DETERMINANTS OFADOPTION OF PHYSICAL SOIL AND WATER CONSERVATION MEASURES IN CENTRAL RIFT VALLEY OF ETHIOPIA: THE CASE OF DALOCHA DISTRICT

M.Sc. Thesis

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DETERMINANTS OFADOPTION OF PHYSICAL SOIL AND WATER CONSERVATION MEASURES IN CENTRAL RIFT VALLEY OF ETHIOPIA: THE CASE OF DALOCHA DISTRICT

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By

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As thesis research advisor, we hereby certify that we have read and evaluated the thesis prepared by Merga Negassa Doje entitled Determinants of Adoption of Physical Soil and Water Conservation Measures in Central Rift Valley of Ethiopia: The Case of Dalocha District. We recommend that it can be submitted as fulfilling thesis requirement.

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DEDICATION

This manuscript is dedicated to my beloved family and the toiling farmers of Dalocha in particular and the farming community of Ethiopia at large.

STATEMENT OF AUTHOR

First, I declare that this thesis is my original work and all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for the M.Sc. degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to borrowers under rules and regulation of the Library. I also declare that this thesis can be submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate, if the University found it necessary.

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BIOGRAPHICAL SKETCH

The author was born on May 7, 1967 at Amuru District of Horo Guduru Wollega Zone, Oromia Regional. He attended his Elementary and Junior Secondary School Education at Amuru School. Then, he joined Shambu Senior Secondary School and completed his secondary education in 1983. He joined the then, Jimma Junior College of Agriculture, now Jimma University, College of Agriculture and Veterinary Medicine, in September, 1983 and completed two years diploma program in general agriculture in November, 1985.

After his graduation, he was employed by Ministry of Agriculture and served the organization for more than 15 years, in Oromia and SNNPRS of different Districts at various levels. Then, he joined Wondo Genet College of Forestry and Natural Resource in October, 2000 in Continuing education program and graduated with B.Sc degree in forestry in December, 2006. After graduation, he continued to serve in Dalocha District office of agricultural development.

Finally, after serving for a total of three years with B.Sc. he joined the School of Graduate Studies of Jimma University, College of Agriculture and Veterinary Medicine in October, 2009 to pursue his M.Sc in Natural Resource Management field of Watershed Management.

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ACRONYMS AND ABBREVATIONS

ADB	Africa Development Bank
CIMMYT	International Maize and Wheat Improvement Center
CSA	Central Statistical Agency
DA	Development Agents
EFAP	Ethiopian Forestry Action Plan
FAO	Food and Agricultural Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
ha	hectare
HH	Household Head
kg	kilogram
m.a.s.l	meter above sea level
mm	millimeter
MoARD	Ministry of Agriculture and Rural Development
NGO	Non-Governmental Organizations
SNNPRS	South Nations Nationalities and People's Regional State
SPSS	Statistical Package for Social Science
SWC	Soil and Water Conservation
TLU	Tropical Livestock Unit
UNEP	United Nations Environmental Program
USAID	United State Agency for International Development
VIF	Variance Inflation Factors
WFP	World Food Program of the United Nations
WOCAT	World Overview of Conservation Approach and Technology
WRI	World Resources Institute

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DETERMINANTS OF ADOPTION OF PHYSICAL SOIL AND WATER CONSERVATION MEASURES IN CENTRAL RIFT VALLEY OF ETHIOPIA: THE CASE OF DALOCHA DISTRICT

ABSTRACT

In central rift valley of Ethiopia, land degradation resulting from soil erosion and nutrients depletion is a serious environmental and socioeconomic problem. Although different soil and water conservation technologies have extensively been introduced and implemented over the past decades, adoption of the measures was not glamorous. Therefore, this study was conducted to identify the determinants of soil and water conservation structures adoption, and to assess the current and common soil and water conservation practices in Dalocha district of Siltie zone. A three-stage sampling procedure was used to identify kebeles, villages and sample households. The data were collected from 120 sample households selected randomly using probability proportional to sample size sampling technique. Qualitative data were generated from focus group discussions, key informant interviews and field observation using checklists, while quantitative data were collected from sampled households using structured interview schedule. Descriptive statistics and binary logistic regression model were employed to analyze the data collected from sample households. Both indigenous and improved soil and water conservation measures are practiced in the study area. The study results revealed that 64% of sample households were adopters and 36% of sample households were non adopters of soil and water conservation measures during study year. Results of the binary logistic regression model showed that land holding size, extension service or contact, active family labour force and slope of farm land positively and significantly affect farmers' decision to adopt soil and water conservation structures. On the other hand, family size and number of dependent members in the household have a negative and significant influence on the adoption of soil and water conservation activities in the study area. Whereas, age, sex, education level, off-farm activities, livestock holding, training, distance of farm plot, tenure security and perception of soil erosion problem show not significant influence on farmers' adoption decision. The result of this study indicates that determinants of adoption of soil and water conservation technologies are a result of interplay of factors such as household demographic, socio-economic, physical and institutional characteristics of specific area. Hence, soil and water conservation intervention should consider not only physical performance of the measures but also recognize the heterogeneity in household characteristics such as family size, dependency ratio, active family labour force, access to extension service, land holding size, slope of farm land and farming system of specific area. Finally, intensive agriculture, strengthening agricultural extension service through extension events and training, promoting family planning in program intervention and integrating engineering practices with food, fodder and other vegetative measures are suggested as recommendation.

Key words: Adoption, Determinants, Ethiopian central rift valley, Soil and water conservation

1. INTRODUCTION

Throughout the world today, depletion of natural resources is among the major problems facing humanity. It was a significant global issue during the 20th century and will remain of high importance in the 21st century because of its adverse impact on land productivity, the environment, and its effect on food security and the quality of life (Eswaran *et al*., 2001). Productivity impacts of land degradation are due to a decline in land quality on site where degradation occurs (e.g. erosion) and off site where sediments have deposited. However, the on-site impacts of land degradation on productivity are easily masked due to use of additional inputs and adoption of improved technology. The problem is most acute where the environment is intrinsically vulnerable and where the population growth is losing control of its own resources (Ludi, 2004).

A survey of soil degradation estimated that nine million hectares of land are tremendously degraded; with their original biotic functions completely disappeared, and 1.2 billion hectares, i.e. ten percent of the earth's vegetative surface, are at least moderately degraded (WRI *et al*., 1996 cited in Demelash and Karl, 2010). Of which about $1/4^{th}$ of these degraded land are found in Africa and Asia and the rest $3/4^{th}$ in North America.

It is more and more agreed that soil degradation is a major threat to the earth's ability to feed people as nearly 16% of the world's agricultural land is affected by soil degradation (UNEP, 2002). Of all the processes leading to land degradation, erosion by water is the most threatening. It accounts for 56% of the total degraded land surface of the world (WOCAT, 2007). In Africa alone, it is estimated that 5-6 million hectares of productive land are affected by land degradation each year (Stocking and Niamh, 2008). Ironically, shifting cultivation on the hill slopes and marginal lands and non-adoption of soil and water conservation practices leads to enormous soil erosion (Wischmeier and Smith, 1994). Soil erosion is a more serious problem in developing countries like Ethiopia where the dependence on the soil resource is more direct. Erosion reduces rootable depth, removes soil organic matter and nutrients and decreases soil water holding capacity.

Ethiopia is considered to have one of the most serious soil degradation problems in the world (Birhanu, 2003). The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/hectares/year, and it can drastically exceed on steep slopes with soil loss rates greater than 300 tons/ha/year (USAID, 2000 cited in Demelash and Karl, 2010). About 45% of the total annual soil loss in the country occurs from cultivated fields, which constitutes only 13.1% of the total land area (Hurni, 1988 cited in Getachew, 2009). Ethiopia lost annually 1.5 billion metric tons of top soil from the highlands by erosion (Tadesse, 2001). Soil erosion and nutrient loss contributed significantly to low agricultural productivity and food insecurity (Shiferaw *et al.,* 2008). The onsite effects of land degradation, mainly in reducing agricultural production, is quite high, with estimated costs ranging from 2 to 6.75% of agricultural gross domestic product per annum (Yesuf *et al.*,2005).

Recognizing land degradation as a major environmental and socio-economic problem, the government of Ethiopia has made several interventions to combat this menace over 30 years period, with the support of international and bilateral agencies (Shiferaw *et al*., 2008). On the highlands terracing, bunding, drainage ditches, area enclosure, and planting trees have found effective soil and water conservation measures and the government and non-governmental organizations have tried to propagate these measures.

Despite all these efforts, it has been demonstrated that farmers who put up the erosion controlling structures on their farm plot and seemed to be adopters in the presence of incentives and coercive pressure were found to behave differently, destroying structures (Bewket, 2003; Ertiro, 2006; Kassahun, 2007). The specific attributes influencing the adoption decision are, however, far from uniform. Adoption of soil and water conservation technologies may therefore depends upon some differences many of which are specific to particular region, village, household, or plot characteristics. This makes the importance of investigating the factors associated with adoption and non- adoption of a given SWC technology to be imperative in the study area.

1.1. Statement of the Problem

One of the immediate problems facing Ethiopia today is land degradation, particularly loss of vegetation cover and soil erosion by water (MoARD, 2010). Dalocha district is part of the rift valley system which has gone through one of the most sever forms of land degradation in the region. According to Abera (2004), the estimated annual rate of soil loss due to erosion ranges from 5 to 47 tons /ha/year in the area. Due to its undulating landscape, fragile soil type, population pressure, deforestation and overgrazing, rainfall variability coupled with over all unsound land management system have been contributed for severe land degradation and soil erosion. The area exhibits, such problem which is adversely affecting the environment and posing a threat to household food security.

To alleviate the problem since 1990s different SWC practices have been undertaken in the area with the support of NGOs, the government and local community. Soil and water conservation technologies mostly implemented on cultivated land with a few exceptions are physical structures mainly *fanya juu* bunds, soil bunds and in few places stone faced soil bunds, diversion drains and gully plugs (Abera, 2004).

However, the efforts made to conserve soil resources and put towards the promotion of the technologies so far seem to have had limited impact in the area. In many cases the soil conservation structures built were dismantled entirely or selectively by farmers. Due to different reasons the SWC practices didn’t bring significant change in arresting soil erosion problems (Abera, 2004). The limited success of the efforts highlights the need to better understand the factors that encourage or discourage the adoption of SWC practices.

Hence, it is difficult to generalize about the determinants of adoption of soil and water conservation technologies in different parts of the country because of the differences in agro-ecological, socioeconomic and cultural settings under which farmers operate. In this regard, it would be worthwhile to undertake area-specific study to identify the factors affecting the adoption of soil and water conservation measures. Therefore, this study attempts to assess determinants of adoption of physical SWC measures on the cultivated landscape with the following objectives.

1.2. Objectives of the Study

General objective

The overall objective of this study is to assess the current soil conservation practices and analyze the factors that determine farmers' soil and water conservation technology adoption in Dalocha district of the central rift valley of Ethiopia.

Specific objectives

- To investigate the determinants of soil and water conservation structures adoption in the study area
- To describe the current and common soil and water conservation practices undertaken in the study area

1.3. Significance of the Study

The farming system of small holder farmers is not only diverse and complex but also risk - prone. Farmers need to understand the diversity, not only as one moves across ecological zones and regions but also across diverse farming system to meet the diverse needs with different cultures, economic back ground and aspirations even within a given zone. Comprehensive understanding of farmers' adoption of soil and water conservation technologies is crucial in designing future research and development strategies. Besides, being an empirical study it will help to add to the empirical literature that uses the combination of both quantitative and qualitative approach to investigate determinants of adoption of soil and water conservation technology by farmers.

Therefore, policy makers will benefit from the research output, since they require household level information to formulate policies and strategies so that their effort would be appropriate in meeting smallholder farmers' need in particular and to bring change in agricultural sector, in general. This work plays its own share for researchers, planners, and extension and development organizations to utilize the results of this study in modifying research and technology intervention.

1.4. Scope and Limitation of the Study

The study was conducted at household level to analyze the determinants of farmers' adoption of soil and water conservation practices in Dalocha district. The findings of the study can be extended to other areas exhibiting similar agro ecological and socio-economic characteristics with certain level of adjustment. Different types of soil and water conservation technologies have been introduced to the study area. Yet, assessment of factors influencing adoption of conservation technologies is limited to physical soil and water conservation structures practiced on cultivated land such as *fanya juu* terraces, soil bunds and stone faced soil bunds. The data for this study came from a single survey using a sample of 120 farm households' from four *kebeles* due to shortage of time and fund.

The recommendations and policy implications of the result of this study may be useful for other areas of similar contexts and as a basis to undertake other detailed and comprehensive regional-wide studies. The results of this study can be used as a reference for other similar studies in other areas.

2. LITERATURE REVIEW

2.1. Definition of Concepts and Theoretical Framework

According to WOCAT (2007), **soil and water conservation technologies** are defined as "agronomic, vegetative, structural and management measures that prevent and control soil degradation and enhance productivity in the field."

Soil and Water Conservation (SWC): "are activities at local level which maintain or enhance the productive capacity of the land in areas affected by or prone to degradation" (WOCAT, 2007). According to Morgan (2005), report soil and water conservation is defined as a set of measures intended to control or mitigate soil erosion and achieve the maximum potential agricultural productivity of a land without damaging the environment. There are a number of soil and water conservation measures. The most important are vegetative measures, tillage practices and mechanical methods.

Soil Conservation can be defined as "a rational use of land resources, application of erosion control measures, and water conservation technologies, and adoption of appropriate cropping patterns to improve soil productivity and to prevent land degradation and thereby enhance livelihoods of the local communities" (Hudson, 1995).

Soil and Water Conservation approaches are ways and means of support that help to introduce, implement, adapt and apply SWC technologies in the field (WOCAT, 2007).

According to Van den Ban and Hawkins (2000), **Adoption** is "a mental process through which an individual passes from first hearing about an innovation to final adoption." According to Feder *et al*. (1985), adoption refers to the decision to use a new technology, method, practice, *etc.* by a firm, farmer or consumer over an extended period of time.
The **"adoption process"** is defined as a decision-making process goes through a number of mental stages before making a final decision to adopt an innovation (Rogers, 1995). Soil and

water conservation technology is adopted only when it is implemented completely and continuously in the farmers' field. As indicated by Dasgupta (1989), adoption is not a permanent behavior. An individual may decide to discontinue the use of an innovation for a variety of personal, institutional, economic and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs. Batz *et al.* (2007) argues that in order to appreciate the process of adoption, it is important to examine what the technology brings not only to the farmers but also to the farm and the whole social system.

Adoption of Soil and Water Conservation Measures: The process of accepting and implementing modern soil and water conservation technologies by the farmers of an area through external support or by his own initiative for better land management practices (Yohannes and Herwege, 2000 cited in Sisay, 2009). Newly introduced soil and water conservation measures can be considered as adopted if the farmers continue to utilize them as part of their production systems after the external assistance is withdrawn. According to Bewket (2003), adoption of a technology can be assessed by analyzing farmers' attitudes, objectives and aspirations of whether they like to use the introduced technologies as part of their farming system.

Adopters of Soil and Water Conservation Measures: are those farmers who put into practices a given soil and water conservation technologies such as terraces (*fanya juu*, soil bunds and stone faced soil bunds and hillside terraces), gully plugs, cut off drain and artificial water ways etc, introduced in their community or farm plot and practiced in a sustained basis.

Non-adopters of SWC Measures: are those farmers who choose not to practice soil and water conservation structures or did so but later abandoned them.

2.2. Diffusion of Soil and Water Conservation Innovation

According to Rogers (1995), **Diffusion** is "the process by which an innovation is communicated through certain channels over time among the members of a social system." According to Van den Ban and Hawkins (2000), an **innovation** is "an idea, practice or object that is perceived as new by an individual or other unit of adoption but which is not always the result of recent research." People do not just welcome every innovation that is put in front of them. Every person reacts differently in the ways that he/she hears about, understand, and finally accept or do not accept an innovation. For the purpose of this study, soil and water conservation technologies such as *fanya juu* bunds, soil bunds and stone faced soil bunds, check dam, cut off drains and water ways, tree planting are considered as innovation.

The innovation-diffusion model states that a technology passed on from its source to end users through a medium of agents and its diffusion in potential users for the most part dependent on the personal attributes of the individual user. The model assumes that the technology in question is appropriate for use unless hindered by the lack of effective communication (Negatu and Parikh 1999, cited in Birhanu, 2003).

According to Rogers (1983), a number of factors act together to influence the diffusion of a certain innovation. The four major factors that influence the diffusion process are the innovation itself, communication channels, time and the nature of the social system into which the technology is being introduced. Diffusion/adoption research analyses how these factors and a number of other factors act together to ease or obstruct the progress of the adoption of a specific technology among its final user (Surry, 1997).

Rogers (1983) elucidates the four most widely used and closely interrelated concepts of diffusion. These are: innovation decision process, individual innovativeness, rate of adoption and perceived attributes.

Innovation-decision process is the mental process through which an individual or other decision making unit passes from first knowledge of an innovation to forming an attitude towards the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers, 1983). This process consists of a series of actions and choices over time through which an individual or an organization evaluates a new idea and decides whether to incorporate the new idea in to ongoing practices. Rogers (1983) identifies five stages in innovation decision process. The stages are knowledge, persuasion, decision, implementation and confirmation. According to this theory, "potential adopters of an innovation must learn about the innovation, be persuaded as to the merits of the innovation, decide to adopt, implement the innovation and confirm (reaffirm or reject) the decision to adopt the innovation" (Figure 1 below).

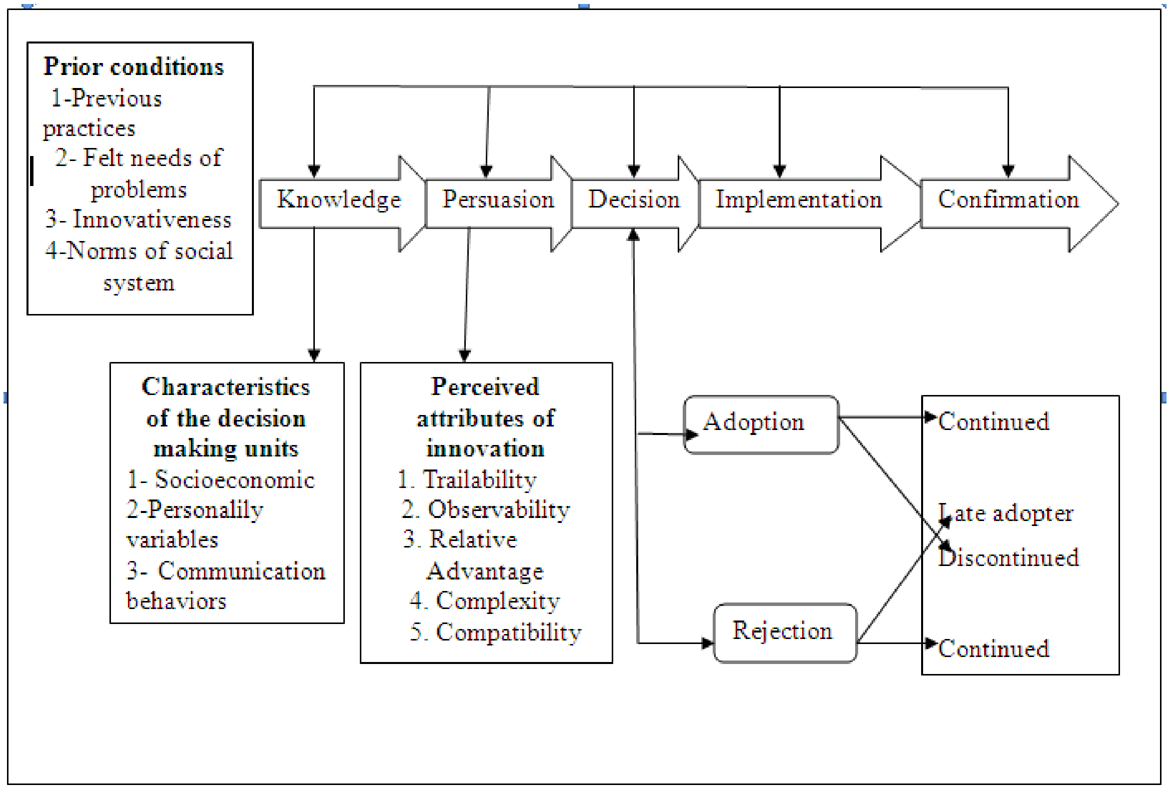

Figure 1. Innovation decision process model

Source: Adopted from Rogers (1983)

The model shows that the adoption process practically considers prior conditions and different characteristics. Adoption could continue after decision to take forward the technology or may also come after rejection as later adoption and again there may be a chance to reject again.

Individual innovativeness is "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a social system" (Van den Ban and Hawkins, 2000). The central point of this concept is that individuals who are predisposed to being innovative will adopt an innovation earlier than those who are less predisposed (Surry, 1997).

Rate of Adoption: it signifies the relative speed with which an innovation is adopted by members of social system (Rogers, 2003). Adoption is a decision to make full use of a new idea as the best course of action available.

Perceived Attributes: the concept of perceived attributes implies that potential adopters evaluate an innovation based on their perception with regard to five attributes of the innovation (Figure 1). Some of the important attributes of an innovation which influence rate of adoption are relative advantage, compatibility, complexity, trailability and observability. This theory state that an innovation will experience an increased rate of diffusion if potential adopters perceived that the innovation: 1) can be tried on a piecemeal basis before adoption, 2) offers observable results, 3) has an advantage relative to other innovations, 4) is not complex and 5) compatible with the existing practices and values.

2.3. Adoption of New Technologies

Adoption of improved technologies in agriculture has attracted the attention of development economists and sociologists because the vast majority of the population in developing countries derives its livelihood from agricultural production (Batz *et al.,* 2007). Adoption studies relate to use or non-use of a particular technology by individual farmers at a point in time, or during an extended period. Adoption therefore presumes that the technology exists, and studies of the adoption process analyze the determinants of whether and when adoption takes place (Colman and Young, 1989 cited in Sisay, 2009). Adoption of improved SWC technologies in developing countries has attracted much attention from scientists and policy makers mainly because land degradation is a key problem for agricultural production (De Graaff *et al.*, 2008).

Kessler (2006) considers SWC totally adopted only when its implementation is sustained and fully integrated in the household farming system. Adoption of SWC measures does not automatically guarantee long-term use. For example, when soil and water conservation measures have been established with considerable project assistance, not all farmers may

continue using the measures. Therefore, introduction of SWC technologies may not lead to sustained land rehabilitation unless the farmers proceed to final adoption.
The decision to adopt a new or improved technology could regard as an investment decision (Caswell *et al*., 2001). This decision may involve fixed costs, while the benefits realized over time. The choice of whether or not to adopt a new technology will, therefore, based on a careful assessment of a large number of technical, economic, social and physical factors (Rogers, 1995). The technical feature of a new technology may have a direct consequence on the decision making process. It appears that the more technically complicated the innovation, the less attractive it may be too many farmers (Kessler, 2006).

The potential capability of the new technology, in terms of enhancing yield, reducing cost of production and give rise to higher profit, are also substantially important. The problem, however, is that when a technology first introduced, uncertainty with respect to its functioning under local settings is often high. Also, it is difficult to tell its economic outcome with certainty. However, over time, as farmers adopt and become familiar with the new technology, the uncertainty and the cost associated with it will fall (De Graaff *et al*., 2008).

The effectiveness of the technology transfer is another important issue that is captured in adoption studies. A lot of resources are invested in demonstration, field days, training and visits. In addition, Guerin (1999) noted problems in the transfer and adoption process, particularly the lack of testing and the limited role of extension agents, as important reasons for non-adoption of recommended technologies. Technology generation and transfer with farmers in a participatory way are essential for the success of any development project. But it is important for researchers to study the effect of the technology after several seasons in order to know the proportion of the farmers who still continue to use it, and for those who do not, the reason behind the discontinuation (Sisay, 2009).

Farmers who move from traditional practice to application of new technologies may do so for a variety of reasons. They may recognize a more efficient and profitable way to produce or they may experience a problem and in an attempt to find solutions arrive at a new practice, like soil conservation measures (Birhanu, 2003). The problems motivating the possible change to conservation include soil degradation, soil erosion or declining crop yields due to deteriorating soil fertility.

According to Caswell *et al*. (2001), many of the conservation technologies can be classified as “preventive innovations” in that they assist the adopters keep away from unwelcome future event such as loss of productive soils. As Rogers (2003) pointed out, preventive innovations have a low rate of adoption because it is hard to demonstrate the advantages of adoption since those benefits occur only at some future, unknown time.

According to Krishna *et al*. (2008), to attain success in soil conservation practices, farmers expected to have perceptions of the problems, and have a positive attitude towards solving them, and then they would gradually accept the methods that they think could solve the problems and adopt after they have sufficiently used. Further he noted that education level of households have positively and significantly influences adoption of agricultural technologies. Adoption of soil conservation measures thus come about after farmers have passed through these three states of mind, except when a short cut applied in the form of incentives or privileges. This type of adoption is weak and unstable, as the farmers might discontinue use of a technology any time when such incentive programs end. Farmers who seemed to be adopters in the occurrence of incentives start to destruct conservation structures (Shiferaw and Holden, 1998) or do not make maintenance and lack of maintenance ultimately leads to destruction.

Adoption of conservation technology should not be regarded as an end in itself, but rather as a continuous decision-making process (Krishna *et al*., 2008). Individuals pass through various learning and experimenting stages from awareness of the problem and its potential solutions and finally deciding whether to adopt or reject the given technology. Adoption of new technology normally passes through five different stages, which include awareness, interest, evaluation, trail, and finally adoption (Rogers, 1983). At each stage there are various constraints (social, economic, physical, and institutional) for different groups of farmers.

2.4. Soil Erosion and its Economic Impact in Ethiopia

In Ethiopia, one of the poorest countries in the world, soil erosion by water contributes significantly to food insecurity of rural households and constitutes a real threat to sustainability of the existing subsistence agriculture (Sonneveld, 2002; MoARD and World Bank, 2007). Yet, it is not a new phenomenon in the country. It is a direct consequence of the past and the present agricultural practices in the highlands. The dissected terrain with nearly 70% of the highlands having slopes above 30% and the high intensity of the rainfall the highlands receive contributed to accelerated erosion (Assefa, 2007).

With the ever-increasing population, development of agricultural production increasingly became enhancing land degradation through deforestation and expansion of new land to fragile and erosion prone marginal lands (Assefa, 2009). The yield reduction as a result of the loss of topsoil each year is increasing substantially. This makes the issue of soil conservation not only necessary but also a vital concern if the country wants to achieve sustainable development of its agricultural sector and its economy at large (Birhanu, 2003).

According to Amede *et al*. (2007), in Ethiopia 17% of the potential annual agricultural GDP is lost because of physical and biological soil degradation. Soil fertility decline alone is causing a progressive annual loss in grain production of 40000 tons. Furthermore, land degradation estimated to have resulted in annual loss of livestock production by 1.1million (TLU) and unless arrested the reduction would rise to 2 million or 10% of the national cattle herd.

FAO (2000) estimate that some 50% of the highlands are significantly eroded, of which 25% are seriously eroded, and 4% have reached a point of no return. The highest average soil loss occurs on currently unproductive land with less vegetation cover that was once under cultivation (Table 1). This large amount of soil loss made the country to be described as one of the most serious erosion areas in Africa and in the world (El-swify and Hurni, 1996).

Table 1. Estimated rate of soil loss in Ethiopia for different land use and cover types

Land cover types	Area covered%	Estimated soil loss(tons/ha/year)	Total soil loss(10^6 t h^{-1})	% of total
Cropland	13.1	42	672	45
Perennial crops	1.7	8	17	1
Grazing and browsing land	51.0	5	312	21
Currently unproductive	3.8	70	325	22
Currently uncultivable	18.7	5	114	8
Forests	3.6	1	4	-
Wood and bush land	8.1	5	49	3
Total	100	12	1493	100

Source: Hurni (1988 cited in Getachew, 2009)

There are several estimates about economic impacts of soil erosion in the country. For instance, (FAO, 1986, as cited in Assefa, 2007) estimated soil erosion to cost Ethiopia on average 2.2% of land productivity annually from that of the 1985 productivity level. Wood (1990) indicated that soil erosion reduces the country's food production by 1-2 % per annum. Sutcliffe (1993) also estimated that erosion costs Ethiopia 2% of its GDP between 1985 and 1990. According to Sonneveld (2002), the economic cost of soil erosion is around US$ 1.0 billion per year; while MoARD and World Bank (2007) state that the minimum annual cost of soil erosion ranges between 2 and 3 percent of the national agricultural GDP. These figures indicate that the economic impact of erosion is significant. Many studies in Ethiopia attributed the widespread poverty, structural food insecurity and recurring famine partly to the environmental degradation problem in general and soil degradation in particular (Bewket, 2003).

Along with soil movement large amount of organic matter, nitrogen, phosphorous, potassium and other nutrients that are necessary for agricultural production are lost every year. Together with the removal of surface soil, the loss of organic matter ranges from 15-1000 kg/ha/year which is equivalent to 1.17-78 million tons of organic matter per year from 78 million ha of cultivated and grazing lands (Hawando, 1997 cited in Ertiro, 2006).

2.5. Soil Erosion and Past Conservation Efforts in Ethiopia

Prior to the 1974 revolution, soil degradation did not get policy attention it deserved (Bekele and Drake, 2003). The famines of 1973 and 1985 provided an impetus for conservation work through large increase food aid. Following these severe famines, the then government launched an ambitious program of soil and water conservation supported by development partners and non-governmental organizations (Ertiro, 2006). Indeed, various interventions have been crafted at both national and local levels to address what is believed by many Ethiopia's critical development challenge. The extent of conservation activities using food aid escalated tremendously and the conservation continued to grow arithmetically though the implementation could not keep pace with the plan. With this, Ethiopia became the largest food–for-work program beneficiary in Africa and the second largest country in the world following India (Pretty and Shah, 1997).

In an effort towards responding to the problem of soil erosion through application of conservation measures on erodible lands, the government of Ethiopia initiated a massive soil conservation program. Since 1980, about 2.3 million ha of land was treated with different bunds (soil, stone and fanya juu), about 1.3 million ha hillside terrace for afforestation; about 1.5 million ha of land planted with different tree species, over 390, 000 ha of land has closed for natural regeneration, 26,000 km of check dam built in the gullies and 526,425 ha of bench terrace interventions were completed (MoARD, 2010) mainly through food for work incentives.

Despite all these efforts, many writers quoted that the SWC campaign was neither effective nor sustainable. For example, Amsalu and De Graaff (2006) showed that SWC activities in the highlands of Ethiopia are faced with several challenges. Despite extensive conservation interventions during the past decades, sustained adoption of the recommended measures by the farmers has not been as expected (Bekele -Tesemma, 1997; Bewket, 2003). Very often, farmers destroy these structures to obtain additional food for maintaining destroyed structures. The monitoring made in one of the sites where conservation intervention was done by the support of the WFP indicated that 40% of the terracing was broken the year after construction (Pretty and Shah, 1997). Limited adoption and spreading of soil and water conservation practices is not only due to technical problem, rather it is due to a socio-economic problem with many constraints playing a role.

Besides, many of the projects sponsored both by the government and the WFP were also criticized for putting emphasis only on mechanical conservation measures, most of which were alien to the farmers. The farmers were virtually considered ignorant of soil and water conservation practices and were excluded from the planning, commenting on and implementation of these conservation measures (Bekele-Tesemma, 1997). Decision which types of conservation measures to use and where to place them were not made by the concerned land user farmers. Only rare attempts were made to include indigenous experience and knowledge (Amsalu, 2006). Although the achievements were remarkable in quantitative terms, the impacts of these efforts were far below the expectations and land degradation continued to be a serious problem (Admassie, 2000). A large sum of money has spent in the name of encouraging environmental protection and coercing farmers to adopt conservation measures.

Since the mid 1990s, implementation of soil and water conservation measures has been undertaken as part of the agricultural extension package of the government. Conservation measures were mostly undertaken in campaigns and without the involvement of the land owner. Farmers were not allowed to remove the structures once built but maintenance was often carried out through different incentive Program (Tesfaye, 2008). However, the practice has largely remained delivery oriented in which the farmers are forced to implement conservation measures designed for them by technical experts (Bewket, 2003).

There is a great concern in Ethiopia about land degradation resulting from soil erosion and its impact on agricultural production. Improving the natural resources base is center to an effort to arrest this vicious cycle and improve the productivity of small holders' farmers who constitute the largest proportion 45.5 percent below the poverty line (FDRE, 1997 cited in Sisay, 2009). Thus, addressing the root causes of reinforcing cycle of declining crop and livestock productivity, natural resources degradation highly associated with population pressure and vulnerability among the vast number of resource poor farmers is a crucial challenge facing Ethiopia.

2.6. Policies towards Soil and Water Conservation in Ethiopia

Policies related to land, the most important resource for the rural poor and of the national governments at different time played an important role in land management in Ethiopia (Bekele, 2003; Shiferaw, 1998). During the feudal regime, prior to 1974 revolution, land tenure system made tenants to be subject to insecure land tenure, and expropriation of an important proportion of their produce and labor by landlords. This created disincentives for adoption of soil and water conservation (Bekele, 2003). Furthermore, the agricultural sector in general and the peasant agriculture in particular did not get the policy attention it deserved due to the focus of the country's development plan on industrial development agenda. According to Aredo (1990), the first two five year plans (1957-62 and 1962-1967) gave priority to large scale commercial farms and exportable crops. The third five year plan (1968-1973) put much emphasis on high input package programs to be implemented in few high potential agro-ecological areas where quick return was expected (Aredo,1990). Small farmers that cultivate almost all-agricultural land and who are complained to agents of soil degradation, and areas that did not promise return in short term but susceptible to soil degradation, failed to get policy attention. Therefore, policy attention towards industry combined with complex system of land tenure variously dominated by absentee landlords, local administrators, church estates and forms of private and freehold tenure hindered the effort to conserve land (Campbell, 1991).

The military regime that took over in 1974 proclaimed land reform. The reform abolished feudal land tenure system and eliminated large holdings, landlessness and absentee landlordism. Although this was expected to improve the situation and provide incentive for investment in soil and water conservation, it could not succeed triggering adoption of conservation practices (Zewdie, 1999). This was because, these reforms were later liquidated by misguided polices and ardent socialist orientation.

For instance, until the late 1980s the economy system that was perused focused on collectivization, nationalization of natural resource including agricultural land, coercive promotion of producers cooperatives, imposition of production marketing quota and forced villagization rather created disincentive and resulted in opposite outcome by decreasing security of land tenure and the profitability of agricultural investment (Bekele, 2003). Despite the fact that the reform policy enabled many landless peasants to gain access to land, the state ownership of land and insecurity of usufruct rights hindered utilizing the full potential of the reform.

After over throw of the military regime in 1991, the current government has made changes in economic policy. Unlike in the previous governments, agricultural sector in general and smallholder in particular received policy attention in the current government from economic development strategy the country has been pursuing. The strategy revolves around agriculture mainly on the improvement of smallholder productivity and expansion of large-scale commercial farms. Along with this, different policies and strategies that favor proper use and management of agricultural land through use of different conservation and rehabilitation mechanisms and rational use of country's land resources have been embarked (Birhanu *et al.,* 2004). These policies and strategies include Rural Development Policy and Strategy, Food Security Strategy, Natural Resource and Environmental Policy, and Land Administration and Use, Forest Conservation and Development Policies. These policies and strategies are expected to restore incentives for improved land resource management. Nevertheless, consistent with the military regime, land and other natural resources remained under state ownership but farmers' are granted only the right to usufruct and the option of periodic land redistribution remained open (Rahmato, 2004). Because of this, land tenure arrangement has topic of heated debate among scholars and politicians on whether the arrangement provides incentive or disincentive on increasing land productivity and land improvement.

Extension is an instrument of persuasion for free choice of individuals so that people could make well-considered choices among alternatives. Unfortunately, such real cooperation between development facilitators and farmers in the agricultural sector has not been strong (Bekele-Tesemma, 1997). During planning soil and water conservation intervention, top-down approach was pursued where government officials tell *kebeles* (farmers) what to do to get the incentive. This approach gave local people little opportunity for discussion and airing about strategies and technologies of implementation in soil and water conservation (Bekele-Tesemma, 1997).

2.7. Empirical Studies on Adoption of Soil and Water Conservation Practices

Studies on the factors affecting adoption of soil 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 technology. Here, try to review some of them because it helps to lay a conceptual basis for identifying the relevant variables to be included in the analysis. Previous studies show that various personal, economic, socio-institutional and physical attributes have influential roles in farmers' decisions on the adoption of SWC measures in Ethiopia (Tesfaye, 2008).

Since the "diffusion of innovation" school (Rogers, 1983) opened up a host of studies in the area of adoption and human behavior, a number of socio-economic studies have been carried out to identify factors affecting the adoption of SWC among farmers. These include: age, gender, education, family size, farm size, labour availability, income, risk perception, perception of erosion, technology attributes, off-farm employment, etc.

Some studies such as Norris and Batie (1987) and Swinton (2003) have attempted to highlight the economic theory underlying farmer behavior in decision-making over conservation practices. McConnell (1983) used production theory where a farmer has an objective to maximize profit; whereas studies such as Norris and Batie (1987) and Swinton (2003) used household model based on utility maximization. In order to adequately determine factors that influence farmers to adopt soil and water conservation technologies, the focus of the adoption analysis needs to go beyond the characteristics of farmers and plots of land (CIMMYT, 1993 cited in Ahmad, 2009).

According to Ervin and Ervin (1982), personal factors, physical, economic and institutional factors influence farmers' decision on soil and water conservation. They found variables related to personal characteristics such as education, perception of the degree of erosion problem and farm experience to be significant. Apparently farmers' perception of erosion is one of the potential factors influencing farmers' decision in adopting soil conservation practices. A group of economic factors, such as transfer of farm to children, off-farm incomes, and debt, exert strong effects on the adoption decisions of farmers.

Tenge *et al.* (2004) identified household variables, farming and economic variables and other external factors as the major determinants of adoption. In the Ethiopian case, several household and socio economic factors that influence the decision to accept SWC measures have been reported. Amsalu and De Graaff (2006) found that, age, farm size, and livestock numbers as the most important factors with significant influence. Farmers' decisions to conserve natural resources generally and soil and water in particular are largely determined by their knowledge of the problems and the perceived benefits of conservation.

Rogers (2003) stated that the characteristics of a given technology are important determinants of adoption. In addition, the characteristics of the farmers such as age, household size, farm size, education, experience and the farming experiences are also some but few factors that may influence the adoption decision. Several studies in adoption of soil conservation are conducted in different parts of Ethiopia. For example Anley *et al.* (2006) in Dedo district indicated that the use of three types of improved soil conservation measures, improved soil bund, cut-off drain and *fanya juu* are significantly influenced by cultivated land to labor ratio, education level of household head, distance of farm plot from home, slope of the farm plot and availability of extension services. In this study perception of soil erosion problem and land security had no statistical support for implementation of soil water conservation practices.

Shiferaw and Holden (1998) examined factors affecting soil 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 characteristics (education, age and family size) land and farm characteristics, perception of technology specific attributes and land quality differentials influence conservation decision of peasants. Lapar and Pandey (1999) found a positive correlation between farmers' years of education and their adoption of SWC measures. Cramb *et al.* (1999) have studied factors affecting soil and water conservation technologies (terrace and hedgerows) in the upland areas of the Philippines. The study concluded that the personal attributes such as age and education were not important in explaining adoption. Similarly, Birhanu (2003) found that adoption of SWC practices were not significantly influenced by age of household in the northwestern Ethiopia.

Amsalu and De Graaff (2006) found in the Beressa watershed high land of Ethiopia, a range of factors influences farmers' conservation decision. However, the factors influencing adoption and continued use of the stone terraces are not the same. Adoption of stone terraces is significantly influenced by age, farm size, perceptions on technology profitability, slope, livestock size and soil fertility, while continued use is influenced by actual technology profitability, slope, soil fertility, family size, farm size and participation in off-farm work. Perception of erosion problem, land tenure and extension contacts show no significant influence on farmers' conservation decision.

Grepperud (1995) presented the analysis of the effects on the resource management of land from different aid policies and concluded that governments should be careful when designing support measures if improved resource management is a policy goal. In his study he recommended that in the design of conservation measures, attention have to be paid both to the distribution in land quality as well as to the distribution of the net returns from adopting soil conservation.

Wide ranges of socioeconomic factors have been shown to influence adoption and continued use of soil conservation technologies at the farm level. Kessler (2006) summarized these factors as personal characteristics of land operators, characteristics of the farm land, access to information system, characteristics of conservation technologies, structural condition of the society in which the farm enterprise is operated. External factors could enhance or inhibit farmers' decisions on soil and water conservation. These factors include: land tenure, access to credit, subsidy, extension services and infrastructure (Shiferaw, 1997). The impact of land tenure varied from tenure system to tenure system (Cramb *et al.,* 1999).

The other variable that has been synonymous with soil and water conservation, particularly in Africa, is the incentive that is mostly stimulated in the form of food-for-work programs. The literature on the diffusion of innovation regards the provision of incentives as an attempt to increase the degree of relative advantage of the new idea or practice, but also as having other functions such as increasing observability and trailability which enables the testing of compatibility (Rogers, 1995). Farmers' perception of soil erosion and their subsequent conservation behavior have mixed results.

In some studies, there was no substantial relationship between soil erosion perception and farmers' conservation behavior, whereas in others, there were direct links. For instance, the perception of erosion was found to be important to the adoption behavior of SWC in the Philippines (Cramb *et al.*, 1999) and at Andit Tid, Ethiopia (Shiferaw and Holden, 1998). They showed that farmers' decisions to retain conservation structures are positively and significantly related to soil erosion perceptions, attitude towards new technology and exposure to new practices.

Studies made by Ervin and Ervin (1982) and Norris and Batie (1987) suggest that perception of soil erosion problem is the first step in adoption process and thus is positively correlated with farmers' adoption decision. Extension is generally expected to show a positive impact on the adoption of external technologies (Rogers, 1995). This view has been testified in a number of studies including those involving soil and water conservation (Baidu-Forson, 1999). According to Tesfaye (2008), access to information about technological options for soil conservation had a significant effect on perceptions of the erosion problem and on retaining the conservation structures, whereby he considers a positive role of extension on adoption.

Baidu-Forson (1999) stated that factors which motivate level and intensity of use of specific soil and water management technologies include higher percentage of degraded farmland, extension education, lower risk aversion and the availability of short-term benefit. These results showed that technologies should be targeted to locations that have large percentages of degraded farmland, and there is a need to provide extension education that demonstrates risk reduction capacities of conservation techniques.

Karki *et al.* (2004) undertook a study in a mid-hill district of Nepal to assess the impact of foreign-aided project in technology adoption and food security and to identify factors determining adoption of improved technology in case of smallholder peasants. The result using binomial logit model and qualitative analysis revealed the coefficient of years of schooling was positively and significantly influenced farmers' adoption decisions on improved agricultural technologies. As the education level of household head increases, the probability of adopting technology was also found to be increased. Similarly, the finding of Ngigi (2003) in *Kobo,* Ethiopia showed positive and significant association between education level of the household and adopting of rain water harvesting technology.

Young and Shortle (2004) applied a logit regression approach to assess how the characteristics of individual landowners and their farm operation influence conservation investments. Results of this study showed operator and operation characteristics were important factors that significantly affect adoption. Alemu (1999) estimated the factors influencing the decisions to invest in soil conservation in Tigray and Oromia regional states of Ethiopia. He found that there is a significant relationship between tenure security and the probability of participating in constructing physical soil conservation. In addition to this, he identified the characteristics of each plot rather than tenures security as important factor influencing the amount of investment that a farmer will make.

In a study undertaken by Siraw (2005) in the Environs of Simien Mountain National park, out of twelve variables fitted in the logit model, farm experience, the total household labour in man equivalent, development agent visit, farmers levels of perception on soil erosion were statistically and significantly related to the adoption of soil and water conservation practices by farmers. Continued use of soil and water conservation measures were positively and significantly correlated with household family size in Tulla district, southern Ethiopia (Tesfaye, 2008). According to sisay (2009), gender has no significant effect on adoption of soil conservation measures but, Adgo (2008) and Petros (2010) found positive and significant influence gender differences on adoption of agricultural technologies in northern Ethiopia.

Biophysical factors play an important role in farmers' decisions regarding soil and water conservation practices (Lapar and Pandey, 1999). Farm attributes such as distance from the homestead and its physical conditions such as its slope, soil type and stoniness, etc., were found to discriminate between adopters and non-adopters of SWC in different parts of the world. These features may also lead to different decisions by the same farmers with respect to different plots owned, which vary in these physical features, let alone by different farmers. Cramb *et al.* (1999) showed that the adoption of hedgerows in particular was more likely on fields, which were larger, steeper, had more erodible soils, and were located close to homestead areas.

Shiferaw and Holden (1998) who studied 452 plots in the highlands of Ethiopia found that the higher the slope category of the plot, the higher the probability that recognition of soil erosion would be above any fixed level. Empirical studies in different parts of Ethiopia reported a positive and significant effect of the slope of a plot on the decision to adopt soil conservation structures (Gebremedhin and Swinton, 2003). McDonald and Brown (2000) indicated that farmers rarely sustain the technical solutions offered by external interventions in the long term unless consideration is given to the various socio-economic, cultural and institutional, as well as physical and technical factors. According to Charles (2006), such factors could be farmer-specific, farm-specific and technology-specific.

Some studies attribute the low level of SWC technology adoption to poor economic status of the farmers, labor shortage, land tenure uncertainty, problems of fitness of the technologies themselves (Bewket and Sterk, 2002; Bekele, 2003; Menale and Holden, 2005 cited in Kassahun, 2007). It is a well-established fact that a technology is abandoned by farmers not because farmers are resistant to change or not because of inherent attribute of the technology itself. But because farmers rationally assess the pros and cons associated with technologies and also because the technology conflicts with other elements of the farming system (CIMMYT, 1993 cited in Ahmad *et al*., 2009).

Farmers' adoption of improved soil and water 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 NGO sector (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 and water conservation technologies, based on the available resources at their disposal and their opportunity for profit.

According to Ertiro (2006), land tenure arrangements had an effect on land investments. Tree planting and soil fertility improvements were only practiced on owned land, while no investments were made on share-cropped fields. Sharecropping is one way poor, young and often landless farmers can overcome the problem of land scarcity. The practice of sharecropping, however, may lead to low adoption of SWC practices, because neither the sharecropper nor the landowners are committed to investing in the land. The land tenure system affected farmers' decision to retain conservation structures positively and significantly in Anna watershed (Ertiro, 2006).

Cary and Wilkinson (1997) used a logistic regression model to predict the relative influence of perceptions of profitability, technical feasibility and of personal environmental concern on the choice of conservation practices in Australia. They found perceived profitability was the most important factor influencing the use of conservation practices. Study confirmed that technology attributes like profitability of a technology were important in shaping adoption of a technology (Kipsat *et al*., 2007). Some studies associating farm tenure (owning or renting) to use of conservation practices show that ownership is significantly related to use of profitable practices but not to use of unprofitable practice (Pamoel, 1977, cited in Birhanu, 2003). Even when practices have not controlled for profitability, the relationship of farm ownership and use of conservation practices has found to be in a positive direction.

Many rural development projects assumed that in developing countries labor is widely available at low cost. And the evaluation criteria for the success of the projects were the number of kilometers of ditches dug or bunds built (Hudson, 1995). It is also a common and widespread practice in countries like Ethiopia food for work projects were based on bartering food for labor. However, Hudson (1995) points that they ended up with mixed results. "Some were successful in reducing famine but few made constructive improvement in soil conservation". Tadesse and Kassa (2004) found in the southern highlands of Ethiopia technology characteristics, farm size, and number of economically active family members and perception of soil erosion problem positively and significantly influence adoption of physical soil and water conservation measures.

Similarly, Anley *et al.* (2006) found that farm size and perception of benefit from soil and water conservation practices positively and significantly influences adoption of soil and water conservation practices in Dedo district. According to Tadesse and Kassa (2004), family size influences the adoption of physical soil conservation measures negatively and significantly. Likewise, distance of a plot from residential area, perceived risk of loss of land in the future, and availability of off-farm employment opportunities negatively and significantly influence farmer's decision to adopt conservation practices.

According to Bekele and Drake (2003), study on SWC decision behavior of subsistence farmers in the eastern highlands of Ethiopia by using multinomial logit analysis showed that plot-level adoption of conservation measures was positively related to access to information, support programs for initial investment, slope and area of the plot. The landholding per economically active person in the family was found to have a negative influence on conservation decisions.

Socio-economic and institutional factors influence the level of investment households committed to soil and water conservation. The size of cultivated land ration of economically active labor to the size of own farm, livestock ownership, farmers perception of soil erosion, type of crop usually grown on farm land, the farmland fragmentation are significantly related to the adoption of SWC practices by farmers (Gudeta, 2007).

Generally, we can understand that different empirical studies have been carried out to see the direction and magnitude of the influence of different factors on farmers' decision behavior regarding adoption of new agricultural technologies like soil and water conservation practices. Therefore, the above evidences and reviews of the studies signify the importance of area specific study to identify the major factors, which are influence or facilitator to the adoption of conservation technology and recommend on the base of results for better achievement.

2.8. Conceptual Framework of the Study

Adoption decisions of different technologies across space and time are influenced by different factors and their association. Factors such as personal and demographic, economic, physical and institutional characteristics determine the probability of adoption of technologies such as soil and water conservation technology. It is obvious that different studies have been conducted to look into the direction and magnitude of influence of different factors on farmers' adoption decision of agricultural technologies. A factor, which is found to enhance adoption of a particular technology in one locality at one time, was found to hinder it in another situation and locality. Although some known determinants tend to have general applicability; it is difficult to develop a one and unified adoption model of the process of technology adoption with defined determinants and hypotheses that hold to everywhere (Rogers, 2003). The dynamic nature of the determinants and the distinctive nature of the areas make it difficult to generalize what factors influence which technology adoption.

The framework emphasized mainly on the relationship of the explanatory variables with dependent variable. The measures of adoption in this study is actual physical presence of conservation structures on farmers' plot and farmers were asked whether conservation structures are put up in their farm field in the past and still exist in each plot of land. Hence, the following conceptual framework depicted the most importance variables expected to influence adoption of soil and water conservation technology in the study area (Figure 2).

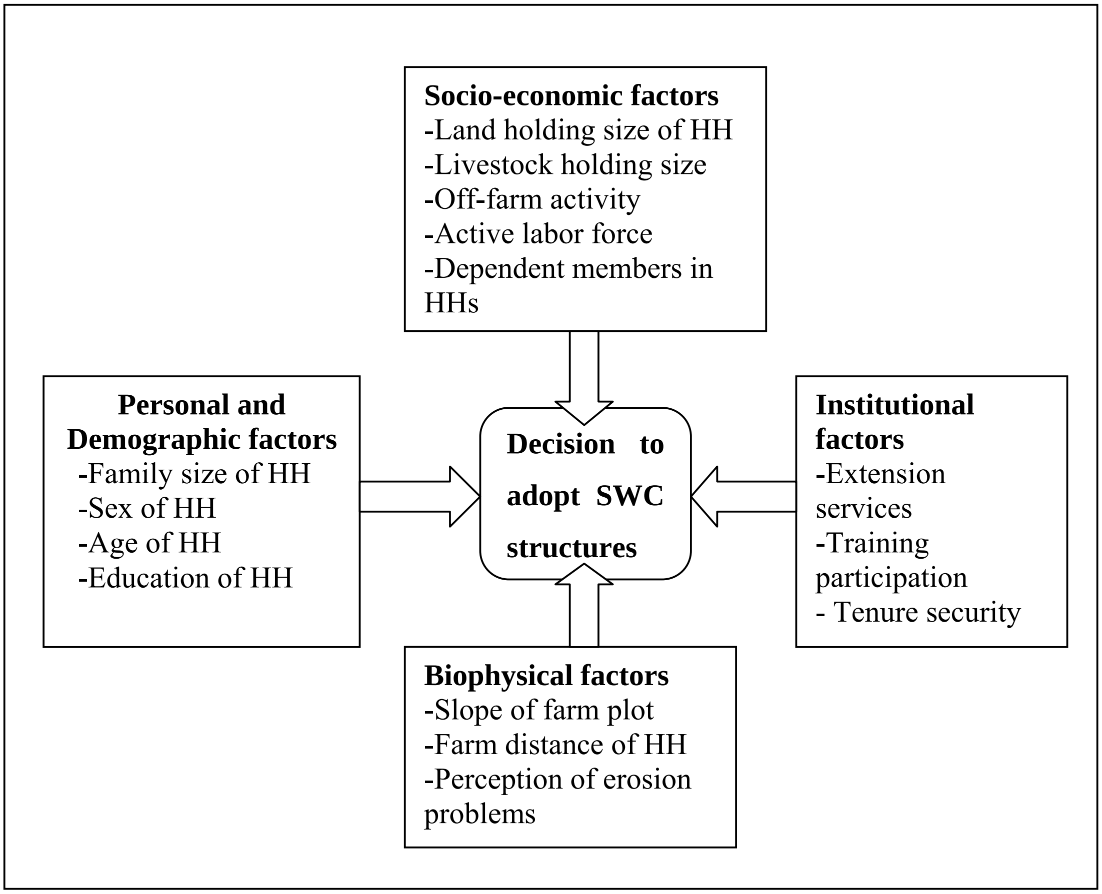

Figure 2. Conceptual framework of the study

Source: Own formulation

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study area, Dalocha district, is located in Siltie Zone of the Southern Nations, Nationalities and People's Regional State (SNNPRS) at about 182 km south west of Addis Ababa (Figure 1). Geographically, it is situated between 7^0 5' N and 7^0 45' N latitude and 38^0 05' E and 38^0 15' E longitudes. It is bordered with Silti district in the north, Lanfuro district in the east, Sankura district in the south, and Hulbarg district in the west. The study area covers 45,843 hectares with an average population density of 214 people per square kilometer making the district one of the densely populated area vis-à-vis the national average that is about 79 people per square kilometer (Dalocha Agricultural Office, 2010). It is one of the 8 districts in Sitie Zone and subdivided into 17 rural *kebeles* and 1 town.

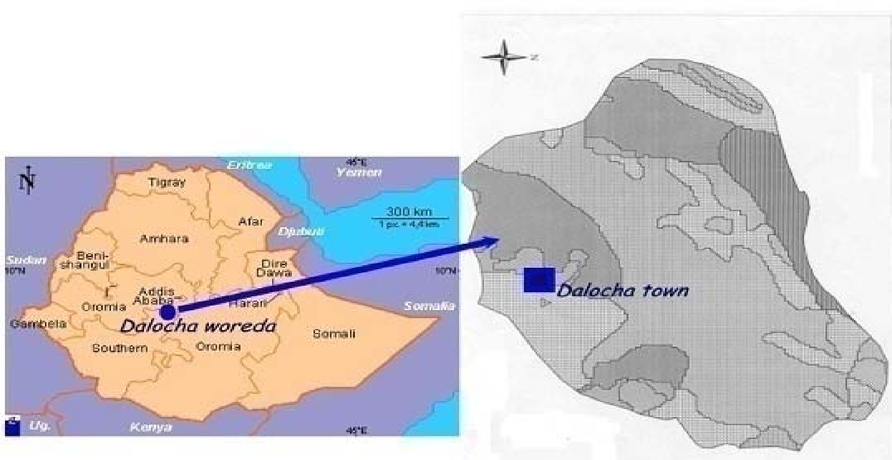

Figure 3. Location map of Dalocha district

Source: Abera (2004)

3.1.2. Climate

The study area has an altitude range of 1800 - 2300 m.a.s.l, situated in moist *Weyna-Dega* agro climate zone. The average annual rainfall ranges from 750-1350 mm and the period marked by a great variability and very erratic rainfall pattern. It has bimodal pattern, which occur between March and May, a period traditionally known as *belg* the (small rains) and between June and September, and traditionally known as *kermt* the (big rainy season). Apart from this, the erratic nature and skewed distribution rainfall causes crop failure some of the year. The mean annual temperature is 18^0c with mean minimum of 15^0c, while the mean maximum temperature is around 29^0c (Dalocha Agricultural Office, 2010).

3.1.3. Soil and topography

The physical future is characterized by rugged topography, dominated by gentle slopes and inclined hills, undulated plains and gully landscape, interrupted by a line of cinder cone and with highly degraded associated foothills. Numerous rock protruding on the surface still show signs that the top soils are eroded. There are significant areas of “bad land”/ravine with severe dissected gully erosion. The dominant soil types are silt clay loam, a light-colored slowly permeable subsoil (Plano sols) and the black cracking clays (vertisols) and (litho sols) on hills, which are highly weathered (Sutcliffe and Melese, 1988 cited in Abera, 2004).

3.1.4. Vegetation

The area was once covered by dense forest which categorized under *Juniperous*, *Podocurpous* and other indigenous species, as can be generalized from remnants of trees scattered on farms. Under the present condition the vegetation cover has removed, and replaced by cultivated fields, grazing land and settlement and some exotic plantation with remnant tree species. Currently, the vegetation of the study area dominated evergreen or semi- evergreen bushes and/or shrubs and occasionally larger trees are much scatted on the field. Wood lots and protection forests have planted mainly along gully edges, roadsides, in protected degraded areas, on old corner of the fields and around homestead (Abera, 2004).

3.1.5. Population

Based on the 2007 population census conducted by the Central Statistical Agency of Ethiopia, with 2.9% annual population growth rate the district has an estimated total of 98,210 populations, of which 48,787 were male and 49,423 female; and 92% of the populations are estimated to be rural inhabitants. In terms of households 12,303 male and 2,029 are female-headed household with average family size of 6.85 (Dalocha Agricultural Office, 2010).

3.1.6. Farming system and land use

The study area is characterized by crop-livestock based mixed farming systems. Agriculture is the principal economic activity and livelihood source in the study area, though some people derive additional income from seasonal migration to nearby towns. It is characterized as a small-scale subsistence farming zone where crop and livestock production interacting in the system. The principal agricultural activity is crop cultivation, which is entirely rain-fed with livestock rearing as a secondary activity. The major cropping system is dominated by maize 40%, *teff* 18%, wheat 16%, sorghum 13%, pepper 5%, barely 2%, pulses and vegetables 3%, while perennial crops cover 3% of land area. The average cereal yield may not exceed 8 quintal/ha, which is less than the national average 12 quintal/ha for major crops (Dalocha Agricultural Office, 2010).

Livestock production is the second most important economic base supporting the livelihood of farmers. It plays a significant role in the farming system and economic activity as a source of draught power and milk, meat, shoat (income and meat) and means of transportation. It provides dung that is important for both fuel and manuring crop fields. The livestock population of the district is composed of 71,630 cattle, 66,104 goat and sheep, 7,230 equines and 278, 845 poultry (Dalocha Agricultural Office, 2010).

With regard to land use types, 63% agricultural land, 5% bush/ shrubs and forests land, 20% grazing land, 8% under settlement and 3% badland (ravine land), and the remaining 1% are water bodies and others. The average land holding per household is estimated to be 1.26 hectares (Dalocha Agricultural Office, 2010).

3.2. Methodology

3.2.1. Sampling procedure

A three-stage sampling technique was used to select the sample farmers. Both probability and non-probability sampling methods were employed in the sampling procedure. Simple random sampling method was used for probability sampling while purposive sampling methods was used for non-probability sampling technique in selecting elements of the study.

In the first stage, the study district was purposefully selected because it is one of Africa Development Bank (ADB) Integrated Watershed Development Project intervention area since 1996. The area represents one of the highest case scenarios on the degree and rate of soil erosion and also a large amount of soil and water conservation work has been undertaken. Once the district was selected, random sampling procedure was employed to select the study *kebeles,* villages and farm households.

In the second stage, among the seventeen *kebeles* found in the district, four *kebeles* were randomly selected. Within the selected *kebeles*, villages were selected randomly using simple random sampling technique. Villages were selected proportional to the number of villages in the selected *kebeles*. There are 5-6 villages in each *kebele* with a total of 21 villages in the four *kebeles*. Two villages were selected randomly from each *kebeles* as sample for the study. A total of eight villages were selected from four *kebeles* using simple random sampling technique for the study.

Establishing sampling frame

In the third stage, farmers in the eight sampled villages were listed. The sample frame was all household heads who owned farm in selected villages. A total of 908 household heads residing in eight villages were taken as the sample frame for this study. After getting the total number of households in the selected villages, the total sample size of the survey was determined using probability proportional to sample size sampling technique (Cochran, 1977).

$$n_o = \frac{Z^2 * (P)(1-P)}{d^2} \longrightarrow n = \frac{n_o}{(1 + \frac{n_o}{N})}$$

Where;

n_o = the desired sample size when population is greater than 10000

n =sample size of finite population correction factors, when population is less than10000

Z = Z statistics for a level of confidence 95% i.e.1.96

P = 0.1 proportion of population to be included in sample i.e. 10%

N = Total number of population

d = margin error or degree of accuracy desired (0.05)

Following this, a total of 120 sample households were taken as sample for the household survey from 908 households residing in eight villages using probability proportional to sample size sampling technique. Finally, total sample size was distributed into the sample villages proportional to the total size of households in order to select the sample households proportional to the size of households in each selected villages (Table 2).

Table 2. Distribution of sample respondents by *kebeles* and villages

Kebeles	Villages name	Total number of household heads	Sample sizes
Wanja Shola	Wanja Sidist	116	15
	Gereno Shadger	109	14
Dube Godabamo	Dufa Dilamo	125	17
	Zemo Albabo	110	15
Jigena Lasho	Lasho	114	15
	Agojafar	138	18
Burka Dillapa	Mecherefa	122	16
	Tuk	74	10
Total		908	120

Source: Own household survey, 2010

3.2.2. Sources and methods of data collection

3.2.2.1. Types and sources of data

In this study, both quantitative and qualitative data were collected from primary and secondary data sources to attain the stated objectives of the study. Data from primary source have been collected using semi-structured interview questionnaires, key informant interviews, focus group discussion and field observation. In order to ensure the reliability and validity of the data collected, triangulation was employed during collection of qualitative data with development agents and the district agricultural office staffs of the study area. Finally, primary data were supplemented with secondary data in order to bridge information gap from primary sources.

Secondary data used for this study was collected from published and unpublished materials such as office records and relevant reports, journals, research papers, books, censes records and data files from internet/web pages.

3.2.2.2. Methods of data collection

For such interwoven research issues a combination of methods was used to collect relevant data. These include semi-structured interview schedule (individual interview), focus group discussions, key informant interviews, and field observation methods were applied to collect detailed information on the adoption of soil and water conservation technologies by local farmers.

Household survey: This is a formal household survey method where interview schedule was employed to elicit information from household respondents. The survey questionnaires was comprised closed and open ended questions. The questionnaire was pre-tested by administering it to selected 8 respondents to evaluate the questionnaires for quantitative information. On the basis of the results obtained from the pre-test, necessary modifications were made on the questionnaires. Prior to conducting the actual data collection, one day intensive training was given to enumerators on how to conduct the interview schedule and procedure to be followed to manage the whole field survey task.

Eight bachelor degree holders' district agricultural experts' and one researcher administered the household survey. The survey was conducted under close supervision of the researcher. The questionnaires were translated into the local language, Amharic to make the questionnaires clear to the enumerators and respondents. For the purpose of this study, the head of the selected household was interviewed using a structured questionnaire which covers a broad range of issues relevant in the process of adoption of soil and water conservation technologies. The main types of data collected from individual interview were household demographic characteristics, socio-economic, biophysical, and institutional characteristics and soil and water conservation practices and constraints of adoption of technologies.

Field survey was conducted from December, 2010 to March, 2011. A random sample of 120 farm households managing 368 farm plots was included in the survey from eight villages as primary methods of investigation. At the interview, the enumerators were taken to a treated field on which soil and water conservation technologies were installed to assess the level of management of the established structures. Assessment of the management levels of conservation structures was done by asking respondents to assert whether the structures on their plots were completely removed, partially removed and well managed or adopted.

Focus Group Discussion (FGD): is one of the most important research methods used to collect qualitative data. Additional qualitative information, such as technology attributes, benefits of soil conservation structures, community participation in planning, adoption of soil conservation practices, role of local level institutions in the promotion of soil conservation technologies, and land management practices etc were collected through four focus group discussions to supplement interview schedule. Focus group discussions were conducted in confidential environment with 6-10 groups of farmer selected purposefully from elders, women, youth and model farmers. A checklist was prepared prior to discussion and researcher facilitated the discussion. With a total of 33 focus group members' discussion held. These techniques helped to acquire useful and detailed information, which would have been difficult to collect through the questionnaire survey.

Figure 4. Focus group discussion with farmers

Source: Own field survey, 2011

Key Informant Interview: is one of the other methods used to collect qualitative data. To complement and supplement the data collected from individual households through semi-structured questionnaire and to have a detailed in sight in to soil conservation practices in the area, a discussion covering different topics with 12 key informants including, four district agricultural experts of different discipline, four development agents, who are working in the locality and four *kebele* leaders were interviewed. This helped to capture some points that were not clearly obtained from household interview and other sources. A checklist was developed and used to guide the interview.

Direct field observation and informal interview: This was done with the purpose of getting guidance to modify structured questionnaire at the beginning stage of the survey and also in order to verify the consistency of gathered data and to ensure the validity of information. In addition to field observation a number of informal discussions with individual farmers and the extension workers were conducted to cross-check and verify additional some information of interest.

These informal techniques helped to acquire useful and detailed information, which would have been difficult to collect through the questionnaire survey. The informal discussion with the farmer provided a forum where they openly expressed their opinions and views with a feeling of being at an equal standing with the interviewer. The rationale of obtaining information about the same fact from multiple methods is to increase reliability of data.

Moreover, personal observations done through transect walk at field work and visit to individual farm plot gave good opportunities to become acquainted with land management practices. In this regard, about 62% of the respondents' fields were observed in order to assess what they did on conservation structures installed on their fields.

3.2.2.3. Methods of data analysis

Following the completion of the data collection, the data were checked, coded and entered into Statistical Package for Social Science (SPSS version 16.0) software computer program for analysis. Both descriptive and econometric methods were used to analyze the data collected from sample respondents. Descriptive statistics were used to provide a summary statistics related to variables of interest. The quantitative data was analyzed using descriptive statistics such as mean, standard deviation, ratios, percentage, chi-square test and t-test. Based on survey data, the characteristics of sampled households were described with respect to adoption behavior of soil and water conservation measures. Chi-square test and the independent sample t-test were used to identify variables that vary significantly between adopters and non-adopters. The t-test was run to detect any statistically significant difference between the mean of the adopter and non-adopter categories with respect to continuous variables. The chi-square test was conducted to detect any systematic association between the dependent variable of interest and specific household characteristics.

Binary logistic econometric model was employed to identify the determinants of soil and water conservation technology adoption. The qualitative data generated by the key informants, focus group discussions, and field observation was used to substantiate and supplement the quantitative results from structured questionnaire.

3.3. Model Specification

Farmers' decision to adopt or reject new technologies at any time is influenced by a complex set of socio-economic, personal and demographic, institutional and physical factors. Analysis of the relationship between adoption and determinants of adoption involves a mixed set of qualitative and quantitative data (Long and Freese, 2006). The dependent variable is dichotomous taking on two values 1 if the farmer adopts SWC measures and 0 if does not adopt conservation measures. Estimation of this type of relationship requires the use of qualitative response models. In econometric literature adoption behavior was estimated using binary choice models. In this regard, the linear probability model, logit and probit models are the most widely used models in empirical studies to approximate mathematical relationship between explanatory variables and the adoption decision (Gujarati, 1995 cited in Tadesse and Kassa, 2004; Tsegaye and Bekele, 2010). Linear probability model is the simplest method, but may not be appropriate, because conditional probability increases linearly with the value of explanatory variables. Unlike linear probability model, logit and probit models guarantees the estimate probability increase but never step outside 0 and 1 interval and the relationship between the probabilities (Pi) and explanatory variable (Xi) is non linear (Gujarati, 1998).

Although the choice between logit and probit models is difficult because of the statistical similarities between the two models in most applications, the only difference being that the logistic distribution function has slightly heavier tails than the cumulative normal function; that is, the normal curve approaches the axes more quickly than the logistic curve (Maddala, 1983 cited in Tadesse and Kassa, 2004). Unlike probit it captures the dynamic aspects of adoption of technologies (Charles, 2006). The logistic regression model is an appropriate statistical tool to determine the influence of independent variables on dependent variables when the dependent variable is dichotomous and the explanatory variables are continuous and dummy (Long and Freese, 2006; Green, 2008). For this study binomial logit model is used because of its comparative mathematical and interpretational simplicity. The dependent variable of model adoption of soil and water conservation structures as a function of series personal and demographic, socio-economic, physical and institutional characteristics of households.

Following Gujurati (1998) and Green (2008), the binomial logistic regression distribution function can be specified as follows:

$$Pi = F(Zi) = F\left[\beta_o + \Sigma\beta_i X_i\right] = \frac{1}{1+e^{-(\beta o + \Sigma\beta Xi)}} \quad \_\_\_\_\_\_\_\_\_ \; 1$$

Where subscript *i* denote the i^{th} observation in the sample

P_i the probability i^{th} farmers is being adopter of SWC measures ranges from 0 to 1

X_i represents i^{th} explanatory variables, i =1, 2, 3. . . n or household characteristics

e is the base of natural logarithms (2.718)

β_o is the intercept term and (β_1, $\beta_{2,\ldots,}$ βn) slope of coefficient to be estimated in the model with each explanatory variable X_1, $X_{2,}\ldots,X_n$.

For ease of interpretation of the coefficients, a logistic model could be written in terms of the odds and log of odd. The odds can be defined as the ratio of the probability that a farmer would be adopter of SWC measures (Pi) to the probability that a farmer would be non-adopter of SWC measures (1-Pi) (Hosmer and Lemeshow, 1989 cited in Bogale and Shimelis, 2009). The probability that a given household is adopter of SWC measures (Pi) is expressed by:

$$\text{Pi} = \left(\frac{1}{1+e^{-Zi}}\right) \quad \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \; (2)$$

The probability that a household non-adopter of SWC measures (1-Pi) is defined by:-

$$(1 - pi) = \frac{1}{1+e^{zi}} = \frac{e^{-zi}}{(1+e^{-zi})} = \frac{1}{1+e^{zi}} \quad \_\_\_\_\_\_\_\_\_ \; (3)$$

Using equation (2) and (3) the odds ratio becomes:

$$\left(\frac{pi}{1 - pi}\right) = \left[\frac{1+e^{zi}}{1+e^{-zi}}\right] = e^{zi} \quad \_\_\_\_\_\_\_\_\_\_\_\_ \; (4)$$

Equation (4) indicates simply the odds ratio is in favor of adopting the technologies.

Finally, taking the natural logarithm of odds ratio of equation (4) it results as,

$$L_i = \ln\left[\frac{P_i}{1-P_i}\right] = Z_i = \beta_O + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n \quad \_\_\_\_\_\_\_\_\_ \; (5)$$

Where Li is log of the odds ratio, which is not only linear in X_i but also linear in the parameters

Zi a linear function of n explanatory variables (X_i)

Ui= is the disturbance term

If the disturbance term (Ui) is introduced to the model, the logit model becomes:

$$Z_i = \beta_O + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + Ui \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} \quad (6)$$

It should be noted that the estimated coefficients do not directly indicate the effect of change in corresponding explanatory variables on probability (Pi) of the outcome occurring. Rather the coefficients reflect the effect of individual explanatory variables on its log of odds {ln [p/ (1-p)]}. The positive coefficient means that the log of odds increases as the corresponding independent variable increases (Neupane *et al*., 2002). The logistic model was estimated using maximum likelihood estimation method due to the nonlinearity of the logistic regression model.

3.4. Working Hypothesis and Variables Specification

The measure of adoption used in this study is the actual physical presence of conservation structures on the farmers' plots. Different variables are expected to affect farmer's adoption of conservation practices in the study area. The major variables expected to have influence on the household adoption of SWC practices were explained below.

The dependent variable of the model (Yi**):** The dependent variable in this study is decision of adoption of soil and water conservation measures that involve a construction of physical structures on farmers' cultivation plot to reduce runoff and the resulting soil loss. Farmers in this group are those who had soil and water conservation structures built by incentive, and/or by their own initiatives on their farm land. We do not actually observe the latent variable (P_i) what we observe is the dummy variable (Y_i).

Hence, Y_i = 1 if Pi > 0; 0 other wise

Since Y_i is dependent variable we can write,

Prob (Y_i =1) = P_i

Prob (Y_i=0) = (1-P_i)

In this study a dichotomous dependent variable indicates whether or not a household adopt soil and water conservation measures 1 for a household using either *fanya juu*, soil bunds, stone-faced soil bunds and water disposal channels or both in at least one of his/her farmland at the time of survey (adopter) and 0 otherwise (non- adopter).

The independent variables of the model (Xi**):** The independent variables of the study are those which are hypothesized to have associations with dissemination and adoption of soil and water conservation technologies. Farmer's decision to use or adopt a given soil and water conservation technology at any time is influenced by the combined effect of household's personal characteristics, socio-economic, physical and institutional factors which are related to their objectives and constraints. Review of literatures, findings of empirical studies, researcher knowledge and farming system of the study area were used to select 15 explanatory variables and structure the working hypothesis. Explanatory variables and their justifications are discussed below.

Sex of the household head (SEXHH): Sex refers to biological differentiation of human being. It is represented in model by dummy (1 if male, 0 female). Due to long lasted cultural and social grounds in many societies of developing countries, women have less access to household resources and also have less access to institutional services. Male headed households have freedom of mobility and better access to information on improved agricultural technologies (Tsegaye and Bekele, 2010). Thus, male-headed households are more likely to adopt soil and water conservation technologies than female headed households positively.

Age of the household head (AGEHH): This is number of years of the household head since birth at the time of the survey and treated as continuous variable. The age of a farmer can enhance or prevent the adoption of soil and water conservation practices. With age, a farmer may get experience about his/her farm and can react in favor of constructing and maintaining soil conservation structures. However, on other side, age is related to the risk management nature of an individual farmer. Therefore, it is hypothesized that age of the household was expected to have either a positive or negative effects on adoption of soil and water conservation structures.

Education level of household head (EDUHH): It refers to the educational attainment of the household head up to the time of survey. It is a continuous variable defined as schooling years of the household head. Education enhances farmers' ability to perceive, interpret and respond to the new events and make appropriate decision. Educated farmers are more likely to adopt new technologies than less educated farmers (Krishna *et al*., 2008) which in turn increase agricultural production. Therefore, education was expected to positively influence on adoption soil and water conservation technology.

Family size of the household (FAMLSIZE): It refers to the total number of household members who resides and eats with respondent's household head. This variable has been treated as continuous variable measured in number. Family size is one of the other important household demographic variables which have influence on farmers' adoption behavior. Soil conservation structures are labour intensive to build and maintain and hence households with large human capital may invest more in soil conservation practices. Family size might have dual effects on land users' conservation decisions (Amsalu and De Graaff, 2006). Thus, in this study family size was hypothesized to have either a positive or negative impacts on the adoption of soil conservation practices.

Active family labor force (ACLABF): It refers to the active family member labor between 15 and 64 years of age. The variable has been treated as continuous variable measured by man equivalent of the family labor. The existence of large number of active labor force in a family are expected to adopt soil and water conservation innovation more than those who lack labor accessibility since soil conservation structures required more labor and have positive relationship. A household with large number of adult members (active agricultural workers in the age bracket of 15-64 years) per unit is more likely to be in a position to try and continue to use conservation technologies (Kidane, 2000 cited in Petros, 2010). Hence, active family labor was hypothesized to influence the adoption decision of conservation structures positively.

Dependent members in the household (DEPMEMB): It refers to the number of children under age of 15 year and old age of above 64 year in the family expressed in number or percent. The existences of large number of children under age of 15 years and over 64 years age in the family shows high dependence ratio and could affect the adoption of soil and water conservation technologies. Thus, it is hypothesized that large number of dependent member in the household affects negatively the adoption of soil and water conservation practices.

Off-farm activities (OFFFARM): It is the involvement of household head or his/her family members in non-farm income generating activities. It is a dummy variable that takes a value of 1 if the farm household members participate in off-farm activities and 0 otherwise. Apart from agricultural activities farmers are known to engage in other off-farm income generating activities to meet their liquidity constraints (Assefa, 2009). Involvement in off-farm activities crowds out resources required to construct and maintain conservation practices. Therefore, it was hypothesized that participation in off-farm activities negatively influence household adoption of conservation practices.

Livestock holding (LIVESTLU): This variable is a continuous variable defined as the total number of livestock owned by a household heads measured in Tropical Livestock Units (TLU). In rural context, livestock holding is an important indicator of wealth position of the household and increased availability of capital that makes investment in conservation feasible. Household who owned large number of livestock were assumed to adopt SWC practices better than others who have less number of livestock. Hence, livestock holding size was expected to influence adoption of physical soil and water conservation technologies positively.

Land holding size of household (FARMSIZE): In the present investigation, this variable stands for the total area of land a household owned measured in hectare, which included cultivated, grazing and fallow land and treated as continuous variable. Land is perhaps the single most important resource as it is a base for economic activity especially in agrarian society. Farm size influences households' decision to adopt or reject new technologies. Hence, landholding size was hypothesized to have either positive or negative relationship with adoption of soil and water conservation technologies.

Access to extension service (EXTEN): Agricultural extension services provided to the farmers are the major sources of agricultural information in the study area. Extension visits or availability of extension services is perhaps the single most important variable that emerged significantly in most of the research work on technology transfer and adoption (Van den Ban and Hawkins (2000). It is a dummy variable that takes a value of 1 if farm household heads have access to extension service through visit by the development agents and 0 otherwise. The more access to extension service through the extension agent visit, the higher is the possibility of farmers being influenced to adopt agricultural innovations. Therefore, it is expected that access to extension service through a visit made by the development agents have a positive relationship with farmers' informed decision for adoption of soil and water conservation technologies.

Participation in training (TRAINING): The other means through which farmers get agricultural information is through participating in different extension events arranged by different institutions. It is a dummy variable that takes a value of 1 if household has attended training in soil and water conservation and 0 otherwise. Training is one of the means by which farmers acquire new knowledge and skills about agriculture and soil and water conservation technologies, which may in turn leads to a change in their attitude and behavior. Hence, participation in training is expected to positively influence farmers' adoption behavior of conservation practices.

Land tenure security (LANDSECU): It is a dummy variable that takes a value of 1 if farmers perceive a risk of loss of land in the future and 0 otherwise. Land tenure security influences farmers' decision to adopt conservation measures by influencing the length of farmers' planning time and sense of responsibility (Chomba, 2004). Hence, it is expected that land tenure security will have a positive association with adoption of soil and water conservation technologies.

Farm distance of household (DISTANCE): This is a continuous variable defined as the average time the farmers must travel from the residential area to the plots has an effect on the status of soil conservation structures. Farmers residing close to their cultivation land invest more on soil and water conservation measures than their counterparts living at distance. It is hypothesized that the further away the plots from homestead the less effort employed in maintaining and adopting soil conservation structures. Thus, we expect negative relationship between adoption of conservation structures and distance of a plot.

Slope of a parcel of land (SLOPE): The topography of the farm land plays an important role in decision of farmers to adopt soil and water conservation practices. This variable is used as a proxy for the erosion potential.

It is a dummy variable that takes the value of 1 if the farm land is steep or very steep slope and 0 otherwise. Steeper slope has been found to have a positive effect on the adoption of soil conservation measures (Ervin and Ervin, 1982). The steeper the slope, the more likely the land will be exposed to erosion. Thus, this variable is hypothesized to have a positive influence on adoption of soil and water conservation measures.

Farmers' perception of soil erosion hazard (PERCERO): This variable measures farmers' perception of the soil erosion problem. Perception of the soil erosion problem is considered to be vital for farmers' conservation decisions. It takes the value of 1 if a household head perceived the soil erosion problem and 0 otherwise. Farmers who have perceived the problem of soil erosion are more likely to be adopting soil conservation structures. Thus, the perception variable is expected to be positively associated with farmers' adoption of soil and water conservation practices.

Table 3. Summary of explanatory variables used in the logistic regression model

Explanatory variables	Expected relationship	Variables description
SEXHH	Positive	Sex of the household head; dummy (1 if male; 0= female)
AGEHH	Positive/negative	Age of the household head in years
EDUHH	Positive	Schooling years of the household head
FAMLSIZE	Positive/negative	The total number of members in a family
ACLABF	Positive	The number of activity family members in the household between age of 15 and 64 years (man equivalent)
DEPMEMB	Negative	Children under age 15 and old age of above 64 year in the family in number
OFFFARM	Negative	Dummy, 1 if the farmer participate in off-farm work; 0 otherwise
LIVESTLU	Positive	Livestock holdings of the household Tropical Livestock Unit(TLU)
FARMSIZE	Positive/negative	Total land area of a household owned in hectare
EXTEN	Positive	Contact with DAs; dummy (1 if there is contact; 0 otherwise)
TRAINING	Positive	Dummy variable; 1 if a farmer trained; 0 otherwise
LANDSECU	Positive	Dummy, 1 if farmer feels risk of loss land in future; 0 otherwise
DISTANCE	Negative	Average distance of a plot from residence (in walking minutes)
SLOPE	Positive	Dummy, 1 if the farm land is steep or very steep slope; 0 otherwise
PERCERO	Positive	Dummy, 1 if farmer perceived erosion as problem; 0 otherwise

4. RESULTS AND DISCUSSION

This part, which is divided in to three sections, attempts to bring together the major findings of the study. The first section tries to identify and analysis demographic, socio- economic, institutional and biophysical characteristics of the sample households and presented using descriptive and bi variant analysis. In the second section description of the current and common soil and water conservation measures practiced in the study area were presented. In the third section empirical analysis of the determinants of adoption of physical soil and water conservation measures were presented using the result of binary logistic econometrics model.

4.1. Demographic and Socio economic Characteristics of Sampled Households

4.1.1. Sex of household heads

Gender difference is found to be one of the factors influencing adoption of new technologies. Due to many socio-cultural values and norms, males have freedom of mobility and participation in different meetings and consequently have better access to information on improved agricultural technology. So, sex was hypothesized to influence adoption of SWC practices positively in favor of male headed households. However, the result of chi- square analysis (χ^2 =1.164, P=0.281) revealed that there is no systematic association between sex of household and adoption soil conservation practices (Table 4).

The result value revealed that there is asymptotic symmetric relation between sex household and adoption of SWC practices. This implies that both female and male households are likely to be adopting soil and water conservation practices. The result of the study is in a complete agreement with findings of (Sisay, 2009), but contrary with the findings of Tesfaye (2008) and Adgo (2008).

Table 4. Relationship between sex of households and adoption of SWC measures

Sex of household	Level adoption of SWC						χ^2- value	P-value
	Non-adopter (N=43)		Adopter (N=77)		Total (N=120)			
	N	%	N	%	N	%		
Male	37	86	71	92.2	108	90		
Female	6	14	6	7.8	12	10		
Total	43	100	77	100	120	100	1.164 (ns)	0.281

Source: Own survey, 2011; Note: ns = non-significant

All of the sample respondents reported that they have participated in the intervention of some soil and water conservation activities in different programs. As described in the (Table 4) majority of sampled household (90%) were male headed while 10% were female head households. Out of the total adopter households (92.2%) and 7.8% were male and female headed respectively.

4.1.2. Age structure of households

Age is one of the personal factors that is useful to describe households and provide clue about the age structure of the sample and the population. The age of household heads varies between 21 and 80 years. About 65% of the sample households were found in the age group of 21- 45 years (young), 29.2% from the age bracket of 46- 64 years (middle) and 5.8% from age bracket of 65- 80 years old (Table 5). About 94.2% of the sampled household heads falls under the age bracket of 21-64 years. The percentage of farmers who don't adopt SWC structures differ much more among age groups. Accordingly, 58.1%, 37.2 and 4.7% of non-adopter farmers had age range of 21- 45, 46- 64 and 65- 80 years respectively (Table 5).

As indicated in Table 5, the mean age of non-adopters and adopters household was 42.70 and 42.75 with a standard deviation of 12.552 and 11.425 respectively. Age was hypothesized to influence the adoption decision of farmers either positively or negatively. The result of t-test shows that there is no significant mean age difference among the age categories between adopters and non-adopters household (t=1.604, P=0.114). A possible explanation is that young farmers did not adopt SWC practices due to the opportunity costs linked with small farm size. This is consistence with findings of Cramb *et al*. (1999) and Birhanu (2003) but contrary with findings of Sisay (2009) and Petros (2010) in north western of Ethiopia. However, Long (2003) found that older farmers are not less likely to use conservation practices on their agricultural land. Hence, the effect of age on adoption of conservation structure is area specific.

Table 5. Relationship between age of household and adoption of SWC practices

Age group (year)	Level of adoption SWC methods						t-value	p-value
	Non adopter(N=43)		Adopter(N=77)		Total (120)			
	N	%	N	%	N	%		
21- 45	25	58.1	53	68.8	78	65.0		
46 - 64	16	37.2	19	24.7	35	29.2		
65 - 80	2	4.7	5	6.5	7	5.8		
Total	43	100	77	100	120	100	1.604(ns)	0.114
Minimum	25		22		22			
Maximum	76		80		80			
Mean	42.70		42.75		42.73			
SD	12.552		11.425		11.789			

Source: Own survey, 2011; Note: ns = non significant

4.1.3. Education level of households

Education is very important for the farmers to understand and interpret the agricultural technology and information coming to them from any direction. To analyze the response of farmers by education level, household heads were categorized into five as illiterate, read and write, grade 1-4, grade 5-8 and grade 9-10 (Table 6). The distribution of total sample households in terms of literacy level has shown that 39.2 percent were illiterate and 60.8 percent were literate.

In this study the literacy was extended from read and write to attending regular school education. Out of the total adopter households, 36.4% of them are illiterate, 9% are read and write, 32.5% from grade 1-4, 19.5% from grade 5- 8 and the rest 2.6% are from grade 9-10 while non- adopter households, 44.1% of them are illiterate, 21% could read and write, 23.3% from grade 1- 4 and 11.6% of them are within grade 5- 8 education level (Table 6). As indicted in Table 6, the average education level of non- adopters and adopters household was 2.45 and 3.01 with standard deviation of 1.53 and 1.697 respectively. The total average education level of sample households was 2.79 with a standard deviation of 1.66.

Table 6. Education level of household heads and adoption of SWC measures

Education level of HH	Adoption level of SWC measures						t-value	p-value
	Non-adopter(N=43)		Adopter (N=77)		Total(N=120)			
	N	%	N	%	N	%		
Illiterate	19	44.1	28	36.4	47	39.2		
Read and write	9	21.0	7	9.0	16	13.3		
1-4 grade	10	23.3	25	32.5	35	29.2		
5-8 grade	5	11.6	15	19.5	20	16.6		
9-10 grade	0	0.0	2	2.6	2	2.6		
Total	43	100	77	100	120	100	1.401ns	0.166
Mean	2.45		3.01		2.79			
SD	1.53		1.697		1.66			

Source: Own survey data, 2011; Note: ns = non significant

Result of t-test (t=1.401, P=0.166) showed that there is no significant mean education level difference between adopters and non-adopters household (Table 6). This implies that the effect of insufficient education is not the main hindrance of adoption of SWC practices among sample farmers. This study is consistent with the findings of Shiferaw and Holden (1998), Tadesse and Kassa (2004) and Sisay (2009) in northern and southern Ethiopia. Similarly study conducted by Beshah (2003) in Konso, Woliata and Wello areas revealed that there is no variation between literacy and illiteracy rate in terms of soil and water conservation adoption. Other studies conducted by Long (2003), Anley *et al. (*2006) and Krishna *et al.* (2008) reported a positive and significant relationship of education with adoption of improved soil and water conservation technology.

4.1.4. Family size of the households

Family size in this study is considered as the number of individuals who reside in the respondent's household, share the dwelling unit and cooking common food. Family size of the household was hypothesized to influence the adoption of SWC practices either positively or negatively.

As shown in Table 7, the mean family size of non-adopters and adopters households was 6.79 and 5.29 persons with standard deviation of 1.72 and 1.95 respectively. The minimum and maximum family size of the sampled households was 2 and 11 persons respectively. The average being 5.83 persons which are greater than what has been reported for the national 5.15 household (CSA, 2008).

Table 7. Association between household family size and adoption of SWC measures

Family size	Non-adopter (N=43)		Adopter(N=77)		Total(N=120)		t-value	p-value
	N	%	N	%	N	%		
1-4	2	4.7	29	37.7	31	25.8		
5-8	31	72.0	32	41.5	63	52.5		
9-12	10	23.3	16	20.8	26	21.7		
Total	43	100	77	100	120	100	-2.426**	0.018
Minimum	3		2		2			
Maximum	11		9		11			
Mean	6.79		5.29		5.83			
SD	1.72		1.95		2.00			

Source: Own Survey, 2011; Note: ** Significant at less than 5% significance level

To check whether there is a significant mean difference in family size between adopters and non-adopters, t- test statistics was run. The result of independent sample t-test (t= -2.426, P= 0.018) shows a statistically significant mean difference between adopters and non-adopters at 5% significance level (Table 7). This implies that a household with a larger family size are less likely involved in soil and water conservation practices. The possible explanation is that as family size increases more family members involved in short term income or benefit generating activities to secure food demand of the household. The result of this study is in harmony of the past findings of Amsalu (2006) who found out that, in the Beressa watershed in the Northern highlands of Ethiopia, farmers with a larger family size are less likely to continue using stone terraces. Another study by Bekele and Drake (2003) also found similar results to ours in the eastern highlands of the country. They noted that in a family with a greater number of mouths to feed, competition arises for labour between food generating off-farm activities, like daily labour, investment and in maintenance of SWC structures.

4.1.5. Active family labor force of the households

Family labor was assumed to be the main source of labor required for farm operations such as land preparation, planting, weeding, harvesting and soil and water conservation etc. Hence, information was generated on labor availability of sample households in order to examine the influence of labor availability on adoption of soil and water conservation technology. The active family labour force availability in man equivalent was calculated for the sample respondents using Samuel and sharp (2007) conversion factors (Appendix 1).

Table 8. Active family labour and adoption of SWC measures in man equivalent

Active labor force	Non-adopter (N=43)		Adopter(N=77)		Total (N=120)		t-value	P-value
	N	%	N	%	N	%		
1-3	34	79.1	42	54.5	76	63.3		
4-6	9	20.9	33	42.9	42	35.0		
Above 6	0	0.0	2	2.6	2	1.7		
Total	43	100	77	100	120	100	3.098***	0.003
Minimum	1		2		1			
Maximum	4		7		7			
Mean	2.65		3.52		3.20			
SD	0.89		1.42		1.32			

Source: Own survey, 2011; Note: *** Significant at less than 1% significance level

As shown in Table 8, the average number of active agricultural workers or labor force in terms of man equivalent for non-adopter and adopter households were 2.65 and 3.52 respectively and the total average is 3.20. The minimum and maximum active labour force in terms of man equivalent is one and four for non- adopters and for adopters household two and seven respectively (Table 8). Generally it is found that, adopters' and non-adopters' households have different distribution of active labour force. This is evident from the t-test result (t=3.098, P =0.003) which shows that there is statistically significant mean active family labor force difference between adopters and non-adopters of SWC structures at less than 1% level (Table 8).This implies that as active family labour increases, the probability of households to adopt SWC practices increases due to the availability of agricultural working labour forces. This result reaffirms previous findings of (Petros, 2010) who found significant mean difference in adoption of conservation tillage in the northern of Ethiopia.

Farmers were asked whether they face shortage of labour for agricultural activities. Out of the total 120 respondents 54 percent faced labor shortage, while 46 percent have available labor for agricultural activities. It seems that non-adopter households experience more labor shortage than adopter of SWC measures households (see Appendix table 2).

At the busiest period of the year the demand for labour reaches its peak and labour shortage happens. To overcome the problem of labour shortage local farmers have an inherited age old traditional mutual labor exchange system locally known as *Gez* which is also common and reported by the majority of the sampled households (65%). Some better off farmers used daily labour and others hire labor for one cropping seasons. Even though, soil and water conservation activities are labor intensive, traditional mutual labor exchange systems were not used and instead family labor and government organized development work force was used dominantly for construction and maintenance soil and water conservation measures when ordered to do so.

4.1.6. Dependent members in the household

It refers to the children less than 15 and old age greater than 64 year in the family expressed in number or percent. Based on this fact this variable was hypothesized to have negative relation with adoption of SWC practices. The population segment under the age of 15 years was around 54% and above 64 was only 1.8% of the total population (Appendix 3). The working age population following the conventional categorization was 44.2%. The total dependency ratio was 125.8%, which was composed of 121.6% child-age dependency ratio and 4.2% old aged dependency ratio (Appendix 3). This means one worker has to support 1.258 heads aging less than 15 and greater than 64 year old age in the household. This figure relatively corresponds to what was reported for the poor household at the national level 1.34 (Ertiro, 2006).

As indicated in (Table 9) the first number of dependent member category (0-2) takes 41.7%, the second category (3-5) take large share for both adopter and non-adopter households (50.8%), and the third category (6-8) takes the minimum (7.5%) dependent member for both types of households. The mean dependent member of non-adopter and adopter households was 4.02 and 2.41 with a standard deviation of 1.83 and 1.32 respectively and total average being 2.99 (Table 9).

Table 9. Dependent members in the household and adoption of SWC practices

Number of dependent members	Non-adopter (N=43)		Adopter(N=77)		Total(N=120)		t- value	p-value
	N	%	N	%	N	%		
0-2	9	20.9	41	53.2	50	41.7		
3-5	25	58.2	36	46.8	61	50.8		
6-8	9	20.9	0	0.0	9	7.5		
Total	43	100	77	100	120	100	-5.545***	0.000
Minimum	1		0		0			
Maximum	9		5		9			
Mean	4.02		2.41		2.99			
SD	1.83		1.32		1.70			

Source: Own survey, 2011, Note: *** Significant at less than 1% significance level

The result of independent sample t-test showed that (t=-5.545, P=0.000) there is statistically significant mean dependent members' difference between adopters and non-adopters household at less than 1% significance level. This implies that households with many children and old aged groups could face labour shortage because of high dependency ratio.

Therefore, this is consistent with the prior expectation that high dependent members' of the household has a role in affecting the probability of adopting SWC measures. This reaffirms the findings of Ertiro (2006) in Anna watershed who found that farmers with high dependent member in the household reduce the probability of maintaining and retaining conservation structures.

4.1.7. Off-farm activities

Off- farm activity is one of the most important means to generate additional income. During slack periods, many farmers can earn additional income by engaging in various off-farm activities in the study area. Petty trade, labor market, hand craft making and selling fire wood were found some of the off-farm activities in which sample households were participating. One of the major interests of the study was to investigate if there was relationship between farmers' adoption of the introduced conservation structures and having other sources of income.

According to the survey result, of the total sampled households about 56.7 % were engaged in off- farm activities. Among the households who participated in off-farm activities, adopter accounted about 37.7% and non-adopter comprise 53.5% (Table 10).

Table 10. Participation in off-farm activities and adoption of SWC measures

Participation off-farm activities	Level of adoption SWC measures						χ2-value	P-value
	Non-adopter(N=43)		Adopter(N=77)		Total(N=120)			
	N	%	N	%	N	%		
Yes	23	53.5	29	37.7	52	56.7		
No	20	46.5	48	62.3	68	43.3		
Total	43	100	77	100	120	100	0.894(ns)	0.344

Source: Own survey, 2011; Note: ns = non significant

The chi-square result test (χ2=0.894, P=0.344) shows that there is no systematic relationship between participation in off-farm activities and adoption of soil and water conservation technology (Table 10). The result of this study confirms the findings of Kessler (2006) who found that farmers with off-farm income have greater flexibility to invest in new technology compared with farmers who rely solely on farm income.

4.1.8. Livestock holding of the households

In the study area mixed farming is practiced with crop and livestock production. Livestock is an important component of livelihood and farming system. A vast majority of the sample households included in this survey own animals of different kind. Livestock provides traction power, means of transport, food, manure and serves as a source of income through sale of animals and their products. In order to make comparison of the livestock size between adopter and non-adopter groups; the livestock size was converted into TLU based on Storck *et al*. (1991) conversion factor (Appendix 4). The results of this study indicates that the livestock holding of sample population ranges from 0 to 17.52 TLU implying the existence of variation among the households in livestock ownership. The average livestock holding size of non- adopter and adopter group of sample households was 4.346 and 4.696 TLU respectively (Table 11).

Table 11. Livestock holding of household and adoption of SWC measures in (TLU)

Livestock owned in TLU	Level of adoption SWC				t-test	P-value
	Non-adopters(N=43)		Adopters(N=77)			
	Mean	SD	Mean	SD		
Cow	0.930	0.934	0.961	1.019	0.870(ns)	
Heifers	0.436	0.698	0.292	0.489	-1.320(ns)	
Oxen	1.256	1.071	1.377	0.987	0.623(ns)	
Bulls	0.192	0.545	0.273	0.542	0.781(ns)	
Goats	0.221	0.537	0.259	0.497	0.398(ns)	
Sheep	0.767	0.710	0.838	0.933	0.429(ns)	
Donkeys	0.374	0.467	0.491	0.441	1.359(ns)	
Mules	0.000	0.000	0.014	0.214	0.746(ns)	
Horses	0.256	0.168	0.043	0.214	0.456(ns)	
Chicken	0.056	0.061	0.059	0.069	0.265(ns)	
Calves	0.087	0.120	0.088	0.126	0.985(ns)	
Total	4.346	3.356	4.695	3.462	0.536 (ns)	0.593
Minimum	0.00		0.53			
Maximum	15.04		17.52			

Source: Own Survey, 2011; Note: ns = non significant

As confirmed by many adoption studies, those farmers who have better livestock ownership status are likely to adopt improved agricultural technologies.

To know whether there is a variation in livestock holding between adopter and non- adopter households, t- test was conducted. The result of t-test (t=0.536, P=0.593) revealed that there is no significant mean difference among adoption categories in TLU as indicated in (Table 11). The result was in contrary with our expectation. This clearly shows the insignificance role of livestock holding in adoption of SWC technology. The result of this study is in agreement with the findings of Bekele and Drake (2003) who reported that livestock holding has no significant relationship to farmers' adoption decision.

4.1.9. Land holding size of the households

Land size and ownership are the two critical rural livelihoods issue for farmers in general in Ethiopia and Dalocha district in particular. As land is a public property owned by the government, farmers have only usufruct right to the plots of farmland they are entitled to. Farmers in the study area use both their own land and rented or shared in land for crop production. The average total land holding of sample households were 1.2 ha with a standard deviation of 0.57. The minimum and maximum total land holding of the households ranges from 0.4 to 3 hectares. Adopters owned, on average larger holding size1.32 hectare than the non-adopters 1.05 hectare (Table 12).

Of the total sampled households, the majority (39.2%) possessed between 0.5- 1 ha of land. Only 9.9% had more than 2 hectare and some 9.2% had less than 0.5 hectare. Among non-adopter farmers about 53.5% had holding size between 0.5- 1 and 23.2% had less than 0.5 hectare. Among adopter households 31.1% had holding size between 0.5-1 ha and 39% owned between 1.1-1.5 ha, 15.6% had 1.6-2 ha and the remaining 13% had greater than 2 hectares.

The size of land owned per household has been shrinking since so long due to the ever increasing human population and land degradation, which is relatively equivalent to the national figure, which is 1.18 hectare (CSA, 2008). The majority of those farmers who own less than 0.5 ha in the area are young, since no redistribution of farm land was made in the study area. However, some young households are owned very small plots of land that got from the holdings of their parents, as the *kebeles* do not have a land pool from which to give land to newly forming families.

Table 12. Landholding size of household heads and adoption SWC measures

Land size in hectare	Level of adoption SWC measures						t-value	p-value
	No adopter(N=43)		Adopter(N=77)		Total (N=120)			
	N	%	N	%	N	%		
< 0.5	10	23.2	1	1.3	11	9.2		
0.5- 1	23	53.5	24	31.1	47	39.2		
1.1-1.5	7	16.3	30	39.0	37	30.0		
1.6 -2	2	4.7	12	15.6	14	11.7		
> 2	1	2.3	10	13.0	11	9.9		
Total	43	100	77	100	120	100	1.997**	0.050
Minimum	0.40		0.50		0.40			
Maximum	3.00		3.00		3.00			
Mean	1.05		1.32		1.20			
SD	0.67		0.52		0.57			

Source: Own survey, 2011; Note: ** significant at 5% significance level

The result of independent sample t-test (t=1.997, P=0.05) shows a statistically significant mean difference between adopters and non-adopters household at 5% significance level. This indicates that as land holding size increases, the higher the likelihood of adoption of soil and water conservation practices by farmers. This result is in line with the finding of Krishna *et al*. (2008) in Nepal who found that large farms are more likely to adopt improved soil conservation technology. Similarly Tadesse and Kassa (2004), Anley *et al.* (2006) and Amsalu and de Graaff (2006) found out that farm size has a positive and significant influence on the farmers' decision to adopt physical soil conservation measures. Tenge *et al.* (2004) in Tanzania found that adoption is low among farmers with small farm size.

4.2. Institutional Characteristics of Sampled Households

4.2.1. Access to extension service

It is a recognized fact that diffusion of information on improved technological alternatives is an important element that contributes positively for the adoption and sustained use of a given technology. Unless there is adequate mechanism for transmitting information, the adoption of any new agricultural practice would not be successful. In the study area, the most important sources of information cited were through communication with neighbourhood, NGOs and the government's agricultural extension service program or development agents.

Extension contact is supposed to have a direct influence on the adoption behavior of farmers. The *Kebele* level extension worker is one of the most important sources of information on agricultural innovations to farmers, especially those who are earlier adopters. Later adopters, however, tend to rely more for information on friends and neighbors who have already tried out the innovation and adopted.

Table 13. Association between extension agent contact and adoption of SWC measures

Contact with DAs/ service	Level of adoption SWC practices						χ2-value	P-value
	Non-adopter (N=43)		Adopter (N=77)		Total (N=120)			
	N	%	N	%	N	%		
Yes	21	48.8	65	84.4	86	71.7		
No	22	51.2	12	15.6	34	28.3		
Total	43	100	77	100	120	100	17.29***	0.000

Source: Own survey, 2011; Note: *** Significant at less than 1% significance level

As respondents' response indicated from the total sampled households 71.7% were reported having contact and had got advice service from development agents, while 28.3% sample households were reported having no contact with development agents (Table 13). This has a serious implication with respect to management of development agents, particularly having three development agents per each rural *kebele.* When adopters and non- adopters were compared, from the total sampled adopter and non-adopter households, 84.4% and 48.8% had got extension service respectively.

The chi-square analysis showed that ($\chi2$ =17.29, P=0.000) there existed highly significant relationship between extension service given by development agents and adoption of soil and water conservation structures at less than 1% significance level (Table 13). This indicated that farmers who have a good contact with development agent have a high probability of adopting soil and conservation practices than those with no contact.

This agrees with priori expectation and confirms the study conducted by Anley *et al*. (2006) who found that level of extension visit were important variables affecting the probability and intensity of using improved soil conservation technologies in Dedo district of Jimma zone.

4.2.2. Participation in soil and water conservation training

The other means through which farmers get soil and water conservation technology information is through participating in different extension events arranged by different institutions. These include training, field day/visit, demonstration and others. Training is an important aspect of disseminating a given agricultural technology. It equips farmers with new knowledge and skills, which help them to perform new practice properly. If a farmer has no skill and technical know-how about SWC technology, he/she may have less probability of its adoption (Petros, 2010). The skill acquired through training helps to carry out a new technology effectively and efficiently. In the study area there are efforts made by district office of agriculture and NGOs to give training to the farmers about soil and water conservation practices. If farmers are well trained in new practice, they may not need more outside support later. He/she himself can properly implement the recommendation.

Table 14. Training participation and adoption of SWC Practices

Training participation in SWC	Non-adopter (N=43)		Adopter (N=77)		Total (N=120)		$\chi2$-value	P- value
	N	%	N	%	N	%		
Yes	12	28	57	74	69	57.5		
No	31	72	20	26	51	42.5		
Total	43	100	77	100	120	100	4.795**	0.029

Source: Own survey, 2011; Note: ** Significant at less than 5% significance level

As illustrated in table 14, about 57.5% of the sample respondents received training in SWC practices. However, 42.5% sample households didn't receive any training in soil and water conservation. Of the trained farmers adopter accounts 74% and non-adopter only 26%. The chi-square result ($\chi2$ = 4.795, P=0.029) shows that there is a significant relationship between training participation and adoption of conservation technologies at less than 5% significance level (Table 14). The result of this study is in agreement with the finding of many authors for instance, Worku (2006) and Adgo (2008) reported that attendance of farmers in training contributed positively to farmers' adoption decision.

4.2.3. Land tenure security

The issue of land tenure is among the strongly contested aspect of agricultural policy. Being the most important institution, land tenure security has important implications in agricultural development in general and natural resource conservation in particular (Karki, 1999 cited in Abera, 2003). Perception on land tenure security is one of the determining factors for farmers' to take risk and invest on their farmland either by adopting agricultural technologies or their labor on land management practices. Farmers were asked whether they perceive a risk of loss of their plot of land in the future, about 52.5% of the sample households' perceived loss of land and about 47.5% of the respondents indicated that they do not anticipate loss of their farm plots in the future (Table 15).

Table 15. Relationship between land tenure security and adoption of SWC practices

Risk of loss of land in future	Non-adopter(N=43)		Adopter (N=77)		Total(N=120)		χ2-value	p-value
	N	%	N	%	N	%		
Yes	24	56	39	50.6	63	52.5		
No	19	44	38	49.4	57	47.5		
Total	43	100	77	100	120	100	0.295 (ns)	0.578

Source: Own survey, 2011; Note: ns = not significant

As indicated table 15, the chi-square analysis showed that there is no systematic relationship between land tenure security and adoption of SWC measures (χ^2 = 0.295, P=0.578). This indicates that land tenure security is not a main factor in determining the adoption of soil and water conservation measures. Other studies arrived at different conclusions with respect to the role of land tenure security in the application of soil conservation practices. In his study Admassie (2000) showed that Ethiopian farmers lack concern for land conservation because of the insecure tenure. Similarly, Bewket (2003) found that 73% of farmers interviewed were discouraged to undertake soil conservation measures by periodic land redistribution in northern highland of Ethiopia.

Informal land transactions such as sharecropping and contractual agreements are quite common agricultural and economic system operating in the study area. In fact, their magnitude increases with scarcity of land. Sharecropping and renting of land for fixed period in cash and borrowing are the two important exchange mechanisms prevalent. Contracting out land is also practiced by some households, in a form locally known as *woledagid*. This form is mostly practiced by households which are not able to meet the basic needs of their members for various reasons. In this form of land transaction there is no legal enforcement either sharecropper or contractor to manage conservation structures built on the farm fields.

4.3. Biophysical Characteristics of Sampled Households

4.3.1. Distance of farm land from the residence

It has been found that distance between the farmland and a homestead is an important factor in the adoption behavior of soil and water conservation practices. It was hypothesized further farm distance negatively correlated with adoption of SWC practices. In the area the average walking time from the residence to the farm plot is about 15.02 minutes. Only 14.2% and 6.7% of the total respondents were walking on average 11-20 minute and above 20 minutes from their residence respectively (Table 16).

During focus group discussion it was indicated that farmers having land far from their residence usually do not give frequent visit to their agricultural field except during ploughing, planting, weeding and harvesting seasons. During slack season, livestock roam on the field freely and destroy conservation structures. This results in lots of spots destroyed which enhances run off beneath the embankments.

The result of independent t- test (t=1.435, P= 0.156) showed that there is no significant mean farm distance difference between adopters and non-adopters household (Table 16). It is found that distance between the farmland and residence is not the most important factor to determine the adoption of soil and water conservation practices. The result is in line with the findings of Amsalu and De Graaff (2006) in Beressa watershed in the northern highland of

Ethiopia and Bekele and Drake (2002) in the Hunde-Lafto area, eastern Ethiopia highlands but, inconsistent with the findings of (Gebremedhin and Swinton, 2003).

Table 16. Association between farm distance and adoption SWC practices

Average farm distance walking minute	Level of adoption SWC measures						t –value	P-value
	Non-adopter(N=43)		Adopter(N=77)		Total(N=120)			
	N	%	N	%	N	%		
<5	13	30.2	31	40.2	44	36.6		
5-10	21	48.9	30	39.0	51	42.5		
11-20	5	11.6	12	15.6	17	14.2		
>20	4	9.3	4	5.2	8	6.7		
Total	43	100	77	100	120	100	1.435 (ns)	0.156
Mean	15.80		16.62		15.02			
SD	1.49		1.73		1.51			

Source: Own survey, 2011; Note: ns= non significant

4.3.2. Slope of farm land

The response of farmers with regard to soil conservation structures showed difference among farmers cultivating different slope categories. For the purpose of this study slope were classified in to flat to gentle slope (0-6%), moderate to steep slope (7-15%) and steep to very steep slope greater than 15% respectively.

Among non- adopters of conservation practice, 49%, 28% and 23% were cultivating on flat to gentle, moderate to steep and steep to very steep slope parcel of plots respectively. On the other hand, among adopter farmers that retained conservation structures on their farm field, 18% found cultivate on flat to gentle slope, 27% on moderate to steep slope while, 55% were on steep to very steep slope (Table 17). As confirmed by informal discussion the non-adopter farmers that removed soil conservation structures from steep slope area can be attributed to narrowing of vertical interval which results in taking up of large portion of the cultivation land.

Table 17. Association between slope of farm land and adoption of SWC measures

Slope categories	Non-adopter (N=43)		Adopter (N=77)		Total (N=120)		χ^2-value	P-value
	N	%	N	%	N	%		
Flat to gentle slope	21	49	14	18	35	29		
Moderate to steep	12	28	21	27	33	28		
Steep to very steep	10	23	42	55	52	43		
Total	43	100	77	100	120	100	8.715**	0.013

Source: Own survey, 2011; Note: ** Significant at less than 5% level

Interestingly, the result of chi-square test (χ^2 =8.715, P= 0.013) disclosed that there is strong relationship between slope of farmland and adoption of soil and water conservation practices at less than 5% significance level (Table 17). This implies as the slope of plot increases, the likelihood of farmers to adopt conservation practices increases than those who cultivate less sloping fields. As it was observed in the field, nearly on all of the plots with steep to very steep slopes the soil conservation structures are well retained and maintained. The result of this study confirms the earlier findings of Shiferaw and Holden (1998), Gebremedhin and Swinton (2003) and Amsalu and De Graaff (2006) who have found that slope has a positive and significant influence on adoption of SWC technologies in the northern Ethiopia.

4.3.3. Farmers' perception towards soil erosion problem

Soil erosion lowers the productivity of land by depleting its resources through various agents. Farmers were asked about soil erosion problem on their farm lands. A higher number of farmers were aware of soil degradation particularly soil erosion, soil fertility decline and development of rills and gullies on their fields. During the field visit, it was observed that most farmers didn't practice technically sound soil and water conservation activities.

As indicated in Table 18, about 100 and 47 percent of adopter and non- adopter sample households were perceived soil erosion problem on their farm fields. From the case taken, only 23.3% and 64% of sample household farmers were practicing traditional and improved types of soil and water conservation practices, respectively. According to (Bewket, 2003a), perception of soil erosion as a problem with economic significance is not sufficient condition for the adoption of soil and water conservation measures though it is a necessary condition.

Table 18. Household perception of soil erosion problem and adoption of SWC practices

Perception of erosion problem	Non-Adopters (N=43)		Adopters (N=77)		Total (N=120)		χ^2 -value	p-value
	N	%	N	%	N	%		
Yes	20	47	77	100	97	81		
No	23	53	0	0	23	19		
Total	43	100	77	100	120	100	3.642*	0.056

Source: Own survey, 2011; * Significant at less than 10% significance level

The chi-square result (χ^2=3.642, P=0.056) revealed that there is significant relationship between perception of soil erosion problem and the adoption of SWC structures at less than 10% significance level (Table 18). The implication is that farmers who feel that their farmlands are prone to soil erosion are more likely adopt physical soil conservation measures than those who do not perceive the problem of soil erosion. The result of this study is consistent with findings of Tadesse and Kassa (2004) who found that farmers' perception of soil erosion problem affects the adoption of soil conservation measures positively and significantly in southern Ethiopia.

4.3.4. Constraints to sustained use of conservation structures

Farmers' decision to adopt soil conservation measures is not only influenced by their perception of erosion hazard but also by the types of technologies and their attributes. As already noted, of the 120 sample respondents in the study area, 43 removed the structures totally and 36 of them removed partially (Table 19). The sample respondents who removed the soil conservation structures totally or partially were asked to mention the reasons for their decision (Figure 5). About 26% of the sample farmers who removed soil conservation structures totally and about 44% of the respondents who removed the structures partially reported that, physical structures are narrowly spaced and posing difficulty in oxen ploughing across the fields (Table 19). Other reasons for removing conservation structures mentioned by 39% and 25% of respondent respectively include the belief that structures consume too much space and put some part of cultivable land out of production and temporal yield declines (Table 19). Moreover, farmers joining plots in need of fertile sediment retained behind embankment and poor design and construction conservation structures were some of the reasons.

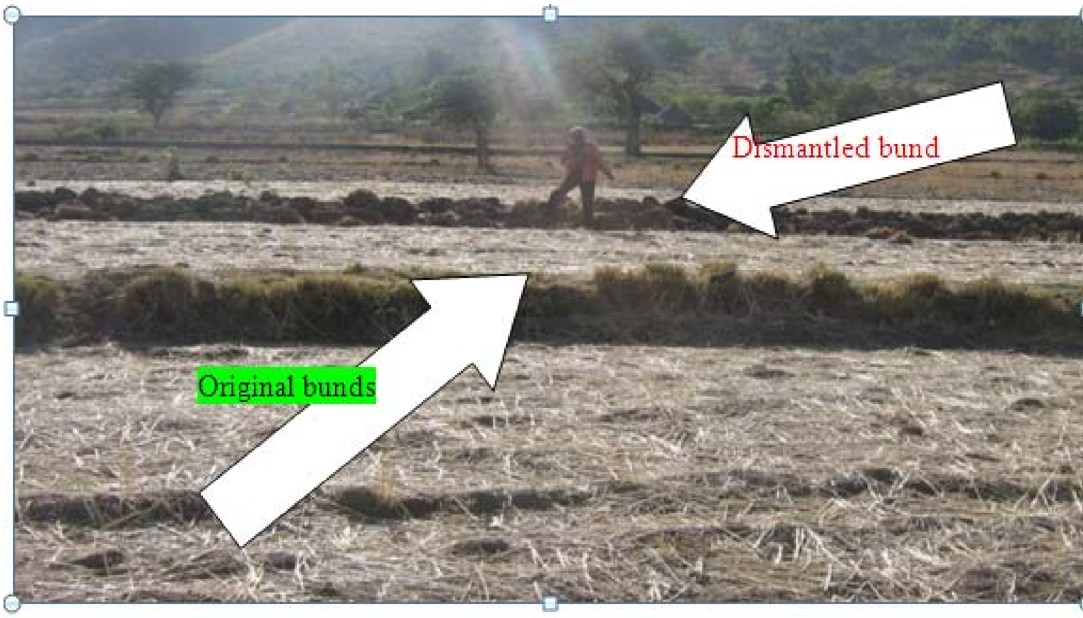

Figure 5. Selective removal of soil conservation structure from farm land
Source: Own field Survey, 2011

Table 19. Distribution of sample households by their reasons for removing SWC Structures totally or partially

Reasons for removing SWC structures	Removed totally		Removed partially	
	N	%	N	%
Hindered oxen ploughing	11	26	16	44
Poorly designed and constructed	8	19	5	14
Structures consume space and put some cultivable land out of production	17	39	9	25
Need of fertile sediment retained	7	16	5	14
Planned to construct new structures	0	0	1	3
Total	43	100	36	100

Source: Own survey, 2011

Farmers were also asked whether they are willing to participate in maintenance of conservation structures without any external support. About 42% of respondents were involved in maintenance of structures while 58% were not willing to do so. Once put up on the plot, conservation structures need to be maintained regularly. Nevertheless, we observed from the field that the practice of maintaining conservation structures is very minimal and this eventually lead to the collapse of the structures (Figure 6 below).

Figure 6. *Fanya juu* bunds on the farmland that needs maintenance
Source: Own field survey, 2011

4.4. Description of Soil and Water Conservation Practices in the study Area

Both traditional and modern soil and water conservation technologies have been practiced in the study area. The measures are fall into agronomic, vegetative and physical measures to offset the effect of soil erosion. Biological or agronomic measures refer to the farming practices while the physical measures aimed to controlling and diverting surface runoff from arable land and/or off-farm land areas. Both measures have similar characteristics for the purpose of moisture conservation and soil trapping. However, they are different in permanency, labour source requirement for construction and design.

4.4.1. Indigenous method of soil and water conservation practices

Indigenous soil and water conservation measures are simple structures of short term nature that could reshuffled to make better use of soil captured above the structures for production. Indigenous soil and water conservation practices have often been ignored or underestimated by development agents, soil conservationists and government staff in the study area (Abera, 2004). Only rare attempts were made to include indigenous experience and knowledge. In response to the problem of soil erosion in the study area farmers have been practicing different indigenous soil conservation and soil fertility management practices, which are either biological (agronomic) or physical in nature. Traditionally, farmers are practicing contour plowing, crop rotation, manure application, flood diversion and drainage ditches construction, planting of trees, sisal and euphorbia in the area.

Traditional flood diversion ditches: Locally known as *meygaren,* is one of the major indigenous soil and water conservation practices commonly constructed on places where, runoff water enters the field, as well as in the middle of some of the bigger agricultural fields to intercept and divert surface run off. The first type is a permanent structure; the latter one is generally made during the preparation of the field and in some cases permanent. Everyone tries to divert the flood from his/her land as much as he/she can.

Drainage ditches: The other common conservation practice is constructing drainage ditches by oxen drawn traditional *maresha* or local hoe. Farmers also mentioned that they have been digging drainage ditches every cropping season diagonally as well as on some parts of the farmland in order to minimize the concentration of water upon the lower section of the farm and remove excess run off or water to nearby situated natural drainage ways or valley areas**.** However, the farmers asserted that through time most of these structures are widened and change to gullies and enhance soil erosion (Figure 7). I could witness the scene during field observation with the key informants. Big dissected gullies associated with the establishment of such conservation structure, especially between the farm boundaries, were commonly observed in many areas.

Figure 7. Gullies developed due to wrong design of traditional water way

Source: Own field survey, 2011

Manure application: The interviewed farmers described that they are incorporating animal manure to their farm plots because they think that terraces alone can't improve soil fertility. Most of them asserted that they are using such soil fertility management practices around their homestead because of their plots are so fragmented. During focus group discussions with farmers, however, it was found out that since the last 5-7 years the farmers used intensively animal manure in order to improve the fertility of soil (Figure 8). The main reason farmers shifted to this practice was attributed to extension support given by development workers and the price of inorganic fertilizer which are unaffordable by the farmers. However, application of farm manure is very minimal due to its use as fuel source in the family.

Figure 8. Soil fertility management practices by manuring in combination with bunds
Source: Own field survey, 2011

Live check dams (barriers): It is also very common to observe plantation of Sisal and Euphorbia at different part of the farm land along the contour. During focus group discussion and field visit, farmers also confirmed that one of the most widely used traditional conservation practices in the area is planting of live barriers by plugging of cutting of Sisal (*Agave sisalana*) and Euphorbia (*Euphorbia classenii*) against soil erosion, in gully bottom and edges to reduce runoff and stabilize gully expansion (Figure 9). The plants are easily established, drought tolerant and not easily edible and destroyed by animals in the area. In general the traditional soil conservation and improvement practices are efficient in some cases, but should be modified and further developed.

Figure 9. Plantation of sisal and euphorbia across the gully as live check dam

Source: Own field survey, 2011

Table 20.Traditional SWC practices implemented by sample households

Type of practices	Frequency	Percent
Drainage ditches	17	15.8
Flood diversion ditches	15	12.5
Manure application	10	8.7
Live check dams	16	13.3
Total	58	

Note: Percentages do not add up to 100 because of multiple responses

Source: Own field survey, 2011

4.4.2. Introduced soil and water conservation measures

Different types of soil and water conservation technologies have been introduced in the area since mid, 1990. They have been introduced with the objectives of conserving, developing and rehabilitating degraded lands and increasing food production (MoARD, 2010). Based on the land use system in which they were constructed, soil and water conservation techniques introduced to the area can be categorized into two conservation strategies namely soil and water conservation measures on farm land and off-farm lands. The widely known and in use of improved soil and water conservation practices are *fanya juu* and soil bunds, hillside terraces, stone faced soil bunds, check dams, cut off drain and artificial water ways, area enclosure and planting of trees.

4.4.2.1. On farm land soil and water conservation practices

Majority of soil and water conservation effort made in the area was directed to controlling soil loss and conserving moisture from cultivated fields. Major soil and water conservation measures introduced on farm land include *fanya juu* terraces, soil bunds, and some stone faced soil bunds. It is only in few places that check dams, cut off drains and water ways were constructed on farm lands.

Soil bunds: These are narrow based channel terraces constructed by digging a ditch along the contour and throwing the soil down the slope to form a ridge. These structures are constructed along the contour when there is a need to retain both the runoff and sediments. By reducing the slope length of the farm land they are effective in controlling soil loss, retaining moisture and ultimately enhancing productivity of land (Lakew *et al*., 2005). These structures were constructed at a vertical interval of 1-2.5 meter depending on the slope gradient of the area.

***Fanya juu terrace*:** The term *fanya juu* is a “Swahili” word used to describe the act of throwing uphill (Bewket, 2003). The *fanya juu* is constructed by digging a ditch along the contour and throwing the soil uphill to form a ridge of banks. Throwing soil uphill to make a terrace causes a reduction in slope, which in itself makes a better contribution to reduce and stops the velocity of runoff and consequently reduces soil loss.

The cross section profile comprising an embankment to impound water, soil and nutrients, a storage area above the embankment to prevents overtopping by runoff. *Fanya juu* terraces are very popular on small holder farmers particularly in semiarid areas where they are effective in conserving moisture and nutrients (Abera, 2004). During focus group discussion farmers indicated that crop beneath *fanya juu* terraces does not suffer from shortage of moisture since it serves as underground irrigation. Compared to soil bunds, *fanya juu* develop into bench quickly. The structure was installed at vertical interval of 1-2 meter depending on the slope of land. *Fanya juu* bunds are most widely practiced types of soil conservation structures in the study area.

Stone-faced soil bunds: These are a combination of stone and soil for the conservation of soil and most of the time undertaken where stone and soils are much available in farm land. The stone faced bunds are reinforced soil bunds in one or both of their sides (Figure 10).

Figure 10. Stone faced soil bunds on steep farm land
Source: Own field survey, 2011

Check dams: These are structures constructed or established across the bottom of a gully to control or reduce the velocity of the runoff and prevent the deepening and widening of the gully and initiate the process of sedimentation. They can be made of any material available locally, such as stones, live or dead branches, wooden pole. Check-dams encourage the growth of vegetative cover in the gully floors, providing protection against further erosion and stabilizing it.

Table 21. Modern physical SWC structures adopted by sample households

Type of structures	Length meter	No of farmer	Percent
Fanya juu bund	8322	41	34
Soil bund	6984	34	28
Stone-faced soil bund	826	16	13
Cut off drain	249	12	10
Artificial water ways	220	7	6
Check dam	245	11	9

Note: Percentages do not add up to 100 because of multiple responses

Source: Own field survey, 2011

Thus, as it was summarized in table 21, the most widely adopted physical soil and water conservation structures on individual plots predominantly done by farmers are *fanya juu* and soil bunds and followed by stone-faced- soil bunds. The survey result illustrated that, among the total adopters of SWC structures 34%, 28%, 13%, 10% , 9% and 6% of the sampled households constructed and adopted fanya juu terraces, soil bunds, and soil-faced stone bunds, cut off drain, check dam and water ways respectively on their farm plots (Table 21). During focus group discussion farmers also confirmed that the most popular conservation structures widely implemented and adopted on cultivated land by local communities are *fanya juu* and soil bunds. It is also reported in his study by Abera (2004).

4.4.2.2. Off-farm land soil and water conservation practices

Different types of soil and water conservation practices have been undertaken especially in off-farm lands that are severely degraded in order to rehabilitate their productive potential. These include area enclosure, hillside terrace, check dams, cut-off drain, artificial water ways and plantation.

Hillside terraces: are physical structures constructed along the contour on steep degraded slope or shallow soils. The main purpose of constructing hillside terraces is for tree planting, to control runoff and erosion, allow sufficient time for percolation of runoff and maintain fertility of soil. These structures are effective when combined with other moisture conservation structures to improve watershed rehabilitation, biomass production and recharging water tables.

Area closure: is a land management practices where severely degraded lands are closed from the interference of livestock or human activities and left for nature to take care of the regeneration processes (Figure 11). It is the most widely adopted and replicated SWC practices in the study area. In order to facilitate the natural process such areas have been planted with different low fertility and moisture level tolerance species. When it is ensured that the area is recovered, the produce will be harvested in a rational way to ensure sustainable productivity. Area closure increases the productivity of degraded and moisture stress areas. Different tree species mainly *Acacia saligna, Acacia decerence, Acacia mearnsii, Acacia melianoxillen*, *Azadirachata indica*, *Casuarina equisetifolia, Eucalyptus camaldulences, Gravella robusta* and leguminous species are planted in combinations with other soil and water conservation structures.

Figure 11.Severely degraded land closed from livestock and human interference
Source: Own field survey, 2011

Cut-off drains: are open and graded channels constructed to intercept and divert the surface runoff coming from higher ground or slopes and protect downstream cultivated land or village. It is safely conveyed runoff into a natural or artificial waterways or river. The supporting embankment in the down slope position is protecting the runoff from spilling over the ditch and damaging fields located down slope.

Artificial water ways: The artificial waterways, also called drainage ways, are man-made channels meant for collecting run off from cutoff drains and bunds, and evacuate it safely into natural drainage systems, where it can empty into streams or rivers.

In an attempt to address the issues of soil erosion problem with in agriculture and non agricultural land escape, different types of SWC structures have been implemented in the study area. As illustrated in table 22, from 1998-2002 E.C through government support program and community participation the following activities were implemented (Dalocha Agricultural Office, 2011).

Table 22. Summary of SWC activities implemented in the district from 1998-2002 E.C

Type of activities	Unite	1998	1999	2000	2001	2002	Total
Fanya juu bund	km	85	91	98	208	324	806
Soil bund	km	42	52	38	65	185	381
Stone-faced soil bund	km	18	16	27	-	-	61
Hillside terrace	km	56	75	88	21	15	255
Cut off drain	m^3	928	1008	1212	1887	1423	6458
Artificial water ways	m^3	1257	1682	2016	1986	1077	6208
Check dam	m^3	1580	2295	2550	3521	1517	11463
Area closure	ha	575	570	985	620	285	3035
Tree planting	ha	62	230	270	361	358	1281

Source: Dalocha Agricultural Office, 2010

4.5. Results of the Econometric Model

The previous section dealt mainly with description of the sample households and test of the existence of association between the dependent and explanatory variables to identify factors affecting adoption of soil and water conservation measures. Identification of these factors alone is, however, not enough unless the relative influence of each factor is known for priority based intervention. In this section, binary logistic regression model was used to see the influence of different personal and demographic, socio-economic, institutional and biophysical factors on adoption of soil and water conservation structures. Before fitting the logit model all the hypothesized independent variables were checked for the existence of a serious multi-collinearity problem. In this study, Variance Inflation Factor (VIF) and contingency coefficients were used to test multi-collinearity for continuous and dummy variables respectively. As a rule of thumb, if the VIF of a variable exceeds 10 that variable is said to be highly collinear (Gujarati, 1998).

The VIF values displayed in (Appendix 5) shows that all continuous explanatory variables have no serious multi-collinearity problem in the data set; most variables have VIF values less than 5 and tolerance less than 1. Moreover contingency coefficients were computed for each pair of qualitative variables to check for the degree of association among the dummy variables. The value of contingency coefficient ranges between 0 and 1, if the value of contingency coefficient is greater than 0.75, the variable is said to be collinear (Healy, 1984 cited in Adgo, 2008). As the result shows the values of the contingency coefficients computed for each pair of qualitative variables were also low (Appendix 4). Based on the result of the multi-collinearity diagnostics test the results of our analysis gave an indication that our model did not suffer from the problem of multi-collinearity. Finally, all the hypothesized explanatory variables were entered to the model.

To check measure of goodness of fit in logistic regression analysis, the likelihood ratio test that follows chi-square distribution with degrees of freedom equal to number of explanatory variables included in the model shows that, the model was significant at 1% probability level. Another measure of goodness of fit was based on a method that classifies predicted value of the dependent variable, adoption of soil and water conservation measures, as 1 if adopted and 0 otherwise. The model correctly predicts 107 of 120 (89.2%) observations. The sensitivity and the specificity of the model was 92.2% and 83.7% for adopter and non-adopter households respectively indicating the model predicts both group fairly accurately (Table 23).

Determinants of adoption of SWC measures: Logistic model results

The maximum likelihood method of estimation was used to elicit the parameter estimates of the binomial logistic regression model and statistically significant variables were identified in order to measure their relative importance on the farmer' soil and water conservation adoption decision. The maximum likelihood method estimation procedure yields unbiased, asymptotically efficient, and normally distributed regression coefficients (parameters).

The maximum likelihood estimates for the binomial logit model are set out in Table (23). A total of 15 independent variables were included into the logit econometric model. Out of the fifteen variables hypothesized to influence the adoption of physical soil and water conservation measures, three were found to significantly influence probability of adoption SWC structures at 1% significance level. These include land holding size (FARMSIZE), family size (FAMLSIZE) and extension service (EXTEN) given by development agents. Three variables were significant at 5% significance level. These variables include active family labour force (ACLABF), dependent members in the household (DEPMEMB) and the slope of farm plot. The remaining nine explanatory variables were hypothesized to influence adoption of physical soil conservation measures did not have statistically significant effects. The significant explanatory variables on adoption in study area are discussed below.

Family size of household (FAMLSIZE): We hypothesized the direction of the influence of this variable to be either way. The estimated model shows that family size affects the adoption of physical soil and water conservation practices negatively and significantly at less than 1% probability level. The odds ratio of this variable is 0.394. This implies that, as family size increases by one person, the likely probability of adopting SWC measures decreases by a factor of 0.394 (Table 23). This is so because households with larger family size are likely to face shortage of agricultural land. As a result, they try to involve in other short-term benefit generating activities and would be less interested in soil conservation measures whose benefits can be reaped in the long run. Moreover, as population increases, landholding per household gradually decreases which in turn has a negative impact on soil and water conservation.

This result is consistent with the previous findings of Amsalu (2006) in Beressa watershed in the highlands of Ethiopia; larger families were less likely to continue using stone terraces. Bekele and Holden (1998) also found similar results in Andit Tid, Ethiopia. They found negative and significant association between family size of the household and adoption of soil conservation structures. The study conducted in Koga watershed highlands of Ethiopia showed that a one-person increase in family size decrease the adoption of soil or stone bund terraces by 3.4 percent (Assefa, 2009). They noted that in a family with a large number of mouths to feed, there was competition for labor between off-farm activities to earn cash for buying food and other basic necessities.

Active labour force in the family (ACLABF): as expected, adoption of soil and water conservation measures was significantly and positively associated with the number of economically active family members and statistically significant at less than 5% significance level. The implication is that households with large number of active agricultural workers are more likely to be involved and invest in soil and water conservation measures, which are known to be labor intensive. The odds ratio of this variable is 2.758. This implies that, as active family labor increases by one person, the odds ratio in favor of decision of soil and water conservation practices increases by factor of 2.758 (Table 23). This result reaffirms previous findings of Tadesse and Kassa (2004) found that households with large number of active workers are positively and significantly associated with adoption of soil conservation measures in Gununo area of southern Ethiopia.

Table 23. The maximum likelihood estimates of the binary logit model

Explanatory variables	Estimated coefficient(B)	Odds ratio Exp(B)	Wald statistics	Significance level	Standard error
SEXHH	0.315	1.370	0.058	0.810	0.305
AGEHH	-0.008	0.992	0.056	0.813	0.033
EDUHH	0.177	1.193	0.536	0.464	0.241
FAMLSIZE	-0.931	0.394	10.476	0.001***	0.288
ACLABF	1.015	2.758	6.535	0.011**	0.397
DEPMEMB	-0.605	0.546	4.432	0.035**	0.287
OFFFARM	0.840	2.317	1.312	0.252	0.734
LIVESTLU	0.016	1.016	0.016	0.900	0.127
FARMSIZE	1.691	5.423	12.772	0.000***	0.473
EXTEN	2.432	11.386	7.653	0.006***	0.879
TRAINING	1.229	3.418	1.821	0.177	0.911
LANDSECU	0.803	2.231	1.058	0.304	0.780
DISTANCE	-0.534	0.586	1.474	0.225	0.440
SLOPE	1.431	0.239	2.597	0.037**	0.888
PERCERO	1.960	2.370	1.874	0.999	0.613
Constant	-0.599	0.050	4.068	0.074	2.298
Pearson chi-square				93.8***	
-2 log likelihood				33.695	
Total sample size				120	
Correctly prediction over all sample				89.2	
Correctly predicted adopters (sensitivity)				92.2	
Correctly predicted non-adopter (specificity)				83.7	

***, **, * Indicate significance at 1%, 5% and 10% level respectively

Source: Model output, 2011

Dependent members in the household (DEPMEMB): as anticipated, the model result confirmed that the variable dependent members of the household negatively affects adoption of soil and water conservation technologies and statistically significant at less than 5%

significance level (Table 23). The odds ratio of this variable is 0.546. This implies that, as dependent member in the household increases by one person, the likely probability to adopt SWC structures decreases by the factor of 0.546 (Table 23). Thus family with high number of inactive members bring high dependency ratio and related negatively to invest and adopt soil and water conservation practices. The result of this study confirms the findings of Tesfaye (2008) who stated that dependent ratio was significantly and negatively related with adoption of conservation technologies. According to Guled (2006), households having children of non productive age could face the probability of not adopting conservation practices because of high dependence ratio than farm households with small family size.

Land holding size of household (FARMSIZE): as expected, the effect of land holding size is found to be positive and significant on farmers' decision to adopt soil and water conservation measures at less than 1% significance level. This result confirms the findings of Amsalu and De Graaff (2006) that found larger farm owned farmers, are more likely to invest in soil conservation measures. The model of odds ratio value indicates as land holding size increase by one unit the probability of farmers adopting soil and water conservation technology increases by a factor of 5.423 (Table 23). According to the model result, households land size accounted 54.23% of the variation in adoption of soil and water conservation technology. This implies that farmers with relatively larger holdings had higher probability of adoption of physical SWC technologies. This can be attributed to the fact that conservation structures occupy part of the scarce productive land and farmers with larger farm size can afford retaining structures compared to those with relatively lower farm size. This result is consistent with the findings of Shiferaw (1997), Bekele and Drake (2003) and Chomba (2004) reported that existence of conservation measures were positively and significantly related to the land size operated.

Extension service (EXTEN): The frequency of visits or availability of extension services is perhaps the single variable that emerged significantly in most of the research work on technology transfer and adoption. Result of the study revealed that, contact with extension agents positively and significantly affects the likelihood to adopt soil and water conservation technologies at less than 1% probability level (Table 23). The possible explanation is that a visit of extension agents to households is likely to increase their awareness about the effects of soil erosion and the knowledge about the SWC technologies and their benefits. Other things held constant; the odds ratio in favor of adopting SWC technology increases by a factor of 11.386 as frequency of extension contact increases by one unit (Table 23). The implication is that farmer who more frequently visits outside of his social system would have more information which helps him to adopt new technology. Some studies indicated that participation in extension events, such as field day/visit and demonstration also increased adoption (Paudel and Thapa, 2004).

The result of this study is congruent with findings of Bekele and Drake (2003), Kipsat *et al.* (2007), and Petros (2010) reported that farm households who have close contact with development agents have positive relation with adoption of soil and water conservation practices which results from effective dissemination of SWC information to the farmers.

Slope of parcel of land (SLOPE): as anticipated, the model result shows that the slope of the land has positive and significant influence on the adoption of physical soil and water conservation measures at 5% significant level. The higher the slope category of a parcel, the greater will be the severity of soil erosion. This means that on sloping parcel of land the impact of soil erosion would be more visible to farmers and force them to take soil conservation measures. The model odds ratio of this variable is 0.239. This implies that, as slope of the farmland increases by one unit, the odds ratio in favor of adopting soil and water conservation practices increases by a factor of 0.239 (Table 23). This is consistent with the finding of earlier studies in different parts of Ethiopia, which reported a positive and significant effect of the slope of a plot on the decision to adopt soil conservation structures (Bekele and Drake, 2003; Gebremedhin and Swinton, 2003; Amsalu and De Graaff, 2006; Anley *et al.*, 2006). The study conducted in Koga watershed, revealed that, a unit increase in the ordinal slope (from flat to very steep slope), increases the probability of adopting soil or stone bund terraces by 16.1 percent (Assefa,2009).

5. SUMMARY AND CONCLUSION

5.1. Summary

The Ethiopia agriculture, which is the main stay of the nation, is under continuous threat from various forms of land degradation. Among these, soil erosion by water remains to be the most important and ominous threat to the nation's future prospects. The study district, due to its undulating landscape, fragile soil type, location in the rift valley, population pressure, deforestation and overgrazing coupled with unsound land management system have been contributing for severe land degradation and soil erosion.

Since, 1990s different soil and water conservation measures have been undertaken in the area with the support of government, NGOs and local community. However, the technologies transferred to the farmers such as soil bunding and terracing brought from abroad are not well adopted and the activities aimed at reducing soil erosion problem and improving agricultural productivity have been dismantled entirely or selectively by farmers.

This study attempted to assess the current and common soil and water conservation practices undertaken in the study area and identify the determinants of soil and water conservation structures adoption. The data was collected from 120 sample households selected randomly using probability proportional to sample size sampling technique.

The data was analyzed using descriptive statistics and binary logistic econometric methods. The study result revealed that 64% sample households were adopter and 36% of them are non-adopter of soil and water conservation measures. The main soil and water conservation measures practiced in the study area are done at individual farm household levels as well as at communal land levels.

The result of descriptive statistics revealed that adopters and non-adopters of soil and water conservation measures differed in some household demographic, economic, biophysical and institutional variables such as family size, active family labour, dependent members in the household, land holding size, extension service and contact, training, slope of plot and perception of soil erosion problem between the two groups, which shows the difference in their soil and water conservation practices adoption behaviors.

A total of 15 variables were fitted in the logit model. Out of the 15 variables hypothesized to influence adoption of physical soil and water conservation measures family size, land holding size and extension service or contact were statistically significant at less than 1% significance level. Three variables were significant at less than 5% significance level. These include the number of active family labour force, dependency ratio and the slope of parcel of farm land. On the other hand sex, age, education level, off-farm activities, livestock holding, land tenure security and farm distance of the households are not statistically significant at conventional level of probability.

5.2. Conclusions

Even though farmers are trying to conserve their lands from soil erosion hazards, it is still persistent problem in the study area. Both indigenous and improved soil and water conservation technologies are practiced by local community and individual farmers on different land use types. The most common mechanical conservation structures undertaken are *fanya juu* bunds, soil bunds, and stone-faced soil bunds, hillside terraces, cut- off drains, artificial water ways, and check dams while the biological or agronomic (soil fertility management) practices includes area closures, traditional ditches, planting of tree, sisal and euphorbia, crop rotation and manure application on cultivated fields.

The findings of the descriptive analysis indicated that farmers' knowledge and experiences are not well taken care of in the designing and implementation of the practices. The other problems, identified include conservation structures consume too much space and put some part of cultivable land out of production and posing oxen ploughing difficulty.

The empirical results revealed that variables such as land holding size, active family labour force, extension service, family size, dependent members in the household and slope of parcel of the farmland were significantly influenced farmers' adoption of soil and water conservation technologies.

Extension services that enhance farmers' understanding on soil erosion problem play a decisive role in promotion of soil and water conservation technologies. This was indicated by significant difference between adopters and non-adopters household in this study. This could be due the fact that farmers who are more access to extension services get information that is useful to make better informed decision to retain conservation structures.

Family size and dependency ratio are the most significant factors that influence farmers' decision to adopt conservation structures negatively. This is due to the fact that households with large family size and high dependent members in the household less likely involved in soil and water conservation practice because more family members involved in short term benefit generating activities to secure food demand of the household.

The result of the study also revealed that farmers with smaller plots were less likely adopts soil and water conservation practices. It is evident that soil conservation structures, when constructed on smaller plots, make it difficult to turn oxen during ploughing and cultivation, further squeezing the small parcel of farm land owned by household.

Hence, an important implication of the results of this study is that any intervention in soil and water conservation should recognize the heterogeneity in household characteristics, land holding size, institutional support such as extension service and physical characteristics of specific site. Thus, there is a need for researchers to come up with appropriate soil and water conservation technologies that address their suitability to both the local ecology and farming systems. Therefore, it is reasonable to conclude that adequate consideration of these variables may greatly contribute to increase the sustained use and adoption of physical soil and water conservation structures.

Thus, any development strategy and program interventions designed to enhance agricultural productivity through promoting soil and water conservation strategies of land management in the study area need to take in to account the aforementioned variables with respect to the types of innovation and farmers preference. Based on the results of this finding the following recommendations are suggested.

5.3. Recommendations

Intensifying agricultural production

Socio-economic and policy related factor such as land holding size was significantly influenced adoption of soil and water conservation technology. Therefore, any policy and program aimed at agricultural development has to give due attention and priority in developing and disseminating technologies that are relevant to the need of smallholder farmers. Further this suggests the need to support farmers who had small land to enhance the adoption process.

Strengthening agricultural extension services

Extension education is center to adopt and use agricultural technologies and information which in turn enhance farmers' adoption of SWC technologies. The result of the study showed that access to extension service positively and significantly influenced the adoption of soil conservation practices suggesting the need for more targeted and continued extension services.

Thus, to sustain the positive contribution of the extension service to the adoption of soil conservation practices, extension services on conservation strategies of land management's should strengthen further by local institution with a due recognition of differences among farmers. This underscores the importance of human capital development in increasing the probability of adopting soil and water conservation technologies.

Strengthening family planning program

Household with large family size and more dependent members negatively and significantly affected adoption of soil and water conservation structures. Therefore, it is very crucial to consider family planning in any development interventions. This could be done by creating awareness and building the capacity of local community in collaboration with health, education sectors and others development partners.

Giving due attention for integration of soil and water conservation practices

The other problems identified include physical structures consume too much space and put some scarce cultivable land out of production, and posing difficulty in ploughing across the fields. These problems entail other alternative measures that go together with the existing engineering practices. Therefore, physical structures need to be integrated with biological as well as agronomic practices to address immediate needs of farmers, such as food and fodder so that land lost for the structures can be compensated. Thus, more effort is needed to disseminate the effective combination of SWC technologies that augment soil fertility, crop and livestock production.

In general a flexible holistic development program is needed to sustain and adopt soil and water conservation practices. Soil and water conservation should be an integral part of soil fertility management, agronomic practices, fodder production, rain water harvesting and wood production at individual and community levels.

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7. APPENDICES

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Appendix table 1.Conversion factors used to estimate active labour force in man equivalent

Age group (years)	Male	Female
< 10	0.00	0.00
10- 13	0.20	0.20
14- 16	0.50	0.40
17- 50	1.00	0.80
> 50	0.70	0.50

Source: Samuel and Sharp (2007)

Appendix table 2. Labour characteristics of sampled households

Do you have available labor to perform work	Adoption level of SWC methods				Total (N=120)	
	Non-adopter (N=43)		Adopter (N=77)			
	N	%	N	%	N	%
Yes	27	62.8	38	49.4	65	54
No	16	37.2	39	50.6	55	46
Total	43	100	77	100	120	100

Source: Own survey, 2011

Appendix table 3. Dependency ratio of sampled households

Household members age category in year	Total HHs family size	Percentage	Dependence ratio
0- 14	377	54	121.6
15- 64	310	44.2	-
> 64	13	1.8	4.2
Total	700	100	125.8

Source: Own survey, 2011

Appendix table 4. Conversion factors used to estimate Tropical Livestock Unit (TLU)

Livestock types	TLU equivalent
Cow and oxen	1.00
Horse/mules	1.10
Donkeys	0.70
Heifers/bulls	0.75
Calves	0.25
Sheep/goats	0.13
Chicken	0.013

Source: Strock *et al*., 1991

Appendix table 5. Variance Inflation Factors (VIF) and tolerance for continuous variables

Variables	VIF	Tolerance
AGEHH	1.398	0.715
EDUHH	1.616	0.619
FAMSIZE	1.924	0.520
ACLABF	1.540	0.649
LIVESTLU	1.589	0.629
FARMSIZE	1.478	0.677
DISTANCE	1.188	0.842
DEPMEMB	1.601	0.625

Source: Computed from survey result, 2011

Appendix table 6. Contingency coefficients for dummy explanatory variables

Variables	SEX HH	OFF FARM	EXTEN	TRAINI NG	LAND SECU	SLOPE	PERCERO
SEXHH	1						
OFFFARM	0.062	1					
EXTEN	0.086	0.004	1				
TRAINING	0.037	0.004	0.149	1			
LANDSECU	0.039	0.194	0.154	0.106	1		
SLOPE	0.017	0.041	0.012	0.026	0.045	1	
PERCERO	0.043	0.024	0.082	0.082	0.007	0.104	1

Source: Computed from survey result, 2011

Appendix table 7. Summary statistics of continuous variables by adoption category

Variable name	Unit	Non-adopter (43)		Adopter (77)		t- test	P-value
		Mean	SD	Mean	SD		
Age of HHs	Years	42.70	12.552	42.75	11.425	1.604(ns)	0.114
Education	Grade	2.45	1.53	3.01	1.697	1.401(ns)	0.166
Family size	Persons	6.79	1.72	5.29	1.95	-2.426**	0.018
Active family labor	Man equ.	2.65	0.89	3.52	1.42	3.098***	0.003
Dependent members	Numbers	4.02	1.83	2.41	1.32	-5.545***	0.000
Livestock holding	TLU	4.346	3.356	4.695	3.462	0.536(ns)	0.593
Land holding size	Hectare	1.05	0.67	1.32	0.520	1.997**	0.050
Farm distance	Minute	15.80	1.49	16.62	1.73	1.435(ns)	0.156

Source: Own computation, 2011; Note: ***, ** indicates significant at 1%, 5% level and ns=non significant

Appendix table 8. Summary statistics of dummy variables by adoption categories

Variables	Response	Percentage proportion across adoption categories			
		Non-adopters(43)	Adopters(77)	χ2-value	P-value
Sex of HHs	Male	37 (86)	71 (92,2)		
	Female	6 (14)	6 (7.8)		
	Total	43 (100)	77 (100)	1.164(ns)	0.281
Off-farm activities	Yes	23 (53.5)	29 (37.7)		
	No	20 (46.5)	48 (62.3)		
	Total	43 (100)	77 (100)	0.894(ns)	0.344
Contact with DAs/services	Yes	21 (48.8)	65 (84.4)		
	No	22 (51.2)	12 (15.6)		
	Total	43 (100)	77 (100)	17.29***	0.000
Training participation	Yes	12 (28)	57 (74)		
	No	31 (72)	20 (26)		
	Total	43 (100)	77 (100)	4.795**	0.029
Land tenure security	Yes	24 (56)	39 (50.6)		
	No	19 (44)	38 (49.4)		
	Total	43 (100)	77 (77)	0.295(ns)	0.578
Slope of plots land	Flat to gentle	21 (49)	14 (18)		
	Moderate to steep	12 (28)	21 (27)		
	Steep to very step	10 (23)	42 (55)		
	Total	43 (100)	77 (100)	8.715**	0.013
Perception of erosion problem	Yes	20 (47)	77 (100)		
	No	23 (53)	0 (0)		
	Total	43 (100)	77 (100)	3.642*	0.056

Source: Own computation, 2011; ***, **, * Indicate significant at 1%, 5%, 10% and ns= non significant

Appendix table 9. Semi-structured household survey questionnaires

Household survey on determinants of adoption of physical soil and water conservation measures in the Central rift valley of Ethiopia: The case of Dalocha district

Please great the interviewee with respecting gender, age, religion and culture. Please circle the answers when choices are given by respondents

Interview Schedule

Name of interviewer____________________ sign_______________

Date of interview________ month ________ year ___________

Name of supervisor ________________signature ______________ date ________

A. General household characteristics

1. Name of household head_________________________
2. Household code number_________________________
3. District________________________
4. Kebele _______________________
5. Village ________________________
6. Sex of household 1) Male 2) Female
7. Age of household head ________________ year
8. Social status 1) Religion leader 2) Kebele administrator 3) kebele administration executive member 4) ordinary member 5) other, specify__________________
9. Education level of household head ___________________ schooling year
10. Family size, age and sex composition of household member

Age group year	Male	Female	Total
1. <10			
2. 10-14			
3. 15-64			
4. >64			
5. Total			

11. Primary occupations of the respondent HH 1) Crop production 2) livestock rearing3) Off-farm activities 4) Mixed farming (crop and livestock) 5) other specify_____________
12. Do you have your own agricultural land? 1) Yes 2) No

13. How could you get access to the land you are using currently? (If they are more than one, please circles more than one answers) 1) Through renting 2) Through share cropping 3) Inherited from the parents 4) Allocated by the Kebele 5) Renting and Inherited 6) Share cropping and inherited 7) Renting and allocated by kebele 8) Inherited and allocated by Kebele

14. If the answer, for Q (13) is 1 and 2 what is/are the reason for rented in/shared in? 1) Extra labor 2) Shortage of land 3) extra in put that I have 4) extra oxen that I have 5) Extra labor and land shortage 6) others specify________________

15. What is /are the reason for rented out/ shared out? 1) Shortage of inputs 2) shortage of oxen, 3) shortage of labor 4) due to debt 5) Shortage of inputs and oxen 6) Shortage of oxen and labor 7) others specify______

16. Do the farmers who rented in your land have the responsibility to protect, maintain structures and use some resources established? 1) Yes 2) No

17. What is the total size of your land holding in ha?

1) Less than 0.50 2) from 0.5 to1 3) from 1.1 to 1.5 4) from 1.6 to 2 5) greater than 2

18. What is the total size of cultivated land in hectare?

Types of the cultivated lands	Size in hectare
1.Your own land and cultivated	
2. Rented in land /shared in cropping	
3. Rented out land / shared out	
4. Total	

19. What were the major crops grown and area allotted in hectare2009/2010?

Crop types	Land allotted in ha	Yield per ha
1. Maize		
2. Wheat		
3. Teff		
4. Sorghum		
5. Pepper		
6. Barely		
7. Other specify		

20. How many parcel of land do you cultivate? 1) One 2) two 3) three 4) four and above

21. What is the average distance of your cultivation field from your residence? 1) Less than five minutes walk 2) 5-10 minutes' walk 3) 11-20 minutes' walk 4) Above twenty minutes walk.

22. How do you perceive the distance of your cultivated land from your residence?

1) Near 2) far 3) very far

23. How do you see the size of your agricultural land over 10 years time? 1) No change 2) decreasing 3) increasing

24. If the size of agricultural land is decreasing over time, what is the reason behind it? 1) redistributed the land to due to increasing population 2) Shared with my children and families 3) land degradation and gully expansion 4) other specify__________

25. What are your options if the land scarcity is a problem? 1) going to settlement 2) migrating to other areas (urban) 3) involving in off- farm activities 4) increasing the productivity of land using modern agricultural technologies(fertilizer, seed, SWC, etc) 5) Off-farm activities & modern agricultural technologies 6) others specify______________

26. How do you understand the fertility of your farmland? 1) Very fertile 2) fertile 3) poor

27. If the fertility is declining, what measures do you apply to enhance the fertility status of land and increase production? 1) application of chemical fertilizer 2) manure 3) crop rotation 4) using SWC practices 5) 1 and 4 6) others specify___________________

28. How do you see the productivity of your farmland over time? 1) Decreasing 2) the same 3) increasing 4) I do not know

29. If the productivity of your farmland is decreasing what is the reason? 1) Frequent cultivation of land without fallowing 2) Soil erosion or mass wash 3) absence of crop rotation 4), other specify ________

30. How do you describe the slope of your farmland? 1) Flat to gentle less than 6% slope 2) Moderate to steep slope (6- 15%) 3) Steep to very steep greater 15% slope

B. Labor availability

31. Do you have enough labor to perform work? 1) Yes 2) no

32. If you have a labor shortage, how do you solve it? 1) By hiring 2) using daily laborers3) cooperating with farmers 4) using relatives 5) others specify_________________

33. If you use hired labor, what types of labor do you hire? 1) Causal 2) permanent 3) both 4) other specify______________________

34. In which farm activities your female family members do participate 1) Sowing 2) weeding 3) Harvesting 4) Transporting 5) Sowing and weeding 6) Weeding and transporting 7) all 8) others, specify______________________

35. Which family members participate in soil and water conservation activities? 1) Men 2) women 3) children 4) all 5) Men and women ___________________

36. Do you or your family work on off-farm activities? 1) Yes 2) no

37. If the answer for question 36 is yes in which type of activities? 1) Daily laborer 2) petty trading 3) hand craft 4) daily labor and petty trade 5) sales of fuel wood 6) other specify_____________

38. Which family members participate in off-farm activities? 1) Men 2) women 3) children 4) men and women 5) all

C. Live stock production (revisit with sense of conservation)

39. Do you participate in live stock production? 1) Yes 2) No

40. If yes for question, (40) describe the livestock types and number you own

1. Cows___________ 5. Goats' __________9. Horses________
2. Heifers' _________ 6. Sheep____________10. poultry_______
3. Oxen _____________ 7. donkeys___________ 11.Calve
4. Bulls_____________ 8. Mules' __________

41. What is/are the source of animal feed (Rank according to their importance?)

Sources	Rank
1. Open grazing land	
2. Crop residues	
3. Hay	
4. others specify	

42. What benefits do you get from livestock production 1) traction power 2) transport 3) food 4) sources in income 5) others specify______________

D. Perception of farmers towards soil erosion problem and adoption of soil and water conservation practices.

43. Do you think (perceive) that soil erosion as problem on your farmland? 1) Yes 2) No

44. If yes for Q (43), how do you describe the degree of soil erosion in your land? 1) Very Severe 2) Severe 3) medium 4) Minor 5) No erosion problem

45. What is the major cause of soil erosion is your opinion 1) soil is erodible 2) deforestation and overgrazing 3) rain fall intensity 4) slope of land 5) continuous cultivation

46. What opinion do you have concerning the loss of soil from your farmland? 1) Reducing the depth of top soil 2) Reducing productivity 3) Reducing water holding capacity 4) Reduce soil depth and productivity 5) all 6) others specify, ______________________

47. Do you think that soil erosion will affect your farmland in the future if the present situation remains unchanged? 1) Yes 2) No

48. What is the trend of soil erosion on your farmland over ten year time? 1) Increasing 2) decreasing 3) no change

49. What would be the consequences of soil erosion on your land 1) loss of soil fertility 2) decline of crop production 3) reduce size of farm land 4) gully expansion 5) shortage of livestock feed

50. Have you ever used traditional SWC practices on your farmland? 1) Yes 2) no

51. If yes for Q (50) which types of traditional SWC measures do you use? 1) Drainage ditches 2) Traditional diversion ditches 3) manure 4) live check dams 5) other specify

52. Have you ever been practicing/applying modern SWC structures on your parcel of land? 1) Yes 2) No

53. If yes for Q (52), which types of modern SWC measures do you use? 1) Soil bund 2) fanya juu terrace 3) check dam 4) water way 5) cut off drain 6) soil bund and fanya juu, 7) stone faced soil bunds 8) other specify__________

54. If you say no for Q (52) what is/ are the reason/s? 1) Absence of interest 2) lack of knowledge 3) my land not need SWC practices

55. In which types SWC programs do you participate in your farm plot? 1) Food for work 2) Cash for work 3) Both 4) other specify__________________________

56. How do you see or perceive the productivity of modern soil conservation measures as compare to the traditional once?1) Less productive than the traditional ones 2) the same as the traditional ones 3) More productive than the traditional ones 4) I do not know

57. How do you perceive (evaluate) the effectiveness of modern conservation measures in controlling soil erosion and conserve moisture as compared the traditional ones? 1) Less effective 2) the same to traditional ones 3) More effective than the traditional ones

58. How do you say about the present status of the SWC structures on your plots? 1) Removed totally/damaged 2) Removed partially (damaged) 3) In good condition 4) Modified (adapted) as per farmers need 5), others specify ____________________

59. Do you adopt soil and water conservation technologies on your farm land or plots? 1) Yes 2) no

60. If any of the SWC activities done in your land were completely or partially damaged what were the problem/ the reasons? 1) Hindered oxen ploughing 2) poorly designed and constructed 3) Structures consume space and put too much cultivable land out of

production 4) Need of fertile sediment retained 5) Planned to construct a new SWC measures 6) other specify_____

61. How do you construct SWC structures? 1) In groups 2) with family labor 3) mass mobilization 4) labor exchange 5) hired labor 6) other, specify____________________

62. Why do you construct SWC structures on your farmland? 1) Imposed to do so 2) To get FFW or cash for work aid 3) because of its benefits voluntarily 4) other specify............

63. Do you maintain SWC structures on your plot? 1) Yes 2) No

64. If you are maintaining how frequent do you maintain SWC structures? 1) Every year 2) within two year 3) when damage happens 4) When there is imposition

65. If you are not maintaining SWC structures on your farm plot, what is the reason? 1) Work is very tedious 2) high maintenances cost 3) in adequate labor 4) neighbors are not willing to maintain 5) lack of skill and knowledge 6) Structures were built without my willingness 7) others,

66. What major problem do you face regarding SWC measures recommended by development actors? 1) Enforcement without willingness 2) In appropriate design of structures 3) lack of technical assistance 4) obstruction of farming operation 5) others, specify__________

67. Have you observed more change in production and productivity of yield in the farmlands that have been treated with SWC structures? 1) Yes 2) no

E. Land tenure security and extension service

68. Whom do you think that land you use belongs to 1) My own 2) the governments 3) other specify?

69. How could the newly married of your family member (s) get land? 1) Shared the already household land. 2) From kebele administration/government 3) could not get land at all 4) others, specify _____

70. Which one of the following conditions is appropriate in your view? 1) Free marketing of land 2) redistributed of land 3) land taxation 4) others specify_____________________

71. Do you think there could be a condition/situation where you lose your plots of land in the future? 1) Yes 2) No

72. Where did you get information about SWC technologies? (Rank then according to their importance if they are more than one)

Source of information	Rank
1. From neighbors	
2. From mass media	
3. From DA’s	
4. From NGO’s	
5.FromDistrictagricultural experts	
6. Other, specify	

73. From where did you get technical advice concerning SWC technologies? 1) DA’s 2) from foreman 3) District experts 4) DAs and district experts5) other specify___________________

74. What kinds of support do you get from these bodies? 1) Training 2) field visit and technical support 3) demonstration 4) materiel supply 5) others, specify_________

75. How do you describe the contact you have with DA’s? 1) No contact 2) limited 3) good

76. How often you have obtained extension advice on soil and water conservation practices? 1)once per month 2) twice per month 3) three times per month 4) Once per three months 5) Twice per three months 6) others, specify___________________

77. Are you satisfied with technical support and service given by DA’s? 1) Yes 2) no

78. Have ever attended training related to SWC? 1) Yes 2) No

79. If yes for question (79), what have you done with skill or knowledge acquired from the training on your plot? 1) Never applied the technology in the field 2) applied but removed them selectively 3) Applied but removed them completely 4) applied and maintains the conservation measures

80. What advantages do you observe from SWC structures constructed on your land? 1) reduce soil erosion 2) increase crop yield 3) increase moisture availability 4) control flood 5) maintain land for future 6) other specify

81. Please tell us the amount of Physical soil and water conservation structures currently existed on your plot in meters1) Fanya juu______2) Soil bund ____3) stone faced soil bund 4)check dam____5) cutoff drain____6) waterway______7) other, specify________________

82. What is your opinion to improve the current efforts towards better soil and water conservation practices?

Appendix table 10. Check lists for key informant interview (Development agents, District MoA experts and *kebele* leaders)

1. Name ______________________ Date _______________Sign __________

2. Education status _________ your profession______________

3. How long have you stayed in the area/ district? ____________________

4. How do you understand about the soil erosion problems in Dalocha district in general and kebeles in particular?

The major causes and extent of soil erosion

____

The attitudes of farmers towards soil erosion problems and conservation measures

____

The consequences of soil erosion on: environment, social, economic aspects

____

5. What efforts have been exerted by government, NGO, community and specially district MoA office with regard to soil and water conservation?

6. How do you see the impacts of separate and /or joint efforts of past SWC intervention?

7. What types of approaches does your office follow in planning, design and implementation conservation practices? Why?

8. What are major strengths and weakness of previous SWC intervention?

9. Which types of SWC measures do you think are most accepted, widely disseminated, and adopted by farmers? Why?

10. What are the major factors that affecting farmers' adoption of SWC technologies in the study area /district?

11. How do you see the attitude and participation of local communities in SWC intervention and maintenance of structures?

12. How do you see the incentive role of FFW/ cash for work program? What is its draw back? What other incentive methods are still needed?

12. Why do you think that farmers are not considering SWC intervention as their normal farming practices?

13. What are the gaps between farmers and development actors in addressing soil and water conservation technologies?

14. What do you think the better options to improve the current efforts towards better soil and water conservation practices?

Appendix table 11. Check lists for Focus Group Discussion (farmers)

Discus on the following points in context to your localities and *kebeles*

1. What are the major causes of soil erosion in your area?
2. What are the common traditional (indigenous) and modern SWC measures practices in your plot and locality?
3. Who has introduced modern SWC technologies to you?
4. How long has it accounted since the introduction of modern SWC measures in your areas?
5. What are the effects/results of SWC practices in your or areas?
6. Discuss the extent how the local community participates in planning, implementation and monitoring SWC and agro forestry practices.
7. How SWC works would be owned and sustained by individuals or communities?
8. Do you get adequate extension services, training, technical and material support from district agricultural office and DA's in the field of soil conservation & agro forestry practices? Please explain your opinion in brief.
9. How do you evaluate the adoption of SWC intervention in your plot/locality?
10. What limitation/problem do you face in establishing and using SWC technologies?
11. What advantages/ benefits do you obtained from SWC intervention?
12. Why do you not consider SWC practices as your normal farming practices?
13. What are the main reasons for removal of SWC structures from the field after installation?