly all weather roads are considered to be as the most significant constraint to small holder farmers' access to markets. The nature and development of production factor market, i.e. output, input and capital market plays critical role in determining the patterns of land use and land management. Where markets are well developed and competent, farmers will respond to the prevailing profitable alternative land use and land management strategies (Singh, *et al.*, 1986, cited by Yesuf, 2005). However, in rural parts where factor markets are poorly developed or missing farm household's production and consumption decision are inseparable, i.e. production and investment decisions are not dictated by profit consideration alone but consumption choices as well. In such settings farmers respond mainly on their endowments (de Janvry *et al.*, 1991; Udry, 1996; Holden and Biswanger, 1998; Holden *et al.*, 2001 cited by Fitsum and Holden 2006).

In the study area the sampled farm households have better market access. They have two market outlets; Adama the capital city of East Shoa and Modjo the woreda's town. With respect to road facility, they are beneficiaries of all-weather-road and vehicles as means of transportation. The distance (in walking minutes) of these markets from the farmers dwelling generally takes from 60 to a maximum of 300 minutes.

4.2. Econometric Results

A system of equations was employed to analyze the impact of adoption of soil bund technology on crop production. While undertaking the analysis the effects of economic, farm and farmer characteristics were accounted for in order to isolate the impact of soil bund adoption on the financial performance of the farm. To control for factors other than soil bund adoption, multiple regression was employed in a two stages econometric model of adoption and the impact of adoption. The first stage of the model consists of an adoption decision model that analyzes the factors influencing the likelihood of adopting soil bund. Results of the first stage model provide an input for the second stage model that can be used to estimate the impact of soil bund on the crop production on financial performance of the farm.

In this study the probit model which analyzes the soil bund adoption was estimated using maximum likelihood method. Estimated parameters from the probit model were used to calculate the predicted probabilities $(\hat{P}soilbund)$ of adopting the specific soil and water conservation practice and the IMR. And the impact evaluating model was estimated using OLS. To address the simultaneity and self selectivity problems in the second model $\hat{P}soilbund$ and the IMR were included as explanatory variables. The econometric soft ware employed to generate the parameter estimates was Stata version 9.

4.2.1. Determinants of Soil Bund Adoption

Before carrying out further analysis, a statistical test was carried out to identify the problem of multicolinearity or possible association among the explanatory variable. To identify this problem Variance Inflation Factor (VIF) and Contingency coefficients were computed for continuous and discreet variables respectively (See Annex 1 Table 1.1 and 1.2). The result obtained showed that there was no significant multicolinearity problem among the explanatory variables.

Table 4.16 presents the estimated results of the regression of the adoption model. The equation has a significant predictive power with 89% correct classification, i.e. the model classified 89% of the farmers in to those who adopted the soil and water conservation technology. The value of the McFadden's (pseudo) R^2 is 0.51. The computed value of the chi-squared statistics (i.e.

134.11) is much larger than the critical value from the chi-squared distribution with 13 degrees of freedom at 1% level (i.e. 29.82). This suggests that the null hypothesis, that all the parameters coefficients (except the intercept) are all zero, is strongly rejected. Moreover, the model is significant at 1% level of significance.

The result of the probit analysis illustrated that the signs of all the estimated parameters were in agreement with the expectation. The model result also showed that the variables like gender, dependency ratio, education, extension and perception were not significant to influence the farm household heads' adoption decision of the specific conservation technology under study. In general, the variation in the adoption decision of soil bund among farm households is strongly explained by the following factors.

i) Farming Experience

In conformity with the hypothesis, the results of this study showed that farming experience had both a positive and significant $(p < 0.01)$ effects on the adoption of soil bund. This result could be explained by the fact that experienced farmers had more resources, and hence, the capacity to invest on soil and water conservation practices. Besides, experience increases the likelihood of understanding the benefits of soil conservation measures which has a positive impact on adoption. A similar result was obtained by Fitsum and Holden (2006).

The marginal effects of the parameter estimate evaluated at the sample mean values of the variables imply that a one unit increase in farming experience produces a 0.58% increment in the probability of adoption of soil bund.

ii) Training

The estimated parameter suggests that training has stimulated the adoption of soil bund by improving the farmer's knowledge about the technology as well as the ability to construct the structure on their farm land. Moreover, it helped them realize that such conservation technologies served their needs in solving soil erosion problems and runoff. This is implied by the positive and significant $(p < 0.01)$ coefficient of the variable from the out come of the regression analysis. This result is in accord with the findings of Traore *et al.*, 1998.

The result of the econometric analysis also revealed that an increase in training participation may induce the adoption of soil bund by 29.78%.

Table 4.16: Regression result of the adoption model[A]

Independent Variables	Estimated coefficient	Robust standard error	z	Marginal effect
Constant	-2.78	0.554	-5.01	
Gender	0.11	0.209	0.52	0.024
Dependency ratio	-0.15	0.143	-1.06	-0.032
Person-land ratio	-0.42**	0.149	-2.79	-0.089**
Farming experience	0.02*	0.008	2.93	0.005**
Education	0.04	0.133	0.28	0.008
Training	1.17*	0.208	5.63	0.298*
Extension	0.03	0.214	0.12	0.005
Land size	1.99*	0.361	5.52	0.428*
Distance of plot from residence	-0.02*	0.004	-5.07	-0.004*
Plot slope	0.40*	0.116	3.46	0.086*
Perception of soil erosion	0.02	0.161	0.11	0.003
Labour-land ratio	0.90*	0.264	3.42	0.194*
Livestock size	0.23*	0.049	4.60	0.049*
Sample size	520			
Dependent variable	Soil bund			
Log likelihood	148.62			
Chi – squared (χ^2)	134.11			
McFadden (R^2)	0.51			

Source: Own survey result (2007).

* *and* ** *imply that the variable is significant at 1% and5 % level respectively.*

[A] *Coefficients and standard errors are robust to hetroskadasticity.*

iii) Land Size

Land size is often considered to have a significant influence in the adoption of innovations. Usually the impact of land size on the adoption of physical soil conservation structures such as soil bund is highly significant. Because such types of conservation technology creates inconvenience for ox-drawn plough by narrowing the farm plot as a result of the reduction of the available cultivable land. Moreover, the investment cost on the conservation structure per unit area in terms of human labour, animal power and area lost to structures are smaller in larger plots as compared to small ones. Hence, farm plots with larger areas tend to increase the overall benefits of adoption of beneficial innovations and so increase the likelihood of adoption (Demeke 2003). In conformity with the predetermined hypothesis, this study also depicted that the size of the farm plot has positive and significant $(p < 0.01)$ influence on the adoption of soil bund conservation practice. Similar results were observed by Okoye (1998); Wegayehu (2003); Kassie and Holden (2005) and Fitsum and Holden (2006).

Computation of the marginal effects showed that a one unit increment in the size of farm plot may increase the probability of adoption of soil bund by 42.80%.

iv) Distance of Plot from Residence

Consistent to the result of the descriptive analysis and our hypothesis, the correlation between the distance of the plot from residence and adoption of soil bund conservation practice is negative and significant at 1% level of significance $(p < 0.01)$. This could be explained by the higher transaction cost associated with distant farm plots in terms of both time and labour spent to undertake new conservation practices as well as to maintain already established structures. The findings of Demeke (2003); Wegayehu (2003) and Kassie and Holden (2005) are in agreement with the result of this study.

From the result of the econometric analysis one can observe that an increase in one unit in the distances between plots and residence discourages the probability of investment in soil and water conservation practices by 0.4%.

v) *Plot Slope*

The nature and degree of slope of the farm land is one of the most important factors indicating the presence of soil erosion on farm plots. In most of the cases the presence of soil erosion and other soil degradation problem lead farmers to put in place protection measures to alleviate the problem. This implies the existence of positive correlation between plot slope and adoption of soil and water conservation practices. In this study the regression analysis revealed that the slope of the farm plot was found to be positively and significantly $(p < 0.01)$ associated with the adoption of soil bund. This result is similar to that of Bekele and Holden (1998); Wegayehu (2003); Yesuf (2003) and Kassie and Holden (2005).

As observed from the result of the regression analysis as the slope of the farm plot increases by one extra unit the probability of adoption of soil bund also increases by 8.59%.

vi) *Livestock Size*

As hypothesized, the estimated probit model shows that the livestock size of the farm household and adoption of soil bund has positive and significant $(p < 0.01)$ association. In most rural areas including Killie watershed area, the size of the livestock holding indicates the wealth status of the farm household. Farmers with large size of livestock holding are rich farmers; thus, they have the capacity and resources to invest on soil and water conservation technologies that will improve the productivity of their farm land. Besides, since oxen are used as a source of power for traction purpose, it plays a crucial role in the preparation and construction of soil bund. Similar results were also obtained by Bekele and Holden (1998) and Wegayehu (2003).

Results of the regression analysis depicts that an increase in livestock holding by one unit will increase the probability to invest on soil bund by 4.87%.

vii) *Labour-Land Ratio*

As expected labour-land ratio has positive and significant $(p < 0.01)$ influence in the adoption decision behavior of the farm household. This could be explained by the labour intensiveness nature of the soil and water conservation technology. Therefore, households with larger number of labour force have a better capacity to perform the construction of soil bund than those households who have small numbers of economically active members in their families. This finding is in agreement with Anley *et al.*, (2006).

The estimated marginal effects (i.e. 19.39%) from the probit model show that the contribution of labour is substantially high in the adoption of soil and water conservation practices.

viii) Person-Land Ratio

Consistent to the expectation, person-land ratio has a negative and significant $(p < 0.05)$ influence on the adoption of soil bund. This could be explained by the fact that with an increment in the size of population, the area of the cultivable land will become smaller to satisfy the food demand of the household. Moreover, adoption of soil bund will further aggravate the problem since the construction of the structure reduces the size of the farm land. The findings of this study concur with Shiferaw and Holden (1998).

The estimated marginal effects from the adoption model shows that an increase in one unit in person-land ratio reduces the probability of adoption of soil bund by 8.9%.

4.2.2. Regression Results of the Impact of Adoption

To show a clear picture of the impact of adoption of soil bund on grain production, the crops grown by the farmers were grouped in to three categories. The first part contains all the crops produced by the farmer taken all together, the second part takes only the main crop (teff) alone and the last part which is categorized as other crops include crops such as wheat, barley, beans, field peas and maize, excluding teff. Teff crop is treated separately because it covers the largest share of the cultivated land and it is also considered as the major cash crop in the area (See table 4.1). The regression result for each category was presented separately from table 4.17 to 4.19.

i) All Crops

Parameter estimates for all crops is presented on table 4.17. The estimated coefficient of determination (R^2) is 0.92 indicating that the model explains at least 92% of the variation in the value of grain production as reported by sample respondents. The likelihood ratio test of the null hypothesis that all the variables (except the intercept) included in the model have zero slopes was rejected at 1% level of significance and the model is also significant at 1% level of significance. Almost all of the signs of the variables are as expected. The variable $\hat{P}soilbund$ as expected is positively related with the value of crop production; however, it is not significantly different from zero. The inverse mills ratio is positive but not significant. This means that selectivity bias wouldn't be a problem if the impact of adopting of soil bund is estimated without taking in to account the decision to adopt the specified soil and water conservation practice.

In general the regression result shows that six out of the fourteen variables included in the model are significantly different from zero. Out of these, five of the variables are positively associated with the value of crop production. Four of them are the major factors of production such as fertilizer, land size, oxen and family labour. In the model, all of these factors are specified in their natural logarithm form and their coefficients can be taken as elasticity of input. The remaining variable that has significant and positive association with crop production is the sex of the household. As expected the regression result showed that male household heads perform better than female headed households in crop production. The last variable, extension, contrary to our expectation has a negative and significant effect.

Contrary to our expectation, slope of the plot is affecting the value of crop production positively. However, it is not significantly different from zero. The positive sign of plot slope may be attributed to the fact that sloppy plots are expected to be given priority to be treated with soil and water conservation practices. And if the farm plot is treated with conservation practice for a longer period of time, the productive capacity of the land is expected to be higher.

The factors such as education, distance of plot from residence, farming experience, person-land ratio and off-farm income affect the value of crop production negatively but not significantly. These results are not strange except for education. Education was expected to be related to crop production positively, because education helps improve the farmers' access to information that would help them apply different productivity improving technologies and agricultural practices. However, the result obtained from the regression analysis is contrary to our expectation.

Table 4.17: Regression result of the impact evaluation model – for all crop [A,B]

Independent Variables	Estimated coefficient	Robust standard error	t
Constant	7.02	0.065	106.68
Gender	0.07**	0.035	2. 07
Education	-0.01	0.011	-0.57
Extension	-0.05**	0.023	-2.19
Plot slope	0.01	0.015	0.53
Distance of plot from residence	-0.0001	0.0004	-0.24
Log (fertilizer)	0.08*	0.004	16.81
Log (land size)	0.76*	0.025	30.45
Log (family labour)	0.08*	0.030	2.70
Log (oxen)	0.11*	0.033	3.29
Log (farming experience)	-0.01	0.015	-0.89
Log (person-land ratio)	-0.02	0.029	-062
Off-farm work	-0.03	0.028	-1.20
$\hat{P}Soilbund$	0.16	0.104	1.57
IMR	0.088	0.076	1.15
Sample size	520		
Dependent variable	Log (Crop value)		
F - statistics	455.71		
R^2	91.65		
MSE	0.1973		

Source: Own survey result (2007).

*, and ** *imply that the variable is significant at 1% level and 5% level respectively.*

[A] *Coefficients and standard errors are robust to hetroskadasticity.*

[B] *Independent variables had an average variance inflation factor of 3.89 indicating that multicollinearity is not a significant problem.*

The negative sign of the distance of the plot from residence is in conformity with our expectation and it may be attributed to the lesser care given to distant farm plots. Participation on off-farm activities proved to have negative impact on the value of crop. The possible reason for the negative outcome is that off-farm work might result in reducing the amount of labour that could be invested for the purpose of crop production. Farming experience is correlated with age implying that farmers having higher farming experience are older farmers. Thus, it is inevitable that productivity efficiency decreases as the farmer gets older. The other variable that has negative association with crop production is person-land ratio. A higher number of persons per hectare of arable land mean a higher consumer per household. The more members the household has, the more likely that most of the crops produced at the farm level would be consumed. This implies that the household will leave fewer resources to invest in land productivity enhancing technologies to augment the level of its productivity.

ii) Main Crop (Teff)

The results of regression analysis on the value of teff crop are presented on table 4.18 below. The model's R^2 was 95%. The result of the F-test indicates that the specified model is significant at 1% level of significance. As expected the variable indicating the impact of soil bund on the value of teff crop production is positive and significant at 5% level of significance.

In concurrence to our result, Kaliba and Rabele (2005) also obtained on their study carried out in Lesotho that the adoption of both short and long term soil and water conservation practices had positive and significant effects on wheat crop production. The positive and significant effects of adoption of soil bund on teff plot indicates that since teff is the main cash crop, in order to obtain maximum yield, farmers grow it on more conserved and fertile part of their farm plot. The computation of the marginal effect shows that a one unit increase in the probability of adopting soil bund increases the value of crop production by 28%. The coefficient of the inverse mills ratio is positive and it is not significant.

The other variables that had coefficients significantly different from zero include all of the factors of production (fertilizer, land, labour and oxen). These variables had positive and significant association with the value of teff crop production.

Table 4.18: Regression result of the impact evaluation model – for main crop (teff)[A,B]

Independent Variables	Estimated coefficient	Robust standard error	t
Constant	7.20	0.373	19.31
Gender	0.002	0.028	0.07
Education	0.003	0.010	0.28
Extension	-0.04	0.031	-1.15
Plot slope	0.02	0.012	-1.49
Distance of plot from residence	-0.0001	0.0004	-0.32
Log (fertilizer)	0.08***	0.054	1.65
Log (land size)	0.86*	0.057	15.13
Log (family labour)	0.04***	0.030	1.92
Log (oxen)	0.02***	0.039	1.53
Log (farming experience)	-0.009	0.015	0.64
Log (person-land ratio)	-0.05	0.029	-1.24
Off-farm work	0.002	0.027	0.07
$\hat{P}Soilbund$	0.28**	0.134	2.08
IMR	0.12	0.101	1.21
Sample size	161		
Dependent variable	Log (Crop value)		
F-statistics	340.25*		
R^2	95.58		
MSE	0.1042		

Source: Own survey result (2007).

, ** and * imply that the variable is significant at 1% level and 5% level respectively.*

[A] *Coefficients and standard errors are robust to hetroskadasticity.*

[B] *Independent variables had an average variance inflation factor of 4.86 indicating that multicollinearity is not a significant problem.*

Those variables that are not significant but positively correlated with the value of teff crop include the sex of the household head, level of education, plot slope and participation in off-farm activity. Education, contrary to the result obtained in the case of all crops and in agreement with our predetermined hypothesis has demonstrated the expected sign. Here participation in off-farm work seems to support teff crop production. The possible explanation could be that the income obtained from off-farm activities might be invested to improve the productivity performance of the crop.

The other explanatory variables that are included in the model were not significantly affecting the value of teff crop positively. These include: extension service, distance of plot from residence, plot slope, farming experience and person-land ratio.

iii) Other Crops (Wheat, Barley, Maize, Field peas and Beans)

An estimated result of the parameters for the category of other crops is presented on table 4.19. The table shows that the coefficient of determination R^2 is 85%. Here also similar to the other regression result the adoption variable is also as expected has a positive association with crop value. This outcome explains that the application of conservation practices improves the productive capacity of the farm land. The inverse mills ratio is positive and not significantly different from zero.

As indicated on table 4.19, six of the fourteen variables had coefficients significantly different from zero. Consistent to our hypothesis, all of the main factors of production (land, fertilizer, labour and oxen power) including the sex of the household head are positively related with the value of crop production. On the other hand, contrary to our hypothesis extension service is also found to have negative and significant association with crop production.

The other factors are not significantly different from zero. Those that are positive include plot slope, distance of plot from residence, and person-land ratio. The signs of these variables are opposite to our hypothesis. The negative impact was ascribed to education, off-farm work and farming experience.

Table 4.19: Regression result of the impact evaluation model for other crops[A, B]

Independent Variables	Estimated coefficient	Robust standard error	t
Constant	7.00	0.088	79.75
Gender	0.09***	0.049	1.92
Education	-0.01	0.016	-0.59
Extension	-0.61**	0.029	-2.11
Plot slope	0.01	0.022	0.90
Distance of plot from residence	-0.0005	0.0006	0.70
Log (fertilizer)	0.08*	0.005	17.71
Log (land size)	0.79*	0.038	21.09
Log (family labour)	0.06***	0.044	1.82
Log (oxen)	0.14*	0.046	3.18
Log (farming experience)	-0.02	0.020	-0.87
Log (person-land ratio)	-0.02	0.042	0.57
Off-farm work	-0.04	0.041	-0.90
$\hat{P}Soilbund$	0.14	0.134	1.12
IMR	0.11	0.096	1.10
Sample size	359		
Dependent variable	Log (Crop value)		
F-statistics	164.31*		
R^2	85		
MSE	0.2194		

Source: Own survey result (2007).

*, ** *and* *** *imply that the variable is significant at 1%, 5% level and 10% level respectively*

[A] *Coefficients and standard errors are robust to hetroskadasticity.*

[B] *Independent variables had an average variance inflation factor of 3.46 indicating that multicollinearity is not a significant problem.*

To sum up, as it is revealed from the regression analysis the impact of soil bund on grain production is positive for the three cases and it is significant only for teff crop. The possible explanation would be that the use of soil bund has improved the soil fertility status of the farm plot. Besides, the significant impact of soil bund on teff crop is explained with the fact that teff is capable of resisting water logging problem as compared to the other crops. Water logging problem may arise because of the clayish nature of the soil of the study area. Therefore, the program officers' should design appropriate drainage system or diversion structure to avoid the water logging problem.

CHAPTER FIVE

Summary, Conclusion and Policy Recommendation

5.1. Summary and Conclusion

Agriculture is considered to be the major driving force that leads the country's economy towards development. However, its contribution has been constrained by resource degradation, unfavorable weather condition and misguided policies. Resource degradation is a complex phenomenon that stems from the interplay of both natural and socio economic factors. In Ethiopia three major factors were identified to have had significant impact on the vicious cycle of resources degradation and ultimate reduction of soil productivity and crop production (Zeleke *et al.*, 2006). These are: the reliance of 85% of the population on a subsistence rain fed production system using simple and traditional tools together with poor agricultural practices; deforestation so as to expand crop land and satisfy the energy demand of the household; livestock pressure and their poor management which mainly depend on free grazing system and the use of crop residues and cow dung as a source of feed for livestock and fuel respectively which resulted in a subsequent loss of humus and soil nutrients.

Considering these complex and interwoven problems of resource degradation and poverty, the solution to change the situation exclusively lies in reducing the negative impacts of the land degrading causes on crop yield through the application of land productivity enhancing technologies such as soil conservation technologies as well as implementation of improved and sustainable land management practices. In the study area, the sampled farm households employed different soil and water conservation practices to arrest or reverse the course of land degradation. These are agronomic practices such as crop rotation, contour plaughing, manure and compost application, tree planting, water way and physical conservation practice such as soil bund. Practices like crop rotation, contour plaughing, tree planting and water way are commonly used by almost all of the farmers and the application of manure and compost is very rare and limited to small number of farmers. Thus, this study focused on soil bund which is the main physical soil and water conservation structure practiced by the surrounding farmers.

This research paper, using primary data collected from 141 farm households' that are selected randomly from Kilie Watershed area, Lume woreda, Oromia Regional State, attempted to identify the major determinant factors influencing farmers' decision to adopt soil bund technology and its contribution on the grain production performance of the farmers. For the purpose of the analysis the main factors included in the study are physical, socio-economic, attitudinal and institutional factors.

To analyze the data obtained from the survey, both descriptive and econometric regression analyses were employed. The descriptive analysis indicated that the sex of the household's head, family size, number of economically active family members, family labour force (in ME), land-labour ratio, farming experience, educational status, land size, plot slope, perception of soil erosion, size of livestock holding, extension service, training on soil and water conservation practices, dependency ratio, person-land ratio, distance of plot from residence and off-farm income to have significant influence on the adoption of soil bund.

In the econometric analysis, two models are specified. The first is a probit model which is used to identify the determinant variables influencing the adoption of soil and water conservation practices. The result of the regression analysis showed that out of the thirteen variables that were selected to explain the farmers' soil and water conservation practices adoption decision behavior, sex of the household head, farming experience, training on soil and water conservation practices, land size, plot slope, labour-land ratio, size of livestock, person-land ratio and distance of plot from residence found had significant influence. Although, farmers characteristics (such as sex and education), attitudinal factors (such as perception of soil erosion) and demographic factors (such as dependency ratio) had been found by other studies to influence the adoption of soil and conservation practices, in this study they are not significantly different from zero. In most of the cases, extension service is important in enhancing the adoption of improved agricultural technologies including soil and water conservation practices. However, in this study extension service was found to have insignificant influence.

In the second model that analyzed the contribution of soil and water conservation practices on grain production, fourteen variables were hypothesized to have influence on crop production performance of the farm household. Regression analysis was run by classifying the crops grown by the farmers into three categories and the result was presented on separate tables: for the whole crops, for the main crop (teff) and other crops (excluding teff). The result indicated that in all of the three cases the impact of adoption of soil bund on crop production has positive sign, however, it was significant (at 5% level of significance) only for the main crop (teff). This implies that along with the application of inorganic fertilizer the use of soil and water conservation practices play important role in increasing the productivity of the land. In the case of whole crops and other crops, the variable soil and water conservation practice is not significantly different from zero. The other variables that have significant influence on the value of crop production include: sex of the household's head and the major factors of production (fertilizer, land size, family labour and draught power).

In general, it is revealed from the regression analysis the impact of soil bund on grain production is positive for the three cases and it is significant only for teff crop. The possible explanation would be that the use of soil bund has improved the soil fertility status of the farm plot. Besides, the significant impact of soil bund on teff crop is explained with the fact that teff is capable of resisting water logging problem as compared to the other crops. Water logging problem may arise because of the clayish nature of the soil of the study area. Therefore, the program officers' should design appropriate drainage system or diversion structure to avoid the water logging problem.

5.2. Policy Recommendation

Soil and water conservation measures are very important technologies that should be adopted by the small holder farmers in order to curb the trend of land degradation in Ethiopia as a whole and in the study area in particular. The adoption of soil and water conservation technology helps to maintain and improve the fertility status of the farm land which increases the crop yield per unit area. This study shows that the adoption of soil bund has positive and significant (for the case of teff crop) impact on the farmers' grain production. Therefore, to expand the use or adoption of the technology policies should give priorities to the following recommendations.

Although the effect of adoption of conservation practices such as soil bund, on land productivity is long term, it was found to have positive impact on grain production. Therefore, to expand the adoption of the conservation practice the government should strengthen the program in the area. To encourage the probability of adoption and intensity of use, research on improved soil and water conservation techniques should play attention to the provision of tangible short term benefits, for instance the provision of improved grasses, fodder tree, etc, seeds that could increase the availability of feed for livestock.

The Government through the agricultural extension service should provide short term trainings to enhance the farmers' awareness and knowledge of understanding about problems of land degradation and the possible way of prevention i.e. how to make use of appropriate soil and water conservation technologies. The training program using on-farm trail should also focus on demonstrating the types and usage of the technologies; how to design, implement, maintain and manage the technology in a sustainable manner.

The size of livestock holding has a significant and positive correlation both on the adoption of the conservation practice and the productivity performance of the farm household. Livestock, especially oxen power serves as a draught power to prepare the soil bund and the cultivable land for sowing. Therefore, targeting farmers having large size of livestock by giving due consideration on the feed source, preventing the disease problem should be the focus of the extension program.

Population pressure has a contribution to land degradation in the study area. Therefore, population policies directed towards reducing the population growth should be given due consideration.

Natural recourses conservation activities need the participation of the community as a whole. Hence, to make the efforts of the conservation practices effective farmers should be organized in small groups (such as environmental protection groups) based on the location of their farm land and other mutual interest. This helps them to mobilize their labor so that they can assist each other (because the construction of soil bund and other conservation practices are labour intensive) and to maintain the sustainability of the structure so as to obtain the desired result.

Issues for Further Investigation

The result of the study revealed that there is negative and significant association between extension services and the value of crop production, which deviates from the expectation. Therefore, to get accurate answer further study is recommended.

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ANNEX

Annex 1: Econometric Test

Multicollinearity

To identify the problem of multicollinearity or association among the potential explanatory variables, Variable Inflation Factor (VIF) for continuous variables and contingency coefficient for categorical variables were used.

VIF and Tolerance are two measures that can guide a researcher in identifying the presence of multicollinearity. Before developing the concepts, it should be noted that the variance of the OLS estimator for a typical regression coefficient (say β_i) can be shown to be the following.

$$Var(\beta_i) = \sigma^2 \big/ S_{ii}\left(1 - R^2\right)$$

$S_{ii} = \sum\left(X_{ij} - \overline{X}_i\right)^2$ and R_i^2 is the unadjusted R^2 when you regress X_i against all the explanatory variables in the model, i.e. against a constant, $X_2, X_3, \ldots, X_{i-1}, X_{i+1}, \ldots, X_k$. Suppose there is no linear relationship between X_i and the other explanatory variables in the model then, R_i^2 will be zero and the variance of $\hat{\beta}_i$ will be σ^2 / S_{ii}. Dividing this into the above expression for $Var(\hat{\beta})$, we obtain the variance inflation factor and tolerance as

$$VIF\left(\hat{\beta}_i\right) = \frac{1}{1 - R^2}$$

$$Tolerance\left(\hat{\beta}\right) = 1/VIF = 1 - R_i^2$$

It is readily seen that the higher VIF or the lower the tolerance index, the higher the variance of β_i and the greater the chance of finding β_i insignificant, which means that sever multicollinearity effects are present. The procedure is to choose each right hand side variable as the dependent variable and regress it against a constant and the remaining explanatory variables. We would thus get $k-1$ value for VIF. If any of them is high, then multicollinearity is indicated. The values of

VIF greater than 20 are suggested as the indicative that the data has multicollinearity problems [Basely, Kuh and Welsch (1990) cited in Green (2003)]. The VIF and Tolerance computed for the continuous explanatory variables include in the model are presented on the table 1.1.

Table 1.1: VIF and Tolerance for continuous explanatory variables

Variables	VIF	1/VIF
Person - land ratio	7.95	0.1258
Land - labour ratio	7.94	0.1259
Dependency ratio	2.22	0.5954
Farming experience	1.68	0.8597
Livestock size	1.16	0.8732
Land size	1.15	0.8898
Distance of plot from residence	1.12	0.8917
Mean VIF	3.16	

Source: Own computation (2007)

For the categorical variables, the contingency coefficient was computed and presented on table 1.2. And the result satisfies the condition that it equals zero when there is no association between the variables (Gujirati 1995).

Table 1.2: Contingency coefficient for categorical variables

	Gender	Education	Training	Perception	Extension	Plot slope
Gender	1					
Education	0.257	1				
Training	0.194	0.445	1			
Perception	0.142	0.329	0.201	1		
Extension	0.127	0.295	0.354	0.081	1	
Plot slope	0.112	0.136	0.366	0.430	0.055	1

Source: Own computation (2007)

Annex 2: Conversion Factors of human labour power

Table 2.1: Conversion Factor of household labour into Man-Equivalent (ME)

Age group (in years)	Male	Female
< 10	0.00	0.00
10-14	0.35	0.35
15 - 50	1.00	0.80
> 50	0.55	0.50

Source: Storck et al., 1991

Annex 3: Conversion Factor of livestock number

Table 3.1: Conversion Factor of livestock number into Tropical Livestock unit (TLU)

Animals	TLU	Animals	Female
Chicken	00.013	Young bulls	1.00
Sheep/goat (adult)	0.13	Cows and Ox	1.00
Sheep/goat (young)	0.06	Donkey (adult)	0.70
Calf	0.25	Donkey (young)	0.35
Heifers	0.75		

Source: ILICA (1990)

Annex 4: Questioner used to collect the data.

1. Date of Interview (day/month/year)_______________________
2. Name of supervisor _______________________
3. Name of enumerator: __________________ Signature ________________

SECTION 1: DEMOGRAPHIC INFORMATION

1. Household heads and family member's information

No.	Name of the household members	Sex Male =1 Female = 2	Age	Member of the house hold relation **(Code A)**	Major duties in the house hold **(Code B)**	Educational Back ground **(Code C)**	Religion **(Code D)**
1							
2						xxxxxxx	xxxxxxx
3						xxxxxxx	xxxxxxx
4						xxxxxxx	xxxxxxx
5						xxxxxxx	xxxxxxx
6						xxxxxxx	xxxxxxx
7						xxxxxxx	xxxxxxx
8						xxxxxxx	xxxxxxx
9						xxxxxxx	xxxxxxx
10						xxxxxxx	xxxxxxx
11						xxxxxxx	xxxxxxx
12						xxxxxxx	xxxxxxx
13						xxxxxxx	xxxxxxx

Code A
1 = Male family head
2 = Female family head
3 = Son/daughter
4 = other relative

Code B
5 = farmer
6 = daily labourer
7 = trader
8 = civil servant
9 = trader
10 = handicapped
11 = retired
12 = student
13 = others (specify)

Code C
14 = illiterate
15 = read and write
16 = grade 1 – 4
17 = grade 5 - 8
18 = grade 9 – 10/12

Code D
19 = Orthodox
20 = Muslim
21 = Protestant
22= others (specify)

SECTION 2: PLOT LEVEL FACTORS AND INCOME FROM CROP PRODUCTION

2. Plot level variables and yield obtained

Plot №	Crop grown or other land use **(code A)**	Area of the plot (in Temad)	Types of crops grown **(code B)**	How the HH did acquire the plot? **(code C)**	How long have you used the plot (# of years)	Distance from Home (walking minutes round trip)	Slope category of each plot **(code D)**	Land quality (soil fertility) **(code E)**	Trend of soil fertility in each plot **(code F)**	Season of harvest **(Code G)**	Level of erosion **(code H)**	Amount of fertilizer used in Kg	Amount and type of seed used **(code I)**	Soil type of the plot **(code J)**	Yield harvested (Kg)
1															
2															
3															
4															

Code A
1 = crops
2 = homestead
3 = grazing
4 = forest
5 = wasteland
6 = woodlot
7 = others (specify)

Code B
8 = Teff
9 = Wheat
10 = Barley
11 = Maize
12 = Field pea
13 = Beans
14 = Chick pea
15 = Vetch
16 = others (specify)

Code C
17 = State
18 = inherited

Code D
19 = flat
20 = moderate
21 = steep 24 = low

Code E
22 = high
23 = medium
27 = unchanged

Code F
25 = Increasing
26 = decreasing

Code G
28 = Belg
29 = Meher

Code H
30 = High
31 = medium
32 = low
33 = none

Code I
34 = HYV
35 = Local

Code J
34 = Clay
35 = sandy
36 = loam

3. If you perceive soil erosion on your plot what features lead you to believe that such problem exists? 1. ……… 2. ………
    1. stoniness of the field
    2. reduction in soil depth
    3. reduction in yield
4. Do you observe appearances of plant species that signify the severity of soil erosion? 1. ………
    1. Yes 2. No
5. If yes what are the names of these species?
    1. ………………………………
    2. ………………………………
    3. ………………………………
6. What do you think is the major cause of soil erosion? (indicate the main two reasons) 1. ……… 2. ………
    1. Over cultivation
    2. Deforestation
    3. Overgrazing
    4. Poor agricultural practices
    5. Cultivation of steep slope lands
    6. Excess rainfall
    7. Others specify
7. Do you use some kind of measures to control soil erosion? …….
    1. Yes 2. No
8. If yes what type of conservation practices

plot No.	Type of S&WC practices **(Use code A)**	Specify the starting time	Area coverage or length soil conservation structure in meters

Code A

1 = Soil bunds
2 = Stone terrace
3 = Fanya juu
4 = stone bund
5 = Others (specify)

9. How did you become aware about soil conservation before you start to use it? …..
    1. Government institutions
    2. NGO
    3. Others (specify)
10. Have you got any training regarding the construction of soil conservation technique? …….
    1. Yes 2. No
11. What advantages have you obtained from the soil and water conservation practices 1. ……… 2. ……….
    1. reduction in soil loss
    2. increase in land productivity
    3. Both
    4. others (specify)

12. State the main two reasons why you didn't adopt soil and water conservation practices
    1. ………. 2. …………
    1. I don't have the information
    2. I don't see the problem of soil erosion on my farm land
    3. Shortage of money
    4. Shortage of labour
    5. Shortage of farm land
    6. Rodent problem
    7. others (specify)
13. If you perceive a decline in your farm land soil fertility what features lead you to believe that such problem exists? 1. …….. 2. ………..
    1. Reduction in yield
    2. Increment in the amount of fertilizer applied per plot
    3. Both
14. Do you observe appearances of plant species that signify decline in soil fertility? …..
    1. Yes
    2. No
15. If yes what are the names of these plants?
    1. ....
    2. ....
    3. ....
16. Which type of practices do you use to maintain the fertility of your farm land?

Plot No	Manure 1 = Yes 2 = No	Compost 1 = Yes 2 = No	Crop rotation 1 = Yes 2 = No	Tree planting 1 = Yes 2 = No	Fallowing	
					1 = Yes 2 = No	Fallowing period

SECTION 3: SOURCE INCOME

17. Your livelihoods mainly depend on: ……….
    1. Cropping only
    2. Livestock only
    3. Both cropping and livestock
    4. Off farm work
18. What is your main source of income? ………….
    1. Crop sale
    2. Livestock sale
    3. off farm activities
    4. others (specify)

19. If off-farm activities are used as income sources, indicate the type of activity? ……
    1 = daily labourer 4 = local drinks seller
    2 =trader 5 = sale of fuel wood

3 civil servant 6 = others (specify)

20. What was the estimated amount of total on-farm income of the household in 2005/06?
    1. ……………….
21. What was the estimated amount of total off-farm income of the household in 2005/06?
    1. ……………….

SECTION 4: HOUSEHOLD SOCIAL CAPITAL AND INSTITUTIONS

22. Does the household head involved in local organizations? (use Yes/No) ______________
23. If yes to question 22,
    23.1. Number of local organizations household is involved in____________
    23.2. Type of local organizations: ____________________
        0 = there is no local organization 3 = saving and credit cooperative
        1 = multi–purpose cooperative 4 = Equb
        2 = marketing cooperative 5 = Ider
        6 = others (specify)
24. Is household involved a member of associations? (Use Yes/No) _________
25. If yes to question 24,
    25.1.In what type of association? ________
        0 = no association 2 = Women Association
        1 = Peasant Association 3 = Youth Association
26. Did your household obtained credit for agricultural activity during the cropping season 2005/ 2006?
    1. Yes
    2. No
24. If yes to question 26, then

No.	Purpose for which the credit is taken **(Code A)**	Type of credit **(Code B)**	Source of the credit **(Code C)**	Amount of the credit in cash (in Birr)	Duration of the credit (in months	Interest rate for the credit

(Code A)
1 = seed
2 = fertilizer
3 = poultry
4 = fattening
6 = others (specify)

(Code B)
7 = in cash
8 = in kind

(Code C)
9 = micro finance
10 = bank
11 = multi purpose cooperatives
12= others (specify)

25. Have you got extension service during the last three years? …………
    1. Yes 2. No
26. Do you find the advice you get from the extension agent helpful? ………
    1. Yes 2. No

27. Distance of households' residence from service giving institutions

Institution	Return trip in minute (walking distance)
Main market	
Local market	
Multi purpose cooperatives	
Bus station	
Highway	

SECTION 5: HOUSEHOLD WEALTH (FOR THE YEAR 2005/06)

28. Land, livestock and assets owned by the household

Item	Amount/number
Land owned (Timad)*	
Livestock	
Cow	
Heifer	
Oxen	
Bull	
Calves	
Sheep	
Goat	
Donkeys, Horse, Mules	
Poultry	
Bee colonies in improved/ transitional/ modified beehives.	
Plow set (yoke, handle, metal point, beam etc.)	
Farm equipment (sickle, axe, hoe, spade etc.)	
Animal Cart	
Others	

SECTION 6: LAND TENURE SECURITY

29. Do you feel secure that the land you cultivate belongs to you?

    1. Yes
    2. No

30. If no indicate two main reasons?

    1. .... 2. ....

Declaration

I the undersigned declared that this Thesis is my original work and has not been presented for a degree in any other University and that all sources of materials used for the Thesis have been duly acknowledge.

Declared by

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Signature: ____________

Date: 12/10/07

Confirmed by Advisor

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Date: 22/10/07

Place and Date of Submission: ____________