



ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

**IMPACT OF SOIL CONSERVATION ON CROP
PRODUCTIVITY IN THE SOUTHERN ETHIOPIAN
HIGHLANDS**

የአድዳ ቤተ-ምህረት
ADDIS ABABA UNIVERSITY
LIBRARY

By

F. B. E.
LIBRARY

DAWIT TESHALE

March, 2007
Addis Ababa



ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

**IMPACT OF SOIL CONSERVATION ON CROP
PRODUCTIVITY IN THE SOUTHERN ETHIOPIAN
HIGHLANDS**

BY

DAWIT TESHALE

**A Thesis Submitted to the School of Graduate Studies of
Addis Ababa University in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Economics
(Natural Resource and Environmental Economics)**

**March, 2007
Addis Ababa**

**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**“Impact of Soil Conservation on Crop Productivity in the
Southern Ethiopian Highlands.”**

By

Dawit Teshale Beyene

Approved by the Board of Examiners:

Mulet Demeke

Advisor

Mulet Demeke

Signature

Getachew Yoseph

Examiner

Getachew Yoseph

Signature

Workech Negatu

Examiner

Workech Negatu

Signature

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for making it all possible in my life.

Then, I would like to extend my gratitude to all individuals who helped me in my endeavor to make this study real.

If it was not to my advisor unlimited professional guidance and constructive comments, I would say this study would not be a successful story. Thus, I am deeply indebted to Dr. Mulat Demeke for his advice, encouragement, support and remarkable patience he showed while advising.

In particular, I am very much grateful to Dr. Menale Kassie for all his valuable insights and constructive comments. It has been a quite learning experience.

I would also like to express my appreciation to Ato Gezahen Boru, Ato Hiwot Desta, and Ato Ermyas Yegezu, who currently live in Damot Gali woreda, for facilitating the study.

I would also like to express my thanks in general to all individuals who helped me from the inception to the completion of the study, as listing the names of all individuals is difficult in this single page.

Finally, my special appreciation goes to all members of my family, friends and relatives who are always there for me; I am where I am because of their strong dedication to my success.

Thanks a billion!

TABLE OF CONTENTS

Acknowledgment	i
Table of contents	ii
Acronyms	iv
List of Tables	v
List of Appendices	vi
Abstract	vii
CHAPTER ONE: INTRODUCTION.....	1
1.1 Back Ground.....	1
1.2 Statement of the problem.....	3
1.3 Research Aims.....	3
1.4 Objectives of the study	4
1.5 Hypotheses of the study.....	4
1.6 Significance of the study	4
1.7 Limitation of the study	4
1.8 Scope of the study	5
1.9 Organization of the study	5
CHAPTER TWO: LITERATURE REVIEW	6
2.1 Environment	6
2.1.1 Definition.....	6
2.1.2. Environmental problems at the farm/household level.....	11
2.1.3. Soil conservation and crop productivity	12
2.2. Theoretical literature	16
2.2.1 Conceptual Framework	16
2.3. Empirical literature	20

CHAPTER THREE: METHODOLOGY OF THE STUDY.....	22
3.1. Data source and type	22
3.2. The study area.....	23
3.3 Method of data analysis.....	28
3.3.1. Estimation method.....	28
3.3.1.1. Econometric framework	29
3.3.1.2. Yield regression.....	30
3.3.2. Specific Variable description	33
3.4. Empirical estimation.....	36
3.4.1. Model specification for yield equation.....	36
3.4.2. Variable description for adoption	38
 CHAPTER FOUR: RESULTS AND DISCUSSIONS	 41
4. DESCRIPTIVE ANALYSIS	41
4.1. General characteristics of households	41
4.2. Major factors of soil conservation.....	43
4.2.1. Factors of soil conservation.....	43
4.2.2. Extent of soil conservation	47
4.3. Econometric tests.....	51
4.4. Estimation result and interpretation.....	52
4.4.1. Soil and water conservation adoption model.....	52
4.4.2. The impact of Soil and water conservation on crop productivity	56
4.4.2.1 For Pooled Sample OLS result	56
4.4.2.2 OLS result for adopters and non adopters of SWC	58
4.4.2.3 Predicted mean Value of the yield	60
 CHAPTER FIVE: CONCLUSTION AND POLICY IMPLICATIONS	 61
5.1. Conclusion.....	61
5.2. Policy implications	65
 Reference	 68
Appendices	73

Acronyms

GDP	Gross Domestic Product
GIS	Geographical information System
GPS	Global Positioning System
HH	Household
LLPPA	Local Level Participatory Planning Approach
OLS	Ordinary Least square
SNNPR	South Nation Nationality People Region
SWC	Soil and Water Conservation
TLU	Tropical Livestock Unit
WADU	Wolayita Agriculture Development Unit

LIST OF TABLES

PAGE

Table 4.1 Summary for descriptive analysis	41
Table 4.2 Soil conservation and household characteristics	43
Table 4.3 Soil conservation practice for adopters	48
Table 4.4 Binary Probit model result	52
Table 4.5 OLS regression result for pooled sample	57
Table 4.6 OLS regression result for SWC adopter and non adopter	59
Table 4.7 The predicted mean yield difference result	60



LIST OF APPENDIX**PAGE**

Appendix 1 Descriptive analysis	73
Appendix 2 Binary Probit model result	74
Appendix 3 Binary Probit model result without expected endogenous variables	75
Appendix 4 OLS regression of yield equation (for pooled data)	76
Appendix 5 OLS regression of yield equation (for SWC adopter)	77
Appendix 6 OLS regression of yield equation (for SWC non-adopter)	78
Appendix 7 Predicted Mean yield difference	79
Appendix 8 Tropical Livestock Units (Tlu)	79
Appendix 9 Location map of Damote Gali	80
Appendix 10 Digital Photo and 3D picture for the study area	81
Appendix 11 Household Level Questionnaires	82

Abstract

Land degradation, especially soil erosion, nutrient depletion and soil moisture stress are severe problems in Ethiopia. Land management, therefore, becomes a key problem area in addressing land degradation and achieving sustainable agricultural development in the country. This research gives emphasis to identify the determinant factors of Soil and Water Conservation (SWC) adoption. In addition, the impact of SWC on crop productivity is also addressed. The study is based on a primary data collected at plot level from 151 randomly selected households operating on 331 plots in Damot Gali Woreda. The binary probit approach is used for the analysis of the adoption decision, and a separate OLS regression is run based on a chow test to assess the impact of SWC on crop productivity for both sub samples. Heckman approach is also part of the analysis. Variables such as sex, age, access to credit, livestock ownership, distance to town market, slope and soil fertility were found to have a statistical significant impact on the adoption model.

Moreover, agricultural inputs application (fertilizer & seed), sex of the household head and soil water conservation have a positive impact on crop productivity. The predicted mean yield difference also shows the positive impact of SWC on crop productivity.

Keywords: Soil and Water Conservation, adoption, Damot Gali, binary probit and OLS regression, crop productivity.

CHAPTER ONE

INTRODUCTION

1.1 Back Ground

The economic development of Ethiopia depends on the performance of the agriculture sector, which supports the life of many Ethiopians. However, its contribution to the development of the country depends how the natural resources base are manage.

Ethiopia is a country found in eastern part of Africa with a total of 1.130 million-km² area, of which 45% is highland and 55% is lowland. Highlands of Ethiopia, which is 1500 meters above sea level, which is 45% of the total landmass, supports 85% of the total population, 98% of regularly cultivated land and 75% of the livestock population of the country (EPA, 2003).

These figures of Ethiopian highlands notify its importance to the country since the country is highly dependent on agriculture, which contribute about 50% of the GDP, over 90% of export revenue and employ more than 85% of the population (EPA, 2003). Hence, the importances of highlands are obvious and show that the country has broad resource base.

Farmers or peasants in the rural area of Ethiopia drive their livelihood from the economic engagement of agriculture. The existence of unfavorable production environment and related constraints has been worsening the lives of rural households by aggravating food insecurity, rural poverty and destitution.

Agriculture includes crop and livestock production and the required production inputs as well as basic infrastructure. As different literatures indicate that, major agricultural activity related problems are land shortage/scarcity, erratic weather condition, absence of market and low market prices, crop and animal diseases, lack of farm inputs and fertilizers, and land degradation with loss of soil fertility, lack financial capacity and access, and problem of technological adoption are major one.

Given the stated problems, Ethiopian highlands are highly degraded. As quoted by Belay (1996) estimation by NCS out of the 54 million hectares of land constituting the highlands 19 million hectares is seriously degraded, 13 million hectares are moderately degraded, while over 2 million hectares of land's soil depth is so reduced that the land is no more able to support cultivation. Hans, et al (1996) support the estimation forwarded by NCS. They add

“Most of the highland terrain has slopes of more than 16% and only a fifth, is considered free from erosion hazard. Most of the productive topsoil in the highlands has been degraded resulting in chronic food shortages and Persistent poverty. Serious erosion is estimated to have affected 25% of the area and 4% of the highlands are now so seriously eroded that they will not be economically productive again in the foreseeable future.” Hans et.al. (1996)

In Ethiopia, the quality and the quantity of natural resources are degraded due to multitude of factors.

Land degradation in the form of soil erosion and soil nutrients depletion pose a threat to the productivity, food security, and poverty in Ethiopia. Due to different reasons in the highlands, as roughly estimated, nearly one billion tones of soil are lost each year (Teferi, 1998). Hurni stated that, soil erosion is the severest environmental problem as the country loses on average 42 metric tons/ha of topsoil every year in cultivated areas (Hurni, 1988). The amount is far exceeding the soil formation rate of 3-7 metric tons/ha per year. The Ethiopian Highland Reclamation Study estimated that by the mid 1980s about 50% of the highlands (27 million hectares) were significantly eroded. According to Stahl (1990) if the situation is not improved, the amount of land incapable of supporting cultivation will reach 10 million hectare by the year 2010.

The need for curbing this problem is critical in order to meet the growing demand for food due to an ever-increasing population pressure. In recognition of this problem, a substantial amount of investment on soil conservation measures and projects has been invested since the 1970s. However, the rate of adoption is low and rarely continued once external support has been withdrawn (Tadesse and Belay, 2004). It is important to create favorable conditions so that a greater number of farmers can take advantage of adopting conservation technologies.

The main emphasis on promoting soil conservation measures in Ethiopia was to reduce soil loss and run-off. It is not clearly known why farmers are slow to adopt the technologies. It is not also clear if it is justifiable to invest on soil conservation measures. Most of the research conducted in the land degradation case in the northern highlands of Ethiopia, with few exceptional (e.g. M. Kassie and Holden, 2005), has focused on the biophysical aspects of the problem- particularly on soil erosion - without much emphasis on the economic, social, or institutional factors that affect how farmers manage their land. Similarly, the policy response to land degradation in Ethiopia has focused on the technical aspects, promoting adoption of particular conservation technology, especially physical structures such as terraces and bunds. Nevertheless, this study tried to assess the productivity impacts of soil conservation measures including the economic, social, and institutional factors that affect how the SNNPR farmers with a special emphasis to the study area manage their land.

1.2 Statement of the problem

Agriculture is the basis of the economy and the life of many Ethiopians. Farmers in the rural area of Ethiopia derive their livelihood from this economic engagement. The existence of unfavorable production environment and related constraints has been worsening the lives of rural households by aggravating food insecurity and rural poverty. In order to protect the land for sustainable agricultural production, land conservation should be integrated into the farming practices.

There are empirical studies conducted in the Northern highlands of Ethiopian, which show the impact of soil conservation on reducing soil loss and run-off. (M. Kassie and Holden, 2005) But it is an unaddressed issue in the southern part of the country. This research intended to bridge this gap and better understand the functional relationship of land conservation and productivity in southern part of the country.

1.3 Research Aims

The overall objective of this research is to identify factors that encourage the adoption of soil conservation measures in Southern Nation and Nationalities People Region (SNNPR) Wolayita

zone of Damote Gale woreda using plot level data. It also deals with the impact of SWC on crop productivity in the study area.

1.4 Objectives of the study

The specific objectives of this study are to:

1. Identify key determinants in the adoption of soil conservation measures in Wolayita zone of Damote Gale Woreda,
2. Identify the impact of soil and water conservation on crop productivity,
3. Recommend an appropriate policy suggestion for sustainable agricultural development and resource preservation.

1.5 Hypotheses of the study

In this study, the validity of the following hypotheses was being tested empirically.

- 1 Awareness and knowledge of a farmer is a key determinant of adoption of soil conservation measures.
- 2 Soil conservation has positive and significant effect on productivity of agriculture

1.6 Significance of the study

This study contributes to the limited literatures of soil conservation and land degradation in Ethiopian. It also assists decision makers to identify which technology works where and under what conditions. Furthermore, it provides information on areas of further research, extension or development schemes.

1.7 Limitation of the study

Due to the nature of the subject matter which needs a sit specific study i.e. Damot Gali is taken as a study area. There is no one fit solution to the general country level problem of environmental degradation.

Shortage of financial resource has contributed to the limitation of the sample size to only 151 (operating on 331 plots) households from the selected study sit. The infrastructural problems in the study area also play a significant role to access some parts of the study areas in the woreda.

1.8 Scope of the study

The scope of the study is limited to identify the determinant factors to adopt soil and water conservation in Wolayita zone of Damot Gali Woreda. Moreover, based on the objectives of the study an impact assessment of soil and water conservation on crop productivity was done on this research study. The major reason for the scope of the study comes from the nature of the subject matter that needs a sit specific study area to recommend a policy suggestion for specific study place. There is no one fit solution to the general country level problem of environmental degradation.

1.9 Organization of the study

The thesis is organized as follows. The first three chapters following the introduction provide the framework for the analyses conducted in later chapters. Chapter two presents the literature review including the conceptual framework utilized as the foundation for the econometric work. Chapter three describes the methodology of the study including data employed, the study area and method of the data analyses. Chapter four provides a descriptive analysis of the data and characterizes the sample households that adopt soil and water conservation during the agricultural seasons of 2006.

Chapter five is a result and discussion part of the paper. Econometric measurement of the interactions and magnitudes of the household demographic and the plot physical characteristics that influence the adoption of SWC and its impact on crop productivity is addressed.

The conclusions and implications of the findings appear in Chapter six. At this point, the findings of the research are summarized and an evaluation of the trends presented.



CHAPTER TWO

LITERATURE REVIEW

2.1 Environment

2.1.1 Definition

Raising the issue of interaction between economic agents and the environment having one to the other dependant relationship, need to have a clear conceptual definition through out the research. The dynamic environmental (including land) change creates an active economy and life to become sustainable. When we say environment, it takes a broader concept and needs to narrow with the concept of Ecosystem. The United Nations Environment Program (UNEP, 2003) defines the ecosystem as:

“A spatially explicit unit of the earth that includes all of the organisms along with all components of a biotic environment within its boundaries.”

Lipper (1998) defines the ecosystem as a complex web of biological and physical relationships that produces and maintains natural capital.

Nibset (1991) defined the environment as ‘the thin skin on the earth’s surface on which life exists’. It is composed of the biosphere, the atmosphere, and all flora and fauna: it includes all forms of living organisms, energy and material resources and the atmosphere.

Furthermore, Hodge (1995) defines the environment in terms of its contribution. The environment provides:

- Raw material and other inputs into production processes such as energy, renewable and non-renewable resources, minerals, water etc,
- Amenity and living space; i.e. the medium where all other species of plant and animal live such as soil, water, nutrients,
- Ecosystem function, which is the assimilative capacity of wastes.

The UNEP (2003) categorize contributions of the environment similar to Hodge’s; summarizing the first contribution by the term provisioning, the last two by the term regulating and enriching. According to the UNEP (2003), the environment enriches the society by its cultural and religious

services such as spiritual components, aesthetic values, social relations, education and scientific values.

In addition, natural resources have the potential to contribute to the long-term economic productivity and welfare of societies (Bariber, 1998) it includes raw materials such as timber, water and soil, as well as environmental services such as waste assimilation and water maintenance. In addition, natural capital provides utilities through the provision of aesthetic and recreational services.

According to T.Tientenberg (1992), advising the relevance of environment and natural resources rived as a composite asset that provides a variety of services. It provides the life support systems that sustain our very existence, provides the economy with raw materials, which transformed into consumer products by the production process, and energy. It provides services directly to consumer (as breath) as well as other ecosystem functions which provide utilities such as recreation, health, cultural and aesthetic services, and provides as with a variety of amenities for which no sub situate exists.

Land is one part of the environment not covered by water and which where humanity enjoys all the means of its survival. Land has different definitions depending on the purpose one has in mind. Durning (1989) defines land as “soil, a store of minerals, terrain, territory, property, or a capital asset.” In the above definition, an important element of land is soil, which has a direct link with agricultural production. As stated in Microsoft Encarta (2003), soil in general is an unconsolidated, or loose, combination of inorganic and organic materials. The inorganic components of soil are principally the products of rocks and minerals that have been gradually broken down by weather, chemical action, and other natural processes. The organic materials are composed of fragments from plants and the decomposition of the many tiny life forms that inhabit the soil. Soils vary widely from place to place. Many factors determine the chemical composition and physical structure of the soil at any given location. The kinds of plants or other vegetation that grow in the soil are also important. Topography, of which the terrain is steep, flat, or some combination, is another factor. In some cases, human activity such as farming or building has caused disruption. Soils also differ in color, texture, chemical makeup, and the kinds

of plants they can support. Soil-forming processes may take thousands of years, and are slowed by natural erosion forces such as wind and rain.

For a life to survive there is a process of interaction between the economic agents and the environment. These economic agents are entities that act to fulfill certain economic objectives such as individual consumers, firms or governments. Taking a human being as one economic agent, who tries to fulfill its basic needs per day may interact with the environment in either a healthy or a steady state to keep the system in safe manner. If a human being is unable to convert consciously the available environmental resources to use value for its own advantage, a result of manmade unbalanced changes happened in the system. These changes, as long as they motivated by the objective of producing marketable products tend to undermine the integrity of the ecosystem. Consequently, externalities and degradation is a result in the natural resource and environment.

For instance, as Tisdell (2000) posit that ‘Natural economic systems are increasingly modified and in some cases destroyed and entirely replaced to facilitate the production of private and marketable commodities.’ Either through this processes of interaction a balanced or imbalance of natural resource usage is happen.

Hence, as it discussed previously, the core objective to create an interaction between the human being and the natural resources lies under the creation of private and marketable products. In this process, economic agents use the environment for two distinct purposes. First, the environment is used as a source of natural resources. These resources are shaped, reshaped and manufactured with human effort into items that are useful to humans. Here environmental resources are making a use as inputs to the production process. Second, it used as a depository to the wastes that are generated in both production and consumption of the goods and services. Both interventions entail substantial potentials to change the environment’s composition with possibilities of threatening the survival and integrity of the environment.

Furthermore, the elements making up the environment have self-correcting mechanisms that tends to heal the ills done to its elements and systems. The Gaia hypothesis (Lovelock, 1987) tells us that much more harm could have been observed had it not been for such healing mechanisms. We should also note that humanity, if and when correct incentive structures are kept in place it is

capable of devising mechanisms that have the ability of containing catastrophe that could result from its own actions and usher in positive and constructive actions that make life in this world sustainable. Thus, afforestation, soil conservation activities and the like are human actions exerted by concerned human institutions that aim at effectively controlling destructive human actions.

One of the major problems stated is land degradation which threatening the integrity of the environment. Land degradation is the process that leads to the loss of biodiversity and productive capacity of the land. It changes in the quality of soil, water, and other characteristics that reduce the ability of land to produce goods and services that are valued by humans. It starts with the impoverishment of, and reduction in vegetative cover, exposing the soil surface to accelerated erosion and leading to reduction in soil organic matter and nutrient content. Examples of land degradation include soil erosion, soil nutrient depletion, and salinization. Some forms of land degradation, such as nutrient depletion, can be halted and even reversed rather easily (e.g., by balancing nutrient application with that taken up in harvested crops). Other forms of land degradation, such as soil erosion or salinization, can be slowed or halted through appropriate management practices but are generally very costly to reverse (IFAD, 1992).

Humans have accelerated these erosion processes by developing the land and clearing away the vegetation that holds water and soil in place. And the like, reforming agricultural soil management methods which include soil conservation helps to restore essential soil nutrients and to reduce erosion. when we say soil conservation is a set of management strategies for prevention of soil being eroded from the earth's surface or becoming chemically altered by overuse, salinization, acidification, or other chemical soil contamination. The principal approaches these strategies take are: choice of vegetative cover, erosion prevention, salinity management, acidity control, encouraging health of beneficial soil organisms, prevention and remediation of soil contamination , mineralization. Decisions regarding appropriate crop rotation, cover crops, and planted windbreaks are central to the ability of surface soils to retain their integrity, both with respect to erosive forces and chemical change from nutrient depletion. Crop rotation is simply the conventional alternation of crops on a given field, so that nutrient depletion is avoided from repetitive chemical uptake/deposition of single crop growth. (Website Wikipedia, the free encyclopedia)

The previous paragraph shows us the importance of Soil, which serves as an input to agricultural production. The physical loss of topsoil, reduction in rooting depth, and removal of plant nutrient are all the result of soil erosion. These processes result in the reduction in soil fertility and quality leading to a decline in soil productivity. Low potential lands “constitute resource poor or marginal agricultural lands, where inadequate or unreliable rainfall, adverse soil conditions, limited fertility and topography limit agricultural productivity and increases the risk of chronic land degradation.” (Barbier, 2000) Land productivity helps to determine total food production, incentives for land use change and consumer food prices. So that, identifying the problem source and the need to curb such a problem is a critical issue in the agricultural sector.

2.1.2. Environmental problems at the farm/household level

As different literatures note that, environmental problems affected farmers can be generated basically from two sources; the first is **outside the farm** and the second is **inside (within) the farm**.

- 1 *outside the farm*; it is taken as an assumption for the characteristic of negative externalities from farmers perspective;
- 2 *Inside the farm*; in this case the farmer can address and solve these problems directly at the farm level without exterior intervention of higher-level institutions.

Regarding the environmental problems created outside the farm at household level, is negative environmental externalities¹ inflicted by soil degradation due to wind and water erosion. If the degree of land degradation is not too high, farmers common agricultural practice application help to restore the productivity of the soil. These practices can range from increase of inputs and fertilizers up to crop rotation, minimum tillage, and proper land management of fallow periods. On the other hand, environmental problems originating inside the farm and leading to land degradation are soil compaction, salinization, acidification, water logging. Also in this case, decisions to address and solve the problems can be taken within the farm with no need of intervention from government at either local or national level, provided that the farmers can afford to pay the costs required and perceive it is in their interest to do so. In other words, they will decide to improve their conservation practices, if they can find financial resources and they expect their returns to increase. (www.fao.org)

For instance, Bishop (1992) classifies the economic effects of soil erosion correspondingly as; on-site and off-site costs. The on-site costs are the direct effects of soil erosion on the quality of the land resource itself. It is express in terms of reduced agricultural productivity. Soil erosion affects agricultural productivity directly by washing away or burying crops or indirectly by changing the property and quality of the soil (Eaton, 1996).



The off-site costs are the indirect effects of soil erosion, which usually take the form of externalities.¹ These results the flow of soil sediment and run-off from one location to another such as another farm land or water way. “Most off-site costs are traced to the effects of silt, soil nutrients or agro-chemical products washed into surface water or leached into subterranean aquifers by rainfall or irrigation run-off” (Bishop, 1992).

Based on these environmental problems created outside the farm or inside the farm level, this research paper basically deals with the major predicament of inside the farm level factors. In effect, it needs the farmer's decision of a remedy measure on the soil water conservation practice.

2.1.3. Soil conservation and crop productivity

Soil degradation is one of environmental problem, has a major implications on agricultural productivity. Agricultural productivity is a measure of the amount of agricultural output produced for a given amount of inputs. Agricultural productivity can be defined and measured in a variety of ways. It includes partial measures, such as the amount of a single output per unit of a single input (e.g. a Kg of seed applied per hectare of land), or in terms of an index of multiple outputs divided by an index of multiple inputs (e.g., the value of all farm outputs divided by the value of all farm inputs). Different measures of agricultural productivity may be of interest in addressing different questions. Land productivity measures, for example, help determine the amount of land needed to meet the consumer's food needs—and thus the potential level of pressure on land currently providing other environmental services. Before, the case analysis and consequence, we look at the natural resources in agricultural production

Capital is a stock of real goods with the potential to produce a flow of benefits or utilities in the future. Natural capital is the stock of goods derived directly from nature that have the potential to contribute to the long-term economic productivity and welfare of societies (Bariber, 2000). This natural capital can be taken as an input to agricultural production, alongside with the inputs such as labor, financial capital. In the context of the agricultural production, the elements of

¹ Externalities occur whenever welfare of some agent depends not only on his or her activity, but also on activities under control of some other agents (Tientenberg 2003).

natural capital includes soil quality (slope, texture, composition), climate (amount and timing of rainfall, wind) water resources (availability, quality) and land cover amount and type of vegetation) (El Serafy, 1990).

In valuing natural resources like any other marketable commodity in terms of monetary value, become difficult task due to the non-existence of market situation for such a case. As a case, natural capital is measured in stocks and flows. These natural capital stocks are commonly divided into renewable and exhaustible categories. Renewable is defined as a plant or animal population with the capacity for reproduction and growth at a significant rate when viewed from man's economic time scale. Such resources are capable of regenerating themselves as long as the environment is favorable to them. These include fish populations, forests and under certain circumstance, soil fertility (Conrad and Clark, 1996)

A main point we note is that, upsets in this nurturing environment may lead to a loss of regeneration capacity and thus the exhaustion of the resources. On the other hand, exhaustible resources are limited in quantity and not producible in any economically relevant period. (Fisher 1981) Extraction of one unit of this resource results in a decrease in the total stock of the resources by exactly the same amount.

From Economists point of view, a traditional approach was accept to the analysis of natural resources use and allocation over time as an investment decision. In the case of exhaustible resources, the impact of soil degradation on agricultural productivity is a dynamic process that is highly heterogeneous across time and space. And the impacts vary by type of degradation. The point what we underline that soil degradation impacts are so highly site and time specific, for that matter it is difficult to assess the economic implications in a generalized fashion. In addition, the fact that humans can influence both the occurrence and impacts of various forms of degradation makes it difficult to assess the economic implications of the process (Erenstein, 1999).

To illustrate the impact of land degradation on agricultural yields the case of soil erosion was taken. Soil erosion caused by water and wind action leading to a loss of soil from the uppermost land layers. As Old man, Hakkeling and Sombroek (1990) estimated that approximately 83% of

the land degradation in developing countries is caused by water and wind induced soil erosion. Erosion can result in the physical deterioration of the soil and/or include chemical deficiencies and toxicities, which in turn impact agricultural crop yields (FAO, 1999)

In the next section, we look at the relationship between soil resources and average agricultural productivity. Lal (1994) has identified the following processes, which are included in soil degradation: accelerated erosion and desertification, compaction and hard setting, acidification, decline in soil organic matter content and biodiversity, and depletion in soil fertility. These process result in changes in soils which in turn have an impact on yield through changes in soil nutrient content, water holding capacity (WHC), organic matter content (SOM), soil reactivity, topsoil depth, salinity and biomass (Scherr, 1999). Soil degradation effects on agricultural productivity manifested through their impacts on the average and variance of yield, as well as the total factor productivity of agricultural production. These impacts translated into economic costs in the form of loss of income (or consumption) and increased costs of production. Resources i.e. the key factors determining the optimal depletion path are the cost of harvesting the resources, its price and the discount rate. For renewable resources, the natural rate of regeneration enters into the calculation. Human intervention can change the natural rate of regeneration through capital investments augmenting the stocks, as well as through depletion.

According to Lal (1990), the relationship between soil erosion and agricultural yields divided into two separate components. The rate at which erosion occurs over time, e.g. the susceptibility of the soil to erosion as measured by tones of soil loss per year, and the relationship between the level of erosion and productivity measured in tones of crop yield loss per unit erosion. The first is a function of two groups of factors: forces that generate erosion and forces that resist erosion. Forces that generate erosion include climate and topography; specifically the amount and distribution of rainfall and wind velocity and the steepness and length of slope. The forces that resist erosion include the degree of land cover as well as several characteristics of the soil including its texture, structure, water logging capacity and transmission properties. Generally, the negative relationship between the level of erosion and impact on crop yields in expected to be stronger in high land areas, which is grater than 1500 mater above sea

Soil erosion causes more severe quality change in cultivable land, due to its exposition of top soil for washout, low vegetative coverage, and so on. The degree to which the soil has already experienced human induced or natural degradation is clearly an important determinant of the current yield impacts of degradation,

In curbing such a problem, the first rational decision making is expected from the economic agent for the remedy measures of which taken to reduce the problem of land degradation by the farmers decision. Farmers can opt for the range of following strategies regarding soil management; i.e. to do nothing on remedy measure up to taking measures to mitigate the negative impacts of erosion on crop yields and variability. The strategy that a farmer adopts will depend on the magnitude and type of costs associated with degradation, and how these costs are compared with the costs associated with adopting any soil management. A key concept necessary to understand the costs of soil management strategies from the farm perspective is that of opportunity costs, which is simply the value foregone by employing a resources in one use, rather than an alternative use. This means consideration of what the farmer is giving up in adopting a particular course of action, i.e. soil conservation. These may incur financial costs such as expense for inputs, loss of output in value term his cultivable land, or loss of livestock feed supplies, as well as non-market costs, such as the loss of leisure or time spent on the construction of conservation technology.

In the case do nothing on remedy measure in soil management, there is a cost of soil degradation associated with erosion, which expressed as the loss of production value i.e. loss of yields, and loss of input efficiency, the magnitude of this loss will vary considerably, depending on the rate of erosion, and the rate of yield loss. As a result the scarce resources of land become abundant due to high problem of soil degradation i.e. erosion. These enforce the farmer to do something from his experience or seek knowledge deriving from any institution regarding to reduce the problem, like follow a strategies regarding soil management.

As a result, farmers constantly begin to make decisions about the relative merits of various conservation investment and depletion options regarding their natural capital i.e. land.

2.2. Theoretical literature

2.2.1 Conceptual Framework

Adoption of agricultural practices is one of the subject areas that have been heavily researched globally. Feder, Just and Zilberman (1985) define adoption as the degree of use of a new technology in long run equilibrium when a farmer has full information about the new technology and it is potential. As Ervin and Ervin (1982) note, most of the studies related to adoption of conservation practices have simply used farm and farmer characteristics without providing the rationale for their inclusion based on theory. Some studies such as McConnell (1983), Ellison and Fundenberg (1993) 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; Ellison and Fundenberg (1993) employed a version of innovation diffusion whereas studies such as Norris and Batie (1987) used household model based on utility maximization.

In order to determine adequately 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). A farmer regarded as both a producer and a consumer (Sadoulet and de Janvry 1995). This implies that a farmer takes into consideration “current consumption and production ends” (Reardon and Vosti 1997; Clay et al. 2002), and also policy and physical effects (CIMMYT 1993). The consumption needs are satisfied through own production though at times they are met through food purchases. Farmers make purchases using cash from crop sales or off-farm earnings. The need for cash is not only for food but also for other household requirements such as health and education.

A farmer may react in a number of ways towards declining production or/and variability in production that undermine consumption needs. Existing practices may be modified or new ones may altogether be adopted (FAO 2001). A farmer may here depend on information diffusion from external parties to learn about a new technology (Ellison and Fundenberg 1993; Knox et al. 1998). Before investing in a soil / water conservation practice brought to a farmer’s attention, he/she looks at the monetary incentives, whether the capacity is there to implement the practice,

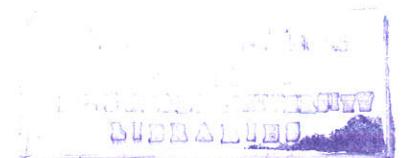
and what constraints he/she is facing (Ervin and Ervin 1982; Reardon and Vosti 1997; Clay et al. 2002).

One of the major concerns of a farmer is how long he/she has to wait before getting the benefits of soil and water conservation investment (Reardon and Vosti 1997; Field 2001). Soil and water conservation practices have different wait periods hence the perceived returns may be slower than the immediate impact of inputs like fertilizer (Reardon and Vosti 1997). Most farmers in developing countries have high preference rates whereby today's consumption of resources is more valuable than the future's consumption (Field 2001). As the challenge for developing countries concerns farmers' potential for mining out the soil vitality to attain short-term gains (Field 2001), farmers in Ethiopia especially in the study area are likely to have better preference for conservation practices as of their past experience and the benefits attained through the production process.

More still, farmers tend to be conscious about uncertainties that may arise from both the physical environment and a new technology (Knox et al. 1998). Farmers in such a situation may feel more comfortable to continue with current practices despite noticing a decline in soil productivity (Reardon and Vosti 1997). They regard such behavior as risk reduction strategies.

For this study purpose, a simple model is adopted. It make a base on the assumptions of; the farmer's primary objective is to be food secure, and wants to generate farm revenues to meet household cash obligations, the farmers face constrained resources in land, management skills and capital hence activities and practices that improve the pressure on these resources are more appealing to farmers. It is specifically assume that the most critical resource constraints among the study area farmers are management skills and capital. In addition, such farmers in the study area faces shortage of lands and over population which force to keep their scarce land assets to next production season and a transfer for the next generation.

Farmers living in a steeply sloped area and face an erratic rain want to reduce risk of erosion shocks as much as possible through those investments in soil and water conservation practices, which expected to mitigate this.



This study considers farmer behavior in the adoption of conservation farming and its counter part yield impact within the analytical framework discussed above and the model employed by M. Kassie and Holden, (2005). A farmer regarded as a consumer and an investor hence an investment model that yields utility over time to a farm household employed.

Conservation effort (θ) is assumed to be an essential input in the production process. Allowing for risk aversion, farmer's maximizes expected utility of income (π).

$$\max_{\theta, X} E[U(\pi)] = \int_0^{\infty} [E[U(\pi)]] e^{-\rho t} dt \quad \dots\dots\dots (1)$$

$$\text{s.t } \pi_t = [f(\theta, X, \beta) + h(\theta, X, \alpha)\varepsilon - C(\theta, X)], E(\varepsilon) = 0$$

Where ρ is a per-period discount factor, π is the per-period return from farming, θ is conservation effort, X is other inputs believed to influence expected yield and yield variability. $f(\theta, X, \beta)$ is a stochastic production function that relates inputs with mean yield, while $h(\theta, X, \alpha)\varepsilon$ relates inputs with yield variance, β and α are parameter vectors to be estimated, ε_t is the error term distributed with mean zero, and $C(\theta, X)$ is a cost function. Output and input price is normalized to one for ease of exposition. The specification of the production function as in the above permits the inputs to have different effects on the mean $f(\theta, X, \beta)$ and the variance of yield $h(\theta, X, \alpha)^2 E(\varepsilon^2)$ (Just and Pope, 1978 cited in M.Kassie and Holden, 2005). The multiplicative stochastic specifications ($f(\theta, X, \beta)u$) restrict the effect of inputs on the variance to be related to the mean (marginally risk reducing inputs are not allowed). Under additive stochastic specification, ($f(\theta, X, \beta) + u$) only the mean of the output distribution is assumed a function of inputs; all other moments are independent of inputs (Antle, 1983 cited in M.Kassie and Holden, 2005).

The current value Hamiltonian after inserting the definition of π into (1) is:

$$H = E[U[f(\theta, X, \beta) + h(\theta, X, \alpha)\varepsilon - c(\theta, X)]] \quad \dots\dots\dots (2)$$

The first order condition (FOC) for conservation input θ is:

$$3) \frac{\partial H}{\partial \theta} = E \left[U \left(\frac{\partial f}{\partial \theta} + \frac{\partial h}{\partial \theta} \varepsilon - \frac{\partial c}{\partial \theta} \right) \right] = 0 \quad \dots\dots\dots (3)$$

Then, soil conservation investment demand function at plot level will take the following forms

$$\theta = \phi(X, \sigma^2, \bar{q}, Z^p, Z^h) \quad \dots\dots\dots (4)$$

where Z^h denotes human capital (e.g. age, education, management skills), physical capital (e.g. livestock wealth, labor, equipment), Z^p represented plot characteristics such as plot size, soil fertility, slope and others, and X include institutional factors such as extension services, access to credit, land tenure and so on. Inserting (4) into the mean output value $f(\theta, X, \beta)$ can yield the following:

$$Y = f(X, \sigma^2, \bar{q}, Z^p, Z^h) \quad \dots\dots\dots (5)$$

The variable X includes the conventional inputs besides some of those listed above. The same sets of covariates as in return as well as the conservation variable assumed to explain the variance of yield (σ^2). In the regression analysis, the reduced form of (4) and (5) estimated.

2.3. Empirical literature

The review of theoretical literature indicates that, different researchers work makes a focus on the impact of modern agricultural inputs like fertilizer and improved seed on the mean crop yield. Other researches conducted in the land degradation case in the northern highlands of Ethiopia, with few exceptional, has focused on the biophysical aspects of the problem, particularly on soil erosion without much emphasis on the economic, social, or institutional factors that affect how farmers manage their land. While a quit limited one, give emphasis to the impact of soil conservation on crop productivity in Northern highland area of Ethiopian.

From the mentioned, few literatures that were examined the direct impacts of soil conservation on mean yield using econometric and cross-sectional data stated as follows. There is an empirical studies conducted in the Northern highlands of Ethiopian by, (M. Kassie and Holden, 2005). The work of Byiringiro and Reardon (1996) using on farm level data in Rwanda, found that farms with greater investments in soil conservation have much better land productivity than other farms. However, the type of conservation was not specified clearly in the article. The work of Shively (1999; 2000) in Philippines found statistically significant impact of contour hedgerows used for conservation on yield using data collected at farm level. In Lesotho, Kaliba and Rabele (2004) found statistical significant positive association between wheat yield and short and long-term soil conservation measures.

The work of M. Kassie and Holden (2005) uses both parametric and non-parametric methods to assess the impact of soil conservation on yield and yield risk using multiple plot level data from the Ethiopian highlands. The results from parametric and non-parametric analysis indicate that yields with conservation are statistically lower than yields without conservation. Risk analysis using regression analysis and normalized second order stochastic dominance analysis did not support the hypothesis that conservation reduces risk compared to the situation of without conservation. Endowment differences between plots with conservation and without conservation and opportunity costs of conservation (area occupied by conservation) may contribute to this result. Results from productivity decomposition showed that plots with and without conservation barely differs in their endowments of soil fertility and soil depth; it was the returns (coefficients) to these variables that matter for productivity difference. The simulation results indicated that

there are possibilities to make conservations more productivity. The implication of the results is that farmers' resistance not to adopt the technology may be associated with lower yield from conservation measures. Thus the results suggest the need for designing and implementing appropriate soil conservation strategies that enhance productivity and are better adapted to local conditions in order to increase rates of adoption.

The work of Kaliba and Rabele (2004) assesses the impact of adopting soil conservation practices on wheat yield in Lesotho. This study uses input output data collected from 50 smallholder farmers in Mafeteng and Maseru districts, the major wheat growing areas in the country. A system of equations used to estimate factors affecting adoption of soil conservation measures, and impact of soil conservation measures on wheat yield. For each farmer's wheat field, based on the soil conservation practices adopted by the farmer, two soil conservation variables related to farmer's soils erosion control methods were used. Two Tobit models and a modified Cobb-Douglas production function used to model adoption and impact of soil conservation measures respectively. The adoption of two soil conservation measures modeled as function of household's demographic characteristics and availability of extension services. The yield equation modeled as a function of inputs used in production and soil conservation efforts. The results indicate that soil conservation efforts were superior to inorganic fertilizer application in terms of increasing wheat yield. Increase in soil conservation efforts, coupled with low inorganic fertilizer use has a potential of increasing wheat production among smallholder farmers in the area.

The previous studies however suffered from two major problems: methodological and inadequate sample size problems. First, all studies assumed single equation model assuming technology has only intercept effects and the same set of variables equally affect both technology adopters and non-adopters. They did not show empirically if this specification represents the reality. Second, except Shively, the remaining studies did not take into account for the endogeneity of the technology and self-selection problem. Third, except M. Kassie and Holden, not all studies took into account for the unobserved heterogeneity that might have impact on their findings. Kaliba and Rabele (2004) study suffered from small sample size (50 households) problem and did not control for plot characteristics variables. If there is, a correlation between soil conservation and the quality of the plot the return to conservation may be biased.

CHAPTER THREE METHODOLOGY OF THE STUDY

3.1. Data source and type

The study uses cross-sectional data collected using a structured questionnaire with both open-ended and closed questions. This research study takes the production period of 2005/06 (1998 E.C production season) as the base period exposure to collect primary data. The survey covered a sample of 151 farmer households (operating in 331 plots) selected randomly from Wolayita Zone Damot Gali Woreda. The random samplings select the two Kebeles of Adi Damota and Taba dwellers to be part of the interviewed household. And the sample size took the budget constraint into consideration. The data collected include; inputs used in production, type of crop grown & production in each field and the various aspects of the demographic characteristics of the respondent, assets, extension information, off-farm participation in the study period. Plot level data, such as existing soil conservation type, area of soil conservation measure, soil type, soil fertility, quality of soil conservation measure, plot area, etc...was collected.

In addition, the Soil conservation measures for the farmer household field determined by observation and physical measure. A soil conservation variable developed during a pre test time based on the number of soil conservation practices adopted by the farmer out of the soil conservation package as advocated by governmental institutions and Ngo's working within the area. The major respondent was the household head. On top of this, group discussions with key informants carried out to get general village level data, while discussion with professionals from NGO's and governmental institutions were taken place for additional information. Secondary information was collected from relevant sources to supplement primary data sources. For econometrics analysis, Stata V9 was employed to the computation and analysis of the data.

Global Positioning System (GPS) measurement instrument also used to measure the exact altitude and location of the study area beside with measuring the distance and time taking from urban market and infrastructure. Remote sensing and Geographical information System (GIS) software also employed to the analysis of the raw data for the application of this study as a visible area photo. Digital photos also strengthen the illustration of the specific study area.

3.2. The study area

According to the Socio-economic report (2003), South Nation Nationality People Region (SNNPR) is located in the southern part of Ethiopia. The region has varied climatic regions that range from Dega (Temperate) around Gamo Highlands to Kola (semi desert) at southern Omo. The region is divided into 13 zones, 8 social woredas, 96 woredas and 19 city administrations. The area of the region is about 118,000 sq. Kms. Moreover, the population is estimated about 14 million. Wolayita zone is one part of SNNPR including different woredas i.e soddo Zuriya, Damot Gali, Damot woyde, Offa, Kindo Koysha, Humbo and Boloso Sore.

Wolayita zone is located 390 Km south of the national capital, Addis Ababa of Ethiopia. In the eastern part of the Zone, there is an escarpment that begins from 2900masl (i.e. mount Damota) which is a steep sloped one. As the GIS and remote sense image indicates that, the area is largely made of mountainous plateaus (See Appendix 9 & 10). It found between the Omo and Belati catchments.

The study area, Damote Gali Woreda, is located in Wolayita zone of SNNPR, some 370Km to the south of Addis Ababa in North Omo zone of Ethiopia. The area lies at 37° 39'E latitude and 6°56'N longitude. The average altitude of the city is 2100 meter above sea level (GPS measure). Moreover, climatically it receives an average annual rainfall of 1400mm and an average annual temperature of 18 degree Celsius (Metrology report)

Based on Zonal Socio-economic report (2005) the basic features of the Damote Gali Woreda are;

- 1 The 2005 population structure of the woreda indicates 316,617 peoples are estimated, of which male and female accounts 161,911 and 165,182 respectively. The total area of the woreda reaches 39,626 in hectare. Of this the land use pattern indicate a 29272 hectare for cultivated land, 2756 hectare fore grazing, 3503 hectare for forest bush and 4095 hectare applies for other land use purpose. However, there is no land for cultivable, irrigable and currently irrigated land in the Woreda.
- 2 This Zone is a densely populated area with a minimum population density of 214 people per sq Km in Kindo Koysha Woreda and a maximum of 750 people per sq Km in Damot Gali. It is also the highest Population density groups in the country. On average, the

maximum and minimum landholding of households are 0.5 hectare and 0.125 hectare respectively; And yet this research result find out that a 0.6 hectare of landholding in the study area.

- 3 The share of agricultural population is about 90% in the Woreda. Due to the scarcity of farmland, which is unable to absorb all the labor force and produce sufficient output for annual consumption of the household, majority of the people are migrated to large-scale state farms (Awash and Metehara state farm) on daily laborer base. And, there exists a quit limited Off-farm employment opportunities through a safety net program based on food/cash for work scheme,
- 4 Traditional ways of farming practice for subsistence agricultural production are dominant with limited use of conventional methods in the study area;
- 5 The Woreda has an experience in the application of land conservation that was introduced by both government institution from the WADU (Wolayita Agriculture Development Unit) program since 1970 and NGOs;
- 6 The Woreda has three agro-ecological zones namely; Dega (2500-3500masl), Woyna Dega (1500-2500masl) and Kolla(500-1500masl). Percentage distributions of the woredas area by the agro-ecological zones account 16.9%, 65.3% and 17.8% for Dega, Woyna Dega and Kolla respectively.
- 7 Extreme population density of the study area make to struggle for survival and forced the society to cultivate more than 30% steeply sloped land (the mountain) though the natural resource conservation law of the region forbid to cultivate steep sloped land.

It is difficult to get quantifiable land degradation (soil runoff) amount in the form of soil erosion for the specific study area, whereas the severity of such a problem entails the direct impact in the agricultural productivity.

The need for curbing this problem is critical in order to meet the growing demand for food due to an ever-increasing population pressure. In recognition of this problem, Ethiopia's government was began organizing conservation efforts in rural areas during the 1970s with WADU (Wolayita Agriculture Development Unit) program and encourages farmers to combat erosion by building a physical structure of conservation like terraces and planting tree seedlings. In fact, a substantial

amount of investment on soil conservation measures and projects has been invested. And a concerted efforts have been going on in the SNNP region specially in Wolayita zone of Damote Gali Woreda in terms of soil and water conservation activities with due effort from Rural and agricultural office and NGOs, during the past regime.

Land conservation strategies focused mainly on the construction of technologies of physical structures depending on the land use pattern, through strategies that combine community-led mass mobilization and food/cash-for-work schemes and private investment. Additional incentives devised to encourage individual households to undertake conservation measures on their holdings through increased provision of extension advice and incentives through the revised program of LLPPA (Local Level Participatory Planning Approach).

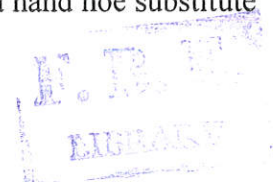
In general, the past experience at country level indicates low SWC adoption rate and rarely continued once external support has been withdrawn (Tadesse and B. Kassa, 2004). It is important to create favorable conditions so that a greater number of farmers can take advantage of adopting conservation technologies.

About the farming system, land use pattern and land management practices of the study area, it was discussed in the following section in detail.

A. Farming system of the study area

The agriculture of the study area is based on a mixed crop-livestock system. In the highland and mid land areas Enset (*Enset Ventricosum*) is a security crop that determines the cropping strategies, land use types, and crop diversification and soil fertility management practices. In Enset culture cereals, root crops and tubers are important elements of the overall farming system, supplemented by livestock raising. The major cereal is maize, which is co-staple crop with Enset. Together they form the basic diet of the population. Another important cereal barely known as food crop in the study area is Teff, while Barley, wheat and Haricot bean are cultivated only to a limited extent. A range of root crops is grown, but the most important ones are sweet potato, Irish potato and taro root. Cassava is becoming a more important food security crop in recent years in the area due to its drought resistance.

The rainfall is a bimodal pattern, giving rise to two distinct cropping seasons. The short rains (Belg season) extend between March and May. The heavy summer rains (Meher or Kremt season) fall between June and October, with a peak in August. The dry season occurs between November and February. Fields are cultivated throughout the year in a multiple cropping system. Due to shortage of farmland, they do not practice fallowing in the area while intensive agriculture dominates in the study area. Long season crops like maize are planted during the short rains and extend the growth duration into the main rains. Meher crops are planted in July and harvested in October, and the field is occupied by taro and sweet potato during the dry season. Fields are cultivated with a wooden plough which has an iron point (Maresh) drawn by two oxen and hand hoe are used to cultivate gardens and rocky soil of steep slopes. In addition, a hand hoe substitute the shortage of plough oxen and used due to the small size of the farmland.



B. Land use pattern

According to 2005 the Woreda office of agriculture report, the land use pattern shows that out of the total area (in hectare) of Damot Gali i.e. 39,626 hectare, cultivated land account 29,272ha. Moreover, grazing land, forest bush land and other land use is accounted 2756ha, 3505ha and 4095ha respectively. Hence, there is no extra cultivable land and currently irrigated land in the woreda.

The next figure 1 shows the land use pattern within the individual holding in the study area. Individual farms are mostly rectangular and oriented down the slope, begin with front yard (planted shadow tree) in front of the hut and followed with Enset garden (Darkoa Field) at the top of the slope, followed by Gosha fields (major farm plot) and Otta or Meta Bita (grass and wood field) further down the slope. The term Darkoa in the local language describes organically enriched and more productive homestead field, while the term Gosha (Masa in Amharic) denotes a field stand for the major farm plot to cereal crop production, of which a less fertile land than Darko. Otta or Meta Bita denotes a field far from the dwelling (at the foot of arable plot) and used as a grass & wood field useful for source of fodder and major fuel wood (eucalyptus tree), so that it doesn't receive any manure. As a result, it is low in fertility and productivity. The major source of fuel in the study area is eucalyptus tree and crop residuals. Traditionally using Dung as a means of fuel is not practiced in the area rather used to form compost.

The following figure indicate the individual landholding structure

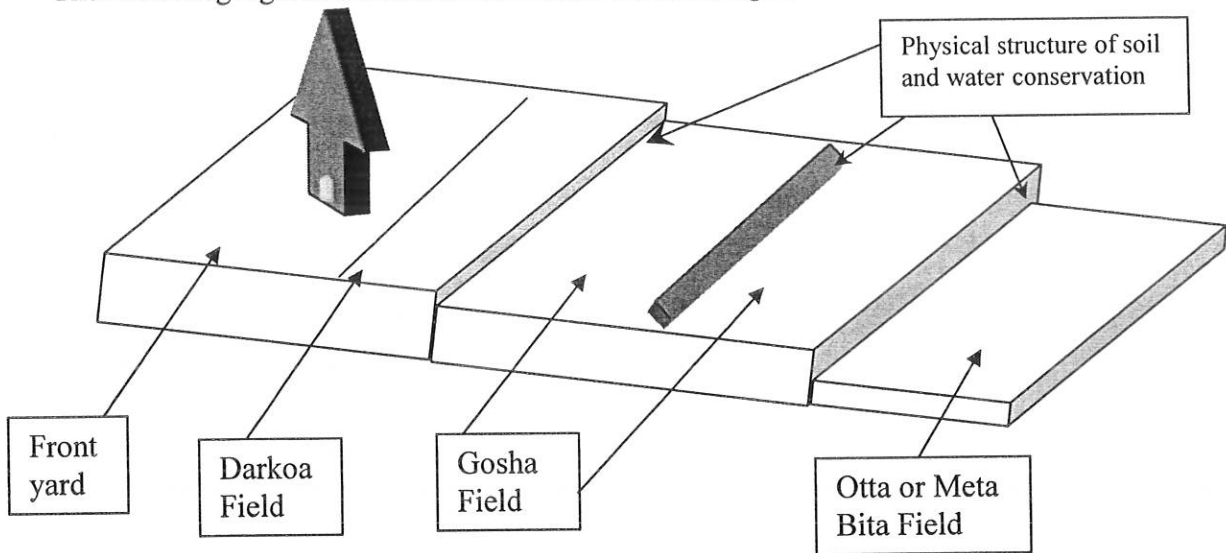


Figure 1 the land use pattern of individual hold

C. Soil type and land management

According to the woreda rural and agricultural office estimate, predominantly arable soils of the study area classified as Eutric Nitisols, which estimated to cover majority of the study area. However, sandy shallow soils are also common in some areas. Taking this into consideration, farmers identify about soil type based on the level of fertility, physical properties such as color (degree of blackness or redness), easiness or difficulty of cultivation, susceptibility to erosion (erodibility), drainage and water holding capacity.

Soil fertility management specially differentiated within the farm, i.e. allocation of major soil fertility inputs of manure and fertilizer and crops between the homestead (Darko) and distant field Gosha is radically different. The Darko especially for Enset, vegetables and taro plots receive more manure and other inputs, because women and children throw any residual into the field due to its nearest to the home. But Gosha field receives limited amount of mineral fertilizer (i.e. compost). Crops are also rationally allocated by soil fertility with fertile soils planted to high value security crops such as Enset, leafy vegetables (i.e. cabbage, pepper, carrots etc). At the demarcation, line of the field sugarcane and Banana is commonly planted which has a multi purpose in the plot i.e. soil conservation and source of food supply. Other demanding crops like maize grown in the majority and upper part of the Gosha field. The soil in the homestead area

enriched through organic sources including manure, retaining and incorporating crop residue and household refuse with nurturing and gardening care of farmers. Within the homestead, the Enset garden receives most organic inputs of manure and other recycled organic materials in order to keep food security for drought period. Inorganic inputs focused on sites or fields that produce the highest yield i.e. Gosha field. Combined usage of organic and inorganic inputs on the same field is not generally practiced. Meanwhile the higher price and shortage in supply of fertilizer constrained the farmers to apply the appropriate amount based on the technical specification per hectare. As a result, farmers forced to use less amount of fertilizer to their plots. In addition, fertilizer is not applied to homestead fields as it is thought that manure fields are fertile and fertilizer does not produce high response on such soil.

The role of gender in soil fertility enrichment follows the land use pattern and the type of crop grown. The role of women is high in homestead fields (Enset garden), while the role of men is high in the distant Gosha field areas. Gardening is traditionally women oriented activity and they are responsible for weeding and fertilizing with a range of organic inputs, particularly animal manure. Within the homestead, there is a part of the field available to grow leafy vegetables and they have full control over the produce in these area.

3.3 Method of data analysis

3.3.1. Estimation method

Econometric methods employed to assess factors contributing to adoption of Soil and Water Conservation (SWC) and their impact on productivity. Probit model was used to assess the determinant of SWC adoption. To analyze the impact of Soil and Water Conservation (SWC) on crop productivity, different regression models were explored depending on which regression model best fit the data. Based on the collected cross sectional data, OLS linear regression models could be fitted with crop productivity indicators as dependent variable. In addition, on the result of Chow test the researcher apply to estimate a separate regression model for each regime (adopters and non-adopters) and measure SWC impact after taking the predicted mean yield difference between adopters and non-adopters. On top of that, some descriptive statistics (e.g. mean of collected variables) is employed.

3.3.1.1. Econometric framework

Based on M. Kassie and Holden 2005, let us defined the commonly used dummy variable regression model to explain briefly some of the econometrics problem associated with assessing technology adoption impact on yield and to serve as a base to develop the general models of interest.

$$1) Y_i = X_i\beta + \theta_i\delta + \varepsilon_i \dots\dots\dots \text{(Yield equation)}$$

$$2) \theta_i = \gamma Z_i + u_i \dots\dots\dots \text{(Adoption equation)}$$

where Y_i represents yield from plot i depending on its conservation (treatment) status; θ_i is a binary treatment indicator variable in the general model identifying whether the plot i is conserved ($\theta_i = 1$) or not conserved ($\theta_i = 0$); X is a matrix of explanatory variables in the general model believed to influence yield and Z is a matrix of characteristics that predict conservation adoption in the general model. The variable X can be a subset of Z .

Estimation of pooled equation (2) using OLS may be suffered from the following misspecification problems. First, conservation (θ_i) might be endogenous to yield equation if there is correlation between conservation θ_i and the error term e_i . The correlation can arise due to dependence between ε_i and u_i [$E(\varepsilon_i u_i) \neq 0$]. The decision to conserve plots or to participate in the soil conservation program could depend on unobserved characteristics of the farm and farmers. This will lead to the familiar self-selection problem. Estimation of (2) by OLS without taking into account for this problem will yield biased estimates of β .

Second, even if one can account for the self-selection process and/or there is no selection problem, using a dummy variable to pick up the effect of technology on yield in a pooled sample of adopters and non-adopters may be inappropriate since it has a restriction on estimated parameters³. In pooled model estimation, we are assuming that estimated parameter has the same effect across individuals and over plots regardless of their adoption status. That is to say, the

³ Adopter and non-adopter in the present study refer to plots since the analysis done at plot level.

same sets of covariates have same impact on adopters and non-adopters (common slope coefficients for both regimes). The dummy regression model saying that, using a dummy variable to pick up the effect of technology means that conservation measure has an intercept effect, which is always the same irrespective of the values taken by other covariates that determine yield (common effect).

However, the effect of conservation on yield might be the result of an interaction with many other covariates. Our descriptive statistics, Chow test result reveal the structural instability in the yield equation between adopters and non-adopters of SWC. So that, estimating equation (1) separately for each group can strengthen the result and show a clear impact of SWC on crop productivity.

Switching regression analysis model used to account for latent characteristics of adopters and dealing with limitation of pooled model estimation. Let look at the yield regression below.

3.3.1.2. Yield regression

The impact of conservation on mean yield can be obtained using switching regression framework. That is one can divide the sample into those plots that adopt conservations and those that do not. Define the two regimes as follow⁴:

$$3) Y_1 = X\beta_1 + h_1(\theta, X, \alpha)\varepsilon_1 \text{ if } \gamma'Z + u > 0$$

$$4) Y_0 = X\beta_0 + h_0(\theta, X, \alpha)\varepsilon_0 \text{ if } \gamma'Z + u \leq 0$$

The switching equation defined as

$$5) \begin{cases} \theta_i = 1 \text{ if } \gamma'Z + u > 0 \\ \theta_i = 0 \text{ if } \gamma'Z + u \leq 0 \end{cases} \quad u \sim (0,1)$$

Where Y_1 is a yield of the plots in the state when plots receive conservation treatment and Y_0 when they do not, ε_1 and ε_0 are production shocks distributed trivariate normal with mean zero and covariance matrix

⁴ The function $f(\theta, X, \beta)$ is denoted by linear function $X\beta$ for ease of formulation of the model.

$$6) \begin{bmatrix} \sigma_1^2 & \sigma_{10} & \sigma_{1u} \\ & \sigma_0^2 & \sigma_{0u} \\ & & 1 \end{bmatrix}$$

Under the selection rule described above, we have

$$7) E(Y_1 / \theta = 1) = X\beta_1 + E(e_1 / u > -\gamma'Z)$$

$$8) E(Y_0 / \theta = 0) = X\beta_0 + E(e_0 / u \leq -\gamma'Z)$$

The least squares method of regressing Y_1 and Y_0 on X is an inconsistent estimator of β_1 and β_0 if the second terms on the right-hand-side of (7) and (8) are non-zero. Heckman was suggested to restore a zero conditional mean in (3) and (4), by including an estimate of the selection bias term, $E(e_1 | u > -\gamma'Z)$ and $E(e_0 | u \leq -\gamma'Z)$, respectively. These terms are proportional to the inverse Mills ratios (we use λ to denote it), and depend only on unknown parameters of (5) which can be estimated by Probit model.

$$9) Y_1 = X\beta_1 + \sigma_{1u}\lambda_1 + e_1 \text{ if } \theta = 1$$

$$10) Y_0 = X\beta_0 + \sigma_{0u}\lambda_0 + e_0 \text{ if } \theta = 0$$

Equation (9) and (10) are defined to be endogenous switching regime model and when $\sigma_{1u} = \sigma_{0u} = 0$ these equations are defined to be exogenous switching regime model. Where the term $\sigma\lambda$ is the truncated mean and λ is defined as follows (Fuglie and Bosch, 1995 cited in M. Kassie and Holden, 2005):

$$9a) \lambda_1 = \frac{\phi(\gamma'Z)}{\Phi(\gamma'Z)} \quad (\text{for positive observations } (\theta = 1))$$

$$10a) \lambda_0 = -\frac{\phi(\gamma'Z)}{1 - \Phi(\gamma'Z)} \quad (\text{for the zero observations } (\theta = 0))$$

Where ϕ and Φ are, respectively, the pdf and cdf of the standard normal distribution. Since λ_1 and λ_0 are generated regressors, the residuals ε_1 and ε_0 in (9) and (10) cannot be used to determine the variance-covariance matrix of the two-stage estimates. Standard errors in the

second stage are corrected by bootstrapping both equations (switching as well as yield equations) simultaneously. The standard errors of (9) and (10) also corrected for clustering effect to produce heteroscedasticity-robust standard errors.

The mean yield difference between adoption and non-adoption of soil conservation can then be estimated as:

$$11) E(Y_1|\theta = 1) - E(Y_0|\theta = 0) = X(\beta_1 - \beta_0) + \sigma_{1u}\lambda_1 - \sigma_{0u}\lambda_0.$$

Examples of studies using this method include Fugile and Boch, 1995; and Khanna, 2001 cited in M. Kassie and Holden, 2005

3.3.2. Specific Variable description

Empirical studies identify numerous variables as being important to a household's decision to use a new technology (like soil and water conservation) and affect the crop productivity. The underlying characteristic of these variables is that, they hypothesized to affect the demand for the adoption of SWC and its impact on crop productivity. Overall, the factors that affect a household's decision to adopt ranges from household socio economic level variables, up to physical and geographical-level variables. Let us look at the specific variables description one by one.

The **gender** of the household head may influence both the adoption of SWC and its impact on crop productivity for various reasons Tesfaye (2003). The agricultural activity needs physically fit person for the laborious work i.e. farming or construction of physical soil and water conservation (like soil bund or Fanya Juu). **Male** and **female** heads of households may have different levels of interest for the house management and physical fitness to manage the farm. As a result, gender has its own impact as a variable and taken into account of the model.

Age of the household head has found to be a significant factor affecting the adoption of SWC Tesfaye (2003). The physical fitness of a given farmer affected due to its age. This enables the household head not to participate in a laborious work of the farming activity, which leads to decrease the efficiency of the farmer, and not ready to take a risk of adoption of new technology.

Education of the household head assumed to have an important variable in determining the adoption of SWC and expected to have an impact on crop productivity. It creates the opportunity to knowledge and awareness concerning the new technology Tesfaye (2003). The household head is taken as either **illiterate (Edu1)**, **complete primary school (Edu2)** or **secondary school (Edu2)**. In this study, primary education level takes as a control variable. The household level of education is important to the timing of new technology adoption.

The **family size (FS)** of a household typically hypothesized to have an impact upon a household's decision to adopt new technologies (i.e. SWC) and has an effect on crop

productivity. Because of the physical characteristics of soil and water conservation structure construction required active labor force, and larger families would theoretically have more economically active family members available to work on the household farming activity in rural area. On the other hand, labor constraints may also affect a household's ability and willingness to adopt and use a new technology (Feder *et al.* 1985).

Asset ownership hasn't incorporated into these studies with mixed different category. **Livestock (Tlu) and land ownership** is hypothesized as a proxy for wealth and found it to be an impact variable on adoption of new technologies with an impact on the crop productivity. Livestock ownership induces the households to apply **compost** for soil fertility improvement. On the other hand, such Households with larger cultivated areas (**Asz_{hi}**) will tend to increase adoption of new technology.

Off-farm income (Offy) is typically seen as significant impact on the decision of households to use new technologies. Households with lower levels of off-farm income or poor access to credit are less likely to be able to afford newer, potentially riskier, technologies (Feder *et al.* 1985). However, since household income is likely to be endogenous to the household decision to apply SWC, incorporating these types of variables in econometric models interpreted with caution.

Access to credit (Acr) and **extension service (Aex)** taken as a variable significantly associated with the adoption of new technology and has expected impact on crop productivity. It hypothesized that, if the household head have access to extension service that leads to an easy information flow and dissemination of the new technology at the grass root level Tesfaye (2003). And the cash credit access assumed to alleviate the major financial constraint of the households and has an indicative to participate on income generating activity of the family. These also increase the household purchasing power to increase the supply of farm inputs for agricultural productivity.

Location of the household farm and its surrounding **environment** will have a significant impact on the use of new technologies such as SWC. **Soil type and quality**, levels of rainfall and other weather and natural phenomena affect crop yields and therefore the profitability of new technology (Feder *et al.* 1985). Farmers' perceptions about the plot attribute matter for their decision regarding adoption of the technology. The researcher expect the following dummy

variables as **slope** (steep $Stp1_{hi}$, moderate $Stp2_{hi}$ and flat $Stp3_{hi}$), soil fertility (fertile $LQ1_{hi}$, medium $LQ2_{hi}$ and low $LQ3_{hi}$) and extent of soil erosion perception (high $Eros1$, medium $Eros2$ and low $Eros3$) to affect both the decision to adopt of SWC and crop productivity.

A farmer has acquired the land either from government by allocation, purchased or inherited and holding for longer time, expected to increase **tenure** security. Land acquisition in number of years matter the number of years the household is cultivated intensively to affect its crop productivity. Tenure security expected to increase the farmer belongingness to protect the scarce land resource from any kind of degradation for sustainable agricultural production at some extent.

Food security (Fod) level of the household also matter the decision to adoption and taken as one variable in the research study. Supply constraints, in the form of poor timing of delivery, may hinder such decisions to use new technologies (Feder *et al.* 1985). The level of food security is measured based on the household's response in number of quarters per year a given household's being food secured.

The relative **level of infrastructure** (access to market town, to all weather road and seasonal road) is typically hypothesized to affect the use of new technologies. It is expected that homestead far away from the town market (Dst_{hi}) need a longer time to cover the round trip per day. The longer time that takes to cover the round trip induces the farmers to concentrate on his farming activity rather than increasing the frequency of town market visit.

Factors that can influence agricultural productivity levels typically grouped as natural capital. This natural capital can be taken as an input to agricultural production, alongside with the conventional inputs such as labor (La), Seed (Sd), fertilizer (Frz) and financial capital. In the context of the agricultural production, the elements of natural capital includes soil quality (slope, texture, composition), climate (amount and timing of rainfall, wind) water resources (availability, quality) and land cover amount (PsZ) and type of vegetation. (El Serafy, 1990).

3.4. Empirical estimation

3.4.1. Model specification for yield equation

As discussed in the previous sections, we try to hypothesize the impact of soil conservation effect on the crop productivity. The researcher tried to estimate the determinant factors of soil water conservation from the observed variables in the study area.

The analysis examines the proximate (direct) determinants of production, which includes household choices about crop choice, labour use, land management, soil conservation practice and other decisions, together with the underlying (indirect) determinants of this choice. The model specification is;

Value of crop production (Y_{hi})

For agricultural production, we focus on the value of crop production per meter square for crop field. Crop production is by far the most important sources of agricultural income in SNNP region in particular of Wolayita Zone Damot Gali Woreda

According to Pender J. (2005), the value of crop production by household h on plot i (i.e. Y_{hi}) is assumed to be determined by:

1. the vector of area planted to different types of crops (C_{hi})
2. the amount of labor used (L_{hi})
3. the annual study period land management practices are used (LM_{hi}) (use of manure, fertilizer, compost, etc)
4. the stock of prior conservation practice on the plot (θ_i) like presence of a structure
5. the natural capital of the plot (NC_{hi}) includes position on slope, soil fertility, other biophysical characteristics
6. the tenure characteristics of the plot (T_{hi}) (how plot acquired and tenure security)
7. The household's endowments of physical capital (PC_h) (land, livestock, equipment) human capital (HC_h) (education, age and gender) social capital (SC_h) (indicated by credit and extension participation in program and organizations)

8. village level factors that determine local comparative advantages (X_v) agro ecological conditions, access to markets and infrastructure, and population density
9. random factors (e_{yhi})

In functional form

$$Y_{hi} = f(C_{hi}, L_{hi}, LM_{hi}, \theta_{hi}, NC_{hi}, T_{hi}, PC_h, HC_h, SC_h, X_v, e_{yhi}) \dots \dots \dots (12)$$

In general, the total value of crop production which is taken as the natural log (ln) value of crop production per meter square of each plot $\ln(Y_{hi})$ is depend on some factors. These includes the choice of crops and farm level prices of these crops, the inputs and land management practices used in producing them, θ'_{hi} (SWC ratio), and the natural condition of the plot

$$\ln Y_{hi} = \alpha_h + \beta_1 C_{hi} + \beta_2 L_{hi} + \beta_3 LM_{hi} + \beta_4 \theta'_{ih} \text{ ratio} + \beta_5 NC_{hi} + \beta_6 T_{hi} + \beta_7 PC_h + \beta_8 HC + \beta_9 SC_h + \beta_{10} X_v + e_{yhi} \dots \dots \dots (13)$$

Equation (13) helps us to evaluate the impact of soil and water conservation on the value of crop productivity using pooled data, which include SWC as one variable. One can note that, in equation (13) the ratio of θ'_{ih} , is the proportion of SWC to area of the plot

$$\ln Y_{hi} = \alpha_h + \beta_1 C_{hi} + \beta_2 L_{hi} + \beta_3 LM_{hi} + \beta_5 NC_{hi} + \beta_6 T_{hi} + \beta_7 PC_h + \beta_8 HC + \beta_9 SC_h + \beta_{10} X_v + e_{yhi} \dots \dots \dots \text{for } \theta_{ih} = 1 \dots \dots \dots (14)$$

$$\ln Y_{hi} = \alpha_h + \beta_1 C_{hi} + \beta_2 L_{hi} + \beta_3 LM_{hi} + \beta_5 NC_{hi} + \beta_6 T_{hi} + \beta_7 PC_h + \beta_8 HC + \beta_9 SC_h + \beta_{10} X_v + e_{yhi} \dots \dots \dots \text{for } \theta_{ih} = 0 \dots \dots \dots (15)$$

Equation (14) and (15) are separated based on the chow test result for an ease analysis of SWC impact on crop productivity. To avoid parametric biases in the yield equation analysis, SWC variable omitted from both equations (14), (15), and run OLS regression to indicate the parameters difference in the coefficient.

3.4.2. Variable description for adoption

Based on Greene (1997) consider adoption of soil and water conservation model, which is a binary dependant variable either the respondent adopt SWC ($\theta = 1$) or does not ($\theta = 0$) in the period in which this survey is taken. Here a set of explanatory factors like demographic and biophysical characteristics of the plot are gathered in a vector X explaining the decision, so that

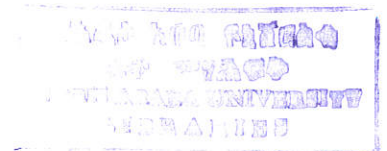
$$\text{Prob}(\theta = 1) = F(\beta'x).$$

$$\text{Prob}(\theta = 0) = 1 - F(\beta'x).$$

Where, the set of parameters β' reflects the impact of changes in X on the probability.

Then the normal distribution has been used to the analysis, giving rise to the probit model is;

$$\begin{aligned} \text{prob}(\theta = 1) &= \int_{-\infty}^{\beta'x} \Phi(t) dt. \\ &= \Phi(\beta'x). \end{aligned}$$



The set of variables hypothesized to determine the soil conservation decision of the household identified as follows.

A. Determinants of soil conservation

Tesfaye (2003) identified different determinants of soil conservation as, the household characteristics, physical properties of the land, and external institutional factors, household characteristics such as age, education, and family size are important factors for the farmer's decision to undertake conservation practices

So that, the determinant factors for soil and water conservation model stated as:

$$\theta_{hi} = f(\text{Sex}, \text{Age}, \text{Edu1}_h, \text{Edu3}_h, \text{FS}_h, \text{Aex}_h, \text{Acr}_h, \text{Offy}_h, \text{Dst}_{hi}, \text{Stp1}_h, \text{Stp2}_h, \text{LQ1}_{hi}, \text{LQ2}_{hi}, \text{Eros1}, \text{Eros3}, \text{Asz}_h, \text{Tlu}, \text{fod}_h, \text{Pdn}) \dots \text{Adoption Equations}$$

Where:

θ_{hi} is soil conservation practice of household i on plot p specified as:

$\theta_{hi} = 1$ if the household h practices soil conservation on plot i ; otherwise 0

the independent variables included in the SWC model, expected signs and justification/assumption are stated as follows

Variable	symbol	Expected Sign	Justification/assumption
Sex	sex	+	Male headed households are more likely to adopt new innovations than female headed households on top of the physical work required to the structure construction; so that, Sex = 1 if HH* head is male, Otherwise= 0. (dummy variable)
Age	Age	-	As farmers become Older, the probability of household undertaking conservation decreases.
Education (dummy variable)	Edu1	-	Educated farmers are best farmers and get the information regarding the benefits & techniques of soil conservation construction. Therefore, illiterate households are less likely to undertake conservation measures than otherwise. Edu1 = 1 if HH head is illiterate; = 0 otherwise
Education	Edu3	+	Edu3 = 1 if HH head is secondary level educate; = 0 otherwise
Family size of the household	FS	+	Family size is classified as dependant age (i.e. < 14 and >65) and independent age (b/n 14- 65) of family member. It is expected that, an increase in family size increases the household's probability of conservation
Access to Extension services (dummy variable)	Aex	+	Extension services increase the access to information of conservation practice Aex = 1 if HH head has access to extension service; = 0 otherwise
Credit access (dummy variable)	Acr	+	Access to cash credit expected to increase the probability of undertaking conservation. Acr = 1 if the household has taken credit before, = 0 otherwise.
off-farm income (dummy variable)	Offy	+	The member of a household engagement in off-farm employment increases financial resource of the household, in which increases the family monthly income and expected to increase the probability of conservation practice (SWC). So that, Offy = 1 if household involved in off-farm employment, = 0 otherwise.
Distance of homestead from town market in Km	Dst _{hi}	+	It expected that homestead far away from the town market is more likely to conserve than nearer ones. This is because the market accessibility for any high value crop production
Slope of plot i (dummy variable)	Stp1 _{hi}	+	It is expected that that steeply sloped plots are more likely to have some kind of conservation structure. Stp1_{hi} = 1 if the plot is Steeply sloped, = 0 otherwise
Slope of plot i (dummy variable)	Stp2 _{hi}	+	Stp2_{hi} = 1 if the plot is moderate Slop, = 0 otherwise

Variable	symbol	Expected Sign	Justification/ assumption
land quality of plot i (dummy variable)	LQ1 _{hi}	-	Fertile land (i.e a land with good quality) is expected to decrease the probability of conservation measure on the plot. Good quality of land indicate the soil fertility & depth of the soil LQ1 _{hi} = 1 if soil is fertile = 0 otherwise.
land quality of plot i (dummy variable)	LQ2 _{hi}	-	LQ2 _{hi} = 1 if soil is medium fertile = 0 otherwise.
Erosion perception (dummy variable)	Eros1	+	High erosion expectation increases the probability of conservation measure on the plot. Eros1 _{hi} = 1 if high erosion = 0 otherwise.
Erosion perception	Eros3	+	Eros3 _{hi} = 1 if low erosion = 0 otherwise.
Area of Land holding	Asz _h	+	As the household area of land holding increases the probability of conservation measure on the plot increases.
Livestock owned by the household in TLU	Tlu	+	It is hypothesized that an increase in the livestock assets owned by the household increases the probability of conservation
Food security of the HH	fod	+	Food secured household is expected to increases the probability of conservation
Per Capita land Holding	Pdn	+	It expected that a densely populated household is more likely to conserve than less densely populated ones. This is because the availability of labor forces and a priority given to sustain agricultural production.

* HHS refers to household.

TLU refers to Tropical livestock unit

Since the analysis was done at the plot level, for those variables that are defined at the household level, the same value is attached to all plots once the household behavior is identified.

CHAPTER FOUR RESULTS AND DISCUSSIONS

4. DESCRIPTIVE ANALYSIS

4.1. General characteristics of households

The researcher has been able to interview 151 people who operate on 331 crop field and base in Damot Gale, which is found in Southern Nation and Nationality People (SNNP) region of Ethiopia. According to the study result, the majority are soil and water conservation adopters (SWC) (58 %) followed by non-adopters (41.9%).

The following table 4.1 summarizes the proportion of main variables from the given sample size. As a case in point, the proportion of male-headed¹ household's respondents is 66.3%, which is relatively larger than the ones headed by females (31.72%). The average household size is 6.6 persons ranging from 2 to 14 household members.

Table 4.1 summary for descriptive analysis

	Result
observation	331
Soil and water conservation θ_{hi}	
➤ adopter	58.01%
➤ non adopter	41.99%
Mean age of head (years)	42.3
Mean family size per HHS* (FS)	6.6
Gender of the HHS head	
➤ Male HH	66.28%
➤ Female HH	31.72%
Gender of the HHS head out of adopters	
➤ Male HH	84.89%
➤ Female HH	15.10%
Education level of HH head (Edu1)	
➤ Illiterate	61.59%
➤ Otherwise	38.41%
Education level of HH head (Edu3)	
➤ secondary level	8.76%
➤ Otherwise	91.24%

¹ A head of a household is a person (male or female) who economically supports or manages the household or for reasons of age or respect, considered as head by the household or declares himself as such or by member of the household.

* HHS refers to household.

	Result
Average livestock ownership (In TLU)	1.87
Mean total land area (in hectares)	0.62
Mean plot holding per HHs in number	3
Access to credit (Acr)	42.60%
Access to Extension (Aex)	58.91%
Off-farm employment participation (Offy)	71.30%
Average time taking to the plot from home (in minutes for round trip)	2
Distance of the home from town market Dst_{hi} (in Km)	6.8
Average time taking to the town market from home (in hour for round trip)	2.67
Slope (Stp1_{hi})	
➤ Steep	49.24%
➤ Otherwise	50.76%
Slope (Stp2_{hi})	
➤ moderate	34.44%
➤ Otherwise	65.56%
Land Quality (LQ1_{hi})	
➤ fertile	14.20%
➤ Otherwise	85.80%
Land Quality (LQ2_{hi})	
➤ medium fertile	58.61%
➤ Otherwise	41.39%
Erosion perception (Eros1)	
➤ high erosion	25.38%
➤ Otherwise	74.62%
Erosion perception (Eros3)	
➤ low erosion	62.24%
➤ Otherwise	37.76%
Per Capita land Holding in hectare	0.1
Average fertilizer usage per Sq. meter in Kg	0.00569
Average seed usage per Sq. meter in Kg	0.00844
Average labor used for farming activity per Sq. meter in man day	0.01050
Average Value of output gained in birr	3800.78

Source; own survey and computation

4.2. Major factors of soil conservation

4.2.1. Factors of soil conservation

As table 4.2 (below) shows, both adopters and non-adopters of SWC have a subtle mean age differences. However, the average family size of households who undertake conservation (7.03) is greater than non-adopters (6.22). Among these, economically active household members show a significant difference from adopters of SWC (2.3) to non-adopters (1.97). It thus indicates that family size and economically active household (HH) members have a significant and positive effect on the household conservation decision due to the laborious work of the SWC physical structure construction.

Table 4.2 Soil conservation and household characteristics

	adopt conservation	non adopt conservation
Percentage of households	58%	41.99%
Mean age of the household head (years)	41.72	43.01
Sex of household head		
➤ Male HH	84.9%	45.32%
➤ Female HH	15.1%	54.68%
Mean family size per household	7.03	6.22
Mean economically active household member	2.3	1.97
Education level of HH head (Edu1)		
➤ Illiterate	48.96%	74.10%
➤ Otherwise	51.04%	25.90%
Education level of HH head (Edu3)		
➤ secondary level	14.06%	1.44%
➤ Otherwise	85.94%	98.56%
Average cattle ownership (in TLU)	2.254	1.356
Mean land holding (in hectares)	0.626	0.615
Average output per crop field(in KG)		
➤ Maize	440.41	330.07
➤ Teff	81.05	80.29
➤ Haricot Bean	78.01	58.03

	adopt conservation	non adopt conservation
Average area for crop field in meter sq.		
➤ Maize	2520.61	2419.17
➤ Teff	836.51	897.51
➤ Haricot Bean	475.82	440.63
Slope (Stp1 _{hi})		
➤ Steep	61.98%	31.65%
➤ Otherwise	38.02%	68.35%
Slope (Stp2 _{hi})		
➤ moderate	32.81%	36.69%
➤ Otherwise	67.19%	63.31%
Land Quality (LQ1 _{hi})		
➤ fertile	5.73%	25.90%
➤ Otherwise	94.27%	74.10%
Land Quality (LQ2 _{hi})		
➤ medium fertile	57.29%	60.43%
➤ Otherwise	42.71%	39.57%
Erosion perception (Eros1)		
➤ high erosion	28.13%	21.58%
➤ Otherwise	71.88%	78.42%
Erosion perception (Eros3)		
➤ low erosion	65.10%	58.27%
➤ Otherwise	34.90%	41.73%
Average distance of plot from home (in minutes)	2	2
Distance of the home from town market(in Km)	7.012	6.515
HHS access to Extension service		
➤ Have access to Ext Service	63.02%	53.24%
➤ Otherwise	36.98%	46.76%
HHS access to credit		
➤ Have access to credit	48.44%	34.53%
➤ Otherwise	51.56%	65.47%
Off-farm employment participation		
➤ participate	69.79%	73.38%
➤ Otherwise	30.21%	26.62%
Per Capita land Holding in hectare	0.0975	0.1078
Average fertilizer usage per Sq. meter in Kg	0.006021	0.005251
Average seed usage per Sq. meter in Kg	0.009323	0.007234
Average labor used for farming activity per Sq. meter in man day	0.010721	0.010344

Source; own survey and computation

As the above table stated that, variables affected adoption of SWC is listed as a summary. The subsequent discussion makes a base on the above table variables with justification for the variance.

Considering sex of the household head, the majorities are male adopters (84.9%) while female-headed households take (15.1%). Among the adopters of SWC, 51.04% are literate while 48.9% are illiterate.

Regarding to land holding size, adopters hold 0.626 hectares while non-adopters hold 0.615 hectares in the study area. The study indicates that majority of soil and water conservation adopters have benefited from increasing the soil management strategy that has enabled them to reduce soil run off. Due to the limited availability of land, one can neither increase acreage of farmland nor apply a fallow system, as they are unviable in the study area. Thus, due to the prevalence of agricultural intensification in the area, households prefer to conserve their land for sustainable agricultural development.

Both Adopter and non- adopters respondents produce maize, Teff and Haricot Bean. As table 4.2 shows, the mean crop output of the mentioned cereals of adopters is, however, greater than non-adopter output.

Those households with good and medium quality of land (fertile) have less tendency of practicing conservation than those of with poor quality land. This is explained by only 5.7% of fertile crop field being conserved while 25.9% of fertile land is not conserved. Similarly, conservation on steep and medium-sloped crop field is higher than flat-sloped ones. This shows by 61.98% of steep and 32.8% moderate sloped crop fields, which conserved, while the remaining is flat slope crop field. Furthermore, steep and moderate sloped crop field accounts 31.65% and 36.69% are none conserved respectively while the remaining land is flat-sloped crop field. Accordingly, we can conclude that physical structure of the plot such as steepness and quality of land (fertility) affects the soil conservation decision of the households.

The average distance of plots from homestead is a less than 2 minutes walk, which are not more than 20 up to 25 meter from the farm field. As section 3.2 illustrates, both SWC adopters and non-adopters live almost next to their farm plot.

Needless to say that the average distance of the town market from the respondents' homestead has a considerable influence on the conservation decisions of the household. The study has identified that the average market distance is 7.01 and 6.51 km from adopters and non-adopters' residents respectively. Thus, the respondents have to cover long distance to get the market. The adoption rate increased when the distance of town market increases due to the time that takes to cover the round trip (2 hours in average). Farmers are, therefore, discouraged to increase frequency of visiting the town market and forced to spend most of his time on farm field.

Regarding about access to extension service and credit to the adopted decision of soil conservation practice; Majorities are those adopters who have access to extension service (63%) followed by 36.9% for those not have access to extension adopters. Whereas, those non-adopters respondents having access and not having access to extension service account 53.4% and 46.7% respectively. On the other hand, Cash credit access and non-access accounts 48.4% and 51.5% for those HH adopt SWC respectively. This is due to the increase of financial capacity and access to new information through the development agents. However, among those households with access to credit, 34.5% do not conserve their soil.

Considering about off-farm employment, those SWC adopters participate in off-farm employment account 69.7%. But within non adopter's respondents majorities are participate or have off farm income (73.4%) followed by non participant households (26.62%). Thus, the study has identified that those farmers engaged in off-farm employment have more advantage to ameliorate the household's financial constrain than non-participants of off-farm income. The study has also identified that the food/cash for work program (safety net) in natural resource conservation at the woreda level is one sources of off-farm employment generation in the study area.



4.2.2. Extent of soil conservation

The structure of soil & water conservation types divided into two. It is the physical structure and vegetalized conservation structure. Firstly, physical structure as defined as the introduction of a new construction of the structure on the farm plot such as soil bund, Terries (Fanya juu ¹), which is done based on the technical specification. Fanya juu is a soil bund type in which a ditch is dug along the contour, with soil being thrown up to form a ridge above it; a natural bench terrace will then form over the course of the following few years. Secondly, Vegetalized structure which made by planting Vetiver grass, pigeon pea and Suspanya on the edge of physical structure.

The major drawback with physical conservations is their opportunity costs and impacts on traditional farming practices. They reduce the available area for planting. The average cultivated area loss due to structures is about 5.6% (0.0082 ha on average) of the plot area. The maximum area loss is about 9.4% of conserved plot size. From a farmer's perspective, an important question is whether crop yield on remaining area can eventually compensate for area occupied by structures. Although mechanical (physical) conservations do not directly increase crop yields, there is important benefit associated with conservations besides arresting the soil loss due to erosion, like production of natural fodder grass and means of food supply. During the insufficiency and drought season when grazing is in short supply, Vetiver huge grass from conservation structures (drought resistant grass) is a source of fed to the animals. Even if there are no markets for the grass or hay, people used the grass for hut (roof) cover in the study area. Beside to this the benefit associated with a means of food supply farmers harvest a pigeon pea for food consumption at household level. Accordingly, we can conclude that from Vegetalized physical structure of the plot farmer's benefit is expressed as a protection of the soil from runoff due to erosion, source of hut construction material, production of natural fodder grass and means of food supply to the household.

¹ *Fanya Juu* is a type of terrace adopted from Kenya. In Swahili, *fanya* means 'throw' while *juu* means 'up'. It thus means 'throwing up the slope' as opposed to 'throwing down the slope' in the conventional soil bund construction. As table 4.3 shows, the majorities (58%) adopt SWC while non-adopters account (41.9%).

Table 4.3 Soil conservation practice for adopters

	Result in (%)
SWC adopters household from the sample	58%
Type of Conservation	
Vegetalized Soil bunds	12.3%
Vegetalized Fanya juu	70.4%
Others	17.3%
First Conservation awareness created by	
Government institution	66.3%
Non Governmental organization	32.5%
Others (neighbor)	1.2%
Time started SWC in years E.C	
before 1979	9.9%
1980-1989	59.1%
1990-1995	21%
after 1996	10%
SWC non adopters household	
	41.9%
Reason for not to conserve	
No erosion problem	31%
Shortage of labor	38%
Lack of knowledge	9.9%
Others (harbor rats problem)	21.1%

Source; own survey and computation

Apart from the above types of conservation, the indigenous conservation type is very popular in the study area. Using manure and covering the land with permanent trees as indigenous conservation type are pervasive practices in most S.N.N.P. region. However, the introduced soil and water conservation structure practiced in the study area since 1970 through WADU program though its adaptation rate is drastically low owing to the termination of WADU program in the area.

The region has changed the previous program (WADU) to LLPPA (Local Level Participatory Planning Approach) in order to conserve the region's natural resources from being affected by human and natural causes. Then, the rate of adoption has been increased tremendously since LLPPA program was on effect. Introduced soil bund and Fanya juu are also incorporated by LLPPA program and deemed as the most popular practices in the study area. However, Vegetalized Fanya juu has proved itself as the most effectual conservation type followed by Vegetalized soil bund in the study area.

Vegetalized Fanya juu has the highest percent of adoption (70.4%) of the adopters, followed by vegetalized soil bund and a mixed structure types, which accounts of 12.3% and 17.3% respectively. In addition, this study also tried to analyze the reason of increasing adoption rate within the new LLPPA program. As mentioned in the earlier section, the physical structure of conservation reduces the available area for planting and imposes output to decline. The multiple benefits from SWC compensate the output loss due to the structure. The study finds out the number of benefits from adoption of SWC. The first benefit is conserving the scarce farmland by protecting soil run off due to erosion. Secondly, farmers get additional benefit of fodder (Vetiver grass & Suspanya) and food (Pigeon Pie). In other words, the structure helps the farmers to increase their food security besides conserving the natural resource. From the prospect of this research objective, the study did not measure the amount of food supply and fodder benefited from soil conservation structure.

Considering the awareness created to adopt SWC, majority of the respondent households adopt the practice when they are first convinced by government institutions (66.3%) followed by Non-governmental organizations (32.5%) working in the area. The remaining adopters persuaded by the information of their neighborhood or relatives.

Majority of adopter respondents (59.1%) was started conservation between the periods of 1980-89 E.c (1988-97 G.c.). And followed by 21% of adopters begin between the period of 1990-95E.c. (1998-2003 G.c). Then, the effectiveness of any SWC application needs more periods to show a significant impact on the crop productivity.

From non-adopter HHs, they give the following reason of; no erosion problem (31%), Shortage of labor (38%) and lack of Knowledge (9.9%) are the mentioned ones. It is also explained that, majority of flat sloped plots does not have any structure type in the crop field. However, from those non-adopter respondents, female-headed HHs takes the major share of the respondents. These indicate the shortage of economically active family members to cover the laborious work of conservation structure investment beside with the burden of home management, which lies on females. Such problems discourage female-headed HHs to adopt SWC even if the respondent has the knowledge regarding the benefit of any conservation structure.

In conclusions, the rate of adoption increased tremendously since LLPPA program was on effect by the regional government due to fine-tuned application of soil conservation measure on the local conditions of the study area. However, Vegetalized Fanya juu has proved itself as the most effectual conservation type followed by Vegetalized soil bund in the study area. On the other hand, the researcher observed that the efforts to reduce natural resource degradation, which heavily relied on food/cash for work critically challenged to have induced “dependency syndrome”.

4.3. Econometric tests

The previous section has dealt with the descriptive analysis of the respondents' household demographic characteristics and biophysical feature of the plot. However, in this section the factors that influence adoption of SWC practice was analyzed by the binary probit model, where as the impact of SWC analysis on crop productivity was done by OLS (Ordinary Least Square). Having assessed the major economic test thoroughly, the study has also portrayed the result of soil conservation adoption. The impact SWC on crop productivity presented at the end of the section.

To precede econometrical analysis and estimation, we begin by undertaken different econometric tests that are carried out to explore the properties of the data. In this manner, a relentless effort was exerted to test whether the data encounters major econometric problems such as heteroskedasticity and structural stability within the model. In order to control the heteroskedasticity problem in the model, which is a common problem in cross-section data, the Stata command robust is used during estimation to minimize the problem. To carry out the regression for computation of mean difference between adopter and non-adopter, the researcher split the sample into SWC adopter and non-adopter and analyzed the crop productivity equation for each sub samples based on the chow test, which used to test the structural stability in the yield equation.

The computed F from chow test at (25,305) shows a result of 1.4163 that exceeds the critical F value (30, ∞), which is equal to 1.34 at the chosen level of 10% . The result implies to reject the null hypothesis of structural stability in the pooled sample of yield equation. The alternative hypothesis thus enables us to run a separate regression for the sub sample of SWC adopters and non-adopters of the yield equation.

4.4. Estimation result and interpretation

4.4.1. Soil and water conservation adoption model

A probit econometric analysis came into effect in order to identify and determine the factors of soil and water conservation adoption. The estimate of adoption model also helped us to identify the determinant factors that influence the household's probability of practicing soil conservation in the study area.

Based on the previous discussion in the literature and methodology part, table 4.4 shows the binary probit estimated results. According the Wald chi-squared statistic and the Log Likelihood Ratio, which endorse the probit model accuracy of the estimation, the overall probit model turned out to be a good fit. The following table (4.4) illustrates the details of the probit results as follows:

Table 4.4 Binary Probit model result

Variables	Dummy Soil and water conservation	
	Parameter estimate	Marginal effect
Sex [♦] (1= male, 0 otherwise)	1.804 ^{***} (0.323)	0.6327 ^{***} (0.0863)
Age	-0.037 ^{**} (0.0166)	-0.0142 ^{**} (0.0062)
Education Edu3 [♦] (1= secondary level; else 0)	1.497 ^{***} (0.5283)	0.3684 ^{***} (0.0642)
FS Family size of the household.	0.2426 ^{***} (0.0897)	0.0908 ^{***} (0.0337)
Acr [♦] (1= has Credit access 0= otherwise)	0.6529 ^{***} (0.2350)	0.2364 ^{***} (0.0798)
Assets of livestock (in TLU)	0.4486 ^{***} (0.1023)	0.1679 ^{***} (0.0373)
Slope [♦] Stp1 _{hi} (1=Steeply slop, 0=otherwise)	1.869 ^{***} (0.3329)	0.6179 ^{***} (0.0846)
Slope [♦] Stp2 _{hi} (1= moderate slop, =otherwise)	2.2008 ^{***} (0.4383)	0.6235 ^{***} (0.0784)

Variables	Parameter estimate	Marginal effect
Land Quality [♦] LQ1 _{hi} (1=fertile, 0= otherwise)	-2.5242 ^{***} (0.4525)	-0.7274 ^{***} (0.0543)
Land Quality [♦] LQ2 _{hi} (1=medium fertile,0= otherwise)	-0.9341 ^{***} (0.2908)	-0.3290 ^{***} (0.0951)
Distance from town market (Km)	0.7298 ^{***} (0.1205)	0.2732 ^{***} (0.0443)
Constant	-7.5146 ^{***} (1.2248)	

Dependent variable:- soil and water conservation $\theta_{hi} = 1$ if the household conserves the plot; else =0

***, **, and * indicate Significance level at 1%, 5%, and 10% level, respectively.

([♦]) dy/dx is for discrete change of dummy variable from 0 to 1.

() Figures in parenthesis are robust standard errors.

Test summary

- Number of observations: 331
- Log Pseudo likelihood function: -99.493202
- Wald chi2 (19) = 139.98
- Prob >Chi-squared = 0.0000
- Pseudo R2 = 0.5581

The coefficient signs of each household-level variable live up to the researcher's expectation, except access to extension service. Basic household characters such as sex, age, and education of the household head also play a significant role on SWC adoption decision in the study area.

Male-headed households found to be more likely to undertake conservation than female-headed ones, at 1% level of significance. Controlling for other variables, male-headed households' probability of undertaking conservation increases by 63.27% at the margin. The study has found out that the lack of information about the technology alongside with the lack of skill to use it, which required active labor force with physical fitness, are some of the factors that prevent most female headed HHs from the adoption. This finding is consistent with the descriptive result (table 4.2), which shows that the number of non-adopted female headed households is more than their male counterparts.

The age of the head found to have a significant and negative influence on the conservation decision of households. As the age of the HH head increases, the probability of undertaking conservation decreases by 1.4% at the margin, controlling for other variables. A year incremental in the age of the household head, the respondent's physical fitness will bring a negative impact on active participation of farming activity. Hence, younger HH heads' are better off in adopting SWC than older ones.

Regarding family size, the average household size is 6.6 persons per house. It hypothesized that larger family sizes increase the households' probability of undertaking conservation. An increase in the family size encourages the probability of adoption by 9% holding other variable constant. As a reason, the household head give priority to sustain food security when the family size increases. And through planning of agricultural production, the household head applies a conservation structure on his scarce resource of land and attain a sustainable agricultural production using his family labor force. These leads to increase the rate of SWC adoption unless and otherwise labor constraint create its own problem.

Educational level of the household head necessitates obtaining access to information for new technologies and being bold enough to take risk. The study has identified that the probability of SWC adoption increased by 36.8% controlling other variables when the secondary level of education is increased. The result, therefore, indicates that a positive sign for the coefficient of secondary level of education rises at 1% level of significance. However, it is insignificant for illiterate dummy variable of a given household. Despite the fact that the lower level of literacy rate of the household head fails to show a significant level to adoption, it is widely believed that education is important for the timing of adoption. And those educated respondents were able to adopt at faster rate than illiterate ones. Those respondents with out schooling already have been able to adopt it by copying the educated ones. Therefore, increasing the level of education will be able to raise the awareness and the knowledge of the household head to adopt new technologies and conservation practices.

The household assets, like livestock ownership, have undoubtedly played a great role to decide on adoption of SWC. Tlu measures the livestock ownership of a household; it has a positive impact on Soil and Water Conservation decisions at 1% level of significance, of which result is

consistent with the descriptive analysis. According to the descriptive analysis, as shown in table 4.2, SWC adopter households have greater numbers of livestock than the non-adopter's ones.

The study also shows that steeply and moderate sloped plots are more likely to conserve than flat plots at high level of significance. It is due to the exposure to soil erosion. At the margin, the probability of SWC adoption for steep sloped plot increased by 61.7 % followed by moderate-sloped plot 62.3 % *ceteris paribus*. On the other hand, good quality (fertile) crop fields are less likely to conserve than less quality plots. Thus, at the margin, plots with high and medium soil fertility are less likely to conserve than poor fertile plots with 72.7% and 32.9% controlling for other variables respectively.

Due to the scarcity of farmland in the research study area, almost all the household respondents own their land next to their homestead, which is based on with in 20 to 25 meters from their compound. This, however, does not have a significant difference between the sub sample of adopter and non-adopter households. Nevertheless, the distance that lies between the respondents' homestead and the town market has a positive and significant effect at 1% level of significances. As the town market's distance becomes afar from the respondents' homestead, the probability of SWC adoption increased by 27.3% at the margin, holding other variables constant. The longer time that takes (on average 2 and half hour) to cover the round trip induces the farmers to concentrate on his farming activity rather than increasing the frequency of town market visit.

An access to cash credit found to have a significant and positive effect on soil conservation decision in the household. This is due to the financial resources that enable the respondents to purchase materials needed for conservation structure and agricultural inputs. Thus, the study reveals that access to credit increases adoption probability by 23.6% at the margin. Assuming that access to credit is as endogenous variable and excludes it from the adoption model variables, it only brings a subtle effect on the other coefficient variables without a change on the level of significance. (See Appendix 3)

Interestingly, access to extension service and off farm employment participation found to have an insignificant effect on soil conservation decision on a given household. It hypothesized that,

access to extension services increase the respondent's access to information of conservation practice in the study area. It also believed that, those development agents (DAs) disseminate and peruse the new technology to the farmers due to their easy access to reach at grass root level. Nevertheless, the following reasons assumed to contribute for the insignificant effect of access to extension service in adoption model. Unfortunately, those DA workers are giving more emphasis to cereals production than natural resource conservation. Hence, there are no specific DA workers assigned for any conservation structure adviser. In addition farmer to DAs ratio is low (1:294) according to 2004/2005 woreda office of agriculture report cited in Zonal socio economic report 2005. These different reasons may be limiting the statistical power to discern the effect of access to extension service on adoption model. In the regression with many explanatory variables, our results should not interpret to mean that access to extension has no total impact on adoption and productivity. It is simply say that, the stated problems affected not to have a robust statistical significant result. In general, DA workers in rural agriculture have a strong capacity to disseminate a new technology in the area.

4.4.2. The impact of Soil and water conservation on crop productivity

The OLS regression results for both pooled sample and a separate of SWC adopter and non-adopter sample shown in table 4.5 and 4.6 respectively. In the survey period of 2006/07, the Model predicted around 69.5 and 52.2 percent of the variability of crop productivity as indicated by the measures of adjusted R-squared for pooled sample and the sub sample of SWC adopter and non-adopters yield equation respectively.

4.4.2.1 For Pooled Sample OLS result

Many variables hypothesized to affect the value of crop production per square meter of the plot ($\ln Y_{hi}$). According to the pooled OLS result table (4.5), the variables that significantly affect the value of crop productivity per square meter of the plot includes:

- Soil and water conservation which take a proportion(ratio) value of SWC area to plot area
- The amount of agricultural inputs applied (Seed and fertilizer) in Kg per Sq. Meter
- The total labor applied for all farming activities measured in man-days.
- Sex of the household head
- Per capita land holding (in ha) and the town market distance from homestead (in Km)

Nevertheless, the other independent variables are being insignificant in the OLS regression.

Table 4.5 OLS regression result for pooled sample

Variable	Symbol	Coefficient	Robust Std. Err.	t	P>t
Proportion of SWC area to crop field area (ratio)	SWCratio (θ'_{ih} ratio)	0.956566	0.56742	1.69	0.093
Seed used per Sq. meter (in kg)	Sd	2.392857	0.65347	3.66	000
Labor used per Sq. meter(in man day)	Lb	1.641127	0.5319	3.08	0.002
Fertilizer used per Sq. meter (in Kg)	Frz	4.25488	0.57139	7.44	000
Sex	sex	0.119316	0.067900	1.76	0.08
Per capita land holding	PCL	1.061060	0.440025	2.41	0.016
town market distance	Dst	0.038472	0.023261	1.65	0.099

Dependent variables:- natural log value of crop productivity per square meter of the plot

Summary

Number of obs = 331
 Prob > F = 0.000
 R-squared = 0.6951
 Root MSE = 0.3235

The hypothesized outcome of SWC makes the research objectives more eye-catching. The proportion of SWC area to the plot area (ratio) has a positive and statistically significant impact on the value of crop production per square meter of the plot. The results indicate that at 10% significance level, those SWC adopters over non-adopters get a positive advantage on the value of crop production per square meter of the plot. Therefore, SWC variable appears to be complementary to increase crop production in the long run beside with conserving the natural resource. Finally the study suggest that, from the dual benefit of soil conservation structure which conserve the natural resource, source of hay and food supply, expanding the adoption of the technology bases of the area specific will have a positive contribution in the sustainable agricultural development of the country.

Regarding the application of the agricultural inputs measured in Kg (seed and fertilizer) has a positive and statistical significant impact on the value of crop production per square meter of the plot. The percentage change of crop production value per square meter of the plot ($\ln Y_{hi}$) with respect to seed input and fertilizer shows more than 100% change in the OLS regression. The higher price and shortage in supply of fertilizer input constrained the farmers to apply the appropriate amount based on the specification per hectare in the study area. The study result, therefore, indicates that farmers forced to use less amount of fertilizer to their plots. In addition, fertilizer is not applied to homestead fields as it is thought that manure fields are fertile and

fertilizer doesn't produce high response on such soil. In summary, the regression results in this section suggest that increasing the application of seed and fertilizers can help to boost the value of crop production per square meter of the plot significantly.

The total application of labor for all farming activity has also a positive and statistical significant impact on the value of crop production per square meter of the plot. The changing percentage of crop production value per square meter of the plot ($\ln Y_{hi}$) with respect to labor shows more than 100% change in the OLS regression. In the other word, labor intensity plays a pivotal role to increase the crop productivity in the study area. The smaller the farm plot and the higher population density of the study area clarify the direct relationship between the crop productivity and the households' labor.

The distance from homestead to town market and per capita land holding have a positive and statistical significant impact on the value of crop production per square meter of the plot in the pooled sample OLS regression. The changing percentage of crop production value per square meter of the plot ($\ln Y_{hi}$) with respect to labor shows town market and per capita land holding shows 3.8% and 106% in the OLS regression respectively. This regression is estimated at plot level and the effect of town market and per capita land holding are calculated by controlling other factors to give the findings a strong statistical power. Due to scarcity of farm land and labor intensive agricultural practice, respondents utilize their land resources effectively with the application of soil conservation practice for sustainable agricultural production in the study area.

From the basic household characters, Sex of the household head has a positive and statistical significant impact on the value of crop production per square meter of the plot in the OLS regression. Those male headed households are more productive than female headed once. It is due to the laborious agricultural work required which create adverse impact on female headed households. The percentage change of crop production value per square meter of the plot ($\ln Y_{hi}$) with respect to sex show 11.9% in the OLS regression.

4.4.2.2 OLS result for adopters and non adopters of SWC

To precede the regression for computation of parametric difference between adopter and non-adopters of SWC coefficient, this research split the yield equation into two sub groups. And then estimates the parameter for each sub groups according to the chow test result.

To avoid parametric bias in the estimation of yield equation between SWC adopters and non adopters, the regression was done after the omission of SWC variable from both yield equation. The estimation result for both sub samples indicate that, majority of the independent variables was not significant to determine crop productivity. But from a given variables, the agricultural input used measured in Kg i.e. seed and fertilizer used for each crop field shows significance.

According to table 4.6 the yield equation has shown a significant parametric difference between SWC adopters and non adopters. It is due to the parametric effect of soil and water conservation in the analysis of yield equation.

Table 4.6 OLS regression result for SWC adopter and non-adopter

Variable	SWC adopters		P value	Non adopters of SWC		P value
	Coefficient	Robust Std. Err.		Coefficient	Robust Std. Err.	
Seed Input(in kg)	2.1008	0.67048	000	3.61062	0.74435	000
Fertilizer input(in Kg)	3.5924	0.73737	000	4.82587	0.87014	000

Dependent variables:- natural log value of crop productivity per square meter of the plot

Summary

Number of obs = 192 for adopter and 139 for non adopters of SWC
 Prob > F = 0.0000
 R-squared = 0.5220 for adopter and 0.6449 for non adopters of SWC
 Root MSE = 0.3782 for adopter and 0.2721 for non adopters of SWC

Concerning agricultural inputs, seed and fertilizer, it is found out a statistical significant coefficient difference in yield equation of adopters and non adopters of SWC. The application of agricultural inputs (seed and fertilizer) has a positive and statistically significant impact on the value of crop production per square meter of the plot in both sub samples. The percentage change of crop production value per square meter of the plot with respect to seed and fertilizer inputs for both adopters and non adopters shows more than 100% change in the OLS regression. The result, therefore, indicates that a significant coefficient difference shown between the sub samples of yield equation. This is due to the adoption of SWC in the farm plot. And it indicates that, there exists an improvement in soil fertility of the adopter's plot which increases the productivity of the farm plot.

4.4.2.3 Predicted mean Value of the yield

This section shows the predicted mean yield difference between adopters and non-adopter's respondents. The predicted mean yield difference result reinforces to show the impact of soil and water on crop productivity in the study area. The following table 4.7 shows the predicted mean value result.

Table 4.7 The predicted mean yield difference result

Group	Observation	Mean	Std. Err.
0	139	1.967517	0.129888
1	192	1.670029	0.094787
combined	331	0.369247	0.114287
difference		0.297488	0.125311

$$\text{difference} = \text{mean}(0) - \text{mean}(1) \quad t = 2.3744$$

$$H_0: \text{diff} = 0$$

$$\text{degrees of freedom} = 329$$

According to the above table, the predicted mean yield difference has a positive and statistically significant result. The result implies that, adoption of SWC has a positive impact on value of crop production per square meter of the respondent farmers plot. Finally, both the result of OLS regression and predicted mean yield difference strengthen the positive impact of soil and water conservation on crop productivity of the respondent's household. Therefore, this study would recommend the expansion of SWC adoption in the study area.

CHAPTER FIVE CONCLUSION AND POLICY IMPLICATIONS



5.1. Conclusion

Agriculture is the basis of the economy and the life of many Ethiopians. Farmers or peasants (80% of the population) in the rural area of Ethiopia drive their livelihood from the economic engagement. The existence of unfavorable production environment and related constraints has been worsening the lives of rural households by aggravating food insecurity, rural poverty and destitution.

The factors explaining poor agricultural performance in the country seem to be associated with environmental problems. The main environmental problems constitute, accelerated erosion and desertification, decline in soil organic matter content and biodiversity, and depletion in soil fertility. Part of the major environmental problems affecting Ethiopia, is land degradation in the forms of soil erosion and nutrient depletion, both of which undermine land productivity in the country especially in the research study area.

The problem of soil erosion is a result of human activities like over-cultivation, over-grazing, poor farming practices, and deforestation. All the above mentioned problems are also a problem in the research study area of Damot Gali highlands. Farmers practice as a response to population growth is also a root cause of soil degradation. Such a problem of land degradation in the form of soil erosion becomes a major cause of the decline in agricultural productivity and total production in the region.

Land conservation strategies focused mainly on the construction of technologies of physical structures depending on the land use pattern through strategies that combine community-led mass mobilization and food/cash-for-work schemes implemented in the study area of Damot Gali woreda since 1970 with the program of WADU (Wolayita Agriculture Development Unit). Currently, the rate of adoption has been increased tremendously since LLPPA (Local Level People Participatory Approach) program was on effect by the regional government due to fine-tuned application of soil conservation measure on the local conditions of the study area. Introduced soil bund and Fanya juu are also incorporated by LLPPA program and deemed as the

most popular practices in the study area. However, Vegetalized Fanya juu has proved itself as the most effectual conservation type followed by Vegetalized soil bund in the study area. Vegetalized structure is made by planting Vetiver grass, pigeon pie and Suspanya on the edge of physical structure.

A point we note that, farmers highly prefer to apply Vegetalized conservation structure in the farm plot from the prospect of a dual benefits. The application of physical conservations on a farm plot reduces the available area for planting. From a farmer's perspective, an important question is whether crop yield on remaining area can eventually compensate for area occupied by the structures. Although vegetialized physical conservations do not directly increase crop yields, but there is an important benefit associated with conservations besides arresting the soil loss due to erosion, like production of natural fodder grass and means of food supply. During the insufficiency and drought season when grazing is in short supply, Suspanya and Vetiver huge grass from conservation structures (drought resistant grass) used to fed to the animals. Even if there is no market for grass or hay, people used the grass for hut roof cover in the study area. Beside to this the benefit associated with a means of food supply farmers harvest a pigeon pea for food consumption at household level. Accordingly, we can conclude that from Vegetalized physical structure of the plot farmer's benefit is expressed as a protection of soil runoff due to erosion, source of construction material for hut, production of natural fodder grass(Suspanya and Vetiver huge grass) and means of food supply(pigeon pie) to the household.

The main objective of this research is to identify factors that determinants the adoption of Soil and Water Conservation in Southern Nation and Nationalities People Region (SNNPR) Wolayita zone of Damote Gali woreda using plot level data. In addition, the impact of soil and water conservation on crop productivity also assessed.

In light of this research, an encouraging level to adoption of conservation practices is observed. A readily explicable factor in terms of the household socio economic and biophysical characteristics of the plot is observed in the adoption of SWC decision. They have implications of the review for research and policy. The household age, sex, education level, livestock ownership, access to credit, distance from town market, slope of the land and soil fertility have a significant role to decision of a SWC structure adoption in the study area.

The finding shows that, addressing conditions that may consider the sex, education level, distance from town market and livestock ownership of the household would positively influence farmers to implement conservation on the plot when tested at 1% levels of significance. In addition, biophysical characteristics of the plot i.e. slope has also a positive impact but soil fertility has a negative and significant impact on adoption decision of SWC at significance level of 1%.

Age, as to expectation, has a role in adoption model inversely. This, understandably, could be due to most farmers' are better off in the younger stage to learn and adopt new technology.

Regarding access to extension service, this study found out that access to extension service did not have a significant impact on both adoption of SWC practice and those of crop productivity. Majority of farmers adopted SWC through LLPPA program using a safety net. And the program has one means of financial source and also helps them to conserve the natural resources. On top of this additional incentives are devised to encourage individual households to undertake conservation structure on their holdings through partial provision of extension advice and incentives related to cash/food for work to reduce food insecurity problem and labor constraint in the study area.

In general, understanding the factors that influenced the use of conservation practice is helpful for sound policy implication to increase adoption of SWC. The findings lead us to addressing the conditions in relation to household demographic factors and biophysical characteristics of the plot that would positively influence farmers to implement conservation practices on the farm plot. In addition, the need to target supporting institutions such as extension services through a due emphasis to soil management skills will create an initiative among farmers to create conducive environment for adoption.

On the other hand, factors that significantly affect the value of crop productivity per square meter of the plot include; Soil and Water Conservation, Sex of the household head, Per Capita land holding, the distance of market town from homestead, the amount of agricultural inputs applied (Seed and fertilizer measured in Kg) and the total labor applied for all farming activities measured in man-days.

The proportion of SWC area to the plot area (ratio) has a positive and statistically significant impact on the value of crop production per square meter of the plot. Therefore, Soil and Water Conservation appears to be complementary to increase crop production in the long run besides conserving the natural resource.

Regarding the application of the agricultural inputs (seed and fertilizer) has a positive and statistical significant impact on the value of crop production per square meter of the plot. While Sex of the household head, the distance of market town from homestead and Per Capita land holding have a positive and statistical significant impact on the value of crop production per square meter of the plot.

To conclude, the dual benefit of soil conservation structure, which conserves the natural resource, source of hay and food supply, expanding the adoption of the technology based on the area specific will have a positive contribution in the sustainable agricultural development of the country. In general, to alleviate the aggravated problem of natural resource degradation in the study area, the expansion of SWC adoption is highly recommended based on a suitable conservation structure type to farmer's farm plot.

5.2. Policy implications

The need to address the problem of land degradation caused by soil erosion in the study area, Damot Gali woreda, is generally known. The solution to this problem lies in reducing the negative impact of soil erosion on crop yields. The result of this study thus recommends that adoption of soil and water conservation can improve the land management practices. Meaning soil erosion impact on crop yields will be decreased. Government's policies and programs can also play important role in farmers' land management decisions by influencing the underlying factors. The policies and programs include macroeconomic and sectoral policies, agricultural research and extension policies and credit and infrastructure development programs etc., which should address the social and economic factors of the households apart from biophysical characteristics of the plot for sound policy. Due to the complex array of factors affecting land management and diverse agro-ecological and socioeconomic conditions in the highlands of SNNPR, particularly the study area, a one-size-fits-all set of policies is unlikely to work effectively across the region. According to findings from this study, some factors from adoption equation, therefore, have a significant effect in the SWC adoption decision of a household.

In order to enhance SWC adoption, the result of the study suggests as follows:

1. The result indicates that majority of soil and water conservation adopters have benefited from increasing the soil management strategy that has enabled them to reduce soil run off. Due to the limited availability of land, one can neither increase acreage of farmland nor apply a fallow system, as they are unviable in the study area. Thus, adopting soil conservation practice should be the best option as part of the agricultural intensification process and conservation of the natural resources in the area.
2. The study also finds out that secondary educational level has a positive and statistical significance probability on SWC adoption. Despite the fact that the lower level of literacy rate of the household head fails to show a significant level to adoption, it is widely believed that education is important for the timing of adoption. Therefore, increasing the level of education will raise the awareness and knowledge of the household head to adopt new technologies and conservation practices.

3. Household characteristics such as sex, age, family size determine the adoption probability of SWC significantly. This shows a room for policy implementers to take household characteristics as one component to improve the adoption rate of SWC. The factors cited as likely to affect farmers to abandon conservation practices i.e. declining household resources such as labor especially to female headed households, should be well monitored and support system designed where appropriate. The safety net program which gives due emphasis to natural resource conservation will create the off-farm employment opportunities and support labor constrained HH in the study area. The off-farm employment opportunities will also alleviate the financial constraint of households on top of the natural resource conservation.
4. The probability of SWC adoption is significantly influenced by biophysical structure of the plot. Therefore, the government policies should realize new ways of reducing soil run-off and nutrient depletion in steep sloped and less fertile land areas, with due consideration of SWC adoption. If not, such mountainous areas should be protected from agricultural practices so that they (mountainous areas) will be preserved for forest management.
5. Access to financial resources through credit found to have a significant effect on the probability of conservation adoption. Hence, creating conducive policy environment for access to credit market could help in securing agricultural tools necessary for conservation activities.
6. Field trials and demonstrations successfully create awareness on returns associated with soil conservation practice to farmers. As a result, for SWC application, the extension services are important in enhancing the adoption of any new farming practices. Adequately trained, well-supported extension services can effectively induce the adoption of soil conservation practices. It is therefore imperative that extension services need to be strengthened in order to enhance the adoption of soil conservation practice. Moreover, farmers will adopt the practices that give high returns.

7. Most of the research conducted in the land degradation case in the highlands of Ethiopia, has focused on the biophysical aspects of the problem -particularly on soil erosion - without much emphasis on economic, social, or institutional factors that affect how farmers manage their land. Similarly, the policy response to land degradation in Ethiopia has focused on the technical aspects, promoting adoption of particular conservation technology, especially the physical structures. Therefore, due attention should be give to socio economic and policy research regarding land degradation.

Finally, erosion levels in Ethiopia are alarmingly high in many areas, and measures will need to be taken to halt the degradation of soil resources from the study area. Agricultural practices that mimic the natural resources conservation practices are needed to have a sustainable agricultural development. This means that, expanding the rate of SWC adoption in the study area at sustainable base create undisturbed surface layer suitable for sustainable agriculture production which have a positive productivity effect in the study area.

REFERENCE

- Antle, J.M. (1983) Testing for stochastic structure of production: a flexible moment based approach. Journal of Business & Economic statistics 1(3):192-201.
- Barbier, E.B. 2000. The economics of environment and development. Cheltenham, UK, Edward Elgar.
- Barrett, C.B. 1996 On price risk and the inverse farm size-productivity relationship. Journal of Developmental Economics 51: 193-215
- Belay Tegene, 1996. Characteristics and Landscape Relationships of Vertisols and Vertic Wvisols of Melbe, Tigray, Ethiopia, Ethiopian. Journal of Science. Vol.19 No.1, Addis Ababa University.
- Berhanu, G. and Swinton, S. (2002) Investment in soil conservation in northern Ethiopia: the role of land tenure security and public programs.
- Bishop J. (1992), Economic analysis of soil degradation, Gatekeeper Series
- Byiringiro, F., and Reardon, T. 1996. Farm productivity in Rwanda: effects of farm size, erosion and soil conservation investments. Agricultural Economics 15:127-136.
- Carter, M.R. 1984 Identification of the inverse relationship between farm size and productivity; An empirical analysis of peasant agricultural production. Oxford Economic Paper 36(1): 131-145.
- CIMMYT (1993). The Adoption of Agricultural Technology: A Guide for Survey Design. Mexico, International Maize and Wheat Improvement Center.
- Clay, D. C., V. Kelly, E. Mpyisi and T. Reardon (2002). Input Use and Soil Conservation Investments among Farm Households in Rwanda: Patterns and Determinants. Natural Resources Management in African Agriculture. C. B. Barrett, F. Place and A. A. Aboud. New York, NY, CABI International.
- Conrad, J.M. & Clark, C.W. 1996. Natural resource economics, Cambridge, MA, USA, Cambridge University Press.
- Dasgupta, P., Mäler, Karl-Göran, 1994. Poverty, institutions and the environmental resource base. World Bank Environment paper 9, The World Bank, Washington DC, 64 pp.
- Deininger, Klaus, and Gershon Feder (1998). Land institutions and land markets. A paper prepared as a background for the coming Handbook on Agricultural Economics. World Bank, Washington, D.C.

- Durning, A. (1989) Poverty and the environment: reversing the downward spiral, World watch paper 92.
- Eaton, D. (1996), The economics of soil erosion: A model of farm decision-making, discussion paper.
- Eaton, D. (1996), The economics of soil erosion: A model of farm decision-making, discussion paper.
- El Serafy, S. 1990. The environment as capital. In R. Costanza, ed. Ecological economics: the science and management of sustainability. New York, Columbia University Press.
- Ellison, G. and D. Fudenberg (1993). "The Rules of Thumb of Social Learning." *Journal of Political Economy* **101**(4): 612-643.
- Encarta © 1993-2003 Microsoft Corporation. All rights reserved.
- EPA (Environmental Protection Authority), 2003. State of Environmental Report for Ethiopia. Addis Ababa.
- Erenstein, O. 1999. The economics of soil conservation in developing countries: the case of crop residue mulching. Wageningen, the Netherlands, Wageningen University.
- Ervin, C. A. and D. E. Ervin (1982). "Factors Affecting the Use of Soil Conservation Practices: Hypotheses, evidence and Policy Implications." *Land Economics* **58**: 277-292.
- FAO (2001). Economics of Soil Productivity in Sub-Saharan Africa. Rome, Food and Agriculture Organization of the United Nations.
- FAO. 1999. Erosion-induced loss in soil productivity and its impacts on agricultural production and food security, by M. Stocking & A. Tenberg. In H. Nabhan, A.M. Mashali and A.R. Mermut, eds. Integrated soil management for sustainable agriculture and food security in southern and eastern Africa. Proceedings of the Expert Consultation, Harare, Zimbabwe, 8-12 December 1997. AGL/MISC/23. Rome.
- Feder, G., R. E. Just and D. Zilberman (1985). "Adoption of Agricultural Innovations in Developing Countries: A Survey." Economic Development and Cultural Change **33**: 255-298.

- Field, B. C. (2001). Natural Resource Economics - An Introduction, New York, NY: McGraw Hill.
- Fisher, A. 1981. Resource and environmental economics. Cambridge, MA, USA, Cambridge University Press.
- Fuglie, K. O., and Bosch, D. J. 1995. Economic and Environmental Implications of Soil Nitrogen Testing: A Switching-Regression Analysis. American Journal of Agricultural Economics 77: 891- 900.
- Greene.H.W. (1997), Econometric analysis, 3rd edition, New York University.
- Hans - Joachim Krugor, et.al., 1996. Indigenous Soil and water Conservation Vatio In Africa. Creating an inventorial of indigenous soil and water conservation measures in Ethiopia. Earth scans Publication Ltd, London.
- Hodge.I, (1995), Environmental Economics, individual incentives and public choices, Macmillan press Ltd.
- Hurni . M, 1988. Degradation and conservation of the resources in the Ethiopian High lands. Inves, J.D. (Ed), Mountbatten Research and Development. Vol. 8 No. 2&3.
- IFAD, 1992. Soil and Water Conservation in Sub-Saharan Africa. Towards Sustainable production by the Rural Poor. A Report prepared for IFAD by CDCS. Amsterdam.
- Just, R.E., and Pope, R.(1978) Production function estimation and related risk considerations. American Journal of Agricultural economics 61: 227-284.
- Kaliba, A.R.M., and Rabele, T. (2004) Impact of Adopting Soil Conservation Practices on Wheat Yield in Lesotho. In: Bationo, A.(Eds.) Managing Nutrient Cycles to Sustain Soil Fertility in Sub-Saharan Africa. Tropical Soil Biology and Fertility Institute of CIAT
- Khanna, M. 2001. Sequential adoption of site-specific technologies and its implication for nitrogen productivity: A double selectivity model. American Journal of Agricultural Economics 83(1): 35-51.
- Knox, A., R. Meinzen-Dick and P. Hazell (1998). Property Rights, Collective Action and Technologies For Natural Resource Management. Washington, D.C, IFPRI.
- Lal, R. (1990). Soil erosion in the tropics: principles and management. New York: McGraw-Hill, Inc.
- Lal, R. 1994. Methods and guidelines for assessing sustainable use of soil and water resources in the tropics. USDA Soil Conservation Service Technical

Monograph No. 21, Washington, DC.

Lipper, L. (1998) Poverty, farmers, and soil resource investment.

Lovelock, J. (1987) *Gaia: A New Look at Life on Earth*, New York: Oxford University Press.

McConnell, K. E. (1983). "An Economic Model of Soil Conservation." American Journal of Agricultural Economics 65(1): 83-89.

Menale Kassie and Holden, S.T. (2005) Parametric and Non-parametric estimation of soil conservation adoption impact on yield and yield risk: paper presented in the 6th International Conference of the European Society for Ecological Economics held June 14-18, 2005.

Microsoft Encarta (2003)

Nibset, E. G. (1991) Leaving Eden: To protect and manage the earth, Cambridge: Cambridge University Press)

Norris, P. E. and S. E. Batie (1987). "Virginia Farmers' Soil Conservation Decisions: An Application of Tobit Analysis." Southern Journal of Agricultural Economics 19(1): 79-80.

Oldeman, R. Hakkeling, R. & Sombroek, W. 1990. World map of the status of human induced soil degradation: an explanatory note. International Soil Reference and Information Centre, Wageningen, the Netherlands, and UNEP, Nairobi.

Pender J. (2005) Econometric Methods for Measuring Natural Resource Management impacts

Reardon, T. and S. A. Vosti (1997). Policy Analysis of Conservation Investments: Extension of Traditional Technology Adoption Research. Sustainability, Growth, and Poverty Alleviation. T. Reardon and S. A. Vosti. Baltimore, The Johns Hopkins University Press.

Sadoulet, E. and A. de Janvry (1995). Quantitative Development Policy Analysis. Baltimore, Maryland, The Johns Hopkins University Press.

Scherr, S. (1999) Soil degradation: a threat to developing-country food security by 2020? Food, Agriculture and the Environment Discussion Paper 27. Washington, DC, IFPRI.

Shively, G.E. (1998) Modeling impacts of soil conservation on productivity and yield variability: Evidence from a heteroskedastic switching regression. Selected paper at annual meeting of the American Agricultural Economics Association 2-5 August 1998, Salt Lake City, Utah.

Shively, G.E. (1999) Risks and returns from soil conservation: evidence from low-income farms in the Philippines. Environmental Monitoring and Assessment 62: 55-69.

_____ (2003), Socio-Economic profile of Wolayita zone, SNNPR Ethiopia. Regional office of population and Finance & Economic Development of Wolayta zone, July 2003.

Stahl, M., (1990), Constraints to Environmental Rehabilitation through People's Participation in the Northern Ethiopian Highlands. Discussion Paper 13,

Tadesse, M., and Belay, K. 2004. Factors influencing Adoption of soil conservation measures in Southern Ethiopia: The case of Gununo Area. Journal of Agriculture and Rural Development in the Tropics and Subtropics 105(1): 49-62.

Teferi Abate (1998), Land, Capital and Labor in the Social Organization of Farmers: Study of House hold Dynamics in South East Wello. Department of Sociology and Social Anthropology, Addis Ababa University.

Tesfaye.B. (2003), Understanding farmers: explaining soil and water conservation in Konso, Wolaita, and Wello Ethiopia, Wageningen University.

Tietenberg, T.H. (2003) Environmental and natural resource economics. USA: Pearson Education, Inc.

Tietenberg, Tom (1992) Environmental and natural resource Economics, 3rd edition

Tisdell, C. (2000) 'Coevolution, agricultural practices and sustainability: Some major social and ecological issues' International Journal of Agricultural Resources, Governance and Ecology, Vol. 1, No. 1.

UNEP, (2003) Poverty and ecosystems: a conceptual framework

Website; www.fao.org

Wikipedia, the free encyclopedia

_____ (2005), Wolaita Zone finance and economic development , Zonal basic socio economic and demographic information, Wolaita Soddo, Nov 2005

APPENDICES

Appendix 1 Descriptive analysis

Variable	Mean	Std. Dev.	Min	Max
Soil and water conservation θ_{hi}	0.5800604	0.4942959	0	1
Sex	0.6827795	0.4660987	0	1
Age	42.26586	9.807017	25	68
Education level of HH head (Edu1) Illiterate	0.5951662	0.491603	0	1
Education level of HH head (Edu3) secondary level	0.0876133	0.2831597	0	1
Family size (FS)	6.685801	2.401592	2	14
Access to extension (Aex)	0.5891239	0.4927377	0	1
Access to cash credit (Acr)	0.4259819	0.4952396	0	1
Livestock in Tlu	1.87716	1.540625	0	10.85
slop steep (Stp1)	0.4924471	0.5006999	0	1
slop moderate (Stp2)	0.3444109	0.4758952	0	1
Land Quality (LQ1 _{hi}) fertile	0.141994	0.3495724	0	1
Land Quality (LQ2 _{hi}) medium fertile	0.5861027	0.4932762	0	1
Erosion perception (Eros1) high	0.2537764	0.43583	0	1
Erosion perception (Eros3) low	0.6223565	0.4855318	0	1
Total land holding in ha	0.6213776	0.3592589	0.19	2.72
off farm employment (Offy)	0.7129909	0.4530507	0	1
food security in number of quarter per year	2.178248	0.9637103	1	4
each crop field/ plot area in Sq. m	1451.732	1444.938	200	12500
Seed used per Sq. meter (in kg)	0.008446	0.0080072	0.02	0.0727
fertilizer used per Sq. meter (in kg)	0.0056974	0.0040261	0	0.0222
Labor used per Sq. meter (in man day)	0.0105631	0.0072073	0.01	0.06
Compost apply to the plot	0.8096677	0.3931576	0	1
SWC area per plot in Sq. m.	56.73716	93.01163	0	1000
Value of crop productivity per plot	10.19719	0.7693774	8.433	13.112
distance to town market (Dst _{hi})	6.803384	1.070946	4.2	9
Average time takes to cover round trip to town market	2.669184	.963651	1.2	5
Per Capita land Holding (in ha)	0.101866	0.0647439	0.02	0.54

Appendix 2 Binary Probit model result

Variables	Dummy Soil and water conservation	
	Parameter estimate	Marginal effect
Dependent variable:- soil and water conservation θ_{hi} = 1 if the household conserves the plot; else =0		
Sex [♦] (1= male, 0 otherwise)	1.804 ^{***} (0.323)	0.6327 ^{***} (0.0863)
Age	-0.037 ^{**} (0.0166)	-0.0142 ^{**} (0.0062)
Education Edu1 [♦] (1= secondary level; else 0)	0.23487 (0.27177)	0.08844 (0.10236)
Education Edu3 [♦] (1= secondary level; else 0)	1.497 ^{***} (0.5283)	0.3684 ^{***} (0.0642)
FS Family size of the household.	0.2426 ^{***} (0.0897)	0.0908 ^{***} (0.0337)
Acr [♦] (1= has Credit access 0= otherwise)	0.6529 ^{***} (0.2350)	0.2364 ^{***} (0.0798)
Assets of livestock (in TLU)	0.4486 ^{***} (0.1023)	0.1679 ^{***} (0.0373)
Slope [♦] Stp1 _{hi} (1=Steeply slop, 0=otherwise)	1.869 ^{***} (0.3329)	0.6179 ^{***} (0.0846)
Slope [♦] Stp2 _{hi} (1= moderate slop, =otherwise)	2.2008 ^{***} (0.4383)	0.6235 ^{***} (0.0784)
Land Quality [♦] LQ1 _{hi} (1=fertile, 0= otherwise)	-2.5242 ^{***} (0.4525)	-0.7274 ^{***} (0.0543)
Land Quality [♦] LQ2 _{hi} (1=medium fertile,0= otherwise)	-0.9341 ^{***} (0.2908)	-0.3290 ^{***} (0.0951)
Distance from town market (Km)	0.7298 ^{***} (0.1205)	0.2732 ^{***} (0.0443)
Aex [♦] (1= has extension access 0= otherwise)	-0.20342 (0.2352)	-.0755474 (0.08656)
area of Land size	-1.003199 (0.7432)	-0.375603 (0.27991)
off farm employment (Offy)	-0.227499 (0.24980)	-0.083470 (0.08975)
food security	0.1635995 (0.12167)	0.061252 (0.04534)
Per Capita land holding	0.15955 (3.830)	0.0597393 (1.4344)
Erosion perception (Eros1) high	0.29507 (0.4514)	0.107055 (0.1578)
Erosion perception (Eros3) low	-0.08898 (0.3985)	-0.033176 (0.14774)
Constant	-7.5146 ^{***} (1.2248)	

***, **, and * indicate Significance level at 1%, 5%, and 10% level, respectively but those coefficient without a star are insignificant
 (♦) dy/dx is for discrete change of dummy variable from 0 to 1.
 () Figures in parenthesis are robust standard errors.

Test summary

- Number of observations: 331
 - Log Pseudo likelihood function: 99.493202
 - Wald chi2 (19) = 139.98
 - Prob >Chi-squared = 0.0000
 - Pseudo R2 = 0.5581

Appendix 3 Binary Probit model result without expected endogenous variables
(Access to credit and Off farm employment participation)

Variables	Dummy Soil and water conservation	
	Parameter estimate	Marginal effect
Dependent variable:- soil and water conservation $\theta_{hi} = 1$ if the household conserves the plot; else =0		
Sex [♦] (1= male, 0 otherwise)	1.7906 ^{***} (0.2911)	0.6293 (0.0776)
Age	-0.0368 ^{**} (0.0157)	-0.0139 ^{**} (0.0060)
Education Edu1[♦] (1= secondary level; else 0)	0.3639 (0.26125)	0.1387 (0.0991)
Education Edu3[♦] (1= secondary level; else 0)	1.4609 ^{***} (0.5152)	0.3751 ^{***} (0.0679)
FS Family size of the household.	0.2683 ^{***} (0.0938)	0.1017 ^{***} (0.0359)
Assets of livestock (in TLU)	0.4653 ^{***} (0.1035)	0.1764 ^{***} (0.0385)
Slope [♦] Stp1 _{hi} (1=Steeply slop, 0=otherwise)	1.905 ^{***} (0.3360)	0.6330 ^{***} (0.0847)
Slope [♦] Stp2 _{hi} (1= moderate slop, =otherwise)	2.206 ^{***} (0.4092)	0.6317 ^{***} (0.0767)
Land Quality [♦] LQ1 _{hi} (1=fertile, 0= otherwise)	-2.6069 ^{**} (0.4564)	-0.7269 ^{**} (0.4850)
Land Quality [♦] LQ2 _{hi} (1=medium fertile, 0= otherwise)	-0.9503 ^{***} (0.2766)	-0.3391 ^{***} (0.0918)
Distance from town market (Km)	0.6541 ^{***} (0.1087)	0.2480 ^{***} (0.0412)
Aex[♦] (1= has extension access 0= otherwise)	-0.1889 (0.2250)	-0.0711 (0.0840)
area of Land size	-1.1980 (0.7883)	-0.4543 (0.3007)
food security	0.2640 (0.1195)	0.1001 (0.0450)
Per Capita land holding	1.6647 (4.0535)	0.6312 (1.5398)
Erosion perception (Eros1) high	0.4177 (0.4393)	0.1516 (0.1505)
Erosion perception (Eros3) low	0.0234 (0.3818)	0.0089 (0.1450)
Constant	-7.5888 ^{***} (1.1860)	

***, **, and * indicate Significance level at 1%, 5%, and 10% level, respectively but those coefficient without a star are insignificant
(*) dy/dx is for discrete change of dummy variable from 0 to 1.
() Figures in parenthesis are robust standard errors.

Test summary

- Number of observations: 331
-Log Pseudo likelihood function: -103.7
- Wald chi2 (19) = 156.32
- Prob >Chi-squared = 0.0000
- Pseudo R2 = 0.5394

Appendix 4 OLS regression of yield equation (for pooled data)

InY (dependant Variable)	Coef.	Robust Std. Err.	t	P>t	[95% Conf. Interval]
Sex	0.1193169	0.0679025	1.76	0.08	-0.0142998 0.2529335
Age	-0.0049072	0.0038792	-1.27	0.207	-0.0125406 0.0027262
edu1	0.062326	0.059975	1.04	0.3	-0.0556912 0.1803432
edu3	-0.0718363	0.0844765	-0.85	0.396	-0.2380669 0.0943943
Familysize (Fs)	0.012772	0.0108826	1.17	0.241	-0.0086426 0.0341865
Access extn Aex	-0.0371083	0.0509459	-0.73	0.467	-0.1373583 0.0631416
Accredit (Acr)	-0.0145147	0.0468744	-0.31	0.757	-0.1067528 0.0777234
Tlu	0.0192724	0.0232558	0.83	0.408	-0.0264897 0.0650346
Tenure	-0.0006675	0.0025696	-0.26	0.795	-0.0057239 0.0043889
Slope (Stp1 _{hi}) Steep	-0.0538334	0.0707414	-0.76	0.447	-0.1930364 0.0853696
Slope(Stp2 _{hi}) Moderate	0.0376381	0.0755684	0.5	0.619	-0.1110632 0.1863395
Land Quality (LQ1 _{hi}) fertile	-0.0146476	0.0867882	-0.17	0.866	-0.185427 0.1561317
Land Quality (LQ2 _{hi}) medium fertile	0.001062	0.0602305	0.02	0.986	-0.1174579 0.1195819
offarm employ (Offy)	-0.0001835	0.0002387	-0.77	0.443	-0.0006532 0.0002862
plot size sq m	5.29E-06	0.0000213	0.25	0.804	-0.0000366 0.0000472
Labor used per Sq. meter(in man day)	1.64113	0.5319	3.08	0.002	0.59447 2.68778
Fertilizer input per Sq. meter(in Kg)	4.25489	0.57139	7.44	0	3.13053 5.3792
Seed used per Sq. meter (in kg)	2.39286	0.65347	3.66	0	1.10698 3.67874
Compost	-0.0185605	0.0643371	-0.29	0.773	-0.1451613 0.1080403
erosion high Eros1	0.0259285	0.0911955	0.28	0.776	-0.1535235 0.2053804
erosion low Eros3	-0.0014748	0.0830327	-0.02	0.986	-0.1648644 0.1619147
Per Capita land holding	1.06106	0.4400251	2.41	0.016	0.1951913 1.92693
Distown (Dst)	0.038472	0.023261	1.65	0.099	-0.0073003 0.0842443
SWC ratio	0.956566	0.5674294	1.69	0.093	-0.1600059 2.073138
Mills	0.0225533	0.0975972	0.23	0.817	-0.1694957 0.2146023
Constant	2.283611	0.2216449	10.3	0	1.847464 2.719758

Dependent variables:- natural log value of crop productivity per square meter of the plot

Number of obs = 331

Prob > F = 0.0000

R-squared = 0.6951

Root MSE = 0.3235

Appendix 5 OLS regression of yield equation (for SWC adopter)

InY(dependant Variable)	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
Sex	0.2636994	0.1505972	1.75	0.082	-0.0336203	0.5610192
Age	-0.0081745	0.0057093	-1.43	0.154	-0.0194463	0.0030972
edu1	0.0228626	0.0823477	0.28	0.782	-0.1397139	0.1854392
edu3	-0.0800791	0.1141091	-0.7	0.484	-0.3053614	0.1452032
familysize(Fs)	0.013933	0.0161453	0.86	0.389	-0.0179423	0.0458083
access extn Aex	-0.0204419	0.0796243	-0.26	0.798	-0.1776418	0.136758
acredit (Acr)	-0.0086868	0.0858848	-0.1	0.92	-0.1782467	0.1608731
Tlu	0.0425453	0.0351475	1.21	0.228	-0.0268454	0.1119359
Tenure	-0.0002103	0.0038012	-0.06	0.956	-0.0077149	0.0072942
Slope (Stp1 _{hi}) Steep	0.0982404	0.1577803	0.62	0.534	-0.2132606	0.4097414
Slope(Stp2 _{hi}) moderate	0.1986364	0.1770688	1.12	0.264	-0.1509453	0.5482181
Land Quality (LQ1 _{hi}) fertile	-0.0126932	0.1989713	-0.06	0.949	-0.4055165	0.3801301
Land Quality (LQ2 _{hi}) medium fertile	-0.0474772	0.0952248	-0.5	0.619	-0.2354767	0.1405223
offfarm employ. (Offy)	-0.0001211	0.0003568	-0.34	0.735	-0.0008255	0.0005833
plot size sq m	0.0000441	0.0000212	2.08	0.039	2.31E-06	0.0000859
Total labor	3.09802	0.631250	4.91	0	1.85176	4.34428
fertilizer input	3.59242	0.73737	4.87	0	2.13665	5.04818
seed input	2.1008	0.67048	3.13	0.002	0.7771	3.4245
compost	-0.0179911	0.107557	-0.17	0.867	-0.2303377	0.1943555
erosion high Eros1	0.1775011	0.1862008	0.95	0.342	-0.1901097	0.5451119
erosion low Eros3	0.0650889	0.1738009	0.37	0.709	-0.2780411	0.4082189
popn. density	0.6225296	0.669598	0.93	0.354	-0.6994383	1.944497
distowm (Dst)	0.053647	0.0533262	1.01	0.316	-0.0516334	0.1589274
mills	0.1824257	0.2137562	0.85	0.395	-0.2395869	0.6044383
constant	1.994436	0.5144675	3.88	0	0.9787378	3.010134

Dependent variables:- natural log value of crop productivity per square meter of the plot

Summary

Number of obs = 192

Prob > F = 0.000

R-squared = 0.522

Root MSE = 0.3782



Appendix 6 OLS regression of yield equation (for SWC non-adopter)

InY (dependant Variable)	Coefficient	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
sex	0.113959	0.0898634	1.27	0.207	-0.0640598	0.2919778
age	-0.005408	0.0067531	-0.8	0.425	-0.0187858	0.0079699
edu1	0.1977702	0.0851591	2.32	0.022	0.0290707	0.3664697
edu3	0.1313384	0.2635598	0.5	0.619	-0.3907716	0.6534484
familysize(Fs)	0.0207112	0.0197198	1.05	0.296	-0.0183536	0.0597761
access extn Aex	-0.0367966	0.0732265	-0.5	0.616	-0.1818577	0.1082644
acredit (Acr)	0.0130555	0.0648854	0.2	0.841	-0.115482	0.141593
tlu	-0.0114092	0.0419683	-0.27	0.786	-0.094548	0.0717297
tenure	-0.0015428	0.0047654	-0.32	0.747	-0.010983	0.0078974
Slope (Stp1 _{hi}) steep	-0.0301762	0.0903341	-0.33	0.739	-0.2091274	0.148775
Slope(Stp2 _{hi}) moderate	0.0975363	0.1095525	0.89	0.375	-0.1194864	0.3145591
Land Quality (LQ1 _{hi}) fertile	-0.098663	0.1165162	-0.85	0.399	-0.3294807	0.1321547
Land Quality (LQ2 _{hi}) medium fertile	-0.0253564	0.0932044	-0.27	0.786	-0.2099935	0.1592808
offarm employ. (Offy)	-0.0000253	0.000357	-0.07	0.944	-0.0007325	0.000682
plot size sq m	-0.0000357	0.0000343	-1.04	0.301	-0.0001037	0.0000323
Total labor	2.420469	4.057699	0.6	0.552	-5.617802	10.45874
fertilizer input	4.825877	0.87014	5.55	0	3.102137	6.59617
seed input	3.610629	0.744353	4.85	0	2.136072	5.085186
compost	0.0335466	0.1025927	0.33	0.744	-0.1696887	0.2367819
erosion high Eros1	-0.1819387	0.1205143	-1.51	0.134	-0.4206766	0.0567991
erosion low Eros3	-0.0957195	0.0998179	-0.96	0.34	-0.293458	0.102019
popn. density	1.687142	0.8468028	1.99	0.049	0.0096324	3.364652
distowm (Dst)	0.0357333	0.0284919	1.25	0.212	-0.0207089	0.0921756
mills	-0.0708102	0.1616216	-0.44	0.662	-0.3909815	0.249361
constant	2.300094	0.3040515	7.56	0	1.697771	2.902418

Dependent variables:- natural log value of crop productivity per square meter of the plot

Summary

Number of obs = 139
 F(24, 114) = 15.34
 Prob > F = 0.0000
 R-squared = 0.6449
 Root MSE = 0.2721

Appendix 7 Predicted Mean yield difference

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
0	139	1.967517	0.129888	1.531353	1.602323	2.332711
1	192	1.670029	0.094787	1.313402	1.483066	1.856992
combined	331	0.369247	0.114287	2.079269	0.144424	0.59407
diff		0.297488	0.125311		-0.4375644	0.147822

diff = mean(0) - mean(1)

t = 2.374

degrees of freedom = 329

Ho: diff = 0

Ha: diff < 0

Ha: diff != 0

Ha: diff > 0

Pr(T < t) = 0.0000

Pr(|T| > |t|) = 0.0000

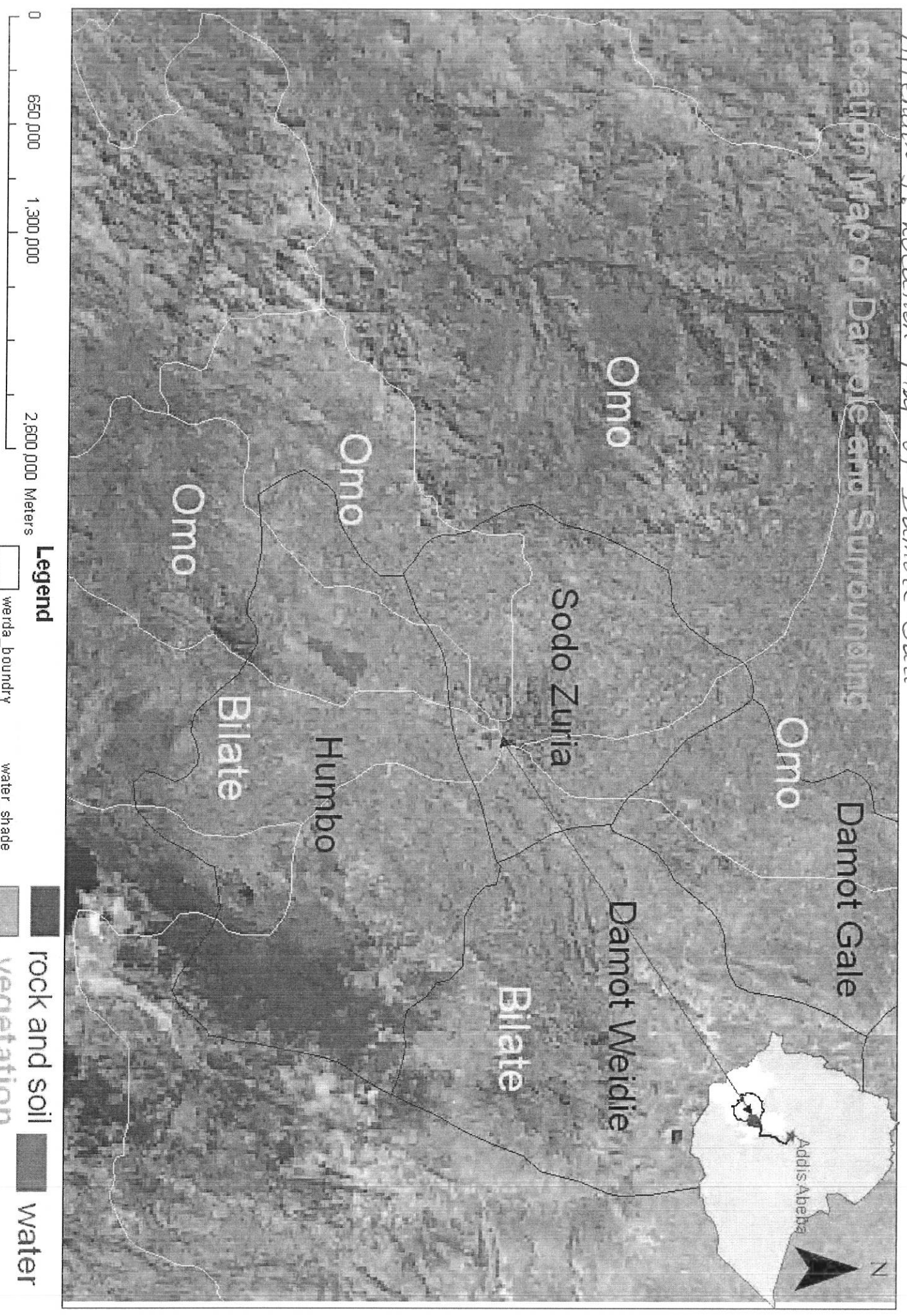
Pr(T > t) = 1.0000

Appendix 8 Tropical Livestock Units (Tlu)

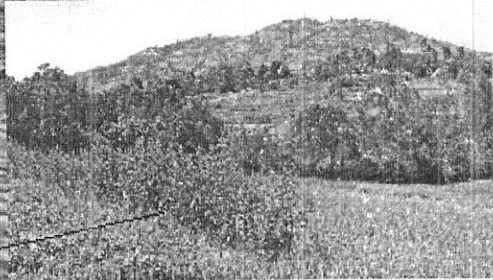
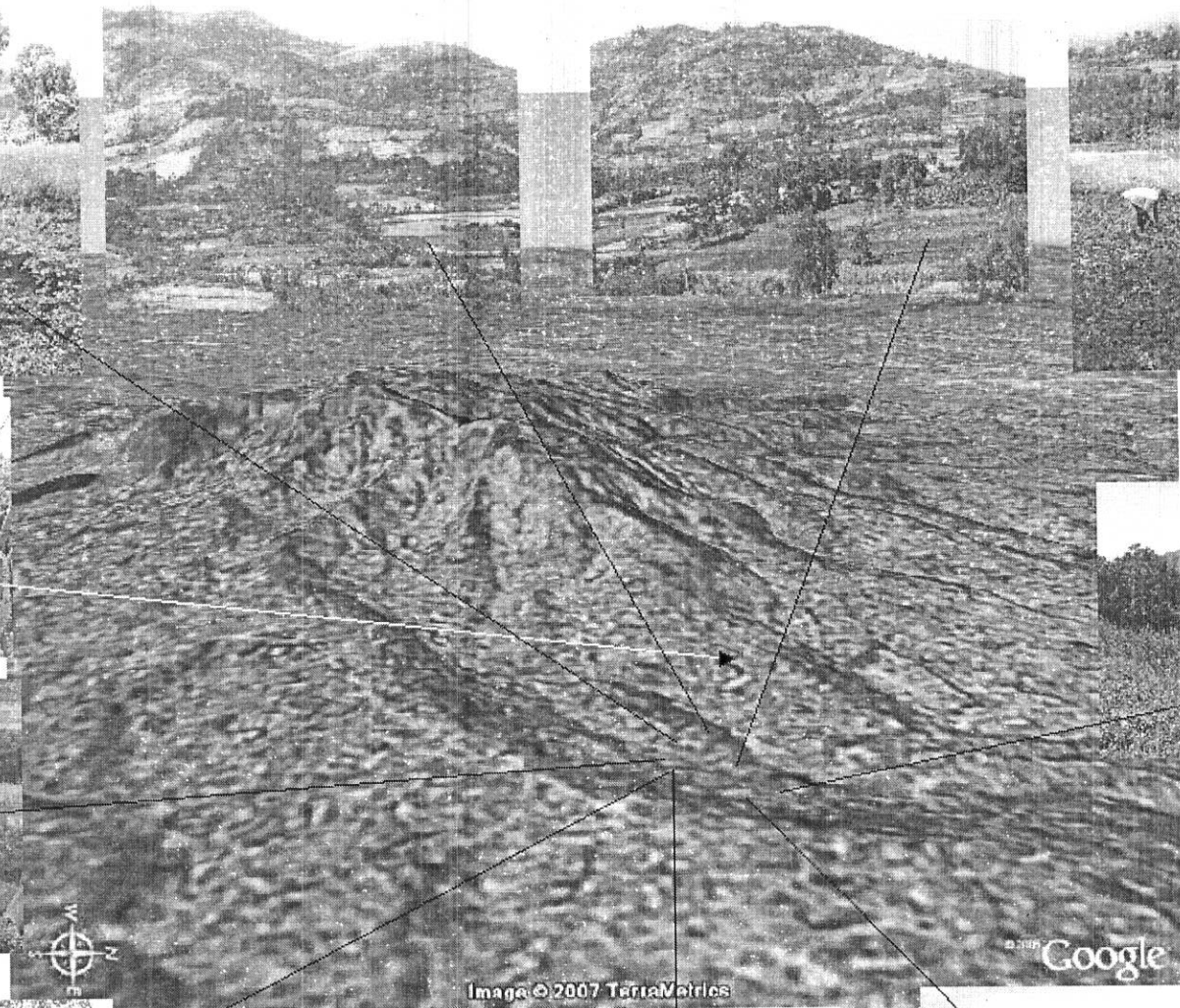
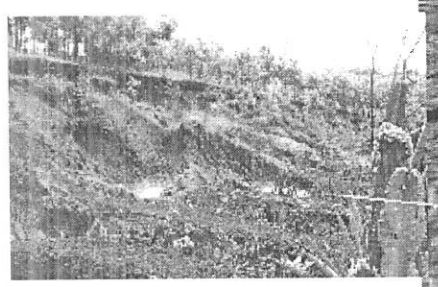
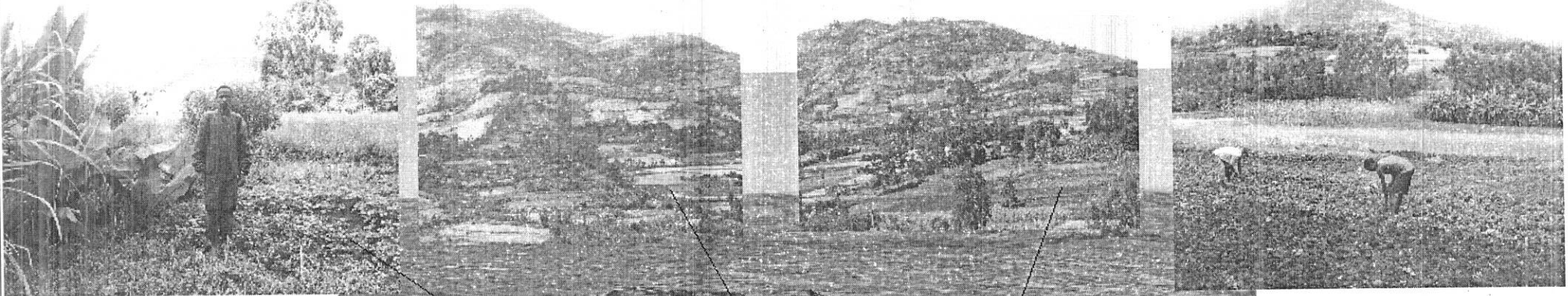
TYPE OF LIVESTOCK	WEIGHT ATTACHED
Calf	0.25
Weaned calf	0.34
Cows and oxen	1.00
Bull	1.00
Hiefen	0.75
Horse	1.1
Donkey (Adult)	0.7
Donkey (younger)	0.35
Camel	1.25
Sheep and goat (Adult)	0.13
Sheep and goat (younger)	0.06
Chicken	0.013

Source: International Livestock Research Institute (ILRI)

Appendix 9: location Map of Damote Gali



Appendix 10: Digital Photo and 3D picture For the Study Area



55°27'32" N

100%

Objective of the questioner

This questioner is making a base to assess the impact of soil conservation on crop productivity at plot level in SNNPR wolita zone Damot Gali woreda. Thank you in advance for your time & kind cooperation to fill the questioner carefully.

- 1. Date of Interview (day/month/year)-----
- 2. Name of supervisor -----
- 3. Name of enumerator: ----- Signature -----
- 4. Total time taken -----

Identifiers

- 1. Region -----
- 2. Zone -----
- 3. PLS/Woreda -----
- 4. Village Name -----



Name of the respondent _____

Head of the household sex (use male or female)

Age

Part 1: Household general information back ground

No.	Name of the household members	Sex (M/F)	<u>Age</u>	<u>Code</u>	Member of the house hold relation (Use Code A)	Major duties in the house hold (Use Code B)	Educational Back ground (Use Code C)	Religion (Use Code d)	Remark
			Under 14... 1	14-60 2					
1									
2									
3									
4									

Codes used in part 1

Code A (Member of the house hold relation)

Head of the household (Male).....1	Uncle/Nephew4
Head of the household (Female).....2	Grand father/mother5
Son/Doughtier3	Brother/Sister in law6
	Others..... 7

Code B (Major duties in the household)

On Farm activity

Farmer8

Off Farm activity

Have a profession of Carpenter/ ...10	Professional Worker (Teacher/health worker/extension worker)..... 16
Blacksmith/..... 11	Permanent employee of government or private organization 17
Weaver 12	Formal Business Man 18
Sales of local drink (Tela/Areki) and Tea/Coffee Cafe 13	
Daily laborer 14	Other (specify)..... 19
Shoe polisher 15	

Not working currently

Student (currently take a course) 20	Unemployed (who need any Job)..... 23
Disabled (not able to work) or retired 21	Unemployed (who doesn't need any Job) 24
Kids..... 22	Other (specify)..... 25

Code C Educational back ground

Illiterate 1	Primary education 5
Writing and reading 2	Secondary education 6
Informal education..... 3	Higher institution 7
Religious/cultural education..... 4	Others 8

Code d Religion

Orthodox.....1	Protestant..... 3	
Muslim.....2	Traditional Believers.....4	Others.....5

Part 2: Household social capital

1. Is household involved in (is a member of) local organizations? (use Yes/No) -----
 2. If **yes** to question (1) above:
 - 2.1. Number of local organizations household is involved in:-----
 - 2.2.Type of local organizations: (Fill the codes only using **Code E**)
- Code -----
3. Is household involved in (is a member of) associations? (Use Yes/No) -----
 4. If **yes** to question (3) above:
 - 4.1. Type of association (Fill the codes only using **Code F**) Code -----

Codes used in part 2

Code E Type of local organization

- 0 = no local organization
- 1 = multi-purpose cooperative
- 2 = marketing cooperative
- 3 = irrigation cooperative
- 4 = saving and credit cooperative
- 5 = Equb
- 6 = Edir
- 7 = specify if any other.....

Code F Type of associations

- 0 = no association
- 1 = Peasant Association (PA)
- 2 = Women Association (WA)
- 3 = Youth Association (YA)

Part 3: Household financial capital

1. Did the household get access to extension? (use Yes/No) -----
 2. Did your household need credit for agricultural activity during the cropping season (CS) 2005/ 2006**? (Yes/No) -----
 3. If **yes** to question (2) above then
Did your household obtain credit during CS 2005/2006? (use Yes/No) -----
 4. If, **No** to question (2) above, then what were the reasons?
(It is possible to give more than one reason)
-
5. If **yes** to question (2) above, then

No.	Source of the credit (Use code G)	Type of credit (Use code H)	Duration of the credit (in months)	Amount of the credit in cash (in Birr)	Interest rate for the credit	Purpose for which the credit is taken

6. Did the household put saving from 2004/05 (in cash)? (Yes/No) -----
7. If **yes** to question (6) above, then for what purpose did the household use it?

Codes used in part 3

(code G) Household source of credit

- 1 = Rural credit and saving institution(OMO microfinance)
- 2 = Formal bank
- 3 = Money lenders
- 4 = from relatives
- 5 = from neighbors
- 6 = from extension program
- 7 = from cooperatives

Types of credit (code H)

- 8 = from NGOs
- 9 = from Church
- 10 = from Mosques
- 11 = from Edir
- 12 = if other specify

- 1 = in cash
- 2 = in kind

Part 4: Household wealth in 2005/06

Land, livestock and assets owned by the household

Item	Amount/number	Each Value (in Birr)
Land owned (Timad)		----
Local & Cross bred (cows, calves, Heifers)		
Local & Cross bred Oxen, Bulls		
Goats		
Sheep		
Donkeys, Horse, Mules		
Local Poultry		
Improved Poultry		
Bee colonies in improved/ transitional/ modified beehives.		
Plow set (yoke, handle, metal point, beam etc.)		
Farm equipment (sickle, axe, hoe, spade etc.)		
Water pumping motor and/or harvested water structure		
Animal Cart		
Others		

Use "0" if properly is not owned or else Actual number otherwise
NA if not applicable

Part 5: Plot level factors and income from crop production

Plot No	Name of the plot (or description)	Crop grown or other land use (Use code I)	Area of the plot (in Temad)	Types of crops grown	How the HH did acquire the plot? Include Duration (Use code K)	Distance from Home (walking minutes round trip)	Slope category of each plot (Use code L)	Land quality (soil fertility) (Use code M)	Season of harvest(Use code P)	Yield harvested (Kg)

Note that: Name of the plot is crop type with area of the plot

One quintal= 100Kg

One Kumta(Kesha)= half quintal = 50Kg one Feresula= 20Kg= 2 basket

1 What part or area of your farm plot damaged due to erosion? -----

Codes used in part 5

Code K Source of land ownership of each plot

- 1 = the state
- 2 = Inherited
- 3 = Rent
- 4 = Share cropping
- 5 = Specify if any other

Code L

Slope category of each plot

- 1 = Flat
- 2 = moderately steep
- 3 = Very steep

Code M

Soil fertility

- 1= High fertility
- 2=Moderate fertility
- 3 = Low fertility

Note: for how many years is under his control must included In years

Code I Crop grown and other land use

- 1 = Crops
- 2 = Homestead
- 3 = Grazing
- 4 = Wasteland
- 5 = Forest
- 6 = woodlot
- 7 = other

Code P Season of harvest

- 1 = Belg
- 2 = Meher

1. If the household isn't involved in agricultural production, then what were the reason(s)? (use code Q) Code

Code Q Reason not to be involved in agriculture

- 1 = health problem
- 2 = lack of farm land
- 3 = lack of Oxen
- 4 = lack of capital
- 5 = unable due to age
- 6 = Student
- 7 = not interested
- 8 = disabled
- 9 = child
- 10 = other specify

Part 6: Household source of livelihood

1. What is the livelihood strategy of the Household? (Rank according to it's priority)

..... Crop

..... Off farm

..... Livestock

..... Specify if any other

..... Mixed farming

rt 7: Inputs for farm activity

Cost of production in 2006 Cropping Season (*Labor Cost*: and other inputs)

No	Name of the plot	Labor power used				Costs of fertilizer, compost/ manure, seed, oxen power, pesticide and herbicide used								
		Type of labour used (Use code R)	Number of labour used	Value in birr	Man day required	Amount of fertilizer used in the plot	Compost/ manure used in the plot		Seed used		pesticide and herbicide used		Oxen power used	
							Amount in Kg	Value in Birr	Amount in Kg	Value in Birr	Amount in Kg	Value in Birr	Oxen pair days	Value in Birr
1														
2														
3														
4														

te : the number of labor measured in terms of labor in days.

Code R Type of labor used in the farming

1 = Family labor

2 = Hired labor

3 = on crop sharing basis

4= other means (specify)

Part 8: Village level factors

1. What is the rainfall trend in your area?
(Underline or put it as low, medium, high rainfall condition) -----
2. What is the extent of erosion in your area? (use low, medium, high erosion)
3. Access to infrastructure and services

Type of service and infrastructure	Are the service available in your area (Y/N)	What is the distance to the nearest service (in Km)	How much time does it take to reach the nearest service? (walking minutes in round trip)
Town market			
Village market			
Cooperative shop			
Bus station			
All weather road			
Seasonal road			
Specify if any other			

Part 9: fuel energy related issues

1. What is the household source of fuel energy? List them
.....
.....

Part 10: Application of soil conservation to farm plot

1. Do you use Soil conservation to your plot? (Use Yes /No).....
Name or numbered the plot identification.....
2. If yes to question No.1, when did the household start to use soil conservation?
(Its specific time period)? -----
3. How did you aware about soil conservation before you start to use it? (Use code S)
.....

Code S From whom the household learn or became aware about soil conservation
 1= Agriculture and Natural Resource office 4= NGOs
 2= District (woreda) administration 5= Relatives
 3= Neighbors 6= specify if any other

4. Have you get any training regarding the construction of soil conservation technique?(Yes/No) if the answer is yes, what kind of training did you get? specify
.....
5. Did the training help you to effectively construct and use your plot? (Yes/No) -----
6. the type of soil conservation existed in each plot

No.	Name of the plot	Type of soil conservation used (use Code T)	Type of crop grown in the last year cropping season	area of land the conservation taken as of the plot in meter	Remark Does the soil conservation type is (Use code) 1=indigenous 2= introduced
1					
2					
3					

Code T Type of soil conservation used

- | | |
|---------------|--|
| 1= Soil bund | 5= Manure |
| 2= Stone bund | 6=Mulching |
| 3=Terracing | 7= contour ploughing |
| 4= fanya juu | 8=other type(specify)
Vetiver grass |

7. Was the type of Soil conservation that you have adopted chosen by your self?(Y/N).....
8. If yes to Question 6, what was your reason for adopting the type of Soil conservation that you choose above? List out more than two specific reasons?
.....
.....
9. Your response to question 7 is **No**, who chooses the type of Soil conservation for your plot.
10. Specially, for which plot do you think Soil conservation is more effective? Why?
.....
11. Investment and maintenance cost for a construction of soil conservation in each plot?

No.	Name of the plot	Investment cost			Remark
		No. of labor	Time it take to construct (man day required)	Raw material	
1					
2					

12. Who cover each cost of investment for soil conservation?
13. What benefit did you get from Soil conservation?
(Tell us the advantage and disadvantage in terms of output, decreasing cost of production, protection of degraded land for sustainable production)
.....

Thank you

DECLARATION

I, the undersigned, declare that this thesis is my original work, has not been presented for a degree in any other university. All the resources of materials used for the thesis have been duly acknowledged.

Declared by:

Name: Dawit Teshale

Signature: 

Date: 05-04-07

Confirmed by:

Name: Dr. Mulat Demeke

Signature: 

Date: 05 April 2007

Place: Addis Ababa University