

The Contribution of Soil and Water Conservation Practices towards Sustainable Rural Livelihoods in Tigray Region, Northern Ethiopia

Abebe Gidey



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The Contribution of Soil and Water Conservation Practices towards Sustainable Rural Livelihoods in Tigray Region, Northern Ethiopia

Abebe Gidey Reda

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List Of Acronyms and abbreviation

ANOVA	Analysis of Variance
a.s.l	above sea level
CSA	Central Statistical Authority of Ethiopian
Df	Degree of freedom
ESA	Economic and Social Affairs
FAO	Food and Agriculture Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
FFW	Food-For-Work
FRA	Forest Resource Assessment
GDP	Gross Domestic Product
HHs	Households
HHH	Household heads
ha	hectare
LDCs	Less developing countries
MOFED	Ministry of Finance and Economic Development
NGOs	Non Governmental Organizations
PSNP	Productive Safety Net Programs
REST	Relief Society of Tigray
SIDA	Swedish International development Authority
SPSS	Statistical Package for Social Science
SSA	Sub-Saharan Africa
SWC	Soil and Water Conservation
SWCP	Soil and Water Conservation Practices
TLU	Tropical Livestock Unit
TPLF	Tigray Peoples Liberation Front
UN	United Nations
UNDP	United Nations Development Programme
USAID	United States. Agency for International Development
WRI	World Resources Institute

Abstract

Severe land degradation affects the livelihood of many farmers in the Ethiopian highlands. In response, the current government has invested in soil and water conservation practices, mainly in the degraded lands. The overall objective of the research was to assess the contribution of soil and water conservation practice towards sustainable rural livelihoods in Tigray region. Research was carried out in Adwa and Emba-Alajie districts. Data were collected from a survey of 300 rural households from December 2012 to May 2013. A multi-stage stratified random sampling procedure incorporating household's survey questionnaires, focus group discussions, and key informants discussions were used to interpret the whole results in general. Data analysis included descriptive statistics, inferential statistical processed through one way ANOVA, t-test and Chi-square test, and Binary logistic regression model have been used.

The first topic assesses the adoption of soil and water conservation practices and its benefits towards livelihoods, in the form of farm wealth groups and spatial gradients. Survey results indicate a considerable proportion of farmers were adopters of soil and water conservation practices among farm wealth groups on their farms. There is such a difference among three farm wealth groups in adoption of soil and water conservation practices. This implies that farm wealth groups are influence, by adoption of soil and water conservation practices. Adoption of soil and water conservation practices is perceived and valued as positive by all the farmers regardless of wealth differences. The findings show five main dominant sources of livelihoods with a small variation in their mean annual income of both farm and off-farm incomes of adopters and non-adopters of soil and water conservation practices. Moreover, the results reveal that there is variation in adoption of soil and water conservation practices and soil fertility management practices among farm wealth groups with respect to variations in plot's spatial gradient and farm sizes. Therefore, to promote conservation efforts, policies should identify social and economic factors with respect to soil and water conservation and integrate them into the plans. Moreover, soil and water conservation practices should not only be aimed at minimizing soil erosion but should also cover other household objectives like securing economic and livelihoods, and follow up process on the proper maintenance and management of the soil and water conservation structures along with integrating agronomic measures using appropriate plant species.

The second topic focuses on investigating the factors that influence natural resources management, perceptions of community benefit from soil and water conservation practices. Results revealed that a large-scale mass mobilization undertaken for more than three decades in soil and water conservation practices has minimized flooding and thus soil erosion or degradation both in the farmlands and off-farm conservation, although it was less in on-farm conservation compared to the off-farm conservation. Results of the study also indicated that perception of farmers towards benefits of conservation attempts in changing and hence important contribution towards livelihoods has been recorded. However, the benefits are not yet adequate. Free grazing and conflicts over communal grazing lands were the major problems, causing the destruction of the physical and biological conservation works. Thus, the local leaders should give accreditation to informal institutions, in order to empower the local community and minimize the conflicts among the society in relation to communal natural resource management.

The last topic assesses determinants of farmers' adoption that affect sustainability of soil and water conservation practice. The empirical results from binary logistic regression model showed, age, literacy, tenure, farm size, and credit access were positive and significant predictors of

adoption of soil and water conservation practices. Extension workers are urgently needed to give education for farmers to maximize public awareness for the sustainable use of soil and water conservation practices, and there is need for sensitization of farmers to form groups to benefit from institutional credit facilities to enhance adoption of soil and water conservation practices, and capacity building of farmers in other livelihoods areas to reduce burden on natural resources.

Key words: contribution, livelihoods, sustainable, adoption, soil and water conservation, slope gradient, northern highlands of Ethiopia

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CHAPTER ONE

1. General introduction

1.1 Background and justification

Depletion of natural resources is among the major problems facing human beings all over the world. Soil loss due to erosion, depletion of surface and ground water and loss of biodiversity are among the principal global environmental problems (Lal and Stewart, 1990; Lal, 2001; Pimental, 2006). From a global perspective, the effect of soil erosion in particular can seriously affect agricultural production, and the well-being of small-scale farmer's. This, in turn negatively affects the national economy (Scherr, 2000; Barbier, 2003). Soil resources is a fundamental concern for many developing countries where non-labour inputs in agriculture are negligible and agricultural land the basis for survival of the vast majority of the population is at critical stage (Barbier, 2003). This resource is under serious pressure and its long-term productive potential is being impaired. In economic terms, land degradation causes a decline in the attributes of land in relation to specific functions of values (Wagayehu, 2003). One of the main policy concerns of governments in low-income countries today is to achieve sustainable development that fulfills both economic and ecological objectives (Aklilu, 2006; Girmay, 2006). Achieving food security, improving people's livelihoods and maintaining and improving the conditions of the natural resource bases are central goals of policy reforms in several of such sub Saharan nations (Kuyvenhoven *et al.*, 1998).

Land degradation and the deterioration of natural resource have become serious problems in the Ethiopian highlands (FAO, 1986; Hurni, 1988; Bojo and Cassels, 1995; Fitsum *et al.*, 1999; Kibrom, 1999; Demel, 2001; Woldeamlak, 2003; Nyssen *et al.*, 2004; Tadesse and Belay 2004; Aklilu, 2006). Different explanations can be forwarded to this daunting performance of environmental problems in the country. The principal causes are the complex interactions of natural, social and economic factors. In general, high degree of dependence on natural resources, rapid population growth, lack of alternative

employment opportunities for the rural population , rudimentary agricultural technology, persistent poverty, poor resource management, and very little or no investments on resource upgrading activities have been realized to have led the country to severe environmental crisis (Bedru, 2007). On the other hand, policies, that made land tenure insecure, offer little incentive to promote sustainable land use practices (Bereket, 2002). Continuous cultivation with limited amendments and complete removal of organic materials from agricultural fields, such as the widespread uses of dung and crop residues for household energy have also substantially contributed to the loss of soil organic matter (Woldeamlak, 2003; Aklilu, 2006). Severe shortages of fuel wood have rendered rural communities increasingly dependent on animal dung for fuel, contributing to the problem of declining soil fertility (Bojo and Cassels, 1995; Fitsum. *et al.*, 1999; Berhanu, 2002; Aklilu, 2006).

Soil erosion by water constitutes the most widespread and damaging process of land degradation (Woldeamlak and Sterk, 2002; Wagayehu, 2003). It induces on-site costs to individual farmers, and off-site costs to society. Some empirical studies (for example , Shiferaw and Holden, 1998; Berhanu, 2002; Berhanu and Swinton, 2003; Wagayehu, 2003; Woldeamlak, 2003; Aklilu, 2006) have underscored that this critical resource is in a state of serious degradation and the problem largely manifests itself in the form of soil degradation and loss of biodiversity. The main effects of soil erosion include reduction of soil depth, removal of soil organic matter, removal of essential soil nutrients, and depleting in water holding capacities of soil which cumulatively lead to a decline in agricultural production (Aklilu, 2006; Gebreegziabher *et al.*, 2006). For example, in 1990 alone, the estimated loss of grain production due to reduced top soil depth ranges from 57,000 to 128,000 tons (Demel, 2001).

The existing environmental, biophysical and socioeconomic indicators provide sufficient evidences of severity of deterioration natural resources in Ethiopia. For example, by the mid-1980s, about half (27 million hectares), over one-fourth (14 million hectares) and over 2 million hectares of the total area of the highlands¹ of Ethiopia were identified,

¹ The Ethiopian highlands, defined as areas above 1500 m. a.s.l., cover about 44% of the total territory of the country.

respectively, as “significantly eroded”, “seriously eroded” and “beyond the point of no return” (FAO, 1986). The same study and study by Bojo and Cassels (1995) estimated that the physical gross annual soil loss ranges from 42 –103 tons ha⁻¹ yr⁻¹. USAID (2000) on the other hand estimated the average annual rate of soil loss in Ethiopia to be 12 tons ha⁻¹ yr⁻¹, and rising to as high as 300 tons ha⁻¹ yr⁻¹ on steep slope where vegetation cover is scant. Based on field measurements on 202 plots in 12 sites of Tigray highlands (Desta *et al.*, 2005) have found a mean annual soil loss from crop land in the absence of soil and water conservation measure was 57 tons ha⁻¹ yr⁻¹.

Because agriculture is the main economic stay and the engine of economic development in Ethiopia, depletion of soil, water and vegetation resource bases will have adverse impacts on agriculture and other sectors of the economy. This is because more than 80% of the total Ethiopian population reside in rural areas and derive their livelihoods from agricultural activities (Wagayehu, 2003; Woldeamlak, 2003; Aklilu, 2006). This heavy reliance on agriculture increases the vulnerability of the national economy to land degradation (Shimeles, 2012). Thus, soil and water conservation is fundamental to the future development of the Ethiopian economy.

Accelerated soil erosion can be reduced by a combination of proper land management practice and appropriate soil and water conservation efforts. Incentives to promote soil and water conservation measures are, therefore, among appropriate areas of intervention to mitigate the adverse effects of erosion (Wagayehu, 2003). Theoretically, physical soil and water conservation structures have the potential to reduce soil loss by decreasing overland flow of water and increase yield by reducing moisture stress on plant growth through retention of rainwater that would otherwise be lost to runoff (Kappel, 1996; Wagayehu, 2003).

The economic argument to rationalize the community mobilization towards soil and water conservation is that it improves resource allocative efficiency in the absence of market incentives for erosion control (Wagayehu, 2003). However, in spite of rapidly growing awareness about soil erosion, its physical causes and effects, and uncertainty about the actual extent and impact of soil erosion in physical terms, and the difficulty of evaluating it due to socio-economic differences over space and time, make it difficult to

determine the economic effect of soil erosion (Erenstein, 1999). Moreover, despite increased understanding of methods of protecting and implementation of various conservation efforts in the past few decades, erosion remains widespread and adoption of conservation practices by farmer's remains limited (Shaxson *et al.*, 1997; Kerr, 1998; Yeraswork, 2000; Berhanu and Swinton, 2003; Mitku *et al.*, 2006).

This could be explained by the fact that the underlying and immediate causes of soil erosion are socio-economic factors that dictate whether farmers should use appropriate soil conserving practices or erosive agricultural practices. In other words, socio-economic forces constrain the desirability and adoption of technical solutions. Imposition of conservation measures by the government without giving farmers a veritable incentive underlie the latter's cynical attitude towards applying conservation measures (Kappel, 1996; Yerswork, 2000; Paulos *et al.*, 2004). That most farmers did not maintain conservation structures they built reveals their reluctance to accept and disseminate soil conservation technologies (IFAD, 1992; Kappel, 1996; Giger, 1997; Pretty and Shah, 1997).

Therefore, as Pretty and Shah (1997) and Tsehaye and Mohammed (2013) rightly put it, the limited success of past conservation interventions underlines the need to rethink on the approaches that have been pursued so far. A lot of discussions have been going on regarding land resource management in general and the limited success of past conservation activities in particular. The debates mostly focused on the policy dictates and conservation approaches that have evolved during the past decades. In general the failure was attributed to the misguided nature of interventions, which disregarded local level biophysical reality of the environment and socio economic conditions of farmers that shape their response to conservation efforts (Woldeamlak and Sterk, 2002). In other words, planning on effective and efficient land management technologies that can be accepted by farmers requires empirical understanding of the magnitude and rate of land degradation, and the diverse socio-economic variables that affect farmers conservation decisions (Woldeamlak, 2003).

Moreover, since there were a limited opportunities available for the local farmers to participate and share their knowledge and experiences in the conservation programs; the

interventionists (local government agencies and NGOs) often undermined farmers initiatives and their indigenous knowledge and practices, Thus, the interventions used incentives in a wrong way to the effect that farmers are left with negative attitudes and misconception about conservation projects (Shiferaw and Holden, 1998; Aklilu, 2006).

The policy makers have reasons to be concerned, as the reduction in farm productivity associated with degradation can affect the aggregate supply or price of agricultural output, the agricultural income, the economic growth, the consumption by poor farm households, and the national wealth (Winters *et al.*, 2004; Woldeamlak and Ermais, 2009). During the 1960s and 1970s, supported by international organizations, Ethiopia initiated and implemented a massive afforestation, soil and water conservation program to boost agricultural production and improve rural livelihoods (Campbell, 1991; Keeley and Scoones, 2000; USAID, 2000; Wagayehu, 2003). The emphasis has been on construction of physical soil and water conservation measures in cultivated fields and afforestation of hillsides, which are common property resources. Various types of stone and soil bunds, bench terraces, cut-off drains, waterways, check dams, grass strips and valley cropping are the prominent technologies. In addition, area closure and revegetation have been applied (Berhanu, 2002; Woldeamlak and Sterk, 2002; Woldeamlak, 2007). However, even though the importance of conserving soil and water in order to guarantee sustainable agriculture has been recognized, and despite many efforts, the results of soil and water conservation interventions are often discouraging (Erenstein, 1999).

Thus, in many parts of Ethiopia, though many efforts have been made in soil and water conservation practices, neither farmer's practices have changed markedly nor farmers have adopted most of the recommended conservation measures (Yeraswork, 2000).

For the attainment of this objective the research follows a household survey. The study was based on a sample survey in Adwa, and Emba-Alajie districts. The selection of Adwa and Emba-Alajie was made by the fact that a great deal of soil and water conservation practices and experiences were undertaken in these districts. In order to collect the desired data for the attainment of the research objectives a multi stage sampling procedures have been used. Though the study involves both quantitative and qualitative

data analysis and presentation; it heavily depends on quantitative method. The quantitative data was generated from sample household respondents through semi-structured questionnaires and both descriptive and inferential statistics have been used. In descriptive statistics frequency and percentages have been used. Through inferential statistics one ways Anova, Chi-square [χ^2] test, and a Binary Logistic Regression model have been used.

1.2 Statements of the problem

A number of studies have been conducted on soil and water conservation in Ethiopia, but most of them focused on farmers participation in soil and water conservation activities, by incorporating the socio economic aspects or benefits to the farmers (Nyssen *et al.*, 2000; Esser *et al.*, 2002; Woldeamlak and Sterk, 2002; Wagayehu, 2003; Aklilu, 2006). However, the findings in such studies did not relate the benefits of soil and water conservation practices to rural livelihoods at household levels or there are little evidences on the contribution of soil and water conservation to sustainable rural livelihoods. This problem initiates the undertaking of this research to further investigate and analyze the nexus between soil and water conservation and sustainable rural livelihoods at household level.

Severe land degradation affects the livelihood of many farmers in the highlands of Tigray, northern Ethiopia (Hurni, 1988; Nyssen *et al.*, 2004). In response, huge efforts are currently made at regional level in Tigray to control soil erosion, for example through the construction of stone bunds and the rehabilitation of steep slopes (Descheemaeker *et al.*, 2006a, 2006b; Nyssen *et al.*, 2007). The impacts of these erosion control measures are subject to debate: some authors state that these efforts do not lead to the desired effect, or are even counterproductive (Keeley and Scoones, 2000; Hengsdijk *et al.*, 2005). Moreover, recent studies focus on the economics and adoption of soil and water conservation practices by farmers in Tigray, but hardly attempt to quantify the agro-ecological impact of such measures (Shiferaw and Holden, 1998; Jagger and Pender, 2003; Berhanu and Swinton, 2003). On the other hand, other researchers have boldly argued that the measures have some what controlled the problem of erosion phenomena, vegetation cover on arable land as well as grass and shrubs between cultivated farm plots.

However, the population of Ethiopia has increased from 34 million to 77 million between 1975 and 2006 (ESA, 2004). Also land management and vegetation cover have improved in the study area. Thus, in the study area more than climatic variables human induced interventions have played the highest role in the improvement of land management and vegetation cover (Nyssen *et al.*, 2007).

As part of the national endeavor, intensive environmental conservation and rehabilitation efforts, especially soil and water conservation practices, were launched in Tigray National Regional State, especially since 1991 (Berhanu *et al.*, 2000). Combating environmental degradation was meant to harness ecological regeneration and ensure long-term economic benefits thereof (Berhanu *et al.*, 2000). In the efforts to reduce the negative impacts of land degradation, rural communities in Tigray made efforts in rehabilitating the degraded lands. Especially users of communal resources mobilized collective action towards achieving sustainable management of resources, such as forests and grazing lands. For instance, rural communities made concerted efforts in constructing stone terraces and soil bunds, establishing exclosures and in participating in tree planting programs since last few decades (Mitiku and Kindeya, 1998; Fitsum *et al.*, 1999). However, remedial measures in the past have focused on physical structures of land rehabilitation. Policy, institutional and participation issues were usually not highlighted in the remedial measures (Berry, 2003).

However, in Tigray region where the study area is found, extensive conservation practices have been implemented since the 1990s with the aim of long term economic benefits and ecological regenerations. However, the effort has not been as successful as it has been expected (Berhanu *et al.*, 2000). Short term benefits expectations of local communities, low profitability of conservation technologies and inadequate institutional and organizational supports have been blamed for the limited success (Mitku *et al.*, 2006).

Moreover, maintaining and enhancing farmers' participation is obviously a continuous challenge (Mitku *et al.*, 2006; Girmay, 2006), that determines the prospect of the attainment of the five key variables of sustainable livelihoods: natural capital, physical capital, human capital, financial capital and social capitals. Thus, considering the intense

degradation of the natural resource base, the sustainable management of common resources in Tigray becomes crucial for policy and development interventions. The sustainability of common resources management depends on internal factors such as rules of access and enforcement mechanisms, and external factors such as policies of land tenure, impacts of drought, and the influences of development interventions (Chisholm, 2004).

The development challenge is therefore identification of the proper institutional arrangements that will prevent over exploitation of common resources by enhancing wise utilization of common resources. Therefore, designing a natural resource conservation mechanism to achieve sustainable development that fulfils both economic and social objectives remains a problem to be tackled (Aklilu, 2006; Girmay, 2006).

Thus, in order to make the existing soil and water conservation practices in Tigray region efficient and self sustaining, it requires investigating the entire problem afresh. Finally, the whole theme of this thesis was focused on the contribution of soil and water conservation for sustainable rural livelihoods at household level and environmental protection concurrently.

1.3 Objectives of the study

The overall objective of the research was to understand the contribution of soil and water conservation practices in sustainable rural livelihoods among farmers with diverse socio-economic standings in line with their varying experiences among different landscape and climatic conditions in conservation measures.

The study has the following specific objectives:-

- To look at the variation in the adoption of soil and water conservation practices among farm wealth groups and its benefits towards livelihood systems at household level.
- To look at the effect of spatial gradient on adoption of soil and water conservation practices and soil fertility management between farm groups
- To explore the factors that influence natural resource management and perceptions of community benefits from soil and water conservation practices

- To assess the determinants that affect sustainability of soil and water conservation at house hold level.

1.4 Research Questions

So as to attaining these prime objectives, the following research questions that need addressing are formulated.

- Does variation among farm wealth groups create variation in the adoption of soil and water conservation practices?
- Does slope variation affect the adoption of soil and water conservation practices and soil fertility management among the farm groups?
- Does the linkage between farmer's natural resource management and perceptions of community benefits from soil and water conservation practices complement each other?
- What factors determine the sustainability of soil and water conservation practices at households?

1.5 Significance of the study

The purpose of this research was to assess and explain the impact of the ongoing soil and water conservation in the improvement of household livelihood and environmental restoration and sustenance. The study also examines the relation between macro level strategies and the livelihood requirements of the rural poor households and the role of different institutions, strategies and structures toward soil and water conservation. Therefore, the result will help farmers to understand more about different conservation practices so as to adopt the best one. It would also provide important inputs to policy makers and insights into resource management options and livelihood strategies. It is also believed that the outcomes of this research informs and assists the various government agencies and NGOs to have an insight on the implication of the ongoing soil and water conservation practices so as to enable them to consider what constitutes genuine community natural resource management practice.

1.6 Organization of the Paper

This dissertation is about the contribution of soil and water conservation practices towards sustainable rural livelihoods from the perspectives of local communities and management problems of the same. Accordingly, the dissertation's is organized as follows.

The dissertation is organized in eight chapters. The first chapter deals with background, statement of the problem, objectives of the study and significance of the study. The second chapter deals with review of conceptual as well as empirical literatures pertinent to the objectives of the study. Chapter three exclusively deals with study area and general methodology pursued; dwells on some general features and description of the study area. Chapter four analyzes the variation in the adoption of soil and water conservation practices among farm groups and its benefits towards livelihoods system at household level. The socio economic condition of the households that reside in the study area, to identify which socio-economic and physical factors have a major influence on the adoption of soil and water conservation practices by the farm wealth groups in the research area and to assess the benefits of soil and water conservation towards livelihoods system at household level. Chapter five examines the effect of spatial gradient on adoption of soil and water conservation practices and soil fertility management. In chapter six assess the linkage between natural resource management, and perceptions of community benefits from soil and water conservation practices. Chapter seven deals with modeling the determinants that affect sustainability of soil and water conservation at households' level. Finally, the conclusion and policy implication are presented in chapter eight.

CHAPTER TWO

2. Literature Review

2.1 The Concept of Sustainable Rural Livelihoods

Agriculture has had many revolutions throughout history. In this regard rural environments in most parts of the world have undergone massive transformations. In some senses, these have been the most far-reaching in their speed of spread of new technologies and the nature of their impacts up on social, economic and ecological systems. Two guiding themes have dominated these agricultural transformations. One has been the need for increased food production to meet the needs of growing populations. The other has been the desire to prevent the degradation of natural resources, perceived to be largely caused by growing numbers of people and their bad practices. Governments have encouraged the adoption of a wide range of conservation practices and technologies, including soil and water conservation to control soil erosion (Pretty and Shah, 1997).

The term sustainable livelihoods relates to a wide set of issues which encompass much of the broader debate about relationship between poverty and environment. Yet in the existing literature (for example), there is often little clarity about how much contradictions or trade off could be addressed between creation of sustainable livelihoods and the environment. A livelihood is considered sustainable if it meets three conditions: firstly, it should be adequate for the satisfaction of self-defined basic needs, secondly, it should be resilient to shocks and stresses and thirdly, it should not undermine the natural resource base that forms the basis of the future options (Scoones, 1998).

The current usage of the sustainable livelihoods concept derives from the work of Chambers and Conway (1992), which argued for the creation of livelihood strategies (for rich and poor) that accounted for their long-term impact in terms of maintaining the natural resource base for use by others and future generations, whilst being resistant to external shocks and stresses. They suggested a measure of 'net sustainable livelihoods',

which encompassed “the number of environmental and socially sustainable livelihoods that provide a living in a context less their negative effects on the benefits and sustainability of the totality of other livelihoods everywhere’. Many SWC practice however lead to smaller harvests in the short term. A solution to such trade-offs would be governmental support of the farmers in the first years of initiating the SWC practices. Carney (1998) and Scoones (1998) focusing on the idea that people construct livelihoods by drawing on a range of assets and entitlements. They suggested the need to understand the livelihood strategies and vulnerability of the poor as the starting point for intervention. The core concepts of the Sustainable Livelihood places the analysis on an individual (household) level, looking and building upwards from the micro to the macro level.

However in doing so, the idea of sustainable livelihoods has been reduced to a more benign conception of the way in which individuals or households manage their resources. A view, which makes it far easier to develop management theory for changing livelihoods as action, is ‘individualized’ and depoliticized (a similar critique is applied to participatory approaches in general (Cleaver, 2001a). Since, soil and water conservation practices can be implemented if they are suitable and sustainable for the people’s (or farmer’s) livelihoods.

2.2 Natural Resource Degradation

Agriculture is the dominant economic sector in Ethiopia that accounts for about 45% of the GDP, and 90% of the foreign exchange earnings, and supports about 85% of the employment. The vast majority of the population lives in rural areas and derives their livelihoods directly or indirectly from agriculture. The agricultural sector is predominantly subsistence in nature, in which the major part of farm production is for household consumption. A mixed farming system, involving both crop production (predominantly rain-fed) and livestock rearing activities, is the dominant type of production system (Medhin and Köhlin, 2008; MOFED, 2010). However, soil degradation in the highlands of Ethiopia is a serious problem that threatens the sustainability of agriculture (Hurni, 1988; Nyssen *et al.*, 2004). Soil erosion is a process

as old as the history of agriculture in the country, but it becomes more severe as land degradation and climatic variability increased.

Ethiopia is one of the Sub-Saharan Africa countries most severely affected by the problem, and water erosion is prominent. The northern Ethiopian Highlands are at high risk of desertification (Nyssen *et al.*, 2004). A large body of literature exists which describes and analyses the main causes and consequences of land degradation. Land degradation, particularly by water erosion, is an important factor in both the long-term decline and the seasonal reduction in food crop production in Ethiopia (FAO, 1986). Although some factors like shortage of rainfall are among the influential contributing factor to the low and declining agricultural productivity in Ethiopia, the major one is reduced soil fertility (FAO, 2000). This is manifested by the decline of crop yields; decline of water and forest resources and by gully formation across the grazing and ploughing fields. Soil erosion mainly occurs in the highlands, which have erratic rainfall that generate erosive runoff (Hurni 1993). According to (Oldeman *et al.*, 1991), more than 50% of the northern Ethiopian highlands suffer from sheet and rill erosion.

The complex inter-linkages between poverty, population growth and environmental degradation offer another dimension to the problem of land degradation (UNDP, 2004; Nyssen *et al.*, 2009). In recent years, rapid population growth has brought several changes. Farm holdings have become smaller and more fragmented. Farmers cultivate fragile margins on steep slopes previously used for grazing. Many households, particularly those owning little land or with large families, have reduced fallow periods. Consequently, more intensive farming and farming on steep slopes undermined soil fertility while increasing the incidence of soil loss from erosion (Yigremew, 1997; Woldeamlak, 2003). As a cumulative effect of continuous land degradation, ever-increasing population pressure, and inappropriate development policies, since the devastating famine in 1973/74, Ethiopia became recipient of food aid.

Despite this widespread problem, in Ethiopia, prior to 1974, the importance of conserving farmland was largely neglected. The problem attracted the attention of policy makers only after the devastating famine problem in 1973/74. After the 1973/74 famines, that coincided with and/or triggered a change of regime in the country, the government has

initiated a massive program of afforestation and soil conservation with the support of international organizations (Wagayehu, 2003). Packages of soil and water conservation programs were prepared for implementation through Food-For-Work schemes (Wagayehu, 2003). Reports on the performance of conservation efforts contradict, as discussed below.

2.3 Soil and Water Conservation Practices: an overview

Following the 1972/73 drought, the former government of Ethiopia initiated a program of soil conservation and afforestation. A watershed treatment approach was adopted for the program and the following three major conservation activities were undertaken : a) physical conservation or structural measures on farm lands which included tied ridges, soil or stone bunds and various types of terraces; b) soil conservation on grazing land which combined area closure and re-vegetation with fodder trees or shrubs; c) soil conservation on forest land which encompassed hillside terracing, planting of multipurpose tree species and fruit (Kappel, 1996; Shiferaw and Holden, 1998; Thomas, 1998; Yerswork, 2000; Berhanu, 2002; Woldeamlak and Sterk, 2002; Wagayehu, 2003; Aklilu, 2006).

Reports frequently publish statistics illustrating the apparent decline of the land resource base utilized by farmers. Many empirical studies conducted in the different parts of the country have reported that crop land expanded in to marginal areas at the expenses of natural vegetation covers. Fassil (1993) and Tsehaye and Mohammed (2013) have also shown that due to the high concentration of both human and livestock population in the highlands of Ethiopia, the continued intensive cultivation in the region exacerbated by inappropriate land use practices, a stagnant productive technology, and other factors have culminated in the present conditions of near ecological disaster. The expansion of cultivated land, commonly in to steep marginal lands without putting in place necessary soil and water conservation measures, led to soil loss from erosion (Nana-Sinkam ,1995; Stocking and Murnaghan, 2000; Woldeamlak , 2003; FAO, 2004; FRA, 2005). Hence, the argument to the contrary, that in some places population growth and agricultural intensification have been accompanied by improved rather than deteriorating

environmental quality in Kenya and Nigeria (Tiffen *et al.*, 1994; Berresem and Rerkasem, 1998; Tiffen, 1998), does not seem to show the general trend of the success of conservation in Ethiopia.

Hence, despite intensive soil and water conservation practices for more than three decades ago, adoption of the intervention in Ethiopia is considerably rather low. This fact is frequently attributed, among other things, to the top-down approach in extension activities, standard-mainly structural-soil and water conservation technologies, and lack of awareness of land degradation by the land users (Kappel, 1996; Giger, 1997; Pretty and Shah, 1997; Thomas, 1998; Yerswork, 2000; Berhanu, 2002; Woldeamlak and Sterk, 2002; Wagayehu, 2003; Aklilu, 2006; Mitiku *et al.*, 2006; Woldeamlak, 2007).

The failure of soil and water conservation measures may be attributable to the defective approaches employed for adoption. Farmers have been minimally involved in soil conservation activities, their indigenous knowledge has been undermined in planning, design, and implementation processes of introducing conservation technologies. As a result, soil and water conservation programs have not been popular among most farmers. Government policies concerning landholding, marketing, pricing, credit and resettlement have discouraged long-term investment and exacerbated these deficiencies. So often, resource users have been blamed for the failure of the plans without any attempt being made to analyze their circumstances (Pretty and Shah, 1997; CSA, 2008; Sørensen and Bekele, 2009). However, in the absence of sound land use policies, this pressure coupled with many other physical, socio-economic and political factors has led to a serious degradation of the land (Thomas, 1998; Yerswork, 2000; Berhanu, 2002; Woldeamlak and Sterk, 2002; Wagayehu, 2003; Aklilu, 2006). Because of these challenges, the rate of adoption is low and even terraces and check dams constructed on farm or grazing lands did not stay long.

2.4 Factors of Technology Adoption of Soil and Water Conservation

Studies on the factors affecting adoption of soil and water conservation practices began, for the most part, in the 1950s (Ervin and Ervin, 1982). Since then, several empirical studies evaluated the factors affecting the adoption of soil conservation practices.

Modeling household's decision to use a new technology is not an easy process. There is substantial variation in the methods and specifications of empirical studies on the adoption of soil and water conservation practices. This section reviews some of the related works from previous studies. The types of models used in some empirical studies as well as the variables employed in similar studies will provide a foundation for this study.

There is rapidly increasing literature on determinants of soil and water conservation adoption in developing countries. The main purpose of soil conservation is not merely to preserve the soil but to maintain its productive capacity while using it (Troeh *et al.*, 1999). Therefore, decisions on conserving soil erosion and rehabilitating degraded land depend on the costs relative to the value of output or environmental benefit expected (Berhanu *et al.*, 2000). Since the value of fertile soil is not infinite relative to other human needs, it is not worth preventing soil erosion unless the benefits gained exceed the costs incurred in conservation activities. Therefore, farmers will not be interested in investing in conservation and bearing associated risks unless they perceive a significant threat posed on productivity due to soil erosion and expect economic gains from conservation practices (Yigremew, 2003). Not only economic return or profit considerations but also other socio-economic circumstances of individual farm households, and risk considerations, may play a significant role in soil and water conservation decisions (Wagayehu, 2003).

As reported by (Shiferaw and Holden, 1998; Lapar and Pandey, 1999) the educational status of household head, slope of a plot, and plot area generally influence conservation decisions positively, whereas age of household head and distance of plot from dwelling affect conservation decision negatively. Pender and Kerr (1998) have also shown that the importance and direction of influence of different variables vary among different sites in the region. Another study conducted by Aklilu (2006) to examine the determinants of farmers' adoption and continued use of introduced stone terraces in the Ethiopian high land watershed showed that factors influencing adoption and continued use of the stone terraces are different. Adoption is influenced by farmers' age, farm size, perceptions on technology profitability, slope, livestock size and soil fertility, while the decision to

continue using the practice is influenced by actual technology profitability, slope, soil fertility, family size, farm size and participation in off-farm work. Perceptions of erosion problem, land tenure security and extension contacts show no significant influence, and the results indicated the importance of household/farm and plot level factors in farmers' conservation decision.

Farmers' adoption of improved soil conservation technology is determined by interactive effects of household socio economic characteristics, resource availability, physical characteristics of the land and institutional support provided by the public or NGOs sector (Mbaga-Semgalawe and Folmer,2000; Garcia, 2001; Paudel and Thapa, 2004). It is important to understand the relationship between these factors and the process of adoption of new technology to improve farm production and sustainable land management. It is assumed that the farmers will compare the advantages and appropriateness of different soil conservation technologies, based on the available resources at their disposal and their opportunity for profit.

The role of tenure security in the northern part of the country is reported to have different relationship with the adoption of land resource conservation technologies. The general conformity is that farmers must have a secure land ownership right, if they are to invest in soil and water conservation in anticipation of long-term benefits. Lack of tenure security erodes confidence in reaping the returns of investment in soil and water conservation. In other words, secure ownership of the land increases the sense of responsibility in applying better land use and management practices (Woldeamlak, 2003). Security of tenure is a critical variable determining incentives to conserve land quality (Tekie Alemu, undated; Belay 1992; Yeraswork 2000; Holden and Yohannes, 2002; Berhanu and Swinton, 2003). Secure land tenure rights clearly reinforce private incentives to make long-term investments in soil conservation (Berhanu and Swinton, 2003). If property rights to land are well-defined and enforceable, farmers will have incentives to conserve soil, as future benefits from soil conservation will accrue to the farmer who makes the investment. Security of tenure will lengthen the planning horizon or lower the effective discount rate.

On the other hand, if property rights are ill-defined or are not enforceable, a mining strategy based on rapid exhaustion of soil fertility will be adopted. The theory of land titling works mostly through the assumption that titling improves tenure security, farmers expected returns to immobile investment in land, conservation and land related capitals goods increase when title are related capital goods increase. Regarding the link from land to investment, Feder (1999) found that land improvements were greatly and more frequent on titled as compared to untitled land in two out of four Thai provinces in Thailand examined, as well as for the pooled sample. Subsequent research findings confirmed that investment in land improvements on titled land is 1.4-2.2 times higher than the case on untitled land in Paraguay, Thailand, and Honduras (Feder, 1999).

In Ethiopia, Asrat *et al.* (2004) found that formal land ownership was not a significant factor in farmers' willingness to pay for soil and water conservation practices. This was due to the farmers' confidence in having long-term access to lands despite the lack of land certification. Research by Fistum and Holden (2006) on the influence of tenure security on farm level investments supports Asrat *et al.* (2004) findings that tenure security has a weaker influence on willingness to invest than perceptions of return on investment and improved crop yields. This argument is supported by the findings of Place and Swallow (2000) that the relationships between property rights and technology adoption are complicated in several respects. They hypothesize that the nature of the technology or investment will affect the relationships between adoption and property rights.

In Central America, increasing concern over deforestation and environmental degradation has motivated renewed attention to land titling and the security of proper rights (Lutz, 1998). However, Faris (1999) found at the South western Nicaraguan agricultural frontier that land titles correlated negatively, ostensibly because the wealthier land owners (who also had formal titles) had greater, capacity for deforesting for the purpose of raising cattle. Titling can increase insecurity and inequity if the process is politically manipulated in favor of the wealthy and political powerful social groups, as happened in Ghana, and Guinea Bissaw (Bruce, 1986).

The possession of legal title to land is not, however, necessary for ensuring the security of land tenure because security is more than just a certification or the use of these technologies is dependent on the existence of several additional factors (Abebe, 2007).

The study made in different parts of Ethiopia attributed the low level of success of natural resource conservation to land tenure insecurity (Yeraswork, 2000; Woldeamlak, 2003). Bekele (1998) found negative association between land tenure insecurity and farmers decision to retain conservation structures on their fields. Wagayehu and Lars (2003) also predicted negative and significant association. Since stable land tenure is very important for adoption of major investments especially terrace construction (Berhanu and Swinton, 2003), the low level of retaining conservation structure throughout the country is attributable to land tenure insecurity (Yeraswork, 2000; Wagayehu and Lars, 2003; Shiferaw , 1998).

Moreover, poverty and market imperfections may create disincentives for conservation investment. Innovations that enhance or conserve the resource base may not also provide immediate benefits to land users. Thus, a different set of policies and targeting strategies may be required to promote such investments (Shiferaw and Holden, 1998). Although, efforts have been made to develop and promote several soil conservation technologies, their adoption has not been widespread. The living conditions of the rural poor in Ethiopian highlands have been worsening because of drought and increasing deterioration of the quality and quantity of natural resources, which are the main basis of subsistence agriculture (UNDP, 2004). It is important to understand the relationship between these factors and the process of adoption of new technology to improve farm production and sustainable land management.

2.5 Previous Empirical Studies on Adoption of Soil and Water Conservation Practices

Understanding why small-scale farmers' adopt soil and water conservation practices is complex. Biophysical and socioeconomic factors are important in this process. The literature indicates that such factors include age, education level, gender, cultural

influence and practices, household income, farm size, farm slope, land tenure, access to extension information, distance to farm land, access to labour, attitudes and perceptions, and population density.

Bodnár *et al.* (2006) analyzed the programmatic approaches to successful adoption of soil and water conservation practices in southern Mali. They found that farmers take several steps to learn about and accept innovations before they adopt them. First, they must have an awareness of particular problems affecting their land, and they must be willing to undertake measures to correct the root problem(s). Farmers then need to recognize what the possible solutions are and be able to acquire the skills to install these corrective measures. Most importantly, they need to believe in the potential benefits of soil and water conservation practices implementation before any are undertaken (Bodnár *et al.*, 2006).

On the other hand farmers may also be hindered by the complexity or social acceptability of an innovation (De Graaff, 1996; De Graaff *et al.*, 2008). Restricted access to necessary inputs, short-term expense, low financial returns, or high risks may discourage adoption of innovations (De Graaff, 1996). In support of these views, Cramb *et al.* (1999) found that household-level cash flow, rather than access to labor, was considered a more important explanatory factor for adoption when on- and off-farm income streams were accounted for.

Shiferaw and Holden (1998) analyzed resource degradation and conservation behavior of farm households in the degraded part of Ethiopian highlands. They modeled peasant households' choice of conservation technology as a two-stage process and employed an ordinal logit model of estimation. Their results showed that perception of the threat of soil erosion, household, land and farm characteristics, perception of technology-specific attributes, and land quality differentials influence conservation decisions of farmers.

Anley *et al.* (2007) and Wel *et al.* (2009) using Tobit model and Bayard *et al.* (undated) using multinomial probit model identified the main factors influencing farmers' decision to adopt and intensify the use of improved and indigenous soil and water conservation measures. Farmer's reasons for adopting and intensification of the use of

improved and indigenous soil and water conservation measures are affected by 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 (Anley *et al.*, 2007). In this study, age of the head of household showed a significant, but negative, effect on use of soil bunding methods; older farmers were less likely to adopt innovations, probably due to shorter planning horizons and inability to invest the required labour in implementation (Anley *et al.*, 2007). The ratio of land size to labour, education level of the household , distance of the farm plot from the household, and slope angle of farm fields all had significant, positive influences on the use of improved soil conservation measures (i.e., soil bund, ditch/trench cut-off drain, and terracing (*fanya juu*)). Farmers who had better access to extension services and improved soil conservation measures invested significantly more in building ditches, trenches, and *fanya juu* (Anley *et al.*, 2007).

Several studies cite a positive correlation between level of education and number of soil and water conservation practices adopted; therefore indicating that formal education is an important variable explaining adoption behavior (Asrat *et al.*, 2004; Tenge *et al.*, 2004; Anley *et al.*, 2007). It is inferred in these studies that higher levels of education facilitate the individual's capacity to learn and to make informed decisions (Anley *et al.*, 2007). Bodnár *et al.* (2006) also found that several steps were essential to learning about and accepting innovations, i.e., awareness of the particular problems, ability to recognize possible solutions, and ability to acquire the skills necessary to implement corrective measures. Bodnár *et al.* (2006) determined that belief in the potential benefits of soil and water conservation practices implementation is also a necessary condition. Hence, the capacity to learn and experiential learning (i.e., years on farm or other observational experiences) become important functional proxies for education level or measures of experience, *per se*.

Tenge *et al.* (2004) concluded the adoption of soil and water conservation technologies is likely increase with a higher level of education and a better security in land tenure. On other hand, involvement in off-farm activities, fragmentation of fields over different

locations and lack of real short-term benefits from SWC to the farmer negatively influenced adoption of soil and water conservation practices (Tenge *et al.*, 2004).

Different factors may contribute either positively or negatively for the adoption of soil and water conservation innovations. For instance, age, farm size, and livestock numbers and the availability and profitability of the technology can have its own impact on adoption. However, adoption of soil and water conservation innovations should start from acknowledging the erosion problem and developing a positive attitude towards soil conservation innovations (De Graaff *et al.*, 2008). Processes of internal sense making and actor specific perceptions are important for the spread of soil and water conservation measures (Yinager, 2012).

Furthermore, Berhanu and Swinton (2003) using a double hurdle model, examined the 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 investment in stone terraces was associated with secure land tenure, labour availability, proximity to the farm stead and learning opportunities via extension education and the existence of local food for work projects. By contrast, short-term investment in soil bunds was strongly linked to insecure land tenure and the absence of local FFW projects. Another study conducted by Aklilu (2006) Using a sequential decision making model in Ethiopia highlands found that factors influencing adoption and continued use of the stone terraces to be different. The same study indicated that adoption was influenced by farmers age, farm size, perceptions on technology profitability, slope, livestock size and soil fertility, while the decision to continue practice is influenced by actual technology profitability, slope, soil fertility, family size, farm size and participation in off-farm work. Another study made by (Tenge *et al.*, 2004) indicated the importance of household /farm and plot level factors in farmer's conservation decision. The variation of conservation practices from one place to another and from one household to another has been a matter of concern for researchers, policy makers, and planners.

2.6 A livelihoods approach to Soil and Water conservation

The livelihoods approach starts with an analysis of people's livelihoods and how these have been changing over time. The sustainable livelihoods framework provides a holistic analytical tool for investigating investment decisions within the context of diverse livelihood strategies. The key challenge in the coming years will be addressing the diverse and potentially conflicting demands of humans and other forms of life, while ensuring that future generations have the same potential to use soils and land of comparable quality. In a multi-level stakeholder approach, down to earth action will have to supplement with measures at various levels, from households to communities, and from national policies to international contentions. Knowledge systems both indigenous and related research and learning processes must play a central role (Hurni, 1988).

2.6.1 Livelihood Assets

People and their access to assets are at the heart of livelihoods approaches. A critical issue in evaluating the impacts of soil and water conservation measures concerns not only the extent to which different forms of capital are enhanced but also whether there are trade-offs between them (McDonald and Brown, 2000). Many studies have looked at the relationship between soil and water conservation and a household's access to assets. (FAO, 1986; Anderson and Thampapillai, 1994) for example, report that, level of income (on- and off-farm); Access to low cost credit; labour availability; low discount rates (i.e. long policy-planning horizons); high levels of education among farmers; access to sound technical advice; secure land tenure are positively associated with the adoption of soil and water conservation.

Seasonal crop failures are common and crop production alone does not fulfill the requirements for survival of the majority of rural households. As a result, rural households adopt a diverse range of livelihood strategies.

Mahmud and Köhlin (undated) investigate the impacts of market and institutional imperfections on technology adoption in a model that considers adoption of fertilizer and soil conservation as joint decisions they found that market imperfections such as limited access to credit, plot size, risk considerations, and rates of time preference as significant

factors explaining variations in farm technology adoption decisions. Relieving the existing market imperfections will most likely increase the adoption rate of farm technologies.

The effect of farm size on soil and water conservation decision is not clear. Large farms could reflect greater capacity that encourages conservation (Cramb *et al.*, 1999; Aklilu, 2006). On the other hand, more land may reduce the need to conserve land (Berhanu and Swinton, 2003), while the potential loss of land for conservation may discourage investments on small farms.

Lack of labour is not the main reason for not investing investment in soil and water conservation but it is more significant constraints to increased investment for those who choose to adopt soil and water conservation practices. However better land ,crop and animal husbandry which proves to be conservation-effective can be seen as a means to the end of better livelihoods, not as an end in itself (McDonald and Brown, 2000).

Tenge *et al.* (2004) pointed out that farmers' behavior regarding soil and water conservation is a result of the interplay among physical, institutional, attitudinal and economic factors. The study also observed that there was lack of understanding of farmers' behavior by the extension providers as regards soil and water conservation that was aggravated by the absence of a learning process that should complement a technical intervention.

Even if farmers are aware of the consequence of soil degradation and its solution, they will sometimes continue to abuse and degrade the soil because of economic or survival necessities or some other reasons (Woldeamlake, 2003). For example, without being provided with alternative energy source, people will cut trees and continue to do so. Therefore, to control soil degradation and to secure peoples will to use conservation measure, it is also essential to fully address their needs and problems or in order to attain widespread adoption of conservation measures, it will be essential to understand why people are still unwilling to accept and implement conservation measure even when they are aware of the continued degradation of land resources. The key element in this

connection is to understand the socio-economic factors governing people activities or doldrums.

Nevertheless, these factors are often over looked planners and implementing agencies who tend to view soil degradation and conservation problems as a function of only physical and technical factors. This is perhaps due to underestimating the role of socio-economic factors in the adoption and continued use of conservation practices, or from lack of appropriate information or both (Belay, 1992). Moreover, lack of access to knowledge, due to ineffective extension services as well as the provision of complementary inputs (such as fertilizers, tools and seeds) were cited as reasons from non-adoption (Boyd *et al.*, 2000).

Those farmers involved for less than five years are more likely investing soil and water conservation than those who have been involved in farming for more than five years to practice soil and water conservation on all their plots (Boyd *et al.*, 2000; Simon *et al.*, 2012) .This runs counter to the hypothesis that farmers who have been involved in farming for more time are more likely to invest soil and water conservation because of greater experience and /or better access to indigenous and non-indigenous knowledge. However, older farmers were likely to be relatively reluctant in their decisions to take up new technologies because of their short planning horizon (Thomas, 1998). Meanwhile, it is also true that older farmers were likely to have more farming experience and would therefore be likely to be more receptive to new soil and water conservation practices (Wagayehu, 2003). This shows that livelihood assets are strongly influenced by personal characteristics and desires, and one's relation to others.

2.6.2 The vulnerability context

A livelihood could be considered sustainable when it can cope with and recover from shocks, and maintain or enhance its capabilities and assets, while not undermining the natural resource base (Hussein and Nelson, 1998; Chambers, 1995). The poor are more dependent on the ecosystems and its services to cater for their various types of demands ranging from food, fuel wood and water to medicinal plants and services to enrich their cultural identity and social well-being (Aklilu, 2006). Common resources like grasslands,

water sources and forests also provide safety cushion during extreme environmental calamities.

Vulnerability faced by poor people, and people's options for responding to vulnerability as it arises. In terms of the sustainable livelihoods concepts the vulnerability faced by poor people includes that brought about by uncertainties in climate, politics, markets and potential conflict situations. In semi-arid areas, climatic vulnerability is characterized by low mean annual rainfall, compounded by high variability in its spatial temporal distribution. Hence, livelihood strategies in semi-arid areas are primarily geared towards coping with a high degree of uncertainty, minimizing risk and meeting subsistence needs, rather than maximizing production and profits (Scoones, 1998). This has implications for individual time preferences and investment decision-making amongst smallholder farmers.

Farmers see little benefit from their investment in soil and water conservation method. They find that erratic rainfall, pests and diseases and a lack of economic resources are far greater threats to their livelihoods than soil erosion. Consequently, soil conservation has a low priority keeping soil in place avoids major off-farm disbenefits (Hellin and Haigh, 2002).

2.6.3 Transforming Structures and Processes

It is by building their stock of capital assets that rural people are able to enhance their livelihoods. How and how far they can do this is determined by the types of policies, structures and institutions. A wide range of policies and intuitions may impact on decisions to invest in soil and water conservation. National environmental policies, land tenure and planning policies and forestry agriculture and livestock policies may have direct or indirect impacts. Policies relating to economic development, food aid, and infrastructure and market development also have a significant influence on decision making. Government policies can act as both incentives and disincentives (Boyd *et al.*, 2000).

In conventional rural development, participation has commonly centered on encouraging local people to sell their labour in return for food, cash a materials. Yet there materials

incentives distort perceptions, create dependencies and give the misleading impression that local people are supportive of externally-driven initiatives. Despite this, development programs continue to justify subsidies and incentives, on the grounds that they are faster, that they can win over more people, or they provide a mechanism for disbursing food to poor people. As little effort is made to build local skills, interests and capacity, local people have no stake in maintaining structures or practices once the flow of incentives stops (Pretty, 1998). Anderson and Thampapillai (1994) also added, in the past, soil and water conservation policies tended to focus on the use of subsidies as an incentive for farmers to adopt environmentally sound production practices and conservation measures. Such policies are established in the beliefs that soil and water conservation measures are inherently desirable and that the benefits of their adoption outweigh the costs of their implementation and maintenance.

The most widely used direct economic incentives have been compensation for labour and support with equipment. While the incentives have enabled the construction of massive soil conservation structures and the use of biological means for soil conservation, the continued use of the practices once interventions phased out had been low (McDonald and Brown, 2000). In response, different countries attempted to combine incentives with participatory approaches to soil and water conservation (Haro *et al.*, 1998; Mandeme, 1998). However, real participation of beneficiaries has not been realized in many of the East African countries. Perhaps as a result, the adoption of soil conservation practices remains low (Yeraswork, 2000). Moreover, the use of indirect economic incentives such as credit supply, extension services, taxes, input and output price support and market development has been limited. These experiences indicate that there is a need to use both direct and indirect incentives combined with real participation of beneficiaries if effective and sustained soil and water conservation effort is to take place (Berhanu, *et al.*; 2000). Stocking and Murnaghan (2000) also stated that in order to enhance cooperation between people and institutions, four principal topics are addressed: the value of local knowledge diversity within local society; different economic perspectives and participation local knowledge, while not replacing formal science, enables the engagement of local people, enlisting their cooperation and interest.

Rather than incentives empowerment is seen as a critical issue farmers may need to be empowered in order to adopt and adapt soil and water conservation measures and in particular to conduct their own experimentation (McDonald and Brown, 2000). Empowerment is related to several factors such as more self confidence, increased income and access to credit and thus its measurement will be very much dependent on the context and related to the specific constraint ensuring empowerment involves three steps identification of the key constraints for farmers identification of the type of empowerment required to enable and ensuring that liberation from constraint does not result in an imbalance of power. But this suggests a much broader and interdisciplinary approach to soil and water conservation taking into account social economic political and institutional factors as well as technical ones (McDonald and Brown, 2000).

However, Lutaz *et al.* (1989) shows that frequently this is not the case and that the benefits from certain conservation techniques, especially those based on mechanical structures do not justify their costs. Unless the off-site costs of soil degradation are high or the price signals that farmers receive are significantly distorted. It is argued that subsidies to enhance adopt of soil and water conservation techniques are economically inefficient. Moreover, Farmers were not given a choice from a menu of soil and water conservation technique and they were bribed in to soil and water conservation through the indiscriminate use of incentives such as food-for work as cash for work, but many are grappling with incentives. It is surprising that only one paper in Bonn was specifically dedicated to this subject (Giger, 1998).

Although it is the current paradigm that soil and water conservation should be undertaken on a voluntary basis to ensure that land users are really interested in soil and water conservation as they invest their own scarce resources in to it, there also is a consensus that they need some form of incentives and support to ease the burden of work and to accelerate the rate of implementation. The questions remains what kinds of support can be provided without jeopardizing maintenance of conservation works and continuation of farmer investment in improved land management practices in the post-project phase?. These arguments do not mean that the use of incentives or subsidies for soil and water conservation should be wholly discarded. Erosion can cause substantial off-farm and

downstream damage and this can be a justification for subsidizing on farm prevention (IFAD, 1992; Prety and Shah, 1997).

The principal reason for most project conservation work to date being so short lived is that land users have either been ignored or instructed, rather than being consulted or trained (Berhanu, 2002; Woldeamlak and sterk, 2002). They usually responded with indifferences. Sometimes, successes are reversed almost immediately. In an evaluation of world food program supported conservation in Ethiopia, the extent of terracing was quoted as being impressive yet monitoring found 40% of the terracing broken the year after construction (SIDA, 1984). Most soil and water conservation projects have paid and continue to pay local people in cash or food for their participation .But this is clearly self-defeating. According to Reij *et al.* (1996) practices shows that where people are paid for soil and water conservation, the end of the project almost invariably leads to a stop in the construction of conservation works (Prety and Shah, 1997; Thomas, 1998).

Only of a few lessons of the past have been learnt and have been exchanged between regions and continents pressing challenge are postponed or suppressed, as land tenure is one of the most sensitive issues with tin societies. If the solution of problems is further postponed to the future, the inefficient allocation of scarce resources, conflicts related to distribution and the destruction of the environment will be aggravated and accelerated (Kirk, 1998; Okoth-Ogeno, 1998). Both in Tanzania and Uganda the farmers are feel secured under the current tenure system and do not consider the acquisition policy to have affected their soil and water conservation efforts. Except for those few farmers who rent their land, the current tenure is not seen as a constraint, but rather an incentive to invest in soil and water conservation (Boyd *et al.*, 2000).

Corrupt and ineffective government institutions and top down approach (Prety and Shah, 1997; Boyd *et al.*, 2000; Jones and Tengberg, 2000; Woldeamlak and Streck, 2002) have led to the disappearance of those soil and water conservation practices dependant on the enforcement of by laws.

2.6.4 Livelihood strategies

DFID (1999) defines the livelihood strategies as all the activities of a household to achieve the livelihood goals. They include productive activities, investment strategies and reproductive choices. Livelihoods approaches try to understand the strategies pursued and the factors behind people's decisions; to reinforce the positive aspects of these strategies and mitigate against constraints.

Three broad clusters of livelihood strategies have been identified, and these are commonly pursued in combination, either simultaneously or in sequence: (i) agricultural intensification/ extensification; (ii) livelihood diversification; and (iii) migration (Scoones, 1998). The priority that people attach to each of these different strategies is a prime determinant of investment in soil and water conservation.

The adoption of soil and water conservation practices represents a decision by households to intensify their agricultural production. It is often assumed that investing in soil and water conservation is automatically beneficial, without looking in detail at costs of soil degradation. The inherent tension between resource conservation and resources exploitation is exemplified by soil and water conservation because the costs are felt more quickly than the benefits. Investments in soil and water conservation tend to generate returns in the long term, but do not necessarily results in the higher yields or income in the short term (Wagayehu, 2003; Berhanu *et al.*, 2000).

Farmer's attitudes to risk will influence their willingness' to invest in soil and water conservation and an important question is how far farmers cope with living in marginal, risk prone environments such as semiarid areas. The decision on whether to invest in soil and water conservation is mediated by the extent to which this increases or reduces the overall risks of a particular livelihood strategy (Anderson. and Thampapillai, 1994).

Most studies indicated that households that are more dependants on crop production for their livelihoods invest more in soil and water conservation. However, access to financial capital (indicated by the availability of farm income) was also seen to play a role. Farmers invested more in soil and water conservation when they needed more cash

income to pay taxes and to purchase services and competitive markets for selling crops were available and they could obtain good prices for the produces (Tenge *et al.*, 2004).

The on-going debate on rural livelihood diversification in the context of climate change is uncertain as to whether livelihood diversification, including on-farm, and off farm activities results in adaptive processes, improvement in well-being, asset accumulation and poverty reduction. Davies and Bennett (2007) argue that livelihoods are diversified and adapted to cope with uncertainty, but also that change can undermine such adaptations. Moreover, off farm livelihood diversification within the context of a sustainable livelihood development is perceived to be an effective strategy for the reversal of the persistent state of rural household deprivation (Devereux *et al.*, 2005). They argued that deprivation within rural farm households is an endemic and growing problem throughout sub-Saharan Africa. The cause of this growth is complex and quite difficult to understand. However, some authors refer unpredictable climate patterns, diminishing environmental resources and the inadequacy of rural household resources that creates a structural inability to sustain reasonable (Anna Toner, 2003).

Hesselberb and Yaro (2006) explain that adaptation through off farm diversification is an important contribution to livelihood security, since farm income consistently fails to meet household expenditures. Consequently, diversification has been promoted as a useful adaption strategy in some developing societies, and it is critical to understand whether off farm diversification really allows peasant farm households to become qualitatively better and economically empowered to engage with environmental and climatic variability in the new world.

The response to their question is rather inconclusive, as argued by Scoones (1998), associated diversification with the ability to increase the household's capacity to withstand exogenous shocks. Ellis (1998) also perceived off farm diversification, including migration, as an accumulation strategy which could lead to improvement in income and assets. Nevertheless, non-diversification is considered to provide one source of surplus for investing into productivity improvement in agricultural methods and other forms of accumulation (Miyuki *et al.*, 2008). They hypothesized that commercialization

could lead to accumulation, but do not indicate which category of the rural poor are likely to benefit.

Furthermore, diversification is argued to offer a risk reduction potential and a means of insurance against the risks confronting rural households in their economic activities (Hussein and Nelson 1998; Ellis, 2003), described diversification as a strategy employed primarily to offset risk, and rural households are known to pursue diverse livelihood strategies to spread the risk of output failure and reduce economic vulnerability. Hussein and Nelson (1998) perceive the adoption of diversified activities is indicative of the use of risk minimization strategies in achieving the provision of household needs. Moreover, Chambers and Conway (1992) argue that poor people in particular are, as matter of course, forced to diversify their sources of livelihood in order to survive in risk-prone environments and uncertain economies prevalent in rural communities in developing countries.

Diversification and livelihood adaptation are seen to be adaptations to short-term fluctuations in longer-term trends, but in marginal agricultural areas adaptation to a potential environmental hazard is structured into the livelihood regimes. Furthermore, the impact of diversification of the livelihood strategy on decisions to invest in soil and water conservation is not clear. On the one hand, the Tanzania case study suggests that off-farm income is an important source of investment funds (similar to the findings of Tiffen *et al.* (1994) in the Machakos study). However the Ugandan evidence suggests that many households have diversified away from crop production in order to generate cash income for the purchase of food and in some cases this has led to a decline in investment in SWC (Boyd *et al.*, 2000).

2.6.5 Livelihood outcomes

Livelihood outcome are the end results of the different combinations of livelihood strategies that people choose to follow. It is impossible to say anything for outsider to judge what constitutes a positive or negative outcome. Because, the outcomes people aspire to will vary greatly at all levels-within households, within communities, within regions and so on. At a broad level, common livelihood outcomes might include more

income; increased well-being; reduced vulnerability; improved food security; and more sustainable use of the natural resource base (Scoones, 1998). A household's decision to invest in soil and water conservation is based on anticipated benefits.

Households in the case studies invest in soil and water conservation primarily to improve yields, usually of cash crops. It therefore seems to represent one component of a strategy to increase incomes in contrast to improving food production and sufficiency. Case study neither was able to elicit information on how investment in soil and water conservation fits into risk management strategies or whether it reflects trade-offs between short and long term benefits (Boyd *et al.*, 2000). However, the relationship between the vulnerability context and investment in soil and water conservation needs further clarification.

CHAPTER THREE

3. Study Area and General Methodology

3.1 Study Area

Tigray regional state is situated in the northern Highlands of Ethiopia, stretching from 12⁰ 15 'N to 14⁰ 57'N, and 36⁰ 27'E to 39⁰ 59' E. The region is bordered in the north by Eritrea, in the west by the Sudan, in the south by Amhara region, and in the east by Afar region (Figure 3.1). For political administration and development purposes Tigray region is divided into 7 zones and 48 districts.

The farming system is a typical mixed crop –livestock system that is carried out on subsistence scale. The livelihood of the people relies on agriculture. Rain fed crop cultivation is dominant in the area. Livestock are important sources of food, income and power for ploughing. The number of livestock owned by a household is an important indicator of economic status in the society. Cattle, sheep and goats are the most important livestock reared in the area. Bee keeping is also an important activity. Among the 48 districts of Tigray regional state, Adwa and Emba-Alajie were selected as the study districts.

Adwa district

Adwa district is located in central zone of Tigray Region, with an area of 1,888.60 Km². Geographically the district is located between 14⁰ 08'43'' N to 14⁰ 11'00'' N, and 38⁰ 53'55'' E to 38⁰ 57'30''E (Figure3.1). It has 17 ²Tabias. The topographical feature is characterized by mountain chains of high towering peaks, plateaus, and hills. Altitude of Adwa ranges from 1500-1900 m.a.s.l. According to the traditional agro-climatic classification of Ethiopia (Hurni, 1998) which considers altitude and temperature Adwa lies in both Kola and Woina Dega agro-climatic zones and the mean annual maximum and minimum temperatures are 20⁰c and 12⁰c respectively.

² Tabia is the lowest administrative unit in Tigray usually comprising of four to five villages

It has a total population of 110852, of which are 55093 male and 55759 female. Adwa occupies a total area of 1,888.60 km² and a population density of 58.7. There are 22394 households in Adwa with an average of 4.95 persons to a household (CSA 2008). The main crops produced in Adwa are sorghum (*Sorghum bicolor* L.), wheat (*Triticum vulgare*), teff (*Eragrostis tef*), finger millet (*Eleusine coracana*) and hanfets. A variety of vegetables and fruits are also grown in irrigated fields of the district. The residents of the study areas are mainly rural dwellers and are dependent on land resources for their livelihoods (CSA, 2008).

Emba -Alajie district

Emba-Alajie district is situated in the southern zone of Tigray Region, with an area of 1,677.94 Km². Emba-Alajie is located between 12° 59' 0" N to 13°00'00"N, and 39°20'00"E to 39° 33' 0" E. It has Kola, Woina Dega and Dega agro-ecology (1500-3200 m. a. s. l.) and the mean annual maximum and minimum temperatures are 22⁰C and 13⁰C respectively.

The district has a total population of 107,972, of which 52,844 are male and 55,128 female; and 7,568 or 7.01% are urban inhabitants (CSA, 2007). Emba- Alajie has a population density of 64.4, which is greater than the Zone average of 53.91 persons per square kilometer. A total of 24,784 households were counted in this district, resulting in an average of 4.4 persons to a household. The main crops produced in Emba-Alajie are wheat (*Triticum vulgare*), barley (*Hordalum vulgare*), and maize (*Zea mays*) and pulses. A variety of vegetables and fruits also grown in irrigated fields of the district. The residents of the study areas are mainly rural dwellers and are dependent on land resources for their livelihoods (CSA, 2008). There are 20 Tabias in the district, out of which two Tabias (Atsela and Ayeba) were randomly selected.

The Study Tabias

Endabagerima

Endabagerima is 5 kilometers south of Adwa and has a total population of 7,948 with 3,950 males and 3,998 females. There are 1,651 households, composed of 1,150 male-

headed households and 501 female-headed households. Endabagerima has a total land area of 3,634 hectares out of which 783 hectares have been cultivated, 865 hectares enclosed, 1,142 hectares earmarked to be enclosed, and 844 hectares under agro forestry use. In Endabagerima *Tabia* has four *kushets*³ (Myweyine Gedame, Tsgerida, and Enaberad).

Mariam Shewito

Mariam Shewito is 15 kilometers east of Adwa and has a population of 6,908 with 3,433 males and 3,475 females. There are 1,570 households, composed of 1094 male-headed households and 476 female-headed households. The *Tabia* occupies a total land area of 3,502 hectares, 618 hectares under cultivation, 616 hectares communal land, 998 hectares enclosed, 700 hectares under agroforestry, and 570 hectares earmarked to be enclosed. In Mariam Shewito also has four *kushets* (Ketema, Daerowini, Genya, and Era).

Atsela

The *Tabia* is situated about 1.5km. north of the town of Adi-shehu. Atsela *tabia* has four *kushets*³: Tahetay Atsela, Lalay Atsela, Wgelne, and Kola Sesat , with a total population of 6209 There is a high population of males (3165) in comparison to females (3044). There are 1,425 households, composed of 961 male-headed households and 464 female-headed households. Atsela has a total of 2287 hectares of cultivated land, 1444 hectares watershed area, 225 hectares of forest, and 618 hectares enclosed area.

Ayeba

Ayeba is 15 kilometers south of Adi-shehu and has a population of 7759 with 3780 males and 3979 females. There are 1,757 households, composed of 1304 male-headed households and 453 female-headed households. *Tabia* Ayeba has four *kushets*, namely, Ayeba, Ayne My, Adi Wongo, and Erer. Ayeba has a total land area of 2,856 hectares,

³ Kushhet refers to a village

with 1773 hectares cultivated, 447 hectares watershed area, 524 hectares forest, and 112 hectares enclosed area.

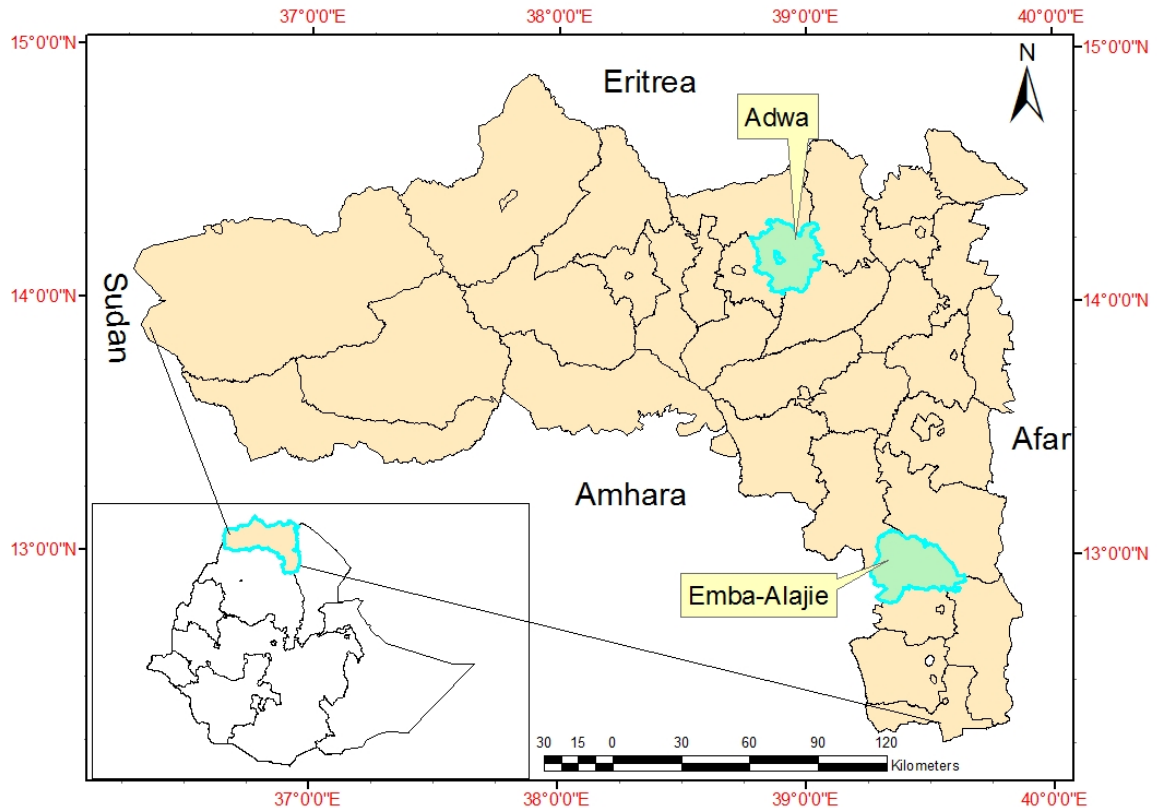


Figure 3:1: Map of the study area. Note that figures (latitudes and longitudes in degrees) along the border of the map are for Tigray region

3.2 General Methodology

The study employed household's survey questionnaires, focus group discussions and discussions with key informants. The study was conducted from December 2012 to May 2013 in two districts of northern Ethiopia, namely Adwa and Emba-Alajje. The study districts and the sample households were selected following multi-stage stratified random sampling procedure.

During the first stage, two zones namely central and southern of Tigray were purposely selected, in consultation with Tigray Region Rural Development and Agricultural experts, because they were identified as having relatively high rate of soil and water conservation practices compared to other zones. Similarly at the next stage, in consultation with District Rural Development and Agriculture offices experts, two districts; i.e.; Adwa from central zone and Emba-Alajie from southern zone were purposely chosen, where again the same appearance of use programs were identified as the reasons.

Thirdly, four Tabias (two from each district were selected for this study. Thus Mariam Shewito and Endabagerima from Adwa and Atsela and Ayeba from Emba-Alajie districts) were randomly selected. Following this 300 sample households were selected, by employing proportional stratified random sampling technique. The sampled households were disaggregated in to wealth groups (rich, medium and poor) based on local farmers 'wealth group classification criteria. Methods of data collection include focus groups discussions, key informants, interview and household survey. Key informants were selected on the basis of their experience. Considering the manageability of the number of samples, nearly 5% was fixed as the strength of sample size.

Table 3-1: Distribution of sample households by Tabias

<i>Name of District</i>	<i>Name of Tabias</i>	Frequency of HHs by wealth groups				Number of samples by wealth groups			
		Rich	Medium	Poor	Total	Rich	Medium	Poor	Total
Adwa*	Mariam-shewito	467	658	445	1570	22	31	21	74
	Endabagerima	236	665	750	1651	11	31	35	77
	Total	703	1323	1195	3221	33	62	56	151
Emba-Alaje**	Atsela	404	596	925	1425	19	28	20	67
	Ayeba	407	621	729	1757	19	29	34	82
	Total	811	1217	1154	3182	38	57	54	149
Grand Total		1514	2540	2349	6403	71	119	110	300

Source: * and ** Adwa and Emba-Alajie District Rural Development and Agriculture offices, 2012/13

The household survey was conducted by 10 data collectors (five in each district). Data collectors were selected based on their experience in similar practices in their area. Field based training was given to all enumerators on how to administer and complete the questionnaire for four days. After training, a pilot survey was carried out in one village outside the selected Tabias. The objective of the pilot survey was to enable enumerators to practice the interview in the field and to get constructive feedback on the contents of the questionnaire. Based on the finding of the pilot survey adjustments were made to the questionnaire and the households' survey was administered using the final /amended version of the survey questionnaire.

The process of data analysis was carried out by using quantitative and qualitative analysis; however the study heavily depends on quantitative method of data analysis. All the collected data were entered into SPSS version 17 .The quantitative data analysis of the study used both descriptive and inferential statistics. Descriptive analysis includes percentage, ratios, and cross-tabulation. In inferential statistical analysis (continuous data) were analyzed through one way ANOVA [Analysis of Variance] and t-test, while, categorical data was analyzed using Chi-square [χ^2] test. Binary logistic regression model was used for the strength of relationship between independent and dependent variables influencing the adoption of soil and water conservation practices. Detailed description on data requirements, methods of data collections and analyses are presented in each of the chapters hereafter as required.

CHAPTER FOUR

4. Adoption of SWC Practices Among Farm Wealth Groups and its Benefits towards Livelihoods System at Household level, in Tigray, Northern Ethiopia

4.1 Introduction

In Ethiopia, agriculture is the main source of livelihood, employment and foreign exchange earnings. It supports the livelihood of about 90% of the poor and generates 90% of the national export trade and greater than 40% of the Gross Domestic Product (Diao, 2010). Nevertheless, agricultural sector in Ethiopia is confronted with diverse environmental problems. Land degradation in the form of soil erosion causes severe damages to crop lands, particularly in the highlands. The steep slopes, erosive rains, improper use of land and water, rapid population growth and dependence on fragmented subsistence farming are major causes of land degradation (Gebreyesus and Kirubel, 2009). For example, the average annual rate of soil loss in Ethiopia is estimated to be 12 tons ha⁻¹ yr⁻¹, and as high as 300 tons ha⁻¹ yr⁻¹ on steep slope where vegetation cover is scant (USAID, 2000). In addition based on field measurements on 202 plots in 12 sites of Tigray highlands Desta *et al.*, (2005) have found a mean annual soil loss from crop land in the absence of soil and water conservation measures to be 57 tons ha⁻¹ yr⁻¹.

Woldeamlak and Sterk (2002) also reported soil loss rates to be in the range between 18-79 t ha⁻¹ yr⁻¹ on two micro-watersheds in northwestern highlands. All the studies conducted on soil erosion in Ethiopia, agree that the rate of soil erosion to be high and constitutes an important problem to agricultural production. Thus, the diverse impacts of soil erosion can be summed as reduction of plants rootable depth, removal of essential soil nutrients, and decreasing soil water holding capacity and, eventually, decline in agricultural production.

Despite the severity of the problem, it is only recently that land conservation has received political attention in the country. Recognizing that land degradation is a major environmental and socio-economic problem, the government of Ethiopia has introduced

several interventions since the 1960s. Extensive conservation projects have been carried out under the auspices of World food Program (Shiferaw and Holden, 1998). As a result, large areas have been covered with terraces, soil bunds, area closures and millions of trees have been planted (Berhanu, 2002). Nevertheless, achievements still fell far below expectations and the country still loses a huge amount of fertile topsoil, and the threat of land degradation is alarmingly broadening (Teklu and Gezahegn, 2003).

People and their access to assets are at the heart of livelihoods approaches. A critical issue in evaluating the impacts of soil and water conservation practices concerns not only the extent to which different forms of capital are enhanced but also whether there are trade-off between them (McDonald and Brown,2000) . Some studies (For example, FAO, 1986; Kerr, 1998; Shiferaw and Holden, 1998; Lapar and Pandey, 1999; Mbagalawewe and Folmer, 2000; Berhanu and Swinton, 2003; Pender and Berhanu, 2004; Holden *et al.*, 2005) indicated that level of income (on- and off-farm); access to low cost credit; labour availability; low discount rates (i.e. long policy-planning horizons); high levels of education; access to sound technical advice; and secure land tenure are positively associated with the adoption of soil and water conservation practices

Given the wide variation in assets held by rural households across most rural African communities (Jayne *et al.*, 2003), it is useful to develop criteria for categorizing households into groups with similar asset bases, welfare status and natural resource management objectives. The appropriateness of one criterion over another is debatable, while cost-effective means of capturing the livelihood strategies of the poor are required to good policy design (Ellis, 2000). Development agencies have tended to use agricultural resource endowments as a major criterion, but this has resulted in poor categorization as the relative importance of off-farm income activities continue to increase (Barrett *et al.*, 2001; Bryceson, 2002; Tittonell *et al.*, 2005). While a household's asset base substantially affects its capacity and willingness to invest in agricultural resources (Kristjanson *et al.*, 2005), households with similar resource endowments demand different technologies because of differences in preferences, objectives, constraints and incentives attached to certain livelihood activities (Barrett *et al.*, 2002; Place *et al.*, 2002).

Thus a range of observable on-farm and off-farm activities needs to be taken into account when categorizing households.

Previous studies show that various personal, economic, socio-institutional and bio-physical attributes have influential roles in farmers' decisions about the adoption of soil and water conservation practices in different areas of Ethiopia. However, studies adoption of soil and water conservation practices associated with farm wealth groups attributes at the local level are limited in the northern highlands of Ethiopia. Appropriate understanding of these factors in Tigray region would assist in the formulation and implementation of the policy interventions designed to induce voluntary and perpetual continued use of soil and water conservation practices.

In this study, farmers were classified into adopters and non-adopters depending on their adoption behavior of soil and water conservation practices. Adopters were those farmers who put into practice given conservation strategies introduced in their community and used them on a sustained basis or the implementation of new soil and water conservation practices. Non-adopters were those who chose not to put into practice most of the strategies. Therefore, this research was designed to look at the variation in the adoption of soil and water conservation practices among farm wealth groups and its benefits towards livelihood systems at household level. For the attainment of this objective data of the socio economic condition of the households, major physical factors that influence the adoption of soil and water conservation practices and benefits of soil and water conservation towards livelihood systems at household level have been collected and analyzed.

4.2 Materials and Methods

In addition to household survey, participatory transect walks with groups of selected farmers from different farm wealth groups and agricultural experts were conducted, in order to look at the variations in the adoption of soil and water conservation practices among farm wealth groups and its benefits towards livelihood systems at household level in Tigray Region. It is a useful technique to characterize and understand biophysical and major terrain features such as: topography, types of adopted soil and water conservation

practices, soil types, slope characteristics and soil depths. Careful observations and semi structured interviewing of villagers were performed during transect walks.

Sampling frame was prepared from the list of farm households of each Tabias. These lists were further stratified according to their wealth into rich, medium and poor farm wealth groups. Grouping was made according to the community's viewpoint, during a village farmers' assembly. This stratification was done, because of the influence of resource endowment on land management and adoption of SWC practices in study Tabias. The criteria used were herd size and the stock of grain for consumption, i.e., farmers in the 'rich' group possessed oxen ≥ 2 , cows ≥ 2 and had enough grain in stock to cover at least for one year consumption, in the 'medium' group farmers possessed < 2 oxen and < 2 cows, had a stock of grain only for one year and the 'poor' group owned one or no oxen, one or no cow and had insufficient grain in stock for consumption. The same procedure and farmers wealth classifications criteria have been used by Assefa (2005) in Tigray region.

The survey questionnaires comprised both closed and open ended types of questions and covered various issues. Data related to the contribution of soil and water conservation towards sustainable rural livelihoods, were collected in terms of livelihood activities such as farm, non-farm and off-farm engagements of each target. Based on multiple responses, household heads were required to classify their plots into flat (3-15%), middle (15-30%) or steep ($> 30\%$) slope categories as per their perceptions. In addition farmers also classified the soils by their types, fertility level and diversity in soil fertility management practices. They then ranked the soil types identified according to their fertility and potential productivity.

The study used descriptive statistics (averages, cross-tabulation, and percentages.). In inferential statistical analysis t-test, ANOVA and chi-square test were used. To this end, the study employed SPSS version 17 software (SPSS, 2010).

4.3 Results and discussions

This section presents and discusses socio economic condition of the households, factors which have a major influence on the adoption of soil and water conservation practices among farm wealth groups and finally, the benefits of soil and water conservation towards livelihoods system at household level.

Table 4-1: some statistical parameters of demographic, social and resource holding characteristics of the respondent

Variable	Adwa	Emba-Alajie	Significance	Total averages
Age (years) ^c				
Mean	47.54	43.1	0.01 ^a	45.35
SD	10.3	9.0		9.9
Sex (%) ^d				
Male	77.5	69.1		73.3
Female	22.5	30.9		26.7
Literacy (%) ^d				
Illiterate	36.4	49.7		43.0
Literate	63.6	50.3		57.0
Marital status (%) ^d				
married	86.1	75.2		80.7
unmarried	-	2.0		1.0
widowed	7.3	10.7		9.0
divorced	6.6	12.1		9.3
Household size ^c				
Mean	6.15	5.54	0.01 ^a	5.8
SD	1.63	1.73		1.70
Land holding (ha) ^c				
Mean	0.83	0.66	0.01 ^a	0.7
SD	0.47	0.29		0.40
Total livestock Unit ^c				
Mean	3.17	2.21	0.01 ^a	2.69
SD	1.93	2.54		2.30

Source: Survey data, 2012/13

^a at 1% level of significance SD= Standard Deviation

^c Continuous variable and use t-test ^d Categorical variables

4.3.1 Household and Farm Characteristics

The survey indicated that the age of respondents ranged from 23 to 73 years of age, with an average of 45 years (Table 4.1). The average age of respondents in Adwa and Emba-Alajie districts was 47.5 and 43.1 respectively. The t -test shows there is significant age difference between the two groups (Adwa and Emba-Alajie) at 1 % level of significance. Of the total respondents, 73.3 % were male headed where as 26.7% were female headed. It was found that 43% of the households in the study areas were illiterate. Very little difference was found in the number of household heads who attended informal education (literate) in the study areas.

The average household size of all respondents was 5.8 persons, while the Tigray Region average was 4 people per household, as reported in the 2007 population survey (CSA, 2007). This is by far greater than what has been reported for the Region. As shown in Table 4.1 the average household size of Adwa is 6.2 where as in Emba-Alajie it is only 5.5. Moreover, results of t -test shows that there is significant household size difference between the two districts at 1 % level of significance.

The average land holding size for both districts was 0.7 ha per household which is below the national average land holding of 1.0 hectare (FDRE, 2012). The one sample t-test, also indicated that ($t=-11.667, p=0.001$).

The average land owned per household in Adwa and Emba-Alajie are 0.83 and 0.66 ha respectively (Table 4.1). But the intra-group land size variation shows farmers in Mariam-shewito to have relatively larger land holding size than the farmers in the remaining Tabias. The variation is statistically significant at 1 percent level of significance indicating this variation could have influenced either positive or negative impacts for adoption of soil and water conservation practices in the area.

The average holding of livestock in the study districts vary between 3.17 TLU in Adwa to 2.21 TLU in Emba_Alajie (Table 4.1) .The total average was 2.69 TLU. The t-test also supports that the difference was significant at less than 1 percent level of significance. The research then seeks to examine whether TLU per household vary among the sample

study areas and household TLU has relationship with adoption of soil and water conservation practices.

Table 4-2: Adopter and non-adopters (% of respondents) and their response whether SWCp is risk involving investment or not by farm groups

Farm groups	Number and % of respondents		% SWC practices as risky input			
	adopter	Non-adopter	Adopter		Non-adopter	
			Yes	No	Yes	No
Rich	50 70.4%	21 29.6%	18.0	82.0	28.6	71.4
Medium	103 86.6%	16 13.4%	21.4	78.6	6.3	93.8
Poor	55 50.0%	55 50.0%	25.5	74.5	27.3	72.7
Averages	208 69.3%	92 30.7%	21.6	78.4	23.9	76.1

Source: Survey data, 2012/13

Survey results and field observations indicated that a considerable proportion of adoption of soil and water conservation among farm wealth groups in study areas. Out of the 300 household's heads, about 69.3% have adopted soil and water conservation practices on their farms (Table 4.2). There is a difference among the three farm wealth groups in adoptions of soil and water conservation practices. Moreover, chi-square test indicated significant positive or negative relationship between adoptions of soil and water conservation practices and farm wealth groups ($X^2=35.976$, $df = 2$, $p = 0.001$). This implies that farm wealth groups do influence adoption of soil and water conservation practices.

Table 4.2 reveals that soil and water conservation practices are risky inputs for both adopters and non adopters of farm wealth groups. Farm wealth groups were asked, if they had risky input for soil and water conservation practices .Accordingly, 78.4% of the total respondents from adopters replied "No". Of which, 82.0%,78.6% and 74.5% of them were rich, medium and poor farm wealth groups respectively while ,non-adopters replied "No"76.1%, from the total respondents of non adopter, 93.8% for medium and 72.7% for

poor farm wealth groups. The Table 4.2 shows that risky is relatively lower for rich and higher for poor farm wealth groups. The interpretation is that better farm wealth groups may have less risky invest in soil and water conservation practices when compared with poor farm wealth groups.

Table 4-3: Slope and soil fertility of farm fields of the surveyed households: % of the respondent

Slope and Plot fertility	Farm wealth groups					
	Rich		Medium		Poor	
	Adopter	Non adopter	Adopter	Non adopter	Adopter	Non adopter
Slope (% of Cases)						
Flat (3-15%)	79.2	41.7	93.3	13.3	63.2	73.7
Middle slope (15-30%)	88.9	29.6	94.0	18.0	70.6	64.7
Steep slope (>30%)	77.8	33.3	93.3	6.7	87.5	62.5
Plot fertility(% of Cases)						
Most fertile (Reguid)	88.9	27.8	85.7	28.6	70.0	55.0
Moderately fertile (Mehakelay)	86.5	35.1	93.8	14.8	62.7	64.4
Least fertile (Rekik)	66.7	100.0	92.9	14.3	44.4	66.7

Source: Survey data, 2012/13

Note: Total over 100% is due to multiple responses

Physical characteristics of plots such as slope and soil fertility status are the most crucial factors that influence sustainable adoption of soil and water conservation practices. Table 4.3 presents the most important plot level characteristics perceived by the farm wealth groups in the study areas. Thus, household heads were asked to categorize the slopes of their plots as steep, middle, and flat slopes. Results indicated that a large section of their land (94.0%) was categorized as middle slope and in medium farm wealth groups and 93.3% of medium farm wealth groups are flat slope and steep respectively. Accordingly, majority of their land was categorized as flat and moderately sloped, but the percentages of flat and middle sloped plots were higher in adopters than non-adopters of soil and water conservation practices in three farm wealth groups, whereas the poor farm wealth groups, the percentages of flat sloped plots were slightly higher in non-adopters than adopters of soil and water conservation practices.

Similarly, household's heads were asked to categorize their plots based on fertility level into three: most fertile (Reguid) , moderately fertile (Mehakelay) , and least fertile (Rekik) . Accordingly, 88.9% of the total farm households categorized their plots from rich farm wealth groups as most fertile (Reguid), and 93.8% of which were from the medium farm wealth groups as moderately fertile (Mehakelay), majority of their land was categorized as moderately fertile and most fertile, but the percentages of moderately fertile and most fertile plots were higher in adopters than non-adopters of soil and water conservation practices in rich and medium farm wealth groups. It implies plots fertility is inversely related with wealth status of different farm wealth groups' holding other factors constant.

Table 4-4: Household features and socio economic characteristics in relation to farm wealth groups

Farm groups	sam ple size (n)	Age and sex of head of the household			Househ old size (no) ^a	Literacy level of the household ^b		Distanc e to the plot ^a	Years on farm ^a	Tenure security (%) ^b		Average annual income per household			Access to credit (%) ^b				
		Age ^a mean and SD	Sex ^b			mean and SD	Illite rate			Literat e	mean and SD	mean and SD			Farm income(in Birr)	Off- farm(in Birr)	Total (in Birr)		
			Male	Female															
Rich	71	46.27 (11.1)	57 (80.3)	14 (19.7)	5.9 (1.8)	26 (36.6)	45 (63.4)	32.9 (30.9)	19.5 (8.1)	yes	83.1	45139	6241	51380	yes	80.3			
										No	16.9				No	19.7			
Medium	119	46.74 (9.7)	95 (79.8)	24 (20.2)	6.1 (1.7)	46 (38. 7)	73 (61.3)	31.5 (24.6)	19.6 (7.6)	yes	84.9	31256	4624	35880	yes	70.9			
										No	15.1				No	29.1			
Poor	110	43.25 (9.2)	68 (61.8)	42 (38.2)	5.5 (1.6)	57 (51.8)	53 (48.2)	33.8 (22.1)	18.2 (8.5)	yes	82.7	20747	3306	24053	yes	66.4			
										No	17.3				No	33.6			
Total	300	45.35 (9.9) ^c	220 (73.3)	80 (26.7) ^c	5.8 (1.7) ^c	129 (43. 0)	171 (57.0) ^d	32.7 (25.3)	19.1 (8.0)	Yes No	83.6 16.4	30688	4423	35111	Yes No	71.3 28.7			

Source: Survey data, 2012/13

n = number of respondents

SD= Standard Deviation

^a Continuous variable and one-way ANOVA

^b categorical variables and use χ^2 test

^c at 5% and ^d at 10% level of significance

4.3.2 Socio Economic Conditions Of Farm Groups

Age household head was one of the demographic characteristics hypothesized to influence the decisions of farmers on the soil and water conservation practices. The survey result indicated that the average age of three farm wealth groups of the households was 45.4 years. One-way ANOVA confirms that there is variation in the average age among the three farm wealth groups: i.e. rich, medium and poor of households ($F_{2,297}=4.007$, $P=0.019$). This indicates that there is a significant difference between the three farm wealth groups. However, it does not necessarily imply that all the means are significantly different from each other. Accordingly, none of the three farm wealth groups differed from one another when Scheffe's range test was made for the multiple comparisons in ANOVA.

Survey results indicate that 26.7 % of the household heads are female. These female headed households are either widowed or divorced. The poor farm households has 61.8 % of males household was greater than the number of females household (38.2%), whereas in the rich farm groups has a greater variation between the male (80.3%) and female household (19.7%). The survey result showed that there is a significant difference in sex of the farm households between the farm wealth groups at 5% level of significance.

The average household size was 5.8 persons for the whole farm wealth groups. As shown in Table 4.4 the average household size for the rich, medium and poor farm wealth groups are 5.9, 6.1, and 5.5 respectively. The maximum average household size is found in medium farm wealth groups (6.1) and the lowest is in poor farm wealth groups (5.5). And the difference is significant at 5 % level in terms of farm wealth groups ($F_{2,297}=3.886$, $p=0.022$). This means that household size may be important in influencing adoption decision in the area.

Low level of literacy and high illiteracy rate is typical in developing countries like Ethiopia. In the study area, the literacy status of farm wealth groups was categorized into illiterate and literate. As shown in Table 4.4, among the 300 farm wealth groups, 57% were literate. Some of the farmers participated in the literacy campaign launched by the

ex-government during the 1980s. Some farmers also attended traditional religious education. Level of literacy was hypothesized to be related with adoption of soil and water conservation practices, because literate farmers are in a better position to get information and use it in such a way that it contributes to their farming practices.

When we look at variations across groups, 51.8% of the poor farm groups were illiterate, which is higher than that of the medium farm groups (38.7%) and the rich farm household (36.6%). The survey result shows that variation statistically significant at less than 1 percent level. Thus, education could have contribution for soil and water conservation adoption in the area.

In addition, tenure security was examined whether it influences adoption or not. As shown in Table 4.4 about 83.6 % of the three farms wealth groups feel secure with the current land tenure system. The most important reason given in support of the existing tenure certification arrangement seems to be related to the users right granted to farmers' landholding security. Justification given by the farm wealth groups stated that land certification increased the probability of getting compensation in case of land takings and they do not have fear of losing their plots.

Moreover, income of households was assessed in the three farm wealth groups. Using an exchange rate of one U.S. dollar (USD) as 18 Ethiopian birr at the time of the study, the approximate average annual income (exclusive of credit) for all households surveyed was 35111Birr or about 1,950 USD per farm wealth groups. Results indicate that, there is significant variation in income among the three farm wealth groups. The average annual income of rich, medium and poor farm wealth groups are 51380, 35880 and 24053 respectively. Average on-farm and off-farm income were approximately 30688 Birr (1704 USD) and 4423 Birr (245.7 USD) per annum respectively. Majority of the poor farm households involved in off farm income mainly either food for work or daily labour, whereas the medium and the wealthier farm households are involved in trading.

The average farm income (estimated at market price) of sample households was 30688 Birr; there is also significant variation in income among the three farm wealth groups. The mean farm income of poor, medium and rich farm households is Birr 20747, 31256

and 45139 respectively (Table4.4). The farm income of the rich farm group is almost double to that of poor farm groups. Two possible reasons for this variation, as expected, could be due to either the relatively larger farm size or increased production and productivity of agriculture due to adoption of soil and water conservation. This clearly implies farm income is low and the farmers cannot rely on agriculture. The low annual farm income has probably forced some of sample households to engage in off-farm activities. Household's survival depends on the ability to generate off-farm income so as to smooth their consumption as means of risk management.

Credit as one component of adoption was examined in this study. Table 4.4 shows that the conditions of credit access to the three farm wealth groups. Farm wealth groups were asked, if they had taken credit from formal institutions in the 20012/13 cropping season. Accordingly, 71.3 % of the total respondents replied "yes". Of which, 66.4%, 70.9%, and 80% were poor, medium, and rich farm wealth groups respectively. From Table 4.4 it appears that the characteristics wealth and income from off-farm labour form the main distinctions among the households in the three farm wealth groups. The rich farm wealth groups needs better access to credit when compared with the medium and poor farm wealth groups. Hence, wealth goes together with formal credit related activities. It appears that wealthier farm groups have better relations with credit institutions; presumably due to the fact that this wealth ensures repayment (assets and livestock are often used as collateral by credit institutions).

The stipulation of interpreting this result is that farmers who did not take credit may not necessarily mean they had no access to it. This means that use of credit may not clearly distinguish between farmers who chose not to use available credit and farmers who did not have access to credit. For instance, farmers may not take credit if it is not affordable, or if they perceived it is associated with some risks, though there is access (availability). This means rationale farmers will use credit if it is profitable. Profitability in turn depends on the cost of credit and the potential returns on investment. Moreover, particularly for those poor farm wealth groups', decision for adoption of soil and water conservation practices are hardly influenced by accessibility to credit facilities, as is not used for long-term soil and water conservation investments.

Table 4-5: soil and water conservation practice (SWCp) adoption by farm groups

Farm groups	Farm size HHH ⁻¹ (ha)	Adopted types of SWCP and % of responses				
		Soil bund	Stone bund	Both soil and stone bund	Agro - forestry	Cut off drain
Rich N=50	.7962	94.9	15.4	10.3	2.6	2.6
Medium N=103	.7856	83.1	30.5	16.9	5.1	3.4
Poor N=55	.7037	87.1	32.3	22.6	3.2	9.7

Source: Survey data, 2012/13

Note: Total over 100% is due to multiple responses and N refers to frequency

4.3.3 Adoption of soil and water conservation practices (SWCPs)

The effects of size of plot was not significant over all ($F_{2, 205}=.891$, $p=0.412$). The average of the rich, medium and the poor farm wealth groups were 0.7962 ha, 0.7856 ha and 0.737 ha respectively.

Generally, the three farm groups have different adoption rates. In addition, there was a difference in the adoption practices among the three farm wealth groups. For example, relatively large sections of the rich and the medium farm wealth groups have implemented soil bund (94.9% and 83.1%) respectively, whereas the poor farm group has 87.1%. However, in case of adopted different types of SWC practices, the poor (stone bund 32% and both soil and stone bund 22%) and medium (stone bund 30.5% and both soil and stone bund 16%) farm wealth groups have better practices than the rich do (stone bund 15.4% and both soil and stone bund 10.3%) farm wealth groups.

The general trends of soil and water conservation practices adoption as delineated by farm wealth groups are presented in Table 4.5. Almost seventy percent of respondents had been implemented some form of soil and water conservation practices on their farms; on average adopted types of soil and water conservation practices implemented were

dominated by soil bund, stone bund, and both soil and stone bund within three farm wealth groups. Respondents' awareness of the different types of soil and water conservation practices was generally good; all but two practices i.e (soil and stone bund) were known to more than 80 percent of respondents and which were confirmed by observations also.

Table 4-6: Soil Fertility Improvement Practices Among Farm Groups in the study Area

Farm groups	Average farm size		Average fertilizer application (kg/ha)		Average manure application (tone/ha)	
	Adopter	Non adopter	Adopter	Non adopter	Adopter	Non adopter
Rich	0.79	0.93	130.00	116.47	1.49	1.71
Medium	0.78	0.66	111.02	90.62	1.23	1.51
Poor	0.70	0.63	81.58	96.89	0.87	0.79
mean	0.76	0.70	107.80	100.27	1.20	1.12
F-value	0.891	4.992	9.716	0.798	10.549	19.859
P-value	0.412	0.009	0.001	0.453	0.001	0.001

Source: Survey data, 2012/13

In spite of the efforts made by the regional government to expand fertilizer use among rural households, its use is at its lower level in terms of adoption coverage and intensity of use (Teame, 2011). Table 4.6 shows that the average application of chemical fertilizers by the rich, medium and poor farm wealth groups was 130 Kg/ha, 111 kg/ha and 81 Kg/ha, respectively from adopters. Similarly, the application of natural fertilizer (manure) tone per hectare during the specified year was not greater than 1.49, 1.23 and 0.87 for the rich, medium and poor farm groups respectively again for adopters .

The mean values of inorganic fertilizers and organic fertilizers (manure) input by different resource endowed farm wealth groups both adopters and non-adopters were compared. Results show statistically significant differences between rich, medium and poor farm wealth groups for inorganic fertilizers and organic fertilizers application. A one way unrelated analysis of variance showed an overall significant effect for applying inorganic fertilizers by adopters ($F_{2,205}=9.716$ $p=0.001$) among farm wealth groups. Scheffe's range test found that the poor farm group differed from the medium farm group

($p=0.010$) and the rich farm groups ($p=0.001$) but no other significant differences were found. The mean fertilizer application of non-adopters by the rich, medium and poor farm groups were 116, 90 and 96 respectively. Moreover, the mean value of the application of manure among the three farm groups by adopters was ($F_{2, 205}=10.54$ $p=0.001$). Scheffe's range test found that the rich farm groups differed from the medium farm group ($p=0.008$) and the poor farm groups ($p=0.001$), the medium farm groups also differed from the rich farm groups ($p=0.018$) and the poor farm groups and the poor also differed from the rich ($p=0.001$) and the medium ($p=0.001$). Similarly, there was also a variation in the three farm wealth groups of non-adopters in application of manure. The mean application of manure for non-adopters was 1.71, 1.51 and 0.79 for rich, medium and poor respectively. Scheffe's range test also found that the poor farm group differed from the medium farm group ($p=0.001$) and the rich farm groups ($p=0.001$) but no other significant differences were found.

Resource-rich households applied significantly higher quantity of inorganic and organic fertilizer when compared to the medium and poor farm groups of both study sites. It was also found that there was a significant difference in the mean values of household manure application across the different farm wealth groups for both adopters and non adopters.

All farm wealth groups are aware of soil fertility management techniques coming from outside or developed within the community. However, they are often unable to translate those in to action, mainly due to insufficient resources and thus remain victims of soil nutrient depletion. Particularly, manures tend to be used only by a few rich farmers, who apply it to small areas around the homestead, mainly due to dung being often used as fuel, relatively small number of livestock per households, and expensive and labour intensive transport of manure.

There were many reasons given by respondents for using or not using manure on their farm fields. Of the total respondents indicating that they have implemented manure management on their farms (with a minimum 0.10 tone/ha, a maximum 4 tone/ha with an averages of 1.18 tone/ha), the majority of the respondents referred to increasing or improving soil fertility as their primary purpose, while some of them adopting this soil and water conservation practices indicated that restoration or enrichment of the soils was

their main objective. Adding manure to improve or increase fertility implies that farmer is supplementing existing condition only with the intension of changing an outcome (increased yield, food production and income) in this case, stewardship of the land not implied.

Table 4-7: Farm Wealth Groups Benefit Ratings on some Indicators of Soil and Water Conservation Practices

Indicators	Farm wealth groups ratings on the benefits of soil and water conservation practices:% of respondents						
		Rich		Medium		Poor	
	Ratings	Adopters	Non – adopters	Adopters	Non – adopters	Adopters	Non – adopters
Land fertility	Increased	68.0	61.9	61.2	50.0	56.4	54.5
	No change	30.0	28.6	34.0	43.8	34.5	41.8
	Decreased	2.0	9.5	4.9	6.3	9.1	3.6
Crop production/yield	Increased	98.0	95.2	98.1	93.8	96.4	96.4
	No change	2.0	4.8	1.0	6.3	3.6	3.6
	Decreased	-	-	1.0	-	-	-
Soil erosion	Increased	26.0	19.0	11.7	12.5	10.9	3.6
	No change	2.0	-	12.6	25.0	29.1	29.1
	Decreased	72.0	81.0	75.7	62.5	60.0	67.3
Flooding	Increased	4.0	-	-	-	-	-
	No change	10.0	-	9.7	12.5	12.7	18.2
	Decreased	86.0	100.0	90.3	87.5	87.3	81.8
Fodder and grass supply	Increased	56.0	66.7	55.3	75.0	56.4	45.5
	No change	22.0	19.0	21.4	18.8	21.8	21.8
	Decreased	22.0	14.3	23.3	6.3	21.8	32.7

Source: Survey data, 2012/13

Five concrete expectations are mentioned: increase the soil fertility, increase crop production/yield; prevent erosion; increase fodder and grass supply; and decrease flooding (see Table 4.7) among farm wealth groups.

The advantage most often mentioned are increase soil fertility; increase crop production/yield; erosion decrease; increase fodder and grass supply; and decrease flooding. The advantage, soil fertility was mentioned by farmers of every farm wealth groups, however there a difference in the ratings of the percentage that “replied” increased soil fertility among farm wealth groups: i.e. 68%, 61% and 56.4% of rich, medium and poor farm wealth groups respectively. Further, the soil fertility and the crop production/yield

are connected directly; this can be state that after making the soil more fertile, the harvest will increase. So may be in a few years even more farmers would say that the harvest increased through the soil and water conservation practices since its implementation. The soil erosion decrease is the also another advantage mentioned by all farmers regardless of farm wealth groups. We can assume that the soil and water conservation practices were successful. The increase fodder and grass supply products were also mentioned by all farmers of farm wealth groups and the rest of the advantages were named by all farmers of farm wealth groups was reducing the risk of flood, The possible explanation is that soil and water conservation practices are successful regardless of adopter and non-adopter and farm wealth groups and are valued as positive by all the farm wealth groups.

The most frequently quoted reason of adoption is to reduce soil erosion. In fact, this is the most mentioned reason of adopting of soil and water conservation practices at all levels of adoption but most especially on farmers with high intensity of adoption compared to non adoption. The next cited reason is to improve the soil fertility which was also mentioned mostly by adopters of soil and water conservation practices and non adopters. Some adopters have believing that it will improve the soil moisture of their farms plots. Others were influenced by increased both yield and soil fertility.

The reasons behind the adoption of soil and water conservation were similar with the mentioned expectations of adoption. Still, reduced soil erosion and improvement of soil fertility were the two major expectations adopting of soil and water conservation. Reduced erosion is the most frequently cited expectation of high adopters and non adopters. On the other hand, adopters with expected more on the improvement in crop productivity as well as those farmers with high adoption. On the other hand, adopters expected that adoption of soil and water conservation practices could help their farms to generate more variation or sources of livelihood. It was observed that most of the expectations mentioned can only be acquired within a long-term period of time such as prospects related to developing to bench terrace, soil fertility improvement, soil loss reduction and increase yield. Immediate benefits were not expected that much from the soil and water conservation practices. Farmers' expectations of long-term benefits perhaps have motivated them to try and continuously adopt the soil and water

conservation. The results also indicate that high adopters have higher expectations or mentioned more expectations compared with non-adopters of soil and water conservation practices.

Majority of the adopters claims that the soil and water conservation has no damaging effect to their cultivated farms. All of the high adopters clearly stated this. Perhaps this served as one of their motivation to continuously adopt the soil and water conservation practice at high intensity. Only a few farmers mentioned some negative effects of adopting of soil and water conservation practice.

Nevertheless, despite the problems experienced by local farmers, most were encouraged to apply soil and water conservation practices on their farms. Yet for them, the gains are far more worthy than the undesirable characteristics of the soil and water conservation.

The fact that only few farmers named a disadvantage of the soil and water conservation practices leads us to the conclusion that the farmers are satisfied with the use of the soil and water conservation practices and see them positively as also concluded before. Still most of the adopters maintained their adoption of soil and water conservation practices since its establishment. However, both the adopters and non-adopter mentioned that soil and water conservation practices have a negative impact on their farms for various reasons. The top three cited reasons for negative impact in their farms. This was mainly due to problem on time, money intensive and labor for its maintenance. Almost half of all the farm wealth groups cited that the regular maintenance of soil and water conservation is problematic, as they only have limited time and labour to do such work. Thus, they stopped applying soil and water conservation practices at some portions and only kept a portion they could maintain and few farmers removed some soil and water conservation structures for easy operation of his tractor during land preparation. Finally, few farmers had totally had a negative perception because the structures of soil and water conservation are source of rodents for both adopters and non-adopters. Due to the very small number of answers, general statements cannot be made.

Table 4-8: Dominant livelihoods activities and contribution to total income

Dominant source of livelihoods		Number	% of households	Mean Annual Income in Birr/year		
				Farm- income	Off- farm	Annual income (in Birr
Sales of crop production	Adopter	79	38	30367	3390	33757
	Non adopter	35	38	26637	4351	30988
	Total	114	38	29221	3765	32986
Livestock keeping	Adopter	11	5.3	33654	7467	41121
	Non adopter	12	13	31381	5422	36803
	Total	23	7.7	32468	5933	38401
Off farm income	Adopter	29	13.9	28401	3685	32086
	Non adopter	12	13	27435	3355	30790
	Total	41	13.7	28118	3563	31681
Income from migration	Adopter	10	4.8	40856	4551	45407
	Non adopter	4	4.3	32973	3350	36323
	Total	14	4.7	38603	4332	42935
Others (agriculture)	Adopter	20	9.6	30993	4674	35667
	Non adopter	6	6.5	25819	4775	30594
	Total	26	8.7	29799	4700	34499
Both sales of crop production and livestock keeping	Adopter	59	28.4	34260	6453	40713
	Non adopter	23	25	27788	3699	31487
	Total	82	27.3	32444	5438	37882

Source: Survey data, 2012/13

4.3.4 Major Livelihood activities and its Contribution

The dominant source livelihood activity was performed using variables representing the percentage contribution to total income coming from crops, off-farm sources, income from migration and both sales of crop production and livestock keeping. Five dominant source of livelihood activities were identified (Table 4.8).

The first livelihood activities can be described as ‘specialization as sales of crop production one hundred fourteen or 38% of the households fall in this category, out of this 79 or 38% of the households are adopters, while 35(38%) are non-adopters of soil and water conservation practices . The mean farm income of adopters and non-adopters

are 30367 Birr and 26637 Birr respectively and the mean off-farm income of adopter and non-adopter are 3390 Birr and 4351 Birr respectively. On the average, their annual income in Birr per year is 32986 birr. The second livelihood activities can be described as 'specialization as traditional livestock keeping. Twenty three or 7.7% of the households fall in this category. On the average, their annual income is 38401 Birr per year. When we look the variation between the two groups, the mean farm income and off-farm income by the adopters was 33654 and 7467 Birr respectively. The mean farm income and off-farm for non adopters was 31381 and 5422 Birr. The intra-group both farm and off- farm income variation shows adopters had relatively better income than non-adopters of soil and water conservation practices in this category. The third is made up of households with off-farm activities. Forty one or 13.7% of the households belong to this cluster. On average annual income is 31681 birr per year. The main sources of off-farm income are food for work activities and causal labour.

The fourth can be grouped as incomes from migration. Only fourteen or 4.7% of the households they earn from local migration, particularly this group belongs to the district of Adwa, they migrated to the western parts of Tigray (Humera). On averages, their annual income is 42935 birr. The mean farm income and off-farm for adopters were better than non- adopters of soil and water conservation practices. The main source of income is trade and labour as well. While, in Emba-Alajie the poor depend on labour migration to Raya and Humera for harvesting season and sesame weeding from August to October. The fifth livelihood activity represents specialization in both sales of crop and livestock production keeping. Eight two or 27.3% of the households belong to this cluster. On average, their annual income is 37882 Birr. They derive dominantly income from stable and followed by traditional livestock keeping.

In this research, the researcher identified the dominant livelihood activities being pursued in the study area, based up on the relative contributions to overall income coming from cropping, livestock, off-farm activities, migration and both crops and livestock. The finding shows five main dominant sources of livelihoods with a small variation in their mean annual income of both farm and Off-farm incomes of adopters and non-adopters of soil and water conservation practices. The highest mean annual income (42935 Birr per

year) were earned by households with a member a steady income from migration or a formal business. As shown in Table 4.8 the mean annual income of adopters was 33757 Birr, which is higher than that of non-adopters (30988 Birr). Next were households that were diversified in to livestock keeping, earning on averages 38401 Birr per year. These were followed by households largely dependent on both crops and livestock keeping, earnings 37882 Birr per year, sales of crop production (32986 Birr per year and households obtaining most of their incomes from less steady, casual off-farm sources (31681 Birr per year). This last, lower mean annual income category, also contained 13.7% of the households. This results supports a trend reported by other authors who found, that a substantial number of households in the study area participates in food-for-work (FFW) activities which involve labour contribution to public works such as road construction or maintenance, soil and water conservation activities, and forest rehabilitation and receiving food in return for their labour services (Berhanu and Swinton, 2003; Hagos *et al.*, 2006).

More than half of the surveyed households (65.3%) fall in to the two categories that are heavily dependent on both sales of crop and traditional livestock keeping income generating activities that is the first and fifth categories (Table 4.8). This clearly implies that although the dominant source of livelihoods of the farm wealth groups are from sales of crops however, the highest mean annual income is derived out of agriculture. These different activities may have a negative effect on soil and water conservation adoption by reducing labour availability. On the other hand, off-farm activities also can be a source of income to invest in farming, soil and water conservation practices.

There is variation in income of the two groups. Both mean annual farm and off-farm income of adopters were more than to that of non-adopters of soil and water conservation in all dominant source of livelihoods. Two possible reasons for this variation, could be due to either the relatively larger farm size adopters possess (Table 4.6) or increased production and productivity of agriculture due to adoption of soil and water conservation practices. Moreover, off-farm income of both non-adopters and adopters is smaller than their respective farm income. This clearly implies off-farm is low (most of them engage as a daily labourers and in safety net program) and the farmers dominantly rely on

agriculture as means of their livelihood. However, the low annual farm income has forced some of the households to engage in off-farm activities.

There are two major reasons were identified as reasons for the engagement of off-farm activities for the result. Firstly, in the study areas, some of households which are food unsecured and as the same time old aged are included in safety net a program, which was considered as major source of off-farm income in the area. Secondly, another strategic reason to rely on off-farm activities is some of farm households have never become food secured every year even at times of good reason this is due to small land size and fragmented plots of land. The implication is that farmers are discouraged to rely on farming, which in turn may result farmer's to under invest in soil and water conservation practices on their farmlands.

4.3.5 Implications of Livelihood Strategies for adoption of soil and water conservation practices

The research then seeks to examine whether different livelihood strategies correspond to the use of adoption of different types of soil and water conservation practices, as different crop, animal and off-farm activities can be managed with differing degrees of intensification, and this research are not sure whether engagement in off-farm activities will encourage or constrain in adoption of soil and water conservation practices.

These livelihood diversification strategies in turn affect decisions by households regarding adoption of soil and water conservation practices. While Morera and Gladwin (2006) found in their studies of Honduras hillside communities that off-farm income activities actually discouraged households from undertaking soil and water conservation practices, in this study the result was opposite, as differentiated the highest 38% and smallest 4.7% of dominant source of livelihoods activities are from sales of crop production and migration respectively. However, the maximum mean annual income comes from migration which is out of agriculture and the minimum mean annual income from off-farm income categories. In this study, households whether diversified their strategies out of agriculture in all dominant sources of livelihoods, adopters of soil and water conservation practices have relatively better income than non-adopters do. It can be

concluded that farm households who have employed locally in off-farm activities can also invest in the adoption of soil and water conservation practices as they have a regular source of income and an understanding of the problems.

4.4 Conclusions

It is frequently argued that various personal, economic, socio-institutional and bio-physical attributes have influential roles in farmers' decisions about the adoption of soil and water conservation practices in different areas of Ethiopia. However, in Ethiopia empirical evidence for adoption of soil and water conservation practices among farm wealth groups and its benefits to livelihoods is limited. Most of the studies conducted in this country did not explicitly address this issue. Thus, this study was conducted to examine the variation in the adoption of soil and water conservation practices among farm wealth groups and its benefits to livelihoods system at household level in Tigray Region. To this end an empirical analysis was done using descriptive in comparative fashion between the three farm wealth groups.

From this analysis the variables age, household size, and literacy status of the household head have variations between the three farm wealth groups, and were significantly different. Tenure security and credit access were also found to be an important as an explanation for the positive answer shown by most of the farmers regardless of the three farm wealth groups.

Although a large section of the farmers were adopters of soil and water conservation practices among farm wealth groups in their farms, a meaningful section of farmers on the other hand were non-adopters. There was such a difference among three farm wealth groups in adoption of soil and water conservation practices. This implies that farm wealth groups do influence adoption of soil and water conservation practices. Furthermore, adopting soil and water conservation practices as risky was relatively lower for rich and higher for poor farm wealth groups. The interpretation was that better farm wealth groups may have less risky invest in soil and water conservation practices when compared with poor farm wealth groups.

Overall, for total adopted types of soil and water conservation practices, among the farm wealth group, the rich farm wealth groups has a better practices particularly in soil bound than the medium and poor farm wealth groups. Moreover, the rich farm wealth groups applied significantly higher quantity of inorganic fertilizer when compared to the medium and poor farm groups of both study sites. It was also found that there was a significant difference in the mean values of household manure application across the different farm wealth groups.

Adoption of soil and water conservation practices is perceived and valued as positive by all the farmers regardless of wealth differences. The farmers point out a lot more advantages than disadvantages of the adoption of soil and water conservation practices. The most important advantages of adopting soil and water conservation practices were soil fertility increase; increase crop production/yield; erosion decrease; increase fodder and grass supply; and decrease flooding. According to the farmers the most limiting factor in terms of adopting soil and water conservation practices are time and money and labour intensive.

The finding shows five main dominant sources of livelihoods with a small variation in their mean annual income of both farm and Off-farm incomes of adopters and non-adopters of soil and water conservation practices. The highest mean annual incomes were earned by households with a member a steady income from migration or a formal business. Next were households that were diversified in to livestock keeping, these were followed by households largely dependent on crops and livestock keeping, sales of crop production and off-farm sources. This last, lower mean annual income category of the households.

This clearly implies that although the dominant source of livelihoods of the farm wealth groups are from sales of crops however, the highest mean annual income is derived out of agriculture. There is variation in income of the two groups. Both mean annual farm and off-farm income of adopters were more than to that of non-adopters of soil and water conservation in all dominant sources of livelihoods. Moreover, off-farm income of both adopters and non-adopters is smaller than their respective farm income. This clearly infer off-farm income is low (most of them engage as a daily labourers and in safety net

program) and the farmers dominantly rely on agriculture as means of their livelihood. However, the low annual farm income has forced some of the households to engage in off-farm activities is due to small land size and fragmented plots of land. The implication is that farmers are discouraged to rely on farming, which in turn may result farmer's to under invest in soil and water conservation practices on their farmlands.

As land degradation is severe in the highlands of Ethiopia, applications of soil and water conservation practices are a must. As a result, there are many efforts made by the government for rehabilitations of natural resources in particular of soil and water conservation practices, such as experience sharing of farmer's field based, giving of workshops for farmers, and agricultural days. However, household endowments or farm wealth differences significantly influence farmers' decisions on adoption of soil and water conservation practices. Therefore, to promote conservation efforts, policies should identify social and economic factors with respect to soil and water conservation and integrate them into the plans, according to the results of the analyses the most important are resources availability and household characteristics. Moreover, conservation should therefore be linked to subsidies if possible and credit facilities for those poor farm wealth groups for long duration period of time because the application of fertilizers in combination with this adoption of soil and water conservation practices is highly important to recover the nutrient balance of the soil.

Any effort to achieve sustainable adoption of soil and water conservation practice should enhance both farm and off-farm income in a way that reinforce each other. The study reveals that when considering promoting modern adoption of soil and water conservation practices, it is important to assess the wealth distribution of households and its implications for risk preferences to the use of soil and water conservation practices. Moreover, soil and water conservation practices should not only be aimed at minimizing soil erosion but should also cover other household objectives, such as the improvement of soil fertility, yield increase and fodder for animals.

CHAPTER FIVE

5. Effect of Slope Gradient on Adoption Of Soil and Water Conservation Practices and Soil Fertility Management

5.1 Introduction

Spatial gradients in the adoption of soil and water conservation practices and soil fertility management refers to variations of soil and water conservation practices and soil fertility management with respect to (i) distances from homesteads, (ii) slopes gradient, and (iii) altitudes. However, in this study only slope gradient and distance from homesteads are considered. Another variable used was household's farm size which refers to the total land holding of a household.

Due to their important altitudinal gradients of mountain regions receive much attention (Becker and Bugmann, 2001). Mountain agriculture systems with steeper slopes gradients are vulnerable to environmental changes for various reasons, such as the cost of accessibility and infrastructure as well as limited opportunity for production gains associated with scale of operation (Becker and Bugmann, 2001). Besides, in most tropical mountains, there are high population densities that lead to acute resource computations. For example, in East Africa and Central America, there are far more than 100 inhabitants'/ km² in all areas with elevation over 2500 m a.s.l (Dixon *et al.*, 2001). Short-term increase in agricultural production is often obtained through increased pressure on the land, i.e. reduced fallowing, removal of vegetation on cropland, conversion of forest and woodlands on steep slopes into rangeland and marginal arable land (Nyssen *et al.*, 2009).

According to Oldeman *et al.* (1991) more than 50% of the northern Ethiopian highlands, for instance, suffer from extreme loss of topsoil due to sheet and rill erosion. It is a common problem in nearly all tropical mountains.

By recognizing the seriousness of the problem of loss of natural resources due to slope in many tropical mountains, huge efforts are undertaken to rehabilitate the land. However, such studies have demonstrated that investments in tropical mountains do pay off in

economic terms (Boyd *et al.*, 2000; Holden *et al.*, 2005). There are conflicting reports that show relations between farm size and conservation efforts. At some instances larger land holdings have been reported to be suitable for soil and water conservation practices and ploughing and hence have positive relationships with soil and water conservation practices and fertilizer application (Holden and Hailu, 2002; Mahmud, 2004; Aklilu, 2006; Maiangwa *et al.*, 2007). On the other hand, other studies indicate that larger land holdings may reduce the need to conserve land indicating negative relationships between farm size and conservation efforts (Croppenstedt *et al.*, 2003; Pender and Berhanu, 2004). This suggests that a closer local level study is required to address the problem.

In addition, farmers residing closer to their cultivated lands likely to invest more soil conservation measures than those further away. This shows that land located closer to residences receive more attention and supervision (Berhanu and Swinton, 2003; Wagayehu and Lars, 2003). Moreover, farmers want to invest more in fields that require minimum efforts (Kessler, 2006). As explained earlier distance of farm plot from homestead is expected to detract investments in conservations due to increased transaction costs (Berhanu and Swinton, 2003; Wagayehu, 2003). Same study found significant and negative correlation between no conservation decisions and distances of a parcel from the residence but positive correlation between distance of the plot and adopting conservation decision. Kessler (2006) also observed that farmers invest more on soil and water conservation in fields situated near to residences. However, this does not hold true for all kinds of soil and water conservation practices. For instance, Chilot (2007) found a positive relationship between plot distance and chemical fertilizer adoption. Hence, it might have negative or positive sign depending on the type of soil and water conservation practices.

Berhanu and Swinton (2003) in their study of investment on soil conservation practices in northern Ethiopia found that plots distant from homesteads discouraged investment in soil conservation practices. Lands with higher slopes significantly more soil/stone bund terraces than flat fields (Aklilu, 2006). Therefore, steepness of a plot initiates farmers to invest in soil and water conservation practices. Hence, there is a positive relationship between slope and soil bund construction. Moreover, as Saliba and Bromley (1986)

observed farmers cultivating steeper slopes install more effective conservation measures than those cultivating level fields. On the contrary, farmers in lesser erosion prone areas (level fields) do not employ conservation measures on their farmlands. In line with this Wu and Babcock (1998) observed frequent conservation practices installed on steeply sloping cultivated fields which reflect the desire of farmers to control soil loss from highly erodible soil. Wagayehu and Lars (2003) and Shiferaw and Holden (1998) found positive association between existence of recommended type of conservation structures and concluded that slope affects farmers' decision to adopt conservation structures positively. Kessler (2006), in turn, found that more sloping fields do not influence the household's decision on how much to invest in soil and water conservation. Yet, they have influence on decisions about the places to install conservation structures.

Natural landscapes are one of the triggering factors for human interventions. Flat and hilly landscapes do require different methods of farming. Different soil types also need different management practices. Given a steep slope and erodible soils, a high rainfall period under low vegetation cover is likely to play an important role in the perceptions and behaviors of farmers on soil erosion and the role of soil and water conservation practices.

In this study, the researcher compared slope variations in the adoption of soil and water conservation practices within and between farm groups in the highlands of Tigray, northern Ethiopia. Based on the previous studies in this region (Asrat *et al.*, 2004; Tenge *et al.*, 2004; Aklilu, 2006), the researcher hypothesized that there is variation in adoption of soil and water conservation practices and soil fertility management practices⁴ among farm wealth groups with respect to variations in plot's spatial gradient, distance of plot's from the homestead and farm sizes.

⁴ Soil fertility management practices: include fallowing and application of inter-cropping, crop rotation, alley cropping, conservation tillage, manuring, improved agronomic practices and fertilizer application. However in this study only fertilizer application and manuring are considered

5.2 Materials and Methods

In order to capture spatial gradient in the adoption of soil and water conservation practices within and between farm wealth groups, the first stage involved was discussions with key informants and groups of farmers from different farm wealth groups and agricultural experts with the aim of obtaining information and views about SWC and its adoption practices. The second stage consisted a formal household survey using pre-designed data collection forms. Data on distance of plots from homestead and slope types were collected. In the third stages transect walk was conducted across groups of selected farmers from different farm wealth groups to obtain physical information and verify the information collected during the formal surveys.

Through proportional stratified random sampling technique 300 households were selected from the four study Tabias (two each from Adwa and Emba-Alajie districts). These lists were further stratified into rich, medium and poor farm wealth groups, on the basis of the socio-economic conditions, and according to the community's viewpoint during a village farmers' assembly in the study area. This stratification was done, because of the influence of resource endowment on land management and adoption of soil and water conservation measures in study Tabias. (Chapter 4). The criteria used were herd size and the stock of grain for consumption, i.e., farmers in the 'rich' group possessed oxen ≥ 2 , cows ≥ 2 and had enough grain in stock to cover at least for one year consumption, in the 'medium' group farmers possessed < 2 oxen and < 2 cows, had a stock of grain only for one year and the 'poor' group owned one or no oxen, one or no cow and had insufficient grain in stock to cover annual consumption. Moreover, careful observation and discussion with the farmers were used to classify the farmers' plots into three different slope categories (Chapter 4).

Information about implementation of specific adoption of soil and water conservation practices, the resource endowment of farmers, soil fertility improvement practices, and adoption of soil and water conservation practices, such as the construction of soil bunds, stone bunds, cut off drains, and agro-forestry were collected through individual interviews by using a structured questionnaire. For the purpose of this study, the head of

the selected households (usually the household head is implicitly assumed to be the decision maker in adoption studies) was interviewed using a structured questionnaire.

Data were analyzed using statistical software packages. First, descriptive statistics were generated for all categorical and numeric variables. Data were then classified by slope and farm wealth groups. Answers to questions regarding implementation of the specific adoption of soil and water conservation practices were recorded using dichotomous responses and data for soil fertility improvement practices were recorded in continuous data form (measurement).

Statistical Package for Social Scientists (SPSS, 2010) was the main tool used to analyze household characteristics so that the outcomes were presented quantitatively in terms of averages, Chi-square (χ^2), cross-tabulation, percentages and Anova. Chi-square (χ^2) analytical test was used to assess whether there is statistical significant difference between two or more nominal variables and the significance difference of slope gradient and farm wealth groups were tested using analysis of variance (ANOVA).

5.3 Results and Discussions

Slope was categorized into flat, medium and steep. As the χ^2 comparisons in Table 5.1 show there is variation in adoption of soil and water conservation practices among farm wealth groups considering slope of plots. In the case of flat slope, 65.9 % were adopters of soil and water conservation. When variations across groups are assessed, 65.5% and 87.5% of adopters were rich and medium farm wealth groups respectively, which is higher than that of poor farm wealth (only 46.2%). The survey result shows variation to be statistically significant at less than 1 percent significance level. There is also variation in adoption of soil and water conservation in middle and steep slope categorized among farm wealth groups and it was significant at less than 1 and 5 percent level respectively. For instance, adopters of soil and water conservation practices were higher in the case of medium (83.9%), as compared to the rich (75.0%) and poor (52.2%) farm wealth groups respectively, (Table5.1). This indicates that wealth status cause variation in the adoption of soil and water conservation practices.

Results of adopted types of soil and water conservation practices are presented in (Table 5.1). Adoption of soil and water conservation practices showed significant variation only flat slope gradient , and it has significant variations were observed with three farm wealth groups.($X^2= 14.44$, $p= 0.071$).

Different types of soil and water conservation practices (i.e. soil bund, stone bund, ditches, cut off drain and others) showed significant variation with slope and farm wealth groups. When delineated by farm wealth groups, Table 5.1 illustrates that the percent of responses of soil and water conservation practices implemented differed among farm wealth groups and slope. This was particularly true of labour intensive soil and water conservation practices (i.e. soil bund, stone bund, ditches, cut off drain and others) and those requiring a longer term to implement and realize a benefit (i.e., agro forestry, grass strips, manure application). Overall, for total soil and water conservation practices, among the farm wealth groups, the rich farm groups have particularly in soil bund (100%) and stone bund (5.6%), the medium farm wealth groups has 65.2% and 21.7% in soil and stone bunds, respectively, whereas the poor farm wealth group has 60.0% and 40% in flat slope . Moreover, there is variation among the three farm wealth groups in adoption of different types of soil and water conservation practices in relation to slope gradients specifically in medium and steep slopes. However, there is no statistically significant relationship (Table 5.1). Slope variation is thus an important factor in determining soil and water conservation practices on individual farm plots, however household income is not a major factor in determining soil and water conservation practices regardless of slope differences.

Soil fertility management used according to slope by different farm wealth groups as one component of adoption was examined in this study, a one way unrelated analysis of variance was applied and, is shown in Table 5.1. One way unrelated analysis of variance proved that there was variation in adoption of soil fertility management practices among farm wealth groups considering slope gradient ($F_2, 126=2.838$ $p=0.062$). In the case of flat slope, Table 5.1 shows that the average application of inorganic fertilizers by the rich, medium and poor farm groups household was 127.6 Kg/ha, 101.8 kg/ha and 88.7Kg/ha, respectively in 2012/13. The survey result shows variation to be statistically

significant at less than 10 percent level of significance. A one way unrelated analysis of variance showed an overall significant effect for applying inorganic fertilizers in middle slope ($F_{2, 131}=4.889$ $p=0.009$) among farm groups. Duncan's range test found that the poor farm group differed from the medium farm group ($p=0.068$) and the rich farm groups ($p=0.010$) but no other significant differences were found.

The application of inorganic fertilizers was 126.4 Kg/ha, 113.4 Kg/ha, and 89.1 Kg/ha for the rich, medium and poor farm wealth groups in middle slope. There is also variation in application of fertilizer in middle slope among farm wealth groups and it was significant at less than 5 percent level. This indicates that wealth status cause variations in the soil fertility management practices. Thus, slope and wealth status could have positive or negative contribution in soil fertility management in the area.

A one way unrelated analysis of variance showed an overall significant effect for applying manure ($F_{2, 131}=4.889$ $p=0.009$) among farm wealth groups. Duncan's range test found that the poor farm group differed from the medium farm wealth group ($p=0.001$) and the rich farm wealth groups ($p=0.002$) but no other significant differences were found as shown in Table 5.1. The mean value of manure application was slightly higher in the rich than medium and poor farm groups in the case of flat slope. Similarly in the case of middle slope, there was variation in utilization of manure application among the three farm wealth groups ($F_{2, 131}=16.345$ $p=0.001$). Tukey HSD^a range test found that the rich farm wealth group differed from the medium farm group ($p=0.005$) and the poor farm groups ($p=0.001$), the medium farm groups also differed from the rich farm groups ($p=0.005$) and the poor farm groups (0.007) and the poor differed from the rich ($p=0.001$) and the medium ($p=0.007$). The average application of manure of the rich, medium and poor farm wealth group households was 1.7, 1.2 and 0.8 tones/ha, respectively in middle slope (Table 5.1). Resource-rich households applied significantly higher quantity of inorganic and organic fertilizer when compared to the medium and poor farm groups of both studies areas. It was found that there was significant difference in the mean values of households manure application across the different farm wealth groups.

The average application of inorganic fertilizer along the slope gradient was 102.3 Kg/ha in flat slope, 108.2 Kg/ha in middle slope and 106.7 Kg/ha in steep slope (Table 5.1). Similarly, the application of natural fertilizer (manure) in tone per hectare during the specified year was 1.1 tone/ha in flat slope, 1.2 tone/ha in middle slope and 1.17 tone/ha in steep slope.

This variation might be due to slope is an indicator of soil and water loss from the farmland. Thus, farmers cultivating sloping fields perceive the threat of soil loss better than farmers who cultivate gentle or level sloping fields. This implies that farmers cultivating vulnerable fields are more likely to adopt and maintained soil and water conservation practices in their farms than those cultivating less vulnerable lands and steep plots might lead to continued use of the measures of different types of soil fertility maintenance and recovery as opposed to flat and medium slopes.

This implies that wealth and slope gradient are an important determinant of soil fertility management. As households show improvements in their social and economic scenarios they are able to buy large amount of fertilizer for their plots. Moreover, manure tends to be used dominantly by rich farmers than medium and poor farm wealth groups respectively regardless of slope.

Table 5-1: Adoption of soil and water conservation practice and soil fertility management with respect to variation in slope gradient by farm wealth groups

Slope category	Farm groups	% of respondents		adopted types of SWCPs and % of response					Soil fertility management (Mean \pm S.E.)	
		adopter	Non-adopter	Soil bund	Stone bund	Both soil and stone bund	Agro - forestry	Cut off drain	Fertilizer application in kilogram (kg)	Manure application (tone/ha)
Flat (3-15%)	Rich	65.5	34.5	100.0	5.6	5.6	0	16.7	127.6(\pm 13.0)	1.4(\pm 0.2)
	Medium	87.5	12.5	65.2	21.7	34.8	4.3	4.3	101.8(\pm 9.4)	1.3(\pm 0.1)
	Poor	46.2	53.8	60.0	40.0	25.0	0	10.0	88.7(\pm 10.4)	0.8(\pm 0.1)
	Total	65.9	34.1	78.9	24.6	24.6	1.8	10.5	102.3(\pm 6.3)	1.1(\pm 0.06)
	X ² P-value	18.988 0.001*		14.44 0.071***					0.062***	
Middle slope (15-30%)	Rich	75.0	25.0	100.0	19.0	14.3	4.8	4.8	126.4(\pm 7.4)	1.7(\pm 0.13)
	Medium	83.9	16.1	86.2	37.9	6.9	3.4	3.4	113.4(\pm 6.9)	1.2(\pm 0.09)
	Poor	52.2	47.8	82.4	23.5	11.8	0	11.8	89.1(\pm 9.4)	0.8(\pm 0.06)
	Total	70.9	29.1	84.5	26.8	9.9	2.8	5.6	108.2(\pm 4.8)	1.2(\pm 0.06)
	X ² P-value	12.685 0.002*		4.764 0.782					0.009**	
Steep slope (>30%)	Rich	70.0	30.0	57.1	28.6	28.6	0	0	120.0(\pm 16.9)	1.5(\pm 0.19)
	Medium	93.3	6.7	90.9	18.2	9.1	9.1	0	110.0(\pm 13.9)	1.2(\pm 0.24)
	Poor	58.3	41.7	80.0	20.0	20.0	0	0	91.7(\pm 14.8)	0.7(\pm 0.14)
	Total	75.7	24.3	85.7	19.0	19.0	9.5	0	106.7(\pm 8.7)	1.17(\pm 0.128)
	X ² P-value	4.676 0.097***		4.370 0.627					0.449	

Source: survey data, 2012/13

Note: Total over 100% is due to multiple responses and numbers in brackets indicate standard error of mean

*, **, *** represent significant at 1%, 5%, and 10% respectively

Average plot distance from the homestead in minutes was categorized into less than 30 minutes, from 31 up to 60 minutes and greater than 61 minutes. As the χ^2 comparisons in Table 5.2 show there is variation in adoption of soil and water conservation practices among farm wealth groups considering distance of plots from homestead. In the case of less than 30 minutes, 68.4 % were adopters of soil and water conservation. When variations across groups are assessed, 65.3% and 87.1% of adopters were from rich and medium farm wealth groups respectively, which is higher than that of poor farm wealth (only 48.6%). The survey result shows variation to be statistically significant at less than 1 percent. There is also variation in adoption of soil and water conservation from 31 up to 60 minutes and it was significant at less than 5 percent level. Adopters of soil and water conservation practices were higher in the case of greater than 61 minutes (78%), as compared to less than 30 minutes (68.4%) and from 31 up to 60 minutes (66.0%) distance to plots from the homestead in minutes respectively, (Table5.2) .This indicates that wealth status cause variations in the adoption of soil and water conservation practices. However, distance to plots from the homestead is not a major factor for adoption of soil and water conservation practices because those farmers far from homestead have adopted better than those whose plots are located near to homesteads.

Results of adopted types of soil and water conservation practices are presented in Table 5.2. Adoption of soil and water conservation did not demonstrate significant variation with respect to variation in distance to plots from the homesteads in the three farm wealth groups. However, there are significant variations in farm wealth groups with respect to variation in distance to plots from the homestead. When delineated by farm wealth groups, Table 5.2 illustrates that the percent of responses of soil and water conservation practices implemented differed among farm wealth groups. Overall, for total soil and water conservation practices, among the three farm wealth groups, the rich farm wealth groups has particularly in soil bund (100%) and stone bund (13.0%), the medium farm wealth groups has 85.7% and 28.6% in soil and stone bund, respectively, whereas the poor farm wealth groups has 65.2% and 26.3% in less than 30 minutes distance to plots from the homestead. Moreover, there is variation among the three farm wealth groups in adoption of different types of soil and water conservation practices in relation to slope specifically from 31 up to 60 minutes and greater than 61 minutes. Slope variation in

distance to plots from the homestead by farm wealth groups is thus not an important factor in determining soil and water conservation practices on individual farm plots, however household income is a major factor in determining soil and water conservation practices regardless of distance differences.

The impacts of plot distances from the homestead on soil fertility management by different farm wealth groups, was examined in this study, a one way unrelated analysis of variance was applied and, as shown in Table 5.2. One way unrelated analysis of variance proved that there was variation in adoption of soil fertility management practices among farm wealth groups, considering in less than 30 minutes ($F_2, 203=4.943$ $p=0.008$). In the case of less than 30 minutes, Table 5.2 shows that the average application of inorganic fertilizers by the rich, medium and poor farm wealth groups households was only 127.5 Kg/ha, 107.2 kg/ha and 91.1Kg/ha, respectively. The survey result proved variation statistically significant at less than 5 percent level of significance. Applying inorganic fertilizers with in greater than 61 minutes showed ($F_2, 38=3.987$ $p=0.027$) among farm wealth groups. The average application of inorganic fertilizers by the poor, medium and rich, farm wealth groups was 89.7 Kg/ha, 129.4 Kg/ha and 171.4 Kg/ha, respectively along on distance farmers 61 minutes category from the homestead.

The average application of inorganic fertilizer along the slope was 106.4 Kg/ha on the plots approached with in less than 30 minutes, 90.7 Kg/ha on plots reached from 31 to 60 minutes and 120.1 Kg/ha on farm plots reached in >60 minutes (Table 5.2). According to some studies plots located near to homesteads are supposed to get better supervision and attention from farming family members (Berhanu and Swinton, 2003; Wagayehu and Lars, 2003). For instance, Chilot (2007) found a positive relationship between plot distance and fertilizer applications. Results of the present study show that there is a positive relation between plots far away from homestead and maintains of soil fertility.

A one way unrelated analysis of variance showed a significant effect of manure application ($F_2, 203=21.076$ $p=0.001$) among the three farm wealth groups. Duncan's range test found that the rich farm groups differed from the medium ($p=0.074$) and the poor ($p=0.001$) farm wealth groups, the medium farm wealth groups also differed from the rich farm wealth groups ($p=0.074$) and the poor farm wealth groups (0.001) and the

poor also differed from the rich ($p=0.001$) and the medium ($p=0.001$). The mean value of manure application was slightly higher in the rich group than medium and poor in the case of nearer plots less than 30 minutes. Similarly in the case of greater than 61 minutes, there was variation in utilization of manure among the three farm wealth groups ($F_2, 38=3.553$ $p=0.038$). The average application of manure in the rich, medium and poor farm wealth groups was 1.5, 1.1 and 0.8 tons/ha, respectively with in (distance plots greater than 61 minutes) (Table 5.2). Resource-rich households applied significantly higher quantity of inorganic and organic fertilizer as compared to the medium and poor farm wealth groups regardless of distance from homestead.

The average application of manure was 1.5 tone/ha along the in less than 30 minutes, 1.1 tone/ha from 31 up to 60 minutes and 1.0 tone/ha in greater than 61 minutes This shows that there is a positive relation between plots located near to homesteads and maintains of soil fertility, and there is also variation in application of manure among the three farm wealth groups with respect to variation in distance to plots from homestead.

Table 5-2: Adoption of Soil and Water conservation practices and soil fertility management with respect to distances of farm plots from the homestead by farm wealth groups

plot Distances from the homestead in time perspective	Farm groups	% of responses		adopted types of SWCPs and % of response					Soil fertility management (Mean \pm S.E.)	
		adopter	Non-adopter	Soil bund	Stone bund	Both soil and stone bund	Agro - forestry	Cut off drain	Fertilizer application in kilogram (kg)per ha	Manure application (ton/ha)
30 minutes and less	Rich	65.3	34.7	100.0	13.0	4.3	0	4.3	127.5(\pm 7.433)	1.58(\pm 0.1)
	Medium	87.1	12.9	85.7	28.6	14.3	4.8	4.8	107.2(\pm 6.259)	1.31(\pm 0.9)
	Poor	48.6	51.4	65.2	26.1	26.1	4.3	8.7	91.1(\pm 8.691)	0.8(\pm 0.05)
	Total	68.4	31.6	92.5	26.3	18.8	5.0	6.3	106.4(\pm 4.445)	1.2(\pm 0.05)
	X ² P-value	26.97 0.001*		5.282 0.727					0.008**	0.001*
From 31 to 60 minutes	Rich	80.0	20	81.8	18.2	9.1	0	0	100.0(\pm 11.95)	1.45(\pm 0.3)
	Medium	82.4	17.6	50.0	50.0	25.0	12.5	0	92.7(\pm 13.66)	1.20(\pm 0.18)
	Poor	42.9	57.1	50.0	50.0	12.5	0	0	82.6(\pm 7.99)	0.90(\pm 0.10)
	Total	66.0	34.0	73.9	43.5	17.4	4.3	0	90.7(\pm 6.32)	1.1(\pm 0.10)
	X ² P-value	8.353 0.015**		5.574 0.473					0.532	0.104
61 minutes and above	Rich	85.7	14.3	100.0	20.0	0	0	20.0	171.4(\pm 28.57)	1.5(\pm 0.42)
	Medium	88.2	11.8	90.0	20.0	30.0	0	0	129.4(\pm 13.42)	1.1(\pm 0.14)
	Poor	64.7	35.3	88.9	11.1	0	0	11.1	89.7(\pm 17.79)	0.81(\pm 0.10)
	Total	78.0	22.0	88.0	16.0	12.0	0	8.0	120.1(\pm 11.18)	1.0(\pm 0.10)
	X ² P-value	3.036 0.219		5.707 0.457					0.027**	0.038***

Source: survey data, 2012/13

Note: Total over 100% is due to multiple responses and numbers in brackets indicate standard error of mean

*, **,*** represent significant at 1%, 5%, and 10% respectively

Farm size was categorized into ≤ 0.5 ha, 0.6-1ha and ≥ 1.1 ha. As the χ^2 comparisons in Table 5.3 show there is variation in adoption of soil and water conservation practices among farm wealth groups considering farm size. In the case of ≤ 0.5 ha (small farm size), 66.9% were adopters of soil and water conservation. When variations across groups are assessed, 80.0% and 80.4% of adopters were rich and medium farm wealth groups respectively, which is higher than that of poor farm wealth (only 50.8%). The survey result shows variation to be statistically significant at less than 1 percent level of significance. There is also variation in adoption of soil and water conservation in 0.6-1ha (medium farm size) among farm wealth groups and it was significant at less than 1.

Adopters of soil and water conservation practices along farm size were 78.8% in ≥ 1.1 ha (large farm size), 69.3% in 0.6-1ha (medium farm size) and 66.9% in ≤ 0.5 ha (small farm size). This shows that there is a positive relation between large farm size and adoption of soil and water conservation practices, and there is variation in adoption of soil and water conservation practices among the three farm wealth groups, the rich farm wealth groups adopt more than the poor wealth groups. Thus, in addition of wealth differences, adoption of soil and water conservation increases as the households have large farm size.

Results of adopted types of soil and water conservation practices are presented in Table 5.3. Adoption of soil and water conservation practices showed significant variation only from 0.6-1ha farm size has significant variations were observed with three farm wealth groups. ($X^2 = 16.11$, $p = 0.041$). With regard to different adopted types of soil and water conservation practices, (Table 5.3) 89.7% of the total respondents were adopters of soil and water conservation practices in relation with medium farm size (0.6-1 ha). Of which, 100 %, 84.6% and 75% were rich, medium and poor farm wealth groups respectively.

Table 5-3: Adoption of soil and water conservation practice and soil fertility management with respect to variation in household's farm size by farm wealth groups

Farm size in (ha)	Farm groups	% of respondents		adopted types of SWCPs and % of response					Soil fertility management (Mean \pm S.E.)	
		adopter	Non-adopter	Soil bund	Stone bund	Both soil and stone bund	Agro -forestry	Cut off drain	Fertilizer application in kilogram (kg)	Manure application (tone/ha)
≤ 0.5	Rich	80.0	20.0	92.3	23.1	0	7.7	0	105.0(\pm 12.5)	1.09(\pm 0.153)
	Medium	80.4	19.6	83.3	37.5	8.3	0	8.3	77.9(\pm 5.31)	1.1(\pm 0.10)
	Poor	50.8	49.2	75.0	45.0	20.0	0	5.0	71.2(\pm 8.55)	0.8(\pm 0.054)
	Total	66.9	33.1	74.6	33.3	9.5	1.6	4.8	79.1(\pm 4.87)	0.9(\pm 0.05)
	X ² P-value	12.613 0.002*		9.180 0.327					0.062***	0.009**
0.6-1	Rich	65.9	34.1	100.0	14.3	9.5	0	0	131.9(\pm 7.24)	1.7(\pm 0.10)
	Medium	92.5	7.5	84.6	23.1	26.9	7.7	0	122.8(\pm 8.08)	1.3(\pm 0.07)
	Poor	44.2	55.8	75.0	0	25.0	0	16.7	103.7(\pm 8.63)	0.86(\pm 0.07)
	Total	69.3	30.7	89.7	15.5	20.7	3.4	3.4	119.5(\pm 4.74)	1.3(\pm 0.06)
	X ² P-value	26.351 0.001*		16.111 0.041**					0.056***	0.001*
≥ 1.1	Rich	70.0	30.0	66.7	0	33.3	0	16.7	143.6(\pm 25.8)	1.8(\pm 0.27)
	Medium	86.7	13.3	70.0	30.0	10.0	10.0	0	160.0(\pm 13.9)	1.6(\pm 0.19)
	Poor	75.0	25.0	60.0	0	20.0	20.0	0	143.7(\pm 33.65)	1.1(\pm 0.15)
	Total	78.8	21.2	87.5	25.0	18.8	12.5	6.3	151.1(\pm 12.56)	1.5(\pm 0.13)
	X ² P-value	1.088 0.580		7.771 0.456					0.821	0.156

Source: survey data, 2012/13

Note: Total over 100% is due to multiple responses and numbers in brackets indicate standard error of mean

*, **,*** represent significant at 1%, 5%, and 10% respectively

Soil fertility managements were compared by farm wealth groups with respect to farm size. In the case of ≤ 0.5 ha (small farm size), Table 5.3 shows that the average application of inorganic fertilizers by the rich, medium and poor farm wealth groups was only 105 Kg/ha, 77.9 kg/ha and 71.2.Kg/ha, respectively. The results of the one-way ANOVA (Table 5.3) indicate that there are significant applications of inorganic fertilizers differences among the three farm wealth groups with respect to ≤ 0.5 ha or small farm size ($F_{2, 127}=2.842$ $p=0.062$). Moreover, there was a variation in application of inorganic fertilizer with respect to medium farm size (0.6-1 ha) among the three farm wealth groups ($F_{2, 134}=2.949$ $p=0.056$).

The average application of inorganic fertilizer along the farm size was 79.1 Kg/ha with in ≤ 0.5 ha (small farm size), 119.5 Kg/ha within 0.6-1ha (medium farm size) and 151.1 Kg/ha in ≥ 1.1 ha (large farm size). This variation might be due to those farmers who have large farm size apply more inorganic fertilizers.

The results of manure application with respect to farm size by farm wealth groups are presented in Table 5.3. The small farm size (≤ 0.5 ha) and medium farm size (0.6-1ha) showed significant variation between the three farm wealth groups ($F_{2, 127}=4.891$ $p=0.009$) and ($F_{2, 134}=16.60$ $p=0.001$), respectively. While no significant variations were observed with larger farm size (≥ 1.1 ha) by farm wealth groups. The mean manure application with respect to small farm size was higher 1.09 tone/ha for rich farm wealth groups and lower 0.8 tone/ha for poor farm wealth groups and with respect to medium farm size (0.6-1ha) the mean manure application was higher 1.7 tone/ha for rich farm wealth groups and lower 0.86 tone/ha for the poor farm wealth groups.

The average application of manure along the farm size was 0.9 ton/ha on small farm (≤ 0.5 ha), 1.3 ton/ha in medium farm size (0.6-1ha) and 1.5 ton/ha on large farm size (≥ 1.1 ha). This shows that there is a positive relation between farm size and maintenance of soil fertility, and there is variation in application of manure among the three farm wealth groups with respect to variation in farm size.

5.4 Conclusions

The aim of this paper was to explore the effect of spatial gradient on adoption of soil and water conservation practices and soil fertility management within and between farm groups in the highlands of Tigray, northern Ethiopia. In this study the effect of slope angle, plot's distance from the homestead and household's farm size on adoption of soil and water conservation practices and soil fertility management in relation to the three farm wealth groups were examined. The changes in slope angle and farm wealth groups significantly affected for the adoption of soil and water conservation and soil fertility management. The variation in slope angle resulted in significant differences in the adoption of soil and water conservation and soil fertility management. On average steep slope gradients was better adopter of soil and water conservation and soil fertility management than middle and flat slope. Changes in farm wealth groups significantly affected adoption of soil and water conservation and soil fertility management. The poor were less adopter of soil and water conservation practices and soil fertility management than the medium and the rich farm wealth groups.

Average plot distance from the homestead and farm wealth groups showed that variation in adoption of soil and water conservation practices and soil fertility management. This indicates that average plot distance from the homestead cause variation in the adoption of soil and water conservation practices, however, average plots distance from the homestead was not a major factor for soil fertility management because those farmers far from homestead were applied well than plots located near to homesteads. Changes in farm wealth groups significantly affected adoption of soil and water conservation and soil fertility management. Adoption of soil and water conservation practice, fertilizer and manure application tends to be used dominantly by rich farmers than medium and poor farm wealth groups. This indicates that wealth status cause variation in the adoption of soil and water conservation practices and soil fertility management.

Changes in farm size and farm wealth groups significantly affected for the adoption of soil and water conservation and soil fertility management. The variation in farm size resulted in significant differences in the adoption of soil and water conservation and soil fertility management. This shows that there was positive relation between large farm size

and adoption of soil and water conservation practices and soil fertility management. Changes in farm wealth groups also significantly affected adoption of soil and water conservation and soil fertility management. The average application of inorganic fertilizers and manure by the rich and medium were higher than poor farm wealth groups respectively. This shows that it has positive relationship between large farm sizes and maintains of soil fertility.

To minimize these differences, interventions should focus on improving farmers' livelihood asset endowments in order to strengthen their capacity to adopt soil and water conservation practices and soil fertility management and as households show improvements in their social and economic scenarios they are able to buy large amount of fertilizer for their plots. Moreover, the burning of dung in poor farm households for fuel can be reduced by improving access of rural households to alternative rural energy sources such as rural electrification and introducing 'energy-saving stoves' could also be a good option.

Generally, adopting soil and water conservation practices has shown positive impacts on the soil conditions. Taking into consideration the benefits of soil and water conservation practices to improving the soil quality and thereby sustainable agricultural productivity, there should be a continuous awareness creation mechanism and a follow up process on the proper maintenance and management of the soil and water conservation practices along with integrating agronomic measures. Moreover, the distribution of fertilizer should be based on the economic status of farmers and it should not be distributed randomly rather on the types soil characteristics that they required for a specific soil units. It should not be basis on quota of districts or Tabias and if possible, the distribution of fertilizer should be on voluntary based. This study distinguish that examining changes that may occur in some major adoption of soil and water conservation practices under different farm wealth groups and slope gradients helps to assess how to minimize soil erosion along spatial gradients and its environmental effects to achieve a sustained soil and water conservation practices in the long run.

CHAPTER SIX

6. Natural Resource Management and Perceptions of Community Benefits from Soil and Water Conservation Practices in Tigray Region: the case of Adwa and Emba-Alajie Districts

6.1 Introduction

Land degradation is an acute environmental problem and major concern of many conservation endeavors in the highlands of Ethiopia. Tigray as part of the Ethiopian highlands is characterized by a higher land degradation and natural resource depletion resulting from various factors such as climatic variations and human activities (Nyssen, 1998; Nyssen *et al.*, 2000; Yeraswork, 2000). The most affected natural resources are soil, water, vegetation and wildlife; but even the cultivated plants are exposed to greater damage, which thus poses a threat to food security as well. Soil degradation is one of the most crucial processes of land degradation and environmental change. The ever-increasing demand for water and the high cost of water development is also an additional major constraint to agricultural development (Tiffen *et al.*, 1994). That is why the northern Ethiopian highlands are suffering from chronic food insecurity, extreme poverty, overgrazing, and climatic variations (Nyssen, 1998; Nyssen *et al.*, 2000; Yeraswork, 2000). In addition, the people in the region heavily depend on subsistence agriculture for food and on forests for wood products and fuel. In short, the people of the region use natural resources to support and enhance life.

In Ethiopia, 85% of the population is engaged in agriculture (CSA, 2007). However, the productivity of this sector is being seriously challenged by unsustainable land management practices both in areas of food crops and in grazing lands. Although there is a dearth of data the extent of common pool resources in the country, managing agricultural resources communally has been a common practice in the rural areas of Ethiopia. The common resources have crucial importance to the livelihoods of rural communities, serving as the main sources of water, feeds for livestock and fuel wood. Soil erosion, soil nutrient depletion, moisture stress, deforestation and overgrazing are the major environmental problems in the region (Fitsum *et al.*, 1999). The lag in agricultural

productivity advancement behind population growth has caused intense land use conflicts, particularly between the agricultural and forestry sectors (Bedru *et al.*, 2009). Due to the high population pressure, almost all grasslands in Tigray have been converted to crop cultivation areas.

As in other parts of Sub-Saharan Africa, the notion of sustainable development, meeting the needs of the present without compromising the needs of future generations, is attracting the attention of national and international policy makers. It is now almost obsolete to conceive environmental management and socio-economic development as adverse and therefore irreconcilable programs. Nevertheless, designing a conservation approach that helps achieve sustainable development that fulfils both economic and ecological objectives remains a challenge (Aklilu, 2006; Girmay, 2006; Mitku *et al.*, 2006). The success of development programs and poverty alleviation efforts depends on greater community empowerment and participation as well as governmental and extension service involvement (Agrawal, 2001).

Sustainable land management is an integral part of the farm management system of agrarian societies. However, due to population pressure and other anthropogenic factors, deforestation and consequent land degradation are observed in the highlands of Ethiopia in general and in the northern highlands in particular. The land degradation not only decreased the fertility of the soil but also resulted in the loss of biodiversity, the lowering of the water table, diminishing prime grazing lands and the overall loss in agricultural productivity (Nyssen *et al.*, 2007). This in turn increased the vulnerability of the area to cyclic droughts, famine and absolute neglect to care for natural resources. Consequently, the region remains food insecure and aid-dependent. The major policy challenge facing Ethiopia is, therefore, how to reduce poverty and secure diverse and viable livelihood options for its populations, without further degrading their scarce resources and the environment.

In order to make the conservation programs sustainable, the Ministry of Forest is mandated to regulate and coordinate the development and implementation of environmental management strategies in Ethiopia. Very recently, Ethiopia is making progress in implementing environmentally sound policies and strategies to address

environmental sustainability alongside the set economic and social development policies. As the majority of the population ekes out a living from the agricultural sector, it is imperative that local communities participate actively in environmental and natural resource management programs (Ethiopia MDGs Report, 2012). As a result, the pace of deforestation and forest degradation has declined from 12.5% in 2000 to 11.9% in 2005 and then to 11.2% in 2010 (World Bank, 2011). A recent report indicates that national forest coverage stands at 12.2% in 2011/12 (MOFED, 2012). Despite certain limitations, the community-based natural resource management is presumed to potentially provide a more collaborative and equitable approach to natural resources management, by aligning land use policies with proper incentives for careful, efficient and sustainable soil and land management practices (Kellert *et al.*, 2000). Ethiopia in particular might take valuable lessons from exemplary community-based natural resource management programs. Community-based conservancies, which have been implemented with relative success in some other African countries, such as Namibia, Zambia and Zimbabwe, could prove useful in developing policies and institutions that support communal solutions to land degradation in Ethiopia (Daniel and Aregai, 2010).

As part of the conservation-based agricultural development strategy undertaken in Tigray, several natural resource conservation and development projects have been under way, especially since 1991. These efforts include the construction of soil and water conservation structures, area enclosures (areas closed from human and animal interference to allow natural regeneration with enrichment of plantations), community woodlots development, community grazing lands management, and the development of small-scale irrigation (Pender *et al.*, 2006).

However, there is a scarcity of evidence regarding the factors that facilitate or hinder community mobilization towards soil and water conservation practices in the region. Therefore, a genuine community participation associated with sustainable soil and water conservation practices is very important to correct the situation. Besides, the participation of concerned stakeholders is now considered essential for effective and sustainable management of natural resource systems. It appears that the community should be convinced to make changes in the soil and water conservation practices to contribute

towards its own improved sustainable livelihood. The rate at which such change can be realized depends on the level of empowerment within the community and the level of support that can be provided by related stakeholders, governmental and non-governmental organizations and research institutions.

The main purpose of this study was to investigate the factors that influence natural resource management and perceptions of community benefit from soil and water conservation practices in order to enhance environmental restoration and sustainable livelihoods and thereby to draw plausible conclusions that contribute to the future improvement of the design and implementation of conservation programs.

6.2 Materials and Methods

The data were obtained from a survey from December 2012 to May 2013 with the help of structured questionnaire, discussions with focus groups and key informants. As final decisions on natural resource management soil and water conservation practices are made by household heads, they are taken as a unit of analysis.

The data included past experience of soil and water conservation practices (years) and for motivating factor and perceptions on community benefits from soil and water conservation practices. The perceptions on community benefits from soil and water conservation practices data contained nine items. Each farmer responded to the nine items on a five-point Likert scale ranging from highly decreased to highly increased. Simple weightings (1 to 5) were assigned to the response categories on the basis of favor and disfavor for the items. The responses with rating of highly decreased, decreased, no change, increased and highly increased were weighted 1, 2, 3, 4 and 5, respectively.

Four farmers focus groups discussions were carried out, one from each of the four Tabias. One more focus group discussion was conducted that pooled people from the representatives of relevant governmental organizations. Each focus group ranging in size from six to eight participants, were carried out using semi-structured questionnaires. Selection of the participants was on the basis of professional background, knowledge and experience on the administrative, technical, and historical perspectives regarding community natural resource management. The composition of the Tabias focus group

members included male and female households, elders' community members, and youth. Participants were asked open-ended questions on the on- farm and off-farm soil and water conservation practices and resource holdings (existing by-laws, voluntary participation in soil and water conservation practices and community resource managements); and communal grazing lands management and institutional factors.

Discussions were held with key informants. The compositions of key informants were experienced guards of enclosures, relevant experts, elderly community members and other administrative units to gain additional insights on issues related to the community-based natural resource management in the Tabias involved.

Moreover, field visits by the researcher and informal discussions were used to get information on how villagers participate and manage on-farm and off-farm (area enclosures conserved by community). Besides, the researcher has organized and held four Tabias community meetings that were designed to discuss on planning, execution and the challenges of soil and water conservation practices, particularly when the community participated in mass mobilization of soil and water conservation campaigns. In addition, review of national policy documents, districts and local bylaws, reports and other literature about the study area also be consulted if found pertinent to the subject of this research. Finally, different government policies and guideline related to soil and water conservation was searched, reviewed and analyzed.

Qualitative information obtained through focus group discussions, in-depth interview and participant observation, was integrated with the quantitative data. The coded responses from the household survey were analyzed using SPSS software. The study used descriptive statistics (frequencies and percentages scores), while Pearson's correlation coefficient was also estimated for all possible paired combinations of the parameters.

6.3 Results and discussions

6.3.1 Soil and Water Conservation Practices

Results of the focus group discussions and in-depth interviews indicated that soil and water conservation practices have been started many years since, especially on the plot

boundary called 'Deret'. 'Deret' is a bund- like structure that is built to divide the plots and at the same time to conserve soil and water .The interval between 'Deret' is not uniform and it is wide. Some of them have not been constructed following the contour lines. Hillside plantation and enclosure started in the 1960s under Emperor Haile Selasie I and activities have been extended ever since. When the military government, took over power, it started to take stronger physical and biological soil and water conservation measures both on community and on private land through the campaign called food-for-work programs (Segers *et al.*, 2008). However, practice shows that when land users are given any form of payments by the government to conserve their lands and water, they tend to assume that the government will also be responsible for the maintenance of what has been constructed, either by paying them or by undertaking maintenance itself. They regarded themselves as labourers rather than participants

Under the current government, soil and water conservation practices have been given great attention to minimize the impact of soil erosion and land degradation as well as to increase the local people's participation in natural resource management. According to the Regional action program, about 692,11hactare of cultivated land and 606,502 hectares of uncultivated land are terraced up to year 2000. Moreover, up to 2011, the campaign for soil and water conservation performed on farm land was 834,478 ha (BOPF, 2011). Free community work is still a year-to-year reality in Tigray. Nowadays, bunding, terracing, trenching, check dam building and closed area planting are done within the framework of food-for-work programs. Currently, governmental and non- governmental organizations are involved in these actions.

On -farm soil and water conservation refers to the conservation activities conducted on private plots or farmlands. According to participants in the focus group discussions, key informant interviews and personal observations, on-farm conservation was relatively weak as compared to off-farm soil and water conservation in the four Tabias. Some of the basic reasons given by the key informants and the focus group discussion participants indicated that local farmers do not take or have little less initiative to conserve, maintain and protect their own farmlands, but rather they wait for the public to conserve and maintain their land and this has been a usual practice. This is mainly associated with lack

of initiative from local administrators because they are more focused on coordinating community mobilization campaigns rather than individual farmers' plots. In addition, since the average landholding size in the study areas is small, which is about 0.7 ha, farmers prefer to engage in off-farm occupations during the dry season. Thus, farmers prefer to engage in food-for-work activities bringing immediate benefits rather than devoting their time to conserve their own plots. Another reason for the negligence in constructing bunds on plots, as forwarded by participants, was that bunds occupy part of the land, form habitats for potential harmful weeds and rodents, while water logging may occur uphill the bunds after heavy rainfall and farmlands are open for grazing during the dry seasons. All the above problems are major challenges for the sustainability of the on-farm soil and water conservation practices.

Off-farm soil and water conservation refers to conservation activities conducted on catchments other than the privately owned farmlands. These include community grazing lands, forest lands, area closures, gullies and other areas of common interest and benefit. Soil bunds, stone bunds, stone check dams, and hillside terraces are built in the watersheds through mass mobilization and food-for-work programs organized by the government of the Regional State of Tigray.

Since regime change in 1991, off-farm soil and water conservation was institutionalized at the lowest community unit in the Region and is now implemented through a household level labour quota system. This labour quota is a system of labour supply from land user households where every adult household member is compelled to contribute 20-40 days per year in soil and water conservation activities free of any payments. Labour mobilization is seasonal and takes place in January /February and July. Labour is mobilized immediately after the harvest season in *January/February* and, for plantation activities, labour contributions are made annually in July. In conservation by mobilization for constructing different bunds, the difference between male and female is only the meter, for adult men 80 meter and for adult women 50-60 meter per year. Absenteeism due to sickness was not considered a form of resistance to community work. Household members who are aged, ill, full-time employees or students are not obliged to participate.

Since the contribution of labour is during the dry season, it did not conflict with farm work and farmers considered the restoration of ecology as a benefit.

Moreover, community owned watershed has been carried out through Productive Safety Net Programs (PSNP) , which is designed to provide employment for the chronically food insecure people who are “able-bodied” labour. However, to qualify for these programs, households are first required to meet the free contribution of labour unless they are exempted by the community. Screening the households that qualify for such compensated work is done with the involvement of community members.

Participants in the focus group discussions and key informants revealed that they were fully involved in the compulsory free labor initiative and supported the idea. Mountains which were bare 20 years ago have been conserved through committed and enthusiastic contribution of free labour for soil and water conservation. However, there were instances when very poor farmers who did not have adequate food went to their private life to work. Most of the local farmers were happy to work and there is a local bylaw that stipulated that anyone who absented himself/herself from community work due to travel to another tabia would be punished by a heavier workload than is normally accomplished in a day.

Because of the mountainous nature of the study areas, the communities were facing difficulty in climbing the mountains. Sometimes the people were also exposed to the dangers of snakebites and landslides and/ or falling rocks as they worked on the hillside watersheds. When there was an accident during communal work in the catchment area, it was difficult to transport the injured person to a clinic timely.

The organization of watershed management started by the federal government that has laid down guidelines and coordinates national activities. The regional states provide training and support for districts, Districts in turn give training and support to Tabias and Tabias (in coordination with district representatives) give training to sub-catchments. Different organizations and institutions (farmers’ unions, women’s associations, youth associations, schools and religious institutions) participate in the planning and implementation of watershed management activities.

These organization of watershed management are coordinated by the council of the Tabia and technical staff from the office of agriculture and natural resources development at the district level. Communities have bylaws approved by the respective Tabias' assembly and adopted by local social courts based on its own assessment and requests from community members. The development committee, composed of members of the council of the Tabia and trained farmers, decides on sites for collective work,. The development committees identify farmlands, grazing lands, gullies, dam catchments and wastelands that need immediate attention. Participating households are organized in small work teams, locally called *Gujile*. At the work site, the people work in groups consisting of about 15–20 individuals, with both men and women carrying out the same activities. Each group has a leader that can be a male or a female. The leader is responsible for planning, sequencing of various activities, scheduling and organizing the people in the group for the work. However, the development agent is in charge of giving out the workload to the group leaders and he/she undertakes the overall supervision of the work.

Despite a number of challenges, such as having less fertile soil and highly degraded lands, through integrated community owned natural resources management, it is possible to create conducive environment for environmental protection and rehabilitation in study area in particular and in Tigray in general. Still, they will require commitment to change into the development of community-based resources approaches, availability of adequate financial and technical resources to do the job. Although it is participatory in implementation, it still remains to be bottom-up approach in planning and evaluation perspectives of conservation practices. The best approach is the one developed with the consent of all stakeholders starting from planning up to evaluation. Therefore, the communities will have some inputs to the planers.

Apart from physical soil and water conservation work, each Tabias encloses degraded lands to allow natural regeneration and carries out afforestation and plantation activities, such as enrichment planting or woodlot establishment. Local resources are mobilized to establish and protect these assets (Berhanu and Swinton, 2003). While most Tabias bylaws in Tigray emphasize self-discipline, plantations and area closures are protected either by rotationally assigned community members or by hired guards, who may be paid

through programme assistance by the non-governmental organization like Relief society of Tigray or the community itself (Girmay, 2006).

Restricted grazing in dry seasons and the selective allowance of livestock were commonly used mechanisms to reduce the livestock grazing pressure on the limited sizes of communal grazing lands in all study the areas. The amount and duration of yearly rainfall was an important factor that determined the duration of the opening and closing periods of the communal grazing lands. There was a trend of using the onset and amount of yearly rainfall as the main reference point to decide on timings for grazing, although there was some variation across the study areas. The number of opening months increased when the amount of yearly rainfall was lower and the duration of the rainy season was shorter. In Adwa, the number of opening months was only one and the duration of the rainfall lasted three months. Most key informants in the study sites elaborated that grazing in the rainy season was prohibited, because allowing livestock to graze on the restricted fields in the rainy season could reduce the grass harvest, by increasing the wastage of grass product due to trampling by cattle. In contrast, a study in Emba-Alajie, the number of opening months was twice or three times sometimes it depends on rainfall condition. This difference in practicing restricted grazing could result from the variations in the socio-demographic conditions, availability of grazing lands, and yearly rainfall, as these were the main factors influencing the institutional arrangements of communal grazing lands management. In addition to reducing the livestock grazing pressure, the restricted grazing in dry seasons enhanced grass regeneration in wet seasons, enabled an economical use of grass, and prevented degradation of the communal grazing lands that could result from overexploitation. Thus, restricted grazing was critical for the sustainable management of communal grazing lands.

This indicates that although all users have equal rights to participate in making decisions concerning communal grazing lands, the various power relations among users, in terms of gender and political power, could reduce the effectiveness of rule enforcement. However, such hillside distribution to the landless poor and youngsters (above 18 years of age) started in 2007/08 in Tigray. As a result, the landless and young people have conserved

the areas by different activities. The areas which were previously found bare are recently rehabilitated, and, the landless people whose means of living previously depending on fuelwood sales has started changing to the production of fruits, vegetables, fodder trees, bee keeping and commercial timber trees like eucalyptus.

In a community having shortage of arable land, like the Tigray region, connecting hillside distribution to the landless people and conservation is crucial. There is a potential for improving the livelihoods of the landless people by restoring the degraded hillside areas through their participation in various conservation activities. As a result of their participation, various income sources were created from the use of hillside areas. In light of these findings, similar conclusions made by Habibah (2010) indicate that farmers can only be active participants in conserving natural resources if they find that it gives them any kind of perceived benefits. Hence, all the benefits from the hillside areas should be clearly identified as environmentally friendly so that the landless people could be directed towards the sustainable pathways.

As the respondents explain, conflict among the users is rare. If there is, it is easily solved by discussion. This can be due to the every meeting of the users in every Sunday in month. The small disagreement among the users implies successful common-property regimes. But the conflict with non users is about the benefit sharing and property right and usually solved with the help of the *Tabia* administration or *Tabia* agriculture office. The respondents also explain that the government and the *Tabia* administration are always besides them. They gave them legitimacy to manage the communal grazing lands

The local institutions were established with the purpose of mediating access, enabling equal allocation of benefits among users, determining the contributions for collective action in protection and maintenance works, and enforcing sanctions on free riders. Accordingly, the local institutions have also sanctions and conflict mechanisms which are very important in having successful communal management.

As the informants explained most of the users participate in selection of the leaders, formulating the bylaws and in any meeting regarding the communal grazing lands. They also participate in contributing cash or labour for protecting the communal grazing lands.

The contribution is related to the rules and regulation of the local community. In *Emba-Alajie*, the communal grazing lands are protected by the local people turn by turn and collected money from each user (the salary of the guard could be 400-600 Birr per month). Therefore, they did contribute cash for guards. All the respondents' response that they contribute labours for the protection of the communal grazing lands. In case of *Adwa*, the users sometimes hired guards (collected money from each user) and they also sponsored by Relief Society of Tigray, the salary of the guard could be 300-400 Birr per month. This shows that the communities are actively participating in monitoring producers. They also have good participation in the communal grazing lands meetings and in contribution of labour and money for the management of the communal grazing lands. This finding follows a study by Agrawal and Yadama (1997) who, in their sample of 279 communities, found that the most important form of user participation was the level of investment by the user group in monitoring and protecting activities. The good participation of the users can be seen primarily as a means to achieve specific goals such as building a better management structure and getting natural resources into a 'good condition'.

At this point, the mutually agreed sanctions were enforced by the *Baito* (the council of the *Tabia*), the local courts of the *Tabias*, and guard of the communal grazing lands. Similarly a study by Berhanu *et al.* (2000) in other parts of Tigray disclosed that rule enforcement by the formal *Baito* (similar to the council of the *Tabia*) system has been common whenever users of communal grazing lands refuse to accept decisions of the *Tabia*' committee members. However, the sanctions are different for all the community using communal grazing lands. The illegal cutters will be punished 20 Birr for first time and 50 Birr for second time in *Emba-Alajie*. If the person cut trees repeatedly, he will be sent to local courts (the local courts of the *Tabias*). The sanctions are not permanent. They can be changed any time according the situation. Similarly, in *Adwa*, the illegal cutters are punished 30 birr and 60 birr respectively. Lastly, if he cuts trees repeatedly, he will be sent to the local courts (the local courts of the *Tabias*). The penalty is sever for these who repeatedly offense. Hence, the presence of collaboration in rule enforcement brought about positive outcome by reducing free riding. This in turn contributed to the protection of the communal grazing lands by preventing overexploitation.

So far there is no land redistribution and giving land for young what they call it hillside distribution (*gobe mekelo*), so the farmer's sense better ownership. However, in the case of communal grazing lands given the ever increasing demand of the users for unrestricted access, the communal grazing lands can be subjected to further pressure. Of course, there exist by laws to guide use of communal grazing lands but there was impediments to the effectiveness of management rules such as low incentives to guards and in some cases ineffective monitoring and enforcement and reduced attitudes of local land users towards communal grazing lands protection.

Table 6-1: Respondents' 'experience in soil and water conservation practices and the motivating factors

Tabias	Respondents years of experience in SWC practices and percentage frequency of respondents			Motives for their participation in SWC(in% of respondents)			
	1-12 Years (Responders in %)	13-24 years (respondents in %)	25-37 years (respondents in %)	own Willingness (%)	Tabias Community Decision (%)	government Agency (%)	others (%)
Meriam-shewito	21.6	70.3	8.1	67.6	5.4	21.6	5.4
Endabagerima	15.6	80.5	3.9	62.3	14.3	19.5	3.9
Atsela	20.9	74.6	4.5	86.6	4.5	9.0	-
Ayeba	29.3	59.8	11.0	54.3	6.2	34.6	4.9
Average	22.0	71.0	7.0	66.9	7.7	21.7	3.7

Source: survey data, 2012/13

6.3.2 Past Experience on Soil and Water Conservation Practices

Soil and water conservation, particularly the traditional ones, have been practiced for long period however, since the study areas were part of a war zone, no significant work had been done until 1991 despite the fact that there were repeated attempts. All of the focus groups agree that soil and water conservation has been a common practice in the four Tabias, particularly since 1991. Largely, soil and water conservation was collective work aimed at solving a common problem through integrated conservation. This means that the integrated conservation method was aimed at a task that could not be done by the individual farmer alone.

Results of the household survey show that on average in the four Tabias, 71% of the household heads participated in soil and water conservation activities from 13 -24 years, while 22% of them participated from 1- 12 years and only 7% of the households participated in soil and water conservation activities for more than 25 years (Table 6.1). All of the respondents contribute 22 free workdays every year to SWC works, regardless of their economic, social, political and demographic differences. The household head respondents replied that the first condition that motivated them to make the free labour contribution is one's own willingness (66.9%), government decision (21.7%), Tabias community decision (7.7%), and others (3.7%). On the other hand, farmers who fail to participate in the 22 free workdays are subject to fine of at least Birr 40 and 100 per day. This indicates that farmers have long years of experience in soil and water conservation and they also fear to be fined for being absent and hence participated with full devotion and commitment.

Table 6-2: benefit ratings on some indicators of soil and water conservation practices by HHHs

Indicators	Respondents ratings on the benefits of soil and water conservation practices								
		Highly Decreased	Decreased	No change	Increased	Highly Increased	Mean	Std. Deviation	Std. Error Mean
Land fertility	Fr %	- -	- -	16 5.3	105 35.0	179 59.7	4.54	0.58	0.03
Crop production/yield	Fr %	- -	1 .3	13 4.3	130 43.3	156 52.0	4.47	0.58	0.03
Fodder and grass supply	Fr %	1 .3	5 1.7	57 19.0	151 50.3	86 28.7	4.05	0.76	0.04
Wood production for fuel	Fr %	13 4.3	64 21.3	103 34.3	82 27.3	38 12.7	3.23	1.06	0.06
Number of trees	Fr %	8 2.7	28 9.3	75 25.0	146 48.7	43 14.3	3.63	0.93	0.05
Water supply	Fr %	8 2.7	23 7.7	49 16.3	126 42.0	94 31.3	3.92	1.01	0.06
Soil erosion	Fr %	92 30.7	119 39.7	50 16.7	20 6.7	19 6.3	2.18	1.13	0.07
Flooding	Fr %	126 42.0	138 46.0	34 11.3	2 .7	- -	1.71	0.69	0.04
livelihood security	Fr %	60 20.0	159 53.0	62 20.7	18 6.0	1 .3	2.14	0.813	0.05

Source: Survey data, 2012/13

6.3.3 Respondents' Perceptions of Community Benefits from Soil and Water Conservation Practices

Most of the respondents believe that there is a lot to be gained from soil and water conservation practices. About 59.7% and 52.0% of respondents rated respectively that land fertility and crop yields highly increased as a result of soil and water conservation practices. The Pearson's correlation coefficient indicates that there is no significant relationship between the literacy status of the respondents and their perception of land fertility as a result of soil and water conservation practices ($r=0.04$, $DF=298$, $p=0.446$) and also it does not have relationship between their literacy status and perception of crop yields due to soil and water conservation practices ($r=-0.018$, $DF=298$, $p=0.751$).

Concerning the restoration of grazing lands, 50.3% of household heads said that grazing lands increased over time; but 28.7% and 19% of the respondents replied that grazing lands "highly increased" and has "no change" respectively. Still, there is a difference in the four Tabias. For example, in the Tabia of Atsela responded that grazing lands is not improving; instead, it is getting lower from time to time.

The focus group discussion participants from the Tabia of Endabagerima confirmed that even though grazing land is small, the area is protected from animal and human intervention and that the people also participated massively in public soil and water conservation. However, the limited sizes of communal grazing lands were open usually. The amount and duration of yearly rainfall was an important factor that determined the duration of opening and closing periods of the communal grazing lands, in Adwa district the opening and closing periods of the communal grazing lands are during the month of Meskerm (September), while in Emba-Alajie district, especially the Ayeba Tabia where the grass production was the highest and the topography is plain, so it has six opening and six closing months.

Fuelwood is one of the critical problems in all Tabias in the study area. People usually use animal dung and few eucalyptus trees grown on their private plots of land. About 48.7% of the household heads said that the number of trees has "increased" but 34.3% of them responded that wood production has "no change". The Pearson's correlation

coefficient indicates that there is no significant and negative relationship between the literacy status of the respondents and perception of the number of trees as a result of soil and water conservation practices ($r=-0.093$, $DF=298$, $p=0.109$) whereas it does a negative relationship between their literacy status and perception of wood production due to soil and water conservation practices($r=-0.155$, $DF=298$, $p<0.001$).



Figure 6:1: Photo January. 2013, in Adwa district

The reason why wood production has decreased, while the number of trees has increased, is that wood distribution from exlosures is yet not allowed. After soil and water conservation was introduced, at least, the degradation and depletion of the natural resource bases are minimized. All respondents agree that, had it not been for soil and water conservation, conditions would have worsened and hence people and animals would not have survived. The survey results indicated that soil erosion and flooding have decreased by 39.7% and 46% respectively. As to the livelihood security, 53% of household heads said that livelihood security decreased over time; but 20.7% and 20% of the respondents replied that livelihood security “no change” and has “highly decreased” respectively.

From the analysis, it was possible to understand that in all Tabias communities have a similar perception about the benefits of soil and water conservation. There is a common

consensus about the positive benefits of soil and water conservation practices. For example, one of the study sites named Endabagerima is found in a lower slope and is surrounded by chains of mountains; it is exposed to flooding but now, thanks to a massive soil and water conservation practices, the area is fully protected from flooding. Moreover, as participants confirmed, new springs have emerged and a discharge from the existing ones improved, new irrigation schemes have been started to be developed with the availability of water, biodiversity is regenerating and wild animals are emerging, and local-climate around the treated watersheds is improving. This result is supported and has been noted in terms of soil conservation, water infiltration, crop yield, biomass production, groundwater recharge, and flood hazard prevention (Berhanu *et al.*, 2003; Taffere, 2003).

This observation is further substantiated by field investigation in Tigray: a photographic record over 30 years, which show the status of natural resources since 1975. The study demonstrate that, in Tigray sheet and rill erosion rates have decreased, infiltration and spring discharge are enhanced, vegetation cover and crop production have improved. The rehabilitation was due to both the improved vegetation cover and to the implementation of physical conservation structures. Similarly, overall land management has improved in 85 % of the analyzed landscapes (Nyssen *et al.*, 2007). However, maintaining and enhancing farmers' participation is obviously a continuous challenge. Thus, it implies that sustained motivation will determine the success or the failure of any future soil and water conservation program in Tigray (Nyssen *et al.*, 2009; Reubens *et al.*, 2011). For this reason, community mobilization for collective action was considered an important intervention aimed at restoring the productive capacity of the land as water was conserved and soil loss was kept minimal.

6.4 Conclusions

The main purpose of this study was to investigate the factors that influence natural resources management and perception of community benefits from soil and water conservation practices in the highlands of Tigray, northern Ethiopia.

The local land users' understanding and perception of soil and water conservation practices is important when sustainable natural resources management options are considered. A large-scale mass mobilization undertaken for more than three decades in soil and water conservation practices has minimized flooding and thus soil erosion or degradation both in the farmlands and off-farm conservation, although it was less practiced in on-farm conservation compared to the off-farm conservation. Results of the study also indicated that perception of farmers towards benefits of conservation attempts in changing and hence important contribution towards livelihoods has been recorded. However, the benefits are not yet adequate. Therefore, if the people of the study areas are to continue with the community- based soil and water conservation practices, they have to realize tangible net benefits in terms of production and income as well as environmental improvements.

Communities of the study areas are facing difficulty with health hazards associated with community work because of the mountainous and hilly nature of topography in Tigray. This is worrying and can affect the contribution of labour to community work. Free grazing is also another major factor causing the destruction of the physical and biological conservation (both stone and soil bunds) works and the conflicts over communal grazing lands. Thus, restricted grazing and resolving the conflicts over communal grazing lands were critical for the sustainable management of communal grazing lands.

The study revealed that the landless people have tackled not only land degradation by applying various hillside conservation methods such as soil/stone bunds, trenches and tree plantation but also, creating alternative income through different activities such as the sales of honey production and growing vegetables.

Soil and water conservation practices in Tigray result in multifunctionality of the land and the livelihood of the community, although inadequate compared to the level of the degradation and depletion of natural resources and the low level of the livelihood of the community. There are certain major observable improvements after the implementation of integrated watershed management such as reduced soil erosion and increased soil moisture availability which could be explained by the increase in crop production; increased groundwater recharge; reduced sedimentation and run-off problems in the

lower parts of the watershed; stabilized gullies and river banks; rehabilitation of degraded lands and improved ecological balance; and introduction of modern beehives and increase in honey production. However, the benefits are not yet adequate.

Thus, in order to make the existing community natural resources management efficient and self-sustaining, it requires intervention by local administrator in the study areas, such as trainings by extension workers are right away required to change the perception of farmers about the benefits of conservation and give information the present successful existing of soil and water conservation practices via sitting best models in the study areas as well as in the region, so this can probably be used to obtain support of the local population. The local administrator should also provide some logistics associated with health care when accident occurs mainly in a large-scale mass mobilization of soil and water conservation practices, and the local leaders should give accreditation to informal institutions, in order to empower the local community and minimize the conflicts among the society in relation to communal natural resources management. Last, from this study raise policy issues that awareness creation among respective stakeholders would be important in the attempt to implement soil and water conservation practices and community natural resources management in sustainable ways.

CHAPTER SEVEN

7. Determinants of Farmers' Adoption of Soil and Water Conservation Practices in Tigray Region, Northern Ethiopia

7.1 Introduction

Soil erosion is one of the most important threats to the sustainability of agricultural systems in the developing countries (Eswaran, 1999; Eswaran *et al.*, 2001). The problem of soil degradation in Ethiopia is also well recognized. The causes and consequences have been substantiated in different regions of the country. Hurni (1988) for example noted that 'soil degradation can be regarded as a direct result of the past agricultural practices in the Ethiopian highlands'. Nyssen *et al.* (2008) also agreed that anthropogenic effects continue to be the main causes and driving factors for soil degradation in Ethiopia. This suggests that Ethiopia can be regarded as a good example where depletion of soil resources is massive. Dominated by small-scale agricultural producers, Ethiopia is one of the most severely eroded countries in the world (Hurni, 1993).

Prevention of such ecological crisis is completely necessary before the area manifests total failure to support human population. Hence, environmental conservation and rehabilitation efforts were started in the 1970s (Campbell, 1991; Keeley and Scoones, 2000; USAID, 2000). However, studies show adoption soil and water conservation by farmers remains low, and soil fertility continues to decline in the northern high lands of Ethiopia (Yeraswork, 2000; Berhanu and Swinton, 2003). Since 1991, soil and water conservation practices have been practiced at large scales. In this regard, Tigray National Regional State is an evident for its intensive environmental conservation and rehabilitation efforts in combating environmental degradation. As part of these efforts, soil and water conservation practices are among the major strategies adopted in the region (Berhanu *et al.*, 2000).

A review of the relevant literature points to the fact that a number of empirical studies have been undertaken on soil and water conservation adoption under Ethiopian context. However, there is no clear understanding of the problems encountered by farmers in the

adoption of recommended soil and water conservation practices. This requires the mapping out of farmers' interests and their own evaluation of soil and water conservation practices under different situations of farmers.

There are limited studies on private farmland management (Paudel and Thapa, 2004) to explain farmers' problems in the adoption of improved soil and water conservation practices. Besides, past studies conducted on soil and water conservation practices in the highlands of northern Ethiopia focused on biophysical aspects and little attention was given to socio-economic factors and it requires further analysis. Therefore, this study attempts to fill that gap by analyzing both the physical and socio-economic factors, such as, household income, household labour, institutional support such as credit, and personal attributes of the household head such as their education, age, and their influence in the adoption of soil and water conservation practices. Findings on the degree to which these factors affect the adoption of soil and water conservation practices will help in the development of locally suitable soil and water conservation practices and approaches.

Previous Empirical Studies on Adoption of Soil and Water Conservation Practices

Empirical studies in developing countries on the adoption of soil and water conservation practices by farmers have considered a broad range of factors. These can be loosely categorized into personal and household attributes, farm/plot and, socio-economic and institutional factors (Knowler and Bradshaw, 2007).

The personal and household attributes include factors like education, age, family size, gender distribution among others. For the most part, there is a positive correlation between level of education and number of SWCPs adopted; therefore indicating that formal education is an important variable explaining adoption behavior (Asrat *et al.*, 2004; Tenge *et al.*, 2004; Ersado *et al.*, 2004; Anley *et al.*, 2007). However, as observed by Scherr and Hazell (1994), education might offer alternative livelihood opportunities in off-farm activities thereby increasing the opportunity cost of labour and competing with labour use for agricultural production.

With regard to the age of the household head, previous research reveals the direction of the influence of this variable to be either way. For example, Sheferaw and Holden (1998)

and Asrat *et al.* (2004) for Ethiopia; Krishna *et al.* (2008) for Nepal found that farmer's age is negatively related to adoption of soil and water conservation practices. On the other hand, Aklilu (2006) for Ethiopia reported that farmer's age is positively related to adoption of soil and water conservation practices.

Wagayehu (2003) find family size to have a significantly negative relation with certain adoption choices. However, Aklilu (2006) who did not find statistically significant relationship between family size and adoption of stone terraces find the continued use of the practice was negatively impacted by the size of the family. Tenge *et al.* (2004) report evidence of gender imbalances was observed significantly more conservation investment occurs in households having more adult males and those with fewer females. This may have negative effects on the adoption of SWC measures because female-headed households have limited access to information on SWC and to land and other resources, due to traditional social barriers. However, Wagayehu (2003); Nkonya *et al.* (2005); Aklilu (2006) do not find any significant effect of gender of household head on the adoption of conservation practices.

Farm size is found to have mixed effects on adoption of soil and water conservation practices. While various studies (Wagayehu, 2003; Ersado *et al.*, 2004; Aklilu, 2006) find positive relation between adoption of conservation measures and farm size, Pender and Kerr (1998) find differential effects of farm size on conservation investment across the three villages they studied in India.

Land tenure is a difficult and often poorly-defined issue in developing countries, especially where varied cultural perceptions of ownership are involved. Rights of tenure and perceived tenure security are thought to be strong indicators of a farmer's attitude and willingness to implement soil and water conservation practices. This result is supported by the literature review that states secured land tenure gives incentives to farmers for applying and continue using land improving investments on their plots (Yeraswork, 2000; Berhanu and Swinton, 2003; Tenge *et al.*, 2004; Kabubo-Mariara, 2007). On the other hand, other authors suggest a challenging view in reporting that land tenure is not a strong indicator of adoption behavior (Place and Swallow, 2000; Asrat *et al.*, 2004; Fistum and Holden, 2006).

Wagayehu and Lars (2003) who found significant and negative correlation between no conservation decision and distance of a parcel from the residence but positive correlation between distance of the plot and adopting conservation decision in Ethiopia. Kessler (2006) also found out that farmers invest more in soil and water conservation in fields situated near to residences. Moreover, farmers cultivating vulnerable to erosion fields are more likely to adopt SWC practices in their farms than those cultivating less vulnerable lands. It implies slope of plots is positively related with adoption of soil and water conservation holding other factors constant (Shiferaw and Holden, 1998; Wagayehu and Lars, 2003; Berhanu and Swinton, 2003; Aklilu, 2006).

Though it is not strong, the association is consistent with recent findings by Pender and Kerr , 1998; Mbagwa-Semgawale and Folmer, 2000; Berhanu and Swinton, 2003; Tenge *et al.*, 2004; Aklilu, 2006). They reported off- farm income on farmers' had negative association with adoption of soil and water conservation practices.

Therefore, the conceptual framework of the adoption of soil and water conservation practices in this article is based on the comparative advantage to farmers in combination with some influence of the personal, socio-economical, institutional, and biophysical factors. The Binary logistic regression model has been used in this study to explain the factors that influence the decision of farmers to adopt or not adopt soil and water conservation practices.

7.2 Materials and Methods

7.2.1 Research Hypotheses

The complexity of the interdependence among different factors, made it difficult to take a separate examination of each factor under consideration. However, generally the hypothesis is that if individual households can earn significant contribution from the outcome of adoption of soil and water conservation (on livestock production and productivity, apiculture, vegetable production and better ecosystem); these households manage sustainably to perpetuate these benefits; otherwise the reverse is true other things

remained constant. Hence, as hypothesized in various adoption studies this study wants to test the following major factors.

Household Livelihood Strategy (Source of Income)

- The impact of those households with off-farm livelihood strategies on adoption of soil and water conservation practices cannot be determined *a priori*.

Household Human Capital:

- Farmers who are older adopt more soil and water conservation practices than younger; thus, age is expected to have positive relationship with soil and water conservation practices.
- Higher levels of literacy, training and secured land tenure are hypothesized to have positive association with adoption of soil and water conservation practices.
- Two opposing relationships are expected between adoption of soil and water conservation practices and household size. On the one hand, the larger the size of the household, the higher the subsistence consumption needs, and given a fixed land, the lower the willing of the farmer to participate in adoption of with soil and water conservation practices. On the other hand, larger household size is the source of labour which is an important input to adopt soil and water conservation practices, because it requires more labour. Hence cannot be determined *a priori*.
- Regarding sex of household head, female-headed households are expected to be less likely to adopt soil and water conservation practices, may be because of their less exposure to external environment and new adoption technology.

Household Physical Capital:

- Household physical capital endowment – land and oxen—is expected to have positive or negative relationship with its investment decision on soil and water conservation practices. So, cannot be determined *a priori*.

Household Financial Capital:

- Household's endowment of financial capital (e.g. household saving and access to credit service), is obviously expected to have a positive relationship with a farm household's investment decision on soil and water conservation practices.

Farmland factors:

- With respect to the influence of the characteristics of farm on the households, farm distance near to their home, steep slope farm plots, and infertile plots are expected to increase use of soil and water conservation practices.

7.2.2 Data sources and analysis

The data for the study was collected from primary sources. The main source of primary data was household survey that was conducted from December 2012 to May /2013 cropping season using a structured survey questionnaire. For the purpose of this study, the heads of the selected households (usually the household head is implicitly assumed to be the decision maker in adoption studies) were interviewed using a structured questionnaire which covers a broad range of personal, social, economical, institutional, and plot level issues relevant to the process of adoption of soil and water conservation practices or the instruments including questions related to the background information of the households such as socio-economic variables to determine the key predictors that differentiate household's strategy choice and choice of soil and water conservation . A random sample of 300 household's heads was included in the survey. Of the total, 208 (69.3%) farmers were adopters of soil and water conservation.

The study heavily depends on quantitative method of data analysis. The study used descriptive statistics (averages, cross-tabulation and percentages) as well as econometric models (Binary Logistic Regression). Frequency tables were generated for general information, t-tests were applied to compare the mean differences between adopters and non adopters, chi square tests were applied to analyze categorical data, and binary logistic regression was applied to find out the degree of relationship between independent and dependent variables influencing the adoption of soil and water conservation practices. To this end, the study employed version 17 of the Statistical Package for Social Science (SPSS) and STATA version 10.

Table 7-1: Definitions of Variables Used in the Regression Analyses

Explanatory Variables	Definition
Expected direction of the relation between HHHS characteristics and decision to adopt the soil and water conservation practices	
AGE(+)	Age of the household head in years
SEXDMY(+)	Sex of respondent; male= 1, Else=0
HHSIZE(+/-)	Total number of household size
HHLIT(+)	Literacy status of household head 1=literate, 0= otherwise
TENURE(+)	Whether a farmer perceives a risk of loss of land in the future; 1 if he/she perceives 0 otherwise
FMSIZE (+/-)	The size of the farm, in hectares
DISTANCE(+)	Average distance of a plot from homestead, in minutes
SLOPE_CAT(+)	Slope category of majority of household head land; flat and mid slope=1, Else=0
TRAINING(+)	Whether training about soil conservation received by the farmer; 1 if a farmer got training and 0 otherwise
CREDIT(+)	Credit access of household head; Yes=1, Else=0
OFF_FARM(+/-)	Whether a farmer engaged in off-farm employment; 1 if a farmer has off-farm employment and 0 otherwise
PERCEIVE(+)	Whether a farmer perceives soil erosion as a problem; 1 if farmer had perceived erosion as a problem and 0 otherwise
LIVESTOC(+/-)	Livestock holding (in TLU)
SOIL_FERTI(+)	Soil fertility category of majority of household head land; infertile=1, Else=0
<p><i>Note:</i></p> <ul style="list-style-type: none"> • <i>Dependent variable- decision to adopt signs (+/-), in braces indicate the expected sign of coefficients of the specified variable to soil and water conservation practices adoption.</i> 	

7.3 Results And Discussions

This section is divided into two parts. The first part discusses mainly the descriptive analysis regarding socio economic characteristics of farmers, and farmers' adoption of soil and water conservation practices. In the second part, econometric analysis (binary logit model) is used to identify the principal factors that determine adoption of soil and water conservation practices in the study area, Northern Ethiopia.

7.3.1 Socio-Economic Characteristics of Farmers

In this section the general household characteristics of adopters and non-adopters are presented and selected variables were used for logistic regression analysis in Section 7.3. In addition to tabular presentation and description of variables, all variables under consideration were tested to see their statistical significance.

Mean ages of adopters and non-adopters were 45.3 and 45.4 years, respectively. This study however, showed that there was no statistically significant difference in age between the two groups. This means age may not be important in influencing adoption decision for soil and water conservation practices.

Statistically significant differences ($p=0.039$) were found in adoption rates between male- and female-headed households (Table 7.2). Male-headed households have adopted more often than female-headed households. This implies that sex could have influence in adoption of soil and water conservation practices.

Household size is a major determinant in adoption of soil and water conservation practices, especially with respect to poor resource farmers who depend solely on family labour to maintain their farms. As shown in Table 7.2, the average household size is also more or less the same (6 persons rounding to the nearest whole number). The difference is not significant at 10 % level. This means the variable may not be important in influencing adoption decision for soil and water conservation practices in the area.

More literate farmers are assumed to increase the ability to obtain process and use of information relevant to the use of new adoption technology. In addition, high rate of literacy increases the capacity and ability to obtain and apply relevant information concerning the use of soil and water conservation practices. In both groups, that is, adopters and non-adopters, it was found that the majority of HHHs had basic literacy, 65.9% and 31.5% among adopters and non-adopters respectively. The survey result shows variation statistically significant at less than 10 percent level. Thus, literacy could have contribution in soil and water conservation adoption in the area.

Farmers' perception of soil erosion and recognizing it as a problem is an important factor that influences the adoption of soil and water conservation practices. Table 7.2 showed significant differences were observed on the level of perception regarding the causes of erosion between adopters (52.6%) and non-adopters (47.4%). Similarly, chi-square tests showed that the use of credit, training about soil and water conservation, techniques a farmer engaged in off-farm employment and soil fertility categories of majority of households land were significantly higher among adopters compared with non adopter (Table 7.2).

Table 7-2: Description and summary statistics (mean and percentage) of the variables used in the binary logistic model (n = 300)

Variable	Description	Adopters	Non adopters	Significance
Adoption	Dependent variable: decision to adopt (%)	69.3	30.7	
Age ^a	Mean Age of the household head in years	45.3	45.4	0.692
Sex ^b	Sex of the respondent (%)			0.039 ^d
	Female (%)	28.4	45	
	Male (%)	71.6	54.3	
Household size ^a	Total number of household members	5.9	5.8	0.330
Literacy ^b	Literacy status of household head (%)			0.054 ^e
	Literate (%)	65.9	31.5	
	Illiterate (%)	34.1	68.5	
Tenure ^b	Farmer's perception towards tenure (%)			0.007 ^c
	Yes (%)	79.8	58.7	
	No (%)	20.2	41.3	
Farm size ^a	The size of the farm, in hectares	0.76	0.74	0.672
DISTANCE ^a	Average distance of a plot from homestead, in minutes	31.8	33.2	0.939
Slope ^b	slope category of majority of household land			0.363
	Flat and mid slope (%)	58.0	42.0	
	Others (%)	65.8	34.2	
TRAINING ^b	Training about soil conservation received by the farmer (%)			0.093 ^e
	Yes (%)	56.2	43.8	
	No (%)	64.9	35.1	
Credit ^b	Credit access household (%)			0.389
	Yes (%)	60.6	39.4	
	No (%)	55.2	44.8	
off farm ^b	A farmer engaged in off-farm employment (%)			0.943
	Yes (%)	58.8	41.2	
	No (%)	59.2	40.8	
PERCEIVE ^b	A farmer perceives soil erosion as a problem (%)			0.023 ^d
	Yes (%)	52.6	47.4	
	No (%)	65.5	34.5	
Livestock ^a	Livestock holding (in TLU)	2.7	2.7	0.386
soil fertility ^b	Soil fertility category of majority of household land (%)			0.291
	Infertile (%)	50.0	50.0	
	Fertile (%)	60.0	40.0	

Source: Survey data, 2012/13

n = number of respondents

a Continuous variable and use t-test

b Dummy variables and use X² test

c, d and e represent significant at 1%, 5%, and 10% respectively

7.3.2 Results of Logistic Regression Model

As highlighted in the literature review, empirical studies have considered a broad range of factors such as credit constraint, limited access to information, farm size, socio-economic and institutional factors to assess adoption of soil and water conservation practices by farmers. Yet, not all factors are equally important in different areas and for farmers with different socio-economic situations. This means the decision to adopt or not a particular measure of soil and water conservation varies depending on age of farmer, educational level of household size, landholding size, livestock ownership and other factors that indicate the wealth status of farmers. This section of the study is devoted to test the relative effect of the variables under consideration towards adoption of soil and water conservation in the study area.

Table 7.3 presents the logit estimates of the determinants of likelihood of soil and water conservation practices adoption. A chi-square test which measures the goodness of fit of the model is found to be significant at 1 percent level; signifying a good fit .i.e., the model is adequate.

With regard to the age of the household head, previous researches reveal that the direction of the influence of this variable is either way. Farmer's age is negatively related to the adoption of soil and water conservation practices (Shiferaw and Holden (1998) and Asrat *et al.* (2004) for Ethiopia and Krishna *et al.* (2008)) for Nepal. On the other hand, Aklilu (2006) for Ethiopia reported that farmer's age is positively related to adoption of soil and water conservation practices. As Table 7.2 shows, the average age of household heads was high, which was about 45 years. In this study age variable has, a positive coefficient and significant at 1 percent level, signifying a strong impact on decision to adopt soil and water conservation practices. This can be explained by the fact that older farmers have longer farming experience and relates to the use of soil and water conservation practices as compared to the younger counterparts. The odds ratio, 1.04 implies that one unit increase in age of household head increases the odds of adopting soil and water conservation practices about 1.04 times, keeping other variables in the model constant. This implies older farmers adopt more soil and water conservation practices than the younger counterparts do.

As observed by Shiferaw and Holden (1998), the effect of household size on the adoption of soil and water conservation practices may be either positive or negative. Larger households are able to provide the labour that is required for establishing and maintaining selected conservation structures and smaller ones may face labour problems which may hinder adoption and sustained use of certain practices. However, Demeke (2003) found out that if a family is larger, there will be more demand for land to meet subsistence needs. Hence, members may not adopt soil and water conservation practices. Result from the logistic regression shows that household size and adoption of soil and water conservation practices has negative association, but not significant at 10 percent level. It signifies that household size was not important factor to influence the adoption of soil and water conservation practices in the area.

To test this hypothesis a literacy status dummy was included in the logit model. The variables literacy status of household head was positively related to soil and water conservation adoption, significant at less than 1% level. The marginal analysis in Table 7.4 also shows that other factors held constant at their mean level, literacy status affected farmer's probability to adopt soil and water conservation by 55.3%, significant at 1 percent level. Moreover, the odds ratio, 4.04 implies that one unit increase in literacy level of a household head increase the odds of adopting soil and water conservation practices about 4.04 times, keeping other variables in the model constant. The implication is that farmers who acquired better literate are more likely to adopt than illiterate. This can be explained that better literacy rate of the household head improved their ability to contact information, and strengthened his/her analytical capabilities with new technology. Moreover, a longer literate leads to a better understanding of the new technology when reviewing the different extension materials, which enhanced adoption of improved soil and water conservation practices.

The relationships between farm size, soil and water conservation practices differ from place to place. Farm size is found to have mixed effects on adoption of soil and water conservation practices. While various studies (Wagayehu and Lars, 2003; Ersado *et al.*, 2004; Aklilu, 2006) indicated positive relation between adoption of soil and water conservation practices and farm size, Pender and Kerr (1998) find differential effects of

farm size on soil and water conservation practices across the three villages they studied in India. However in this study, farm size was found to influence adoption of soil and water conservation practices positively and significant at 5 percent level. The odds ratio, 2.73 implies that one unit increase in farm size of a household head increases the odds of adopting soil and water conservation practices about 2.73 times, keeping other variables in the model constant. The positive influence might be explained that a large proportion of farmers with larger farm sizes tend to use soil and water conservation practices on any of their plots. This may be the reason that there is significant relationship between large farm size and the probability of adoption of soil and water conservation.

Land tenure as an important predictor was also assessed and the result shows, as expected, a positive and significant relationship at 5 percent level, signifying a strong impact on decision to adopt soil and water conservation practices. Thus, farmers that have accessed to land they cultivate through inherited or obtained from the Tabias administration are more likely to adopt soil and water conservation practices than their counterparts that renting or share-cropping. The odds of a farmer that inherited land to adoption of soil and water conservation practices is 2.11 times the odds of farmers that accessed for renting or share cropping. This can be explained by the fact that farmers cultivating their own lands are more secured compared to those rented. The possible explanation is that land ownership has some influence on adoption of soil and water conservation practices. Most farmers feel secure under the current land tenure system, and tenure is not a constraint in most cases. However a few farm groups who rent land mainly young people and new landless regard insecure tenure as a constraint in the adoption of soil and water conservation practices.

Table 7-3: Factors that affect sustainability of soil and water conservation (logit model)

Explanatory Vars.	Coef.	Odds Ratio	Z-value	P-value
AGE	0.042*	1.043	2.58	0.010
SEX	0.343	1.409	1.05	0.294
HOUSEHOLD HEAD SIZE	-0.105	0.899	-1.10	0.272
LITERACY	1.396*	4.042	4.63	0.000
TENURE	0.749**	2.116	2.34	0.019
FARM SIZE	1.005***	2.731	2.11	0.035
DISTANCE	0.004	1.003	0.62	0.537
SLOPE_CATEGORY	0.052	1.053	0.22	0.825
TRAINING	-0.103	0.902	-0.31	0.758
CREDIT	0.822 **	2.274	2.71	0.007
OFF FARM	0.082	1.085	0.26	0.794
PERCEIVE	0.378	1.459	1.24	0.215
LIVESTOCK	-0.005	0.995	-0.08	0.940
SOIL FERTILITY	-0.368	0.692	-0.96	0.337
CONSTANT	-4.013*		-3.68	0.000
Number of valid obs = 300 LR chi2(14) = 67.41 Prob > chi2 = 0.0000 Log likelihood = -151.21524 Pseudo R2 = 0.1823 *, **, *** represent significant at 1,5%, and 10% respectively.				

Source: Model Output, 2012/13

As expected of this study, the coefficient of distance of a farm from homestead was found to be positive but not significant. This should have given them the opportunity to pay more attention to nearby farms with less care to distant farms. This can be attributed to the fact that farmers give more attention to nearby plots and the care given to distant plots is low. Therefore, the greater distance of a plot from homestead, and the fragmented nature of the plots may have discouraged farmers from giving the necessary care and maintenance of soil and water conservation practices. This finding is not in agreement with (Wagayehu, and Lars, 2003) who found significant and negative correlation between no conservation decision and distance of a parcel from the residence but positive correlation between distance of the plot and adopting conservation decision in Ethiopia (Kessler, 2006) also found out that farmers invest more in soil and water conservation in fields situated near to residences.

Table 7-4: Marginal Effects of Adoption Variables

Explanatory variables	Partial derivatives(dy/dx)	Z	P-value	Mean value of variables
AGE	0 .008	2.61	0.009	45.34
SEX*	0.067	1.03	0.305	0.66
HOUSEHOLD HEAD SIZE	-0.020	-1.10	0.270	5.82
LITERACY *	0.273	4.78	0.000	0.55
TENURE*	0.154	2.21	0.027	0.73
FMSIZE	0.192	2.13	0.033	0.71
DISTANCE	0.001	0.62	0.537	32.62
SLOPE_CATGORY*	0.009	0.22	0.825	1.72
TRAINING*	-0.019	-0.31	0.758	1.29
CREDIT*	0 .157	2.74	0.006	1.46
OFF_FARM*	0.015	0.26	0.794	0.48
PERCEIVE*	0.074	1.22	0.224	0.62
LIVESTOCK	-0.001	-0.08	0.940	2.70
SOIL_FERTILTY*	-0.074	-0.92	0.358	0.20

Source: Based on Model Output, 2012/13

The slope of a plot was included as an explanatory variable. Considering the assumption of the higher the slope category of a plot, the greater will be the severity of soil erosion. This means that on sloping plot the impact of soil erosion would be more visible to the farmers and force them to take remedial actions. This is because slope is an indicator of soil and water loss from the farmland. Thus, farmers cultivating sloping fields perceive the threat of soil loss better than farmers who cultivate gentle or level sloping fields. This implies that farmers cultivating vulnerable fields are more likely to adopt soil and water conservation practices in their farms than those cultivating less vulnerable lands. It implies slope of plots is positively related with adoption of soil and water conservation holding other factors constant. The finding supports to that of (Shiferaw and Holden ,1998; Wagayehu and Lars , 2003; Berhanu and Swinton 2003; Aklilu , 2006). As per the same authors, the conclusion was that a positive and not significant effect of the slope of a plot on the decision to adopt soil and water conservation practices.

Another important factor analyzed in the adoption model is the level of off-farm income. Off-farm employment does not necessarily lead to more sustainable land use. Rather, better access to off-farm activities reduces farmers' incentives to invest on soil and water

conservation practices. It has positive sign but not significant. Though it is not strong, the association is consistent with recent findings by (Pender and Kerr, 1998; Berhanu and Swinton, 2003; Tenge *et al.*, 2004; Akililu, 2006). They reported off-farm income on farmers' had negative association with adoption of soil and water conservation practices. However, it was hypothesized that the more the farmer earns off-farm income the less liquidity problem he/she faces so that he/she is more likely to adopt soil and water conservation practices even in the absence of credit access. It has positive sign but not significant at 10 percent level.

The positive influence might be explained that farm income is low and the farmers cannot rely on agriculture. The low annual farm income has probably forced some of sample households to engage in off-farm activities. Household's survival depends on the ability to generate off-farm income so as to smooth their consumption as means of risk management. Major reason could be that majority of the households rely on non-farm activities as they have very small and fragmented farm size. The implication is that farmers are discouraged to rely on farming, which in turn, may result farmer's to under invest on their farmlands.

Contrary to our expectations, the effect of soil fertility on adoption decision was found to have negative association, but not significant at 10 percent level. Plots with both fertile and infertile soils negatively influenced farmers' adoption of soil and water conservation. possibly the majority of the farmers of their farm land in plain and mid slope areas and they did look only short term economic benefits of the land or they did not see the negative effects of erosion on their plots in the long term.

Access to credit and adoption of soil and water conservation practices is given much emphasis in many empirical studies. In the same way in this study the effects of credit was assessed. The result showed, as expected, a positive and significant at 1 percent level, signifying a strong impact on decision to adopt soil and water conservation practices. The odds in favor of adopting soil and water conservation increased by a factor of 2.27 for adopters probably because they had better credit access. The marginal effect analysis (Table 7.4) also shows credit access affected farmer's probability to adopt soil and water conservation by 14.6%, other variables remained at their mean level,

significant at 1% level of confidence. This implies that households with better access to credit are more likely to have higher probability of adopting soil and water conservation than those without access.

Moreover, other variables, such as training, perception of soil erosion, and livestock, did not significantly influence the adoption of soil and water conservation practices and had only weak explanatory power in the model.

7.4 Conclusions

The findings of this study have important policy implications for the adoption of soil and water conservation practices. Any further improved conservation technology initiative should aim at enabling local farmers to adopt soil and water conservation practices conducive to increasing income as well as to enhancing soil conservation. Descriptive data analysis showed that only 69.3% of the household adopted soil and water conservation practices.

The descriptive analysis of most of the household heads characteristics and physical characteristics assumed to influence adoption of soil and water conservation were found to have significant variation between the adopters and non-adopters. From this analysis the variables, sex, literacy level, training about soil and water conservation, perception of the households in relation to soil erosion and tenure status variations between the two groups were significantly different. Thus, it can be concluded that these variables could be important factors in adoption of soil and water conservation decision.

An econometric estimation of selected variables that were hypothesized to affect the adoption of soil and water conservation practices was done using logistic model. The study also revealed that age (significant at $P < 0.010$), literacy (significant at $P < 0.000$) tenure (significant at $P < 0.019$), farm size (significant at $P < 0.035$), and credit access (significant at $P < 0.007$) have positive influence on adoption of soil and water conservation practices while household size, training, perception of the households in relation to soil erosion, soil fertility and number of livestock have negative effect on adoption of soil and water conservation practices in the study area and they were not significant.

These findings strengthen the fact that in order to achieve sustainable adoption of soil and water conservation practices, institutional and economic factors should be given special attention. Based on the study findings, the following implications were drawn.

In the area due to small farm size and fragmented plots of land households are characterized by food insecurity. Any effort to achieve food security should enhance both farm and off-farm income in a way that reinforce each other, extension workers or development agents are urgently needed to give educate the farmers to maximize public awareness for the effective and sustainable use of soil and water conservation practices, and the availability of credit is not a solution by itself unless it is accompanied by better rearrangement on repayments. Farmers should be given repayment grace period in times of complete crop failure. Credit access should not also associate with the wealth status of farmers such as oxen and landholdings to address the poor to participate in the application of modern technologies. Finally there is need for sensitization of farmers to form groups to benefit formal training of all community in soil and water conservation technologies and capacity building of farmers in other livelihoods areas to reduce burden on natural resources.

CHAPTER EIGHT

8. Summary And Conclusions

For Ethiopia, land is a vital resource, in view of the fact that agriculture is the engine and leading economic sector; however severe land degradation affects the livelihood of many farmers in the Ethiopian highlands. In response, the government has invested in soil and water conservation practices, mainly in the degraded lands. Nevertheless, past attempts to restore the degraded parts of these resources were not able to offer expected results. This entails the need to undertake further studies on the extent of the problem and in order to make the existing soil and water conservation practices in Tigray region self sustaining, it requires investigating the entire problem afresh.

Generally, the central focuses of this study were to assess the contribution of soil and water conservation practices for sustainable rural livelihoods at household level and environmental protection concurrently in two districts of northern Ethiopia, namely Adwa and Emba-Alajie. In general, the major or key topics of this study were adoption of soil and water conservation practices among farm wealth groups and effects of spatial gradients, livelihoods activities, perceptions of community benefits of soil and water conservation practices to farmer's livelihoods and to their environment, linkage between community natural resource management and to their environment and, modeling the determinants that affect sustainability of soil and water conservation.

Chapter 2 and 3 provides relevant literatures, and briefly provide the setting of the research area focusing on socioeconomic and physical features of the study area. It also provides a description of the general research methodology and the analytical approach.

Chapter 4 presents adoption of soil and water conservation practices among farm wealth groups and its benefits towards livelihoods system were assessed through household survey and participatory transects walks with groups of selected farmers from different farm wealth groups and agricultural expert. The study used descriptive statistics (averages, cross-tabulation, and percentages). In inferential statistical analysis t-test, ANOVA and chi-square test were used.

Chapter 5 assesses the effect of spatial gradient on adoption of soil and water conservation practices and soil fertility management were assessed. To this end, data were then delineated by spatial gradient and farm wealth groups. Answers to questions regarding implementation of the specific adoption of soil and water conservation practice and data for soil fertility improvement were recorded using dichotomous and continuous data form (measurement). Chi-square (χ^2) analytical test was used to assess whether there is statistical significant difference between two or more nominal variables and the significance difference of spatial gradient and farm wealth groups were tested using analysis of variance (ANOVA).

Chapter 6 examines the linkage between community natural resource management and their perceptions on the benefits of soil and water conservation practices'. In this regard, focus group discussions, semi-structured questionnaire, key informants interview and field visits by the researcher were carried out to obtain the required information

Chapter 7 investigated the determinants of adoption of soil and water conservation practices. Data were collected by a means of questionnaire from a random sample of 300 farm households during December 2012 to May 2013 in two districts of northern Ethiopia, namely Adwa and Emba-Alajjie. T-tests were applied to compare the mean differences between adopters and non adopters, chi square tests were applied to analyze categorical data, and binary logistic regression was applied to predict variables that influence the adoption of soil and water conservation practices.

Synthesis

This dissertation is prepared in such a way that each of the four core chapters can be read more or less independently. Consequently, on the basis of the findings of each chapter, conclusions and policy implications were given at the end of each chapter. Therefore, this chapter provides synthesis of policy and practical implications of the findings. Four major research objectives (chapter 1 section 1.3) were formulated. In order to meet these research objectives, data (mainly primary data) were collected and various analytical tools were applied. The major findings and policy implications from the study presented below.

Adoption of soil and water conservation practices among farm wealth groups and its benefits to livelihoods at household level, were assessed through a sample survey and transect walks in two districts of Adwa, and Emba-Alajie. Results indicated that considerable proportion of farmers were adopters of soil and water conservation practices on their farms in study areas, one third (quarter) of the farmers on the other hand were non adopters. Wealth status has significant variation in the adoption of soil and water conservation practices. This implies that wealth influences adoption of soil and water conservation practices. Moreover, the rich category applied significantly higher quantity of inorganic fertilizer and manure than medium and poor farm groups of both study sites. Adoption of soil and water conservation practices was perceived and valued as positive by all the farmers regardless of wealth differences. The farmers pointed advantages soil and water conservation practices outweigh the disadvantages.

The finding also shows five main dominant sources of livelihoods with a small variation in their mean annual income of both farm and off-farm incomes of adopters and non-adopters of soil and water conservation practices. Moreover, off-farm income of both adopters and non-adopters was smaller than their respective farm income. The major reasons were some of households which are food unsecured and as the same time old aged are included in safety net a program and another strategic reason to rely on off-farm activities is some of farm households have never become food secured every year even at times of good reason. In this study households whether diversified their strategies out of agriculture in all dominant sources of livelihoods, adopters of soil and water conservation practices have relatively better income than non-adopters do. Therefore, it can be concluded that farm households who are engaged in off-farm activities can also invest in the adoption of soil and water conservation practices as they have a regular source of income and an understanding of the problems.

Therefore, to promote conservation efforts, policies should identify social and economic factors with respect to soil and water conservation and integrate them into the plans, according to the results, social and wealth status have significant variation in the adoption of soil and water conservation practices. Moreover, conservation should therefore be linked to subsidies if possible and credit facilities for those poor farm wealth groups for

long duration period of time because the application of fertilizers in combination with this adoption of soil and water conservation practices is highly important to recover the nutrient balance of the soil. Any effort to achieve sustainable adoption of soil and water conservation practice should enhance both farm and off-farm income in a way that reinforce each other. The study reveals that when considering adoption of soil and water conservation practices, it is important to assess the wealth distribution of households and its implications for risk preferences to the use of soil and water conservation practices. Moreover, soil and water conservation practices should not only be aimed at minimizing soil erosion but should also cover other household objectives, such as the improvement of soil fertility, yield increase and fodder for animals. Finally, the livelihoods of the individual farmers show hardly any direct links with soil and water conservation practices but a few are to be found.

Analysis of effect of spatial gradient on adoption of soil and water conservation practices and soil fertility management were examined. Adoption of soil and water conservation and soil fertility management were influenced by changes in spatial gradient and farm wealth groups. Spatial gradient and farm wealth groups showed variation in adoption of soil and water conservation practices and soil fertility management. This indicates that spatial gradient and farm wealth groups cause variation in the adoption of soil and water conservation practices, however, average plots distance from the homestead was not a major factor for soil fertility management because farmers far from homestead were applied well than plots located near to homesteads. Large farm size and rich farm wealth groups showed significant and positive relation with adoption of soil and water conservation practices and soil fertility management.

To minimize these differences, interventions should focus on improving farmers' livelihood asset endowments in order to strengthen their capacity to adopt soil and water conservation practices and soil fertility management. As households show improvements in their social and economic scenarios they are able to buy large amount of fertilizer for their plots. Taking into consideration the benefits of soil and water conservation practices to improving the soil quality and thereby sustainable agricultural productivity, there should be a continuous awareness creation mechanism and a follow up process on

the proper maintenance and management of the soil and water conservation practices along with integrating agronomic measures.

Analysis of natural resources management and perceptions of community benefit from soil and water conservation practices indicated that a large-scale mass mobilization undertaken for more than three decades in soil and water conservation practices has minimized flooding and thus soil erosion or degradation both in the farmlands and off-farm conservation, although it was less practice in on-farm conservation compared to the off-farm conservation. Results of the study also indicated that perception of farmers towards benefits of conservation attempts is changing and hence important contribution towards livelihoods has been recorded. However, the benefits are not yet adequate. Communities of the study areas were facing difficulty with health hazards associated with community work because of the mountainous and hilly nature of topography in Tigray. This is worrying and can affect the contribution of free labour to community work. Free grazing was also another major factor causing the destruction of the physical and biological conservation (both stone and soil bunds) works and the conflicts over communal grazing lands.

Thus, in order to make the existing community natural resources management efficient and self-sustaining, it requires intervention by local administrator in the study areas, such as trainings by extension workers and give information the present successful existing of soil and water conservation practices via sitting best models in the study areas as well as in the region, so this can probably be used to obtain support of the local population. Thus, the local leaders should provide logistics associated with health care when accident occurs, give accreditation to informal institutions, in order to empower the local community and minimize the conflicts among the society in relation to communal natural resource management. Last, from this study raise policy issues that awareness creation among respective stakeholders would be important in the attempt to implement soil and water conservation practices and community natural resources management in sustainable ways.

Determinants of farmers' adoption of soil and water conservation practices were assessed. Any further improved conservation technology initiative should aim at enabling

local farmers to adopt soil and water conservation practices conducive to increasing income as well as to enhancing soil conservation. Descriptive data analysis showed that only 69.3 percent of the household adopted soil and water conservation practices. The descriptive analysis of most of the household heads characteristics and physical characteristics of their plots assumed to influence adoption of soil and water conservation were found to have significant variation between the adopters and non-adopters. The empirical results from binary logistic regression model showed, age, literacy, tenure, farm size, and credit access were positive and significant predictors of adoption of soil and water conservation practices.

Thus, in order to achieve sustainable adoption of soil and water conservation practices, institutional and economic factors should be given special attention. Extension workers or development agents are urgently needed to give education for farmers to maximize public awareness for the effective and sustainable use of soil and water conservation practices, and the availability of credit is not a solution by itself unless it is accompanied by better rearrangement on repayments. Farmers should be given repayment grace period in times of complete crop failure. Credit access should not also associate with the wealth status of farmers such as oxen and landholdings to address the poor to participate in the application of modern technologies. Finally there is need for sensitization of farmers to form groups to benefit formal training of all community in soil and water conservation technologies and capacity building of farmers in other livelihoods areas to reduce burden on natural resources.

Generally, the findings of this study revealed that there are variations in the adoption of soil and water conservation practices among farms wealth groups with diverse socio-economic standing in line with their varying experiences among different landscapes or spatial gradients in conservation measures are prevalent in two districts of northern Ethiopia, namely Adwa and Emba-Alajie. This requires that there is an urgent need to improve the existing soil and water conservation practices and links with rural livelihoods. This could be achieved through new applied technologies for studying natural resources management and should include studying spatial gradients across social and biophysical boundaries, considering existing situations and limitations of adoption

and implementation of soil and water conservation practices, diversifying off-farm economic activities, investigation of spatial gradients from the household level to the plot level. Moreover, through better understanding of local power structures in determining how resources are controlled and allocated, this could be achieved through integrated approach natural resources management and developed with the consent of all stakeholders starting from planning up to evaluation. The pressure on the agricultural lands in this study area and especially Tigray Regional State will be even greater in the future and danger of soil erosion or land degradation will increase. Due to this fact, more coordinated activities to implement soil and water conservation technologies as well as research would have paramount contribution in solving the problems.

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