ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Assessing the Impacts of Soil erosion on Farm-land and Conservation Practices in Sululta Woreda, Oromia Regional State, Ethiopia.

M.A Thesis

By: Getachew Alemu

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A Thesis Submitted to the School of Graduate Studies of the Addis Ababa University in Partial Fulfillment of the Requirements for Degree of Master of Art in Geography and Environment Studies.

By

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Advisor:- Asmamaw Legass (PhD)

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Abbreviations and Acronyms

CSA	Central Statistical Agency
DAs	Development of Agriculture
EFAP	Ethiopia, Ministry of Natural Resources Development and Environmental Protection
EHRS	Ethiopian Highland Reclamation Study
ENMA	Ethiopia National Metrology Agency
FAO	Food and Agriculture of Organization
FFW	Food- for -Work
GDP	Gross Domestic product
ha	Hectare
HHH	Household heads
m.a.s.l	meter above sea level
MoA	Ministry of Agriculture
NGO	Non Government Organization
SPSS	Statistics Package for Social Science
SWC	Soil and Water Conservation
SWAO	Sululta Woreda Administrative Office
SWAARDO	Sululta woreda agricultural and rural development office
UNEP	United Nation Environmental Program

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ABSTRACT

The study was conducted on assessing the impact of soil erosion and conservation practices in Sululta woreda Oromia regional state, Ethiopia with the objectives of assess people's perception on the extent, and consequences of soil erosion and conserving soils by constructing soil conservation measures. To address the objectives of the study both primary and secondary data were collected. The primary data were collected from 131 sample households who are selected from 3 kebele Administrations in Sululta woreda and household sample was obtained using a simple random sampling technique. Interview was conducted with expert of woreda, elder and leader person in selected kebeles, field observation and discussion was made among different communities about the impact and soil conservation practices were constructed.

Farmers perceived the causes of soil erosion in their lands as slope steepness of cultivation fields, overgrazing and absence of fallowing with many time preparations of soil for cropping and similarly, they perceived indicators of the existence of erosion. For them, poor crop production, absence of fertile top soil, gully development and stoniness of soil were main indicators to soil erosion on their land. Severity of soil erosion in the study area explained as severe, moderate, minor soil erosion and cultivation fields had severe erosion risk. Consequently, farmers well understood the impact of soil erosion on their farms and recognized as loss of topsoil, reduction of yield over time, requiring high input and management, lack of farm land and grazing field, and out migration.

Soil conservation measures practiced in the study area included stone bunds, cutoff drains, soil bunds, waterways, check dams. Yet farmers have been using biological and agronomic soil conservation measures either separately or in combination with structural soil conservation measures. Practices of structural soil conservation measures have been influenced by many factors. Aged farmers have practiced structural soil conservation less likely than young farmers. Female farmers also showed high interest towards structural soil conservation, yet they invested little and rarely practiced. On the contrary, educated farmers, household sizes, farmers involved in off farm jobs, perceiving soil erosion well, having contact with DAs and training provide a fertile ground for increased practice of structural soil conservation measures.

Thus, the important recommendations which are found to be of paramount importance from the findings of this study include: bottom-up participatory planning, implementation and monitoring by the real stakeholders at grassroots, publicity on land management practices, which should be done mostly on mass media, training the farmers and others.

Key words:- Soil erosion, impact of soil erosion, soil conservation.

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Mengistu K. and Siegfried B. (2011) stated that land degradation has become a global environmental threat currently drawing spread wide attention from the international community. It has an abysmal effect on agricultural productivity especially in developing countries where agriculture remains one of the largest sectors of the economy.

According to Tigneh (2009) Ethiopia is well-endowed in diversified natural and cultural resources among the sub-Saharan African countries and its tropical location combined with impressive altitudinal variation within short range of distance allows the country to enjoy both temperate and tropical types of climates. As a result, the country has rich biodiversity relatively fertile soil and large volume of fresh water resources (Tigneh, 2009). Despite its enormous biophysical potential, the country has been affected by the interlinked and reinforcing problem of land degradation and extreme poverty (Tigneh, 2009). Land degradation caused by soil erosion an environmental treat hampered agricultural production (Mulugeta and Karl, 2010).

Habtamu (2006) suggests that the impact of soil erosion is mainly severe in the highlands (areas >1500 masl) which constitute 43% of the country. Due to its favorable climate for crop production, animal rearing, and relatively fertile soils and less disease incidence the Ethiopian highlands hosted about 88% of the national population (FAO 1986). The pressure on the biophysical resource base is, therefore, very severe in the highlands of the country than the lowlands.

The average annual rate of soil loss on cropland in the country is estimated to be 42 tons/hectare/year which results to 1 to 2% of crop loss (Hurni, 1993) and 1493 million tons of soil loss/year due to water erosion. The soil formation rate for the country is less than 2 tons/ha/years and hence, the average rate of soil loss/ha/year is much higher than the rate of soil formation. Soil loss rates are of greater than 300 tons/ ha/year on steep slopes areas (USAID, 2000).

The pressures on the environmental resources do not only undermine the capacity of agricultural production but also threatens the sustainability of the ecological systems. The decline in the agricultural productivity of the highland areas of Ethiopia has largely been associated with high population density leading to high rate of deforestation, intensive cultivation of steep slopes and lack of effective conservation measures (Shibiru, 2010). As Alemneh (2003) and Mulugeta and Karl (2010) have confirmed the natural resources of the country are under intense pressure of fast population growth and inappropriate farming and management practices. In highly agricultural economy low income developing countries reversing the deteriorations of land productivity resulting and ensuring adequate food supplies to the fast growing population is a formidable challenge (Mengistu K. and Siegfried B., 2011).

In Ethiopia soil conservation has been carried out with limited success. There is less-willingness to accept and maintain the extensively introduced practices of soil conservation. Besides, soil erosion is a major contributor to the prevailing food insecurity of Ethiopia. Thus, soil conservation is vital to the achievement of food security, poverty reduction and environmental sustainability in the country (Woldeamlak, 2007).

1.2. Statements of the Problem

Although soil conservation has widely accepted environmental, economic, social and political benefits for both individual landholders and the wider community, adoption of such measures is commonly low due to various factors (Kibemo, 2011). Consequently, severe erosion continuous to affects the farmer's agricultural land and their livelihoods (Kibemo, 2011). He pointed out that the rich top soils are washed off by runoff and the exposed sub-soil are generally deficient in available plant nutrients. The unique topography, type of soil, deforestation, intensive rainfall and low level or non of land management and the type of land use practiced have resulted in heavy runoff that induced soil erosion particularly in the northern and central highlands of the country.

The most severe environmental problems of less developed countries are found in rural areas where most of the people live (Holden, 1996). Overpopulation, deforestation and large density of animals that trample the soil are contributing to faster degradation of the soil resources. The inherent nature of the soils affects soils vulnerability to water and wind erosion. Physical soil degradation such as the movement of soils away from its place, compaction, reduction in aeration and reduced permeability and sealing of the soil are largely accelerated by poor soil management practices or by the removal of soil covers by the land users or overgrazing (Solomon, 1994). Soil erosion is by far one of the main cause land degradation in Ethiopia.

Chemical soil degradations refer to loss of nutrients through erosion in runoff. Finer soil fractions are the most vulnerable to erosion. Nutrients, being abundant in these finer soil fractions, are also lost to erosion. Further nutrient losses occur through chemical degradation, i.e. deterioration of properties of the soil that occur as a result of acidification and salination or sodification. The latter is common in arid and semi-arid areas where rainfall is inadequate to leach excess salts down through the profile. The acidification process may be accelerated through burning and clearing of vegetation, continued use of acid containing fertilizers and excessive irrigation (Thomas, 1997). Similarly, biological degradation refers to the process that leads to a decline in the humus content of soil through mineralization (Solomon, 1994).

Estimation made on the amount of soil loss from farming plots and deposited elsewhere or leaving the country is very variable. There are several estimates about economic impacts of soil erosion in the country. For instance, Wood (1990) indicated that erosion reduces the country's food production by 1-2 % per annum. FAO (1986) estimated soil erosion to cost Ethiopia on average 2.2% of land productivity annually from that of the 1985 productivity level. Suticliffe (1993) also estimated that erosion costs Ethiopia 2% of its GDP between 1985 and 1990. These figures imply that the economic impact of erosion is significant in the country. This is expected because of the diversity of relief, agro-ecology, soils and land uses are from one location of Ethiopia to another (Paulos, 2001).

According to Kassu (2011) land degradation mainly resulting from soil erosion and nutrient depletion, can be singled out as one of the most vital environmental problems creating an unprecedented threat to food security of the country. Hence, Ethiopian agriculture and livelihoods of rural community have been adversely affected by land degradation the major drivers of which are soil erosion and deforestation. Soil erosion and consequent soil loss and soil fertility depletion reduce land productivity which in turn lowers the level of farm income of households. Furthermore, soil depth reduction results in poor water holding capacity that affects productivity of crops. Generally, environmental resource concerns are crucial for Ethiopia due to the strong and direct link between the most basic needs of human beings and natural resources in least developed countries (Mitchel, 1991).

The study area, Sululta woreda, is located in central Ethiopia where the ecosystem is very fragile and hence soil erosion, land fragmentation, deforestation and land pressure are severe. Continuous cultivation with little protection measures exacerbated the level of soil erosion and hence land productivity has significantly declined from time to time. As a result, the soil becomes unable to satisfy the rapidly growing demands of population and majority of rural inhabitants are suffering from food insecurity. This is mainly because of that the soil is incapable to support cultivation caused by soil erosion and its related problems. In the area, erosion problems and measures to tackle were rarely investigated.

The farmer's attitude towards the soil conservation and implementation of measures are influenced by different factors. Yet, factors affecting the practice of soil and water conservation measures by farmers have not been closely examined in the area and often poorly understood. Various studies (Bekele and Holden, 1998; Abera, 2003) have identified and discussed the factors that affect farmers' adoption of practices that control erosion and enhance long-term production and productivity. Technologies that conserve soil may not be compatible with the socioeconomic settings of the farmers. Some technologies may be expensive because they require the limited resources the farmer has and end up with little success. Still other technologies that control erosion but they may not result in fulfilling the immediate needs of the farmers. This makes the importance of investigating the factors associated with adoption or non-adoption of a given technology imperative.

1.3. Objectives of the Study

1.3.1. General Objective

The overall aim of this study is to assess the impact of soil erosion and conservation practices in mitigating the problems of soil erosion.

1.3.2. Specific Objectives

The study attempt to:-

1. Assess people's perception on the extent, and consequences of soil erosion.
2. Investigate the effects of soil conservation measures.
3. Identify the driving forces of soil erosion in the study area.

1.4. Research questions

Understanding soil erosion and its impact is significant in promoting soil and water conservation measures and improving agricultural productivity. Therefore, this study attempts to answer the following research questions.

1. How the local people perceive the extent and consequences of soil erosion?
2. What is dominant soil conservation measures practiced in the study area?
3. What factors influence farmers' practice of soil conservation measures?
4. What are the major deriving forces of soil erosion?

1.5. Scope of the Study

To circumvent the impacts of erosion, it is important to know the severity of the problem and the main controlling factors. Since different landscapes vary in sensitivity to erosion due to differences in their geomorphologic, geological and vegetation attributes, it is also necessary to identify high erosion risk areas in order to plan site-specific management interventions. Depending on the prevailing erosion processes and controlling factors, the efficiency of soil conservation measures may vary. This calls for the assessment of the soil conservation potential of different management practices. The scope of this study was to assess the constraints of soil erosion, its impacts, controlling and management alternatives in Sululta woreda of central Ethiopia.

1.6. Significance of the Study

Severe land degradation and excessive soil erosion is responsible for the recurring drought in the woreda. However, the evaluation of the challenge of land use/land cover changes and soil erosion within the study area has not been thoroughly practiced. Therefore, this study will provide base line information on the issues of soil erosion and conservation practice in relations to the biophysical set up. It will also provide firsthand information on spatial extent of soil erosion risk of the study area. Basically, such information are vital for establishing the past, present condition and predicting the future trends of soil erosion, soil and water resource conservation and the physical resources of in the woreda. Furthermore, the research contributes in identifying soil conservation practices implemented by people in the area and their effectiveness in controlling soil erosion. Therefore, the finding of this study will primarily benefit the local farmers, woreda land manager and NGOs, as it evaluates the impact of their programs on the wellbeing of the land and livelihood of farmers. Finally, based on the results of the research, policy recommendation will be forwarded in further redesigning sustainable soils management techniques. Thus, policy makers, development planners, concerned local land managers, and NGOs can be benefited from the outcome of the research to improve the conservation programs of the area to equitable to the nature of the land quality.

1.7. Limitation of the Study

It is actually a local level study and thus focuses mainly on issues related with the impacts of soil erosion and conservation practices within the area. The findings of the research work may be used as a base to solve some of the country's environmental problems, if it is conducted on wider scale including all kebeles of the woreda. However, due to money and labor constants, it was too tedious and out of the reach of to include all kebeles. Thus, the study focused on three rural kebeles of the woreda. Further lack of time and financial resources was the other constraints.

1.8. Organization of the Thesis

This research paper has been divided into six chapters. The first chapter deals with the introduction part which states background, statement of the problem, research objectives, questions, Scope, significance of the study and organization of the paper. In the second chapter briefly describes the background of the study area. Chapter three discusses the research methodology to be carried in selecting the sample respondents, generating the required data in relation to the specified research objectives and methods of data analysis. Chapter four deal with review of literatures on the research topic. The literature review focus on the impact of soil erosion and conservation soil and water practices carried to control erosion challenge and so on. Chapter five deals the analysis and interpretation of the data. The conclusion and recommendations of the study will be explained in chapter six.

CHAPTER TWO

2. DESCRIPTION OF THE STUDY AREA

2.1. Location

Sululta is one of the woreda in the Oromia Region of Ethiopia that situated at about 40km north of Addis Ababa. It was part of former Mulona Sululta woreda which was separated for Mulo and Sululta woredas. Part of the Oromia Special Zone Surrounding Finfinne, sululta is bordered by Wuchale and Yaya Gulale woreda in north, Addis Ababa city Administration and Wolmera woreda in south, Jida and Bereh woreda in east and Mulo woreda in west direction (SWAO, 2014). Astronomically, the area is situated between 9.07^0-9.52^0 Northing and 38.53^0-38.98^0 Easting.

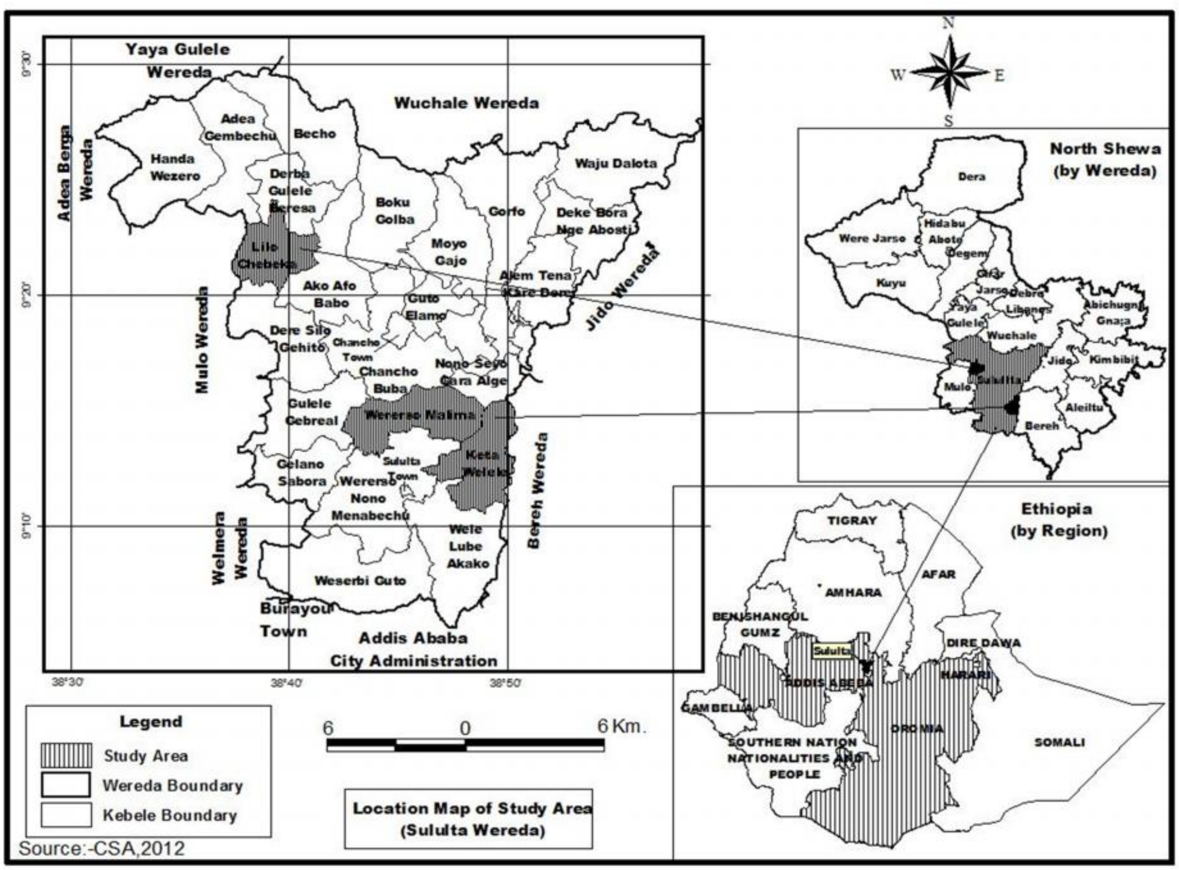


Figure 1: Map of the study area

2.2. Topography and soil

The nature of topography of particular entities has multi dimensional implication up on the development of physical infrastructure, human way of life and the existing type of flora and fauna. The landforms of the area are made up of river cut-gorges, valleys, plateaus, mountains and plains. Thus, plains account (46%), rugged topography (22%), plateaus (26%) and mountain (6%) are commonly observed in the study area (SWAARDO, 2014), and the altitude ranges from 1500m to 3075m above sea level (Topo-sheet, Ethiopian Mapping Authority 1:250,000 (NC 37-10).

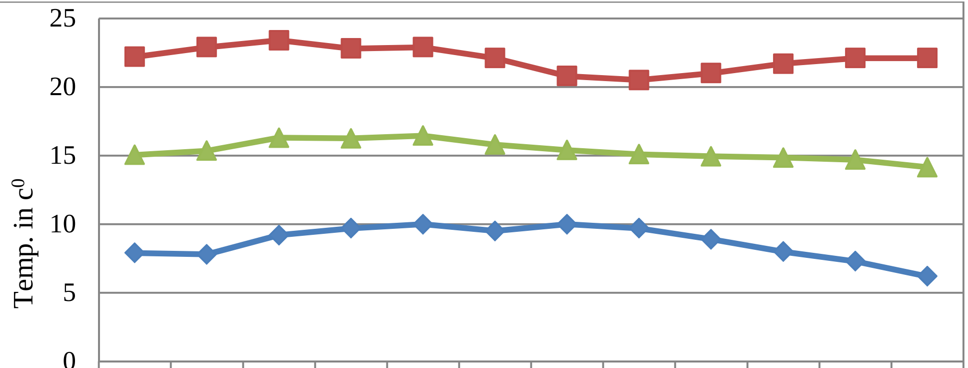
According to the data from Sululta woreda agricultural and Rural Development office (2014), Cambsoil, Nithosols, Vertisols account 49%, 24.5%, and 0.5% respectively. The remaining soils consist 26% of the study area.

2.3. Climate

Among different climatic elements temperature and rainfall have a considerable impact on agrarian country like Ethiopia. The climatic types prevailing over the regional state of Oromia may be grouped into three, with their respective sub-divisions. They are dry climate (the hot arid, semi-arid, dry sub-humid climates), tropical rainy climate (the tropical humid and tropical sub-humid climates) and temperate rainy climate (the warm temperate humid, the warm temperate per humid and the cool highland climates). Due to its location within the tropics, the region receives high solar radiation in fact modified by its high altitude. As a result, highland areas of the region experience low temperature and high rainfall, while lowland areas (below 1500m) experience high temperature and low rainfall (Ahmed Hussein *et al*., 2011). Temperature and rainfall distributions of the study area have been discussed hereunder.

2.3.1. Temperature

The temperature distribution of the study area is mainly the reflection of elevation. Accordingly, it comprises varied thermal zones ranging from Kola (Tropical), which account 3.6% to Dega (temperate) that covers 71% of the study area. The Woina Dega (sub tropical) climate comprises 25.4% of the area. The mean annul temperature of the area is 15.36^{0}C. The mean minimum and maximum temperature of the area are 6.2^{0}c on Dec. and 22.9^{0}c on Feb. and May respectively. May is the hottest months of the area with an average of 16.4 c^{0} mean annual temperature. On the contrary, the coldest month of the study area is December.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Annual mean min.Tem. (c0)	7.9	7.8	9.2	9.7	10	9.5	10	9.7	8.9	8	7.3	6.2
Annual mean max. Tem.(c0)	22.2	22.9	23.4	22.8	22.9	22.1	20.8	20.5	21	21.7	22.1	22.1
Annual mean Tem. (c0)	15.05	15.35	16.3	16.25	16.45	15.8	15.4	15.1	14.95	14.85	14.7	14.15

Figure 2: Mean monthly temperature distribution of Sululta woreda 2001-2013 (source: ENMA, 2014).

2.3.2. Rainfall

The total annual rainfall of the study area is about 1722.6 mm and the average is 143.5 mm (ENMA, 2014). The study area has two rainy seasons, kiremt and belg. Belg is the little and short rainy season that last between March and May. The kiremt season which is the longest rainy season lasts between June and September. The highest and lowest rainfall occurs in July 512.8 mm and November 6.4 mm respectively. The rainfall that occurs during the kiremt season is very intensive. Hence, high soil loss of water erosion occurs during kiremt season (ENMA, 2014). According to the information obtained from Ato Belay Teshome who is the natural resource expert of Sululta woreda tells:-

The area was previously Belg producing region, now a days, the short rains (Belg) occurring between February and April are erratic and not sufficient for rain fed crops production.

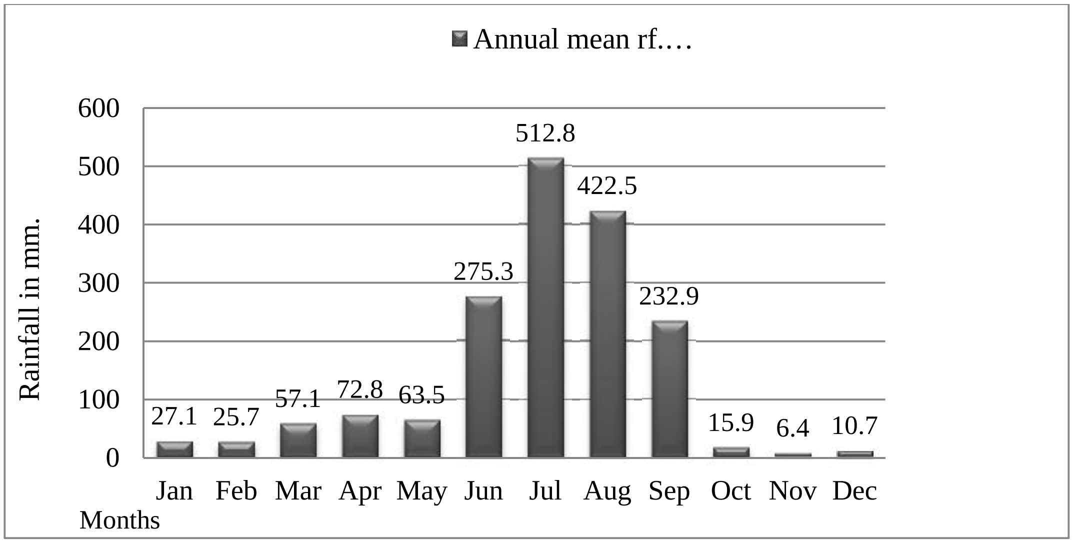


Figure 3: Mean monthly rainfall distribution of sululta woreda 2001-2013 (source: ENMA, 2014).

2.4. Drainage pattern

Muger is the most important drainage basin which together with its tributary Duber, Gorfo Aleltu, Laga Dima, Sibilu, Germama and laga Dhokatu drains into Abay River that flow into the Mediterranean sea. The majorities of the study area are severely eroded by water erosion. As a result, gullies and rill erosion are in many places (SWAARDO, 2014).

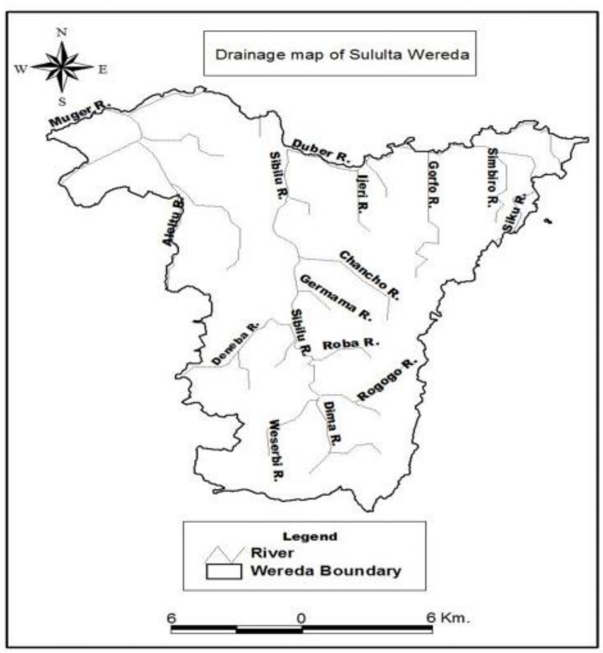


Figure 4: Drainage Map of Solulta Woreda (Topo-sheet, Ethiopian Mapping Authority 1:250,000 (NC 37-10).

2.5. Vegetation cover

The area had once been covered by forest as generalized from the remnant tree species dominated by juniper procera (Tid), oleo Africana (Woira) and podocarpus (Zigba). The surrounding mountainsides were covered with forest dominated by *Juniperus procera*, and the lower slopes supported groves of Acacia, but now most of the hillsides are covered with plantations of Eucalyptus with only the odd native tree remaining, except for the groves protected by the presence of a church. The vegetation cover has been mainly cleared to obtain cultivation fields and grazing lands (SWAARDO, 2014). Remnant indigenous vegetation such as juniper procera, oleo Africana and other species have scattered distribution. Thus, like other part of the country, the natural vegetation of the area has been degraded due to mainly human and animals influence.

2.6. Population

According to CSA, 2013 on population Projection of Ethiopia for All Regions at Woreda Level from 2014-2017 North showa have 1,733,919 total populations, of which 1,528,290 are rural people and 205,633 are people living in urban center. The study area inhabited by 156,679 total population (CSA, 2014), of whom 135,459 (86.46%) its population are rural dwellers and 21,220 (13.54%) are urban dwellers with population density of 136.1 people per km^2. The proportion of male and female in suluta woreda are 67,748 and 67,711 in rural area and 10,315 and 10,905 in urban center respectively. The woreda had 23 kebeles and 3 towns (Chancho, Duber and Derba).

2.7. Land use

The total area of Sululta woreda is 115,123 hectare. According to the data from GIS based poverty analysis and mapping in rural Oromia regional state (2012) about 71,242 hectare (61.88%) of the total land is cultivated. The rest of the area is occupied by several land uses pattern such as grassland, tree cover, and shrub (See table 1).

Table 1: Distribution of Land use/land cover in the study area in hectare.

Land use type	Area in Hectare	Percentage of woreda
Cultivated land	71,242	61.88
Tree cover	5,090	4.42
Grassland	26,080	22.65
Shrub	9,112	7.92
Timber plant	10	0.01
Bare soil	1,519	1.32
Other	2,070	1.80
Total	115,123	100

2.8. Economic activities

The dominant economic activities in the study area are crop productions integrated with livestock raisings. The crop pattern and production depends on agronomic factors such as altitude, climate, soil and rainfall. A wide variety of crops are grown in the study area. However, crop production is at subsistence level. The major factors responsible for the low productivity are increase in population growth, land scarcity, loss of soil fertility and erosion problem, shortage of farm oxen, lack of agricultural inputs, occurrence of drought, erratic nature of rainfall and pest occurrence. Livestock husbandry is also an important sector of the area's economy (SWAARDO, 2014).

Table 2: Major sources of income and their approximate shares in woreda (2013).

Types of income	Percentage
Crop production	51
Livestock	39
Handcraft	4
Trade	3
Others	3
Total	100

Source : SWAARDO, 2014

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1. Study period to collect data

The fieldwork for this study was carried out from mid February to the first week of June 2014. Three enumerators, who have completed grade ten, were recruited from each sample kebeles with the objective that they better approach and handle the farmers whom they personally know very well. Furthermore, the researcher is the resident of the area and believes that the enumerators can collect more precise data if they are assigned to the community whose socio-economic characteristics they know better. To achieve the objectives set, relevant data were collected through field survey in the study area and related documentary source were reviewed.

3.2. Types and Sources of Data

Data for this study was captured from two sources: primary and secondary sources. The main primary sources of data were farmers. Hence, field observation, focus group discussion (FGD), interviews with selected elder farmers, Woreda agricultural experts, Kebele administrators and other informants were primary data sources. In addition, secondary sources of information used for this study.

3.3. Sample design and procedures

Sululta woreda is divided in to 23 rural kebeles. Accommodating 16,422 HHHs, it was not practicable to include all the site in the survey, due to financial and time constraints. Hence, it was planned to follow the study by using sample method. Accordingly, two-stage sample design was adopted. The first stage was the selection of kebeles in the study woreda, where there is relatively high soil erosion has observed and conservation practices have been started. Purpose oriented selection of Kebeles was made to ensure meaningful representation of the area under study. Out of twenty three kebeles Lilo chebeka from Woina-dega, Kata walele and Warerso malema from Dega were selected. At this stage the researcher has taken very great care so that the selected kebeles could represent the woreda in terms of socio -

economic, physical characteristics agro-ecological zone sufficiently. The second stage was the random selection of household's heads from each sample Kebeles. This was carried using the household heads registration list that the researcher obtained from selected kebeles. About 383, 507, 419 household heads were identified in Lilo chebeka, Kata walele and Warerso malema respectively.

Based on the total household and the constraints present, the researcher opted for a sample size of 10%. Accordingly, the number of household to be included in detailed survey was fixed as presented in table 3.

Table 3: Sampling distribution of household heads in three kebeles.

Sample Kebeles	Total households	Numbers of sample households
Lilo chebeka	383	38
Kata walele	507	51
Warerso malima	419	42
Total	1,309	131

Source: SWAARDO, 2014

3.4. Methods of data collection instruments

The researcher will use different methods to gather the information about the problem under study. These methods of data collection instrument employed include quantitative data (household survey) and qualitative data (interview guides for kebele leaders and elders persons, interview at woreda expert or DAs, as well as FGD and reviewing of documentary sources).

3.4. 1. Household survey

Structural questionnaire was used to obtain the household's overall Socio-economic characteristics. It includes, among others, questions on demographic characteristic of the household, land holding characteristics of the respondent and their perception, soil erosion indicator, cause and its impact and possible soil conservation practices.

3.4.2. Interview guide

Interview is prepared to direct the interviews to be conducted with employee (environmental experts) of woreda Agricultural office, elder person in the selected kebeles. The purpose of this guide is to secure additional data that may not be clearly secured the questionnaires to be filled by respondents. It is also designed in such a way that it helps the interviews and the interviewees focus the discussion on issues related to the research questions. Thus, this interview is meant to secure only relevant data that could not be obtained through other means of data collecting tools.

3.4.3. Focus group discussion

Focus group discussions and field observations were also made to substantiate the data obtained by interviews and questionnaires. Discussions were made with group of different individuals in the community. The researcher has also made field observations and tried to grasp knowledge on some of the environmental and socio-economic conditions of the farmers.

3.4.4. Review of documentary sources

Research results, documents and other related literature were used as secondary data in this research. Several libraries, document centers and offices were visited in order to obtain the secondary data used in this paper.

3.5.Data analysis and Presentation

Questionnaires and different socio-economic data which are gathered from respondents will quantitatively analyze and presented in table, graph, chart and percentage. In addition to this the data analyzed by descriptive and frequency using Statistics Package for Social Sciences (SPSS) software and Microsoft Excel. Discussion held with DAs, key information on soil erosion problem and conservation measures will analyzed qualitatively. The data which are gathered through field observation, interview, and focus group discussion will qualitatively analyze and presented.

CHAPTER FOUR

4. REVIEW OF RELATED LITERATURES

4.1. Definition and concept of land degradation

According to Teka (2010) land degradation refers to the decline in quality of the land. As Catherine, *et al.*, (2009) stated land degradation is the consequence of multiple processes such as increasing population, intense land cultivation, uncontrolled grazing, and deforestation often lead to, or exacerbate, soil erosion (Bewket, and Sterk, G. 2002), physical factors like climate, soil properties, topography and vegetation characteristics (Mitiku *et al.*, 2006) that directly and indirectly reduce the utility of land. Land degradation has been a major global issue during the 20th century and remains to be high as one the international agenda of the 21st century (Lal, 2001). Land degradation becomes one of the major global environmental issues because of its impact on global food security, quality of the environment, lowering of the land productivity (Young, 1997). Similarly, land degradation is a major environmental threat to the sustainability of agricultural productivity and provision of food security to many people in Ethiopia (Bedru, *et al.*, 2006).

UNEP (1992) defines land degradation as a reduction of resource potential by one or combination of processes-including water and wind erosion, a long-term reduction in the amount or diversity of natural vegetation, salinization, or sodification acting on the land. In addition, defined by the FAO as a "process which lowers the current and/or potential capability of soil to produce goods and services", land degradation is a composite term. The extent and type of problems experienced depend upon scale and nature of external pressures combined with the sensitivity and resilience of the land itself-determined by on soil character and management.

From the various components of land degradation, the present research focuses to investigate the extent, drivers and measures of soil erosion. The processes leading to land degradation, erosion by water accounts for 56% of the total degraded land surface of the world (Oldeman *et al*., 1990) and Teka (2010) have shown that the main cause of land degradation in Ethiopia is soil erosion. The erosion in Ethiopian highlands, amounting to nearly one billion tons of soil lost each year is due to natural causes exacerbated by human activities, particularly overgrazing, over cultivation and deforestation. This view has been supported in the work of Tamirie Hawando (1995). In addition, Yohannes (1999) reported that many environmentalists, policy makers and researchers agree that land degradation mainly caused by soil erosion has been one of the chronic problems in Ethiopia.

4.2. Concepts of soil erosion

Soil erosion was defined earlier by Bennet (1939) as the vastly accelerated process of soil removal brought about by human interferences with the normal equilibrium between soil building and soil removal. Also Catherine, *et al.*, (2009) explained that soil erosion is the wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice melt, gravity and anthropogenic agents. By removing the most fertile topsoil, erosion reduces soil productivity and, where soils are shallow, may lead to an irreversible loss of natural farmland. According to Gobin, *et al.*, (2003) soil erosion, in particular, is regarded as one of the major and most widespread forms of land degradation.

4.3. Soil Erosion in the Northern Ethiopian Highlands

The Ethiopian highlands are the centre of the economic activity of the country with over 85 percent of the country's population and 75 percent of livestock and they are the source of many of the country's major rivers (including the Blue Nile) (EHRS, 1984). These highlands occupy approximately 45 percent of the total land area of the country. Despite their importance, FAO (2000) estimated that some 50% of the highlands are significantly eroded, of which 25% are seriously eroded, and 4% have reached a point of no return. The area of cropland that constitutes 13% of Ethiopia's land mass is the leading region of soil loss, with an average erosion of 42 t $ha^{-1}yr^{-1}$ (see Table 4).

Lal (2003) estimated that the area of land affected by soil erosion through water today is about 1094 million ha at a global scale, of which 751 million ha are severely eroded. As sources cited by Deore (2005), study on global soil loss has indicated that soil loss rate in the North America is 16 ton/ha/year in Europe it ranges between 10 – 20 ton/ha/year, while in

Asia, Africa and South America between 20 and 40 tons/ha/year. According to data from Oromia Bureau of Agriculture and rural development in 2014, in Ethiopia, it is estimated that 1.5 billion tons of soil being eroded every year. Similarly in North Shewa 152-214.80 tons/ha/year soils has lost (Wold Aregay Berehe, 1996).

The Ethiopian high lands presently constitute one of the most degraded lands in Africa. Compared to other areas highland areas of the country, the rate is very high in the central and Northern highlands, indicating erosive cropping practices on steep slopes (Constable and Belshaw, 1989). If the current rate of erosion continues, some 18 % of the areas in these highlands will become completely unsuitable for cropping. This long-term affect of soil loss (unless effectively controlled) on the ecological balance and survival of a society is often not captured by cost estimates of soil erosion based only on production value for certain years. This ecological degradation threatens not only millions of Ethiopians today, but more millions of Ethiopians as yet to come (Solomon, 1994).

Table 4: Estimated rate of soil loss under various land use/land covers in Ethiopia.

Land use/land cover	% Area	Estimated soil loss ($t\ ha^{-1}\ y^{-1}$)	Total soil loss ($10^6\ t\ h^{-1}$)
Cropland	13.1	42	672
Perennial crops	1.7	8	17
Grazing and browsing land	51.0	5	312
Currently unproductive	3.8	70	325
Currently uncultivable	18.7	5	114
Forests	3.6	1	4
Wood and bush land	8.1	5	49
Total	100.0		1493

Source: Hurni, H. 1993

4.4. Drivers of soil erosion

Humberto B. and Rattan L. (2008) pointed out that anthropogenic activities involving deforestation, overgrazing, intensive cultivation, soil mismanagement, cultivation of steep slopes, and urbanization trigger and accelerate the hazard of soil erosion. Land use and management, topography, climate, and social, economic, and political conditions influence soil erosion. In developing countries, poverty is one cause of soil erosion. Resource-poor farmers lack means to establishing conservation practices delaying or completely excluding the adoption of conservation practices that reduce soil erosion risks. Subsistence agriculture forces farmers to use extractive practices on small size farm (0.5–2 ha) year after year for food production (Lal, 2007). Soil erosion on a field scale is affected by different interlinked processes and factors. The leading three human factor causes of accelerated soil erosion are: deforestation, overgrazing, and mismanagement of cultivated soils. About 35% of soil erosion is attributed to overgrazing, 30% to deforestation, and 28% to excessive cultivation (FAO, 1996) and four major natural factors affect soil erosion: climate, soil, topography, and land use (USDA, 2008).

Rainfall drives erosion according to its intensity (how hard it rains) and amount (how much it rains). It is closely related to rainfall partly through the detaching power of raindrops striking the soil surface and partly through the contribution of rain to runoff (Morgan, 1995). This applies particularly to erosion by overland flow and rills, for which intensity is generally considered to be the most important rainfall characteristic. Erodibility defines the resistance of the soil to both detachment and transport. Erodibility varies with soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical content (Morgan, 1995). The silt and clay content determines soil erodibility. Similarly, the potential ability of rainfall to cause erosion is referred to as its erosivity. When raindrops strike bare soil, practically all of the energy is consumed as work done against the soil surface in the disruption of soil aggregates, compaction of the soil surface, and splash of soil particles into the air (Rosewell *et al.,* 2000). *Erosion control in cropping land* (Anon., 2009) indicated that high-intensity rainfall creates a serious risk, as heavy rainfall on bare soil causes the soil surface to seal. Rainfall starts to run-off, increasing erosion potential as the run-off begins to concentrate.

Morgan (1995) slope length steepness and shape, on the other hand, are the topographic characteristics that most affect erosion and deposition. Erosion would normally be expected to increase with increases in slope steepness and slope length as a result of respective increases in velocity and volume of surface runoff (W.E. Larson, *et al.,* 1983: 460). Similarly, soil structure influences the ease with which soil can be eroded. Soils with a medium to fine texture, a low level of organic matter content, and weak structural development are most easily eroded. Typically these soils have low water infiltration rates and therefore are subject to high rates of water erosion and are easily displaced by wind energy (David Pimentel and Michael Burgess, 2013).

4.5. Forms of water erosion

There are various forms of water erosion such as; rain splash, overland flow/ sheet/ sub-surface flow, rill and gully erosion (Morgan, 1993). As Ann McCauley and Clain J. (2005) classified that there are three main forms of water erosion: - sheet, rill and gully erosion.

4.5.1. Sheet erosion

Sheet erosion occurs as a shallow 'sheet' of water flowing over the ground surface, resulting in the removal of a uniform layer of soil from the soil surface. Although often difficult to recognize, sheet erosion is responsible for extensive soil loss in both cultivated and non-cultivated environments. Raindrops detach the soil particles, and the detached sediment can reduce the infiltration rate by sealing the soil pores. The eroding and transporting ability of overland flow depends on the rainfall intensity, infiltration rate, slope steepness, soil properties, and vegetative cover (Fangmeier *et al*., 2006).

4.5.2. Rill erosion

G. Wall (n.d.) rill erosion results when surface runoff concentrates forming small yet well-defined channels. Rill erosion occurs due to concentrated rather than shallow flow. Runoff water that concentrates in small channels erodes soil at faster rates than interrill erosion. The force of flow and the soil particles creeping along the rill bed enlarge rills. Rill erosion is the second most common pathway of soil erosion. The rills are easily obliterated by tillage operations but can cause large soil erosion especially under intensive rains. Rill erosion is a function of soil erodibility, runoff transport capacity, and hydraulic shear of water flow. Soil erosion occurs mostly through the simultaneous action of interrill and rill erosion in accord with the steady-state sediment equation (Foster, 1982). If water concentration and flow velocity exceed the soil-specific threshold of adhesion, pre-rill erosion forms small and shallow rills with a depth of a few cm. Further development of pre-rills is called rill erosion if it forms channels up to 50 cm deep (Mitiku, 2006).

4.5.3. Gully erosion

Gullies were defined as erosion channels deeper than six inches (Peter, H and John R.M., 2002). Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and can threaten roads, fences and buildings. Gullies are relatively steep-sided watercourses which experience ephemeral flows during heavy or extended rainfall (Bruce, 2006). Humberto B. and Rattan L. (2008) continued gully erosion removes entire soil profiles in localized segments of the field. As gullies grow, more sediment is transported. Mitiku (2006) gully erosion may result from rill erosion. It forms channels deeper than 50 cm, which causes additional processes destabilizing the gully walls, such as small landslips. The rate of gully erosion depends primarily on the runoff-producing characteristics of the watershed, the drainage area, soil characteristics, the slope in the channel, and the alignment, size, and shape of the gully (Bradford *et al*., 1973).

The state of Queensland, (2006) managing Queensland's natural resources for today and tomorrow stated that vegetation is the primary, long term weapon in controlling gully erosion but structures may be needed to stabilize a gully head or to promote siltation and vegetative growth in the gully floor. While structures may be subject to decay and become less effective over time, vegetation can multiply and thrive and improve over the years.

4.6. Consequences of soil erosion

Accelerated soil erosion causes adverse agronomic, ecologic, environmental, and economic effects both on-site and off-site environments. Soil erosion does not only affect agricultural lands but it also adversely influence the quality of forest, pasture, and rangeland resources. Farmland soils are, however, more susceptible to erosion because these soils are often left bare or with little residue during the cropping seasons. Even during the growing season, row crops are susceptible to soil erosion. The on-site consequences involve primarily the reduction in soil productivity, while the off-site consequences are mostly due to the sediment and chemicals transported away from the source into natural waters by streams and depositional sites by wind (Humberto B. and Rattan L.2008). According to John Kerr and N.K. Sanghi (1992) soil erosion is a problem that imposes both on- and off-farm costs. The problem of soil erosion has been a problem ever since land was first cultivated. The consequence of soil erosion occurs both on- site and off-site. In Ethiopia, the on-site impacts of soil erosion are most frequently studied, typically by estimating the productivity losses as economic cost of soil erosion. Less well known and documented are the off-site costs of soil erosion (Eyasu, 2003).

4.6.1. On-site problems

On site effects are those that are happens at the site where erosion occurs (FAO, 1986). The primary on-site effect of erosion is the reduction of topsoil thickness, which results in soil structural degradation, soil compaction, nutrient depletion, loss of soil organic matter, poor seedling emergence, and reduced crop yields. Removal of the nutrient-rich topsoil reduces soil fertility and decreases crop yield. Soil erosion reduces the functional capacity of soils to produce crops, filter pollutants, and store Carbon and nutrients. One may argue that, according to the law of conservation of matter, soil losses by erosion in one place are compensated by the gains at another place. The problem is that the eroded soil may be deposited in locations where either no crops can be grown or it buries and inundates the crops in valleys (Ademola and Paul, 2007). In Ethiopia, the Ethiopian Highland Reclamation Study (EHRS) estimated an on-site productivity loss of 60 million Ethiopian Birr in 1986 due to soil erosion (Sutcliff, 1993).

4.6.2. Off-site problems

An off-site effect are those which occurs when runoff and sediments from one field, watershed or waterway enters to another (Santra, 2001). Aylward (2004) concluded that, regardless of the perceived seriousness of the soil erosion problem, economists and natural scientists agree that downstream or offsite effects of land-use change are in most cases perceived as negative and potentially serious. Ademola and Paul (2007) pointed out that Off-site erosion, that is, the consequences of erosion down slope or downstream, involves costs due to the consequences of sedimentation of dams (reduced production on irrigated land, reduced energy and fish production), sediment load in rivers (reduced water quality and consequent health problems, diminished aesthetic value for recreation areas, impeded navigation and costs of dredging), reclamation activities (sediment removal, buffer strip plantation), and estimating the casualties, costs of injuries, and infrastructure damage due to landslides, mud flows, and flash floods).

4.7. Soil Conservation in Ethiopia

Soil conservation in Ethiopia is not only closely related to the improvement and conservation of ecological environment, but also to the sustainable development of its agricultural sector and its economy at large. In an effort towards responding to the problem of soil erosion through application of conservation measures on erodible lands, the Ethiopian government initiated a massive soil conservation program following the 1975 land reform and established PAs, which were involved in mobilizing labor and assignment of local responsibilities (BEKELE and HOLDEN, 1998).

Between 1976 and 1990, 71,000 ha of soil and stone bunds, 233,000 ha of hillside terraces for afforestation, 12,000 km of check dams in gullied lands, 390,000 ha of closed areas for natural regeneration, 448,000 ha of land planted with different tree species, and 526,425 ha of bench terrace interventions were completed (USAID, 2000) mainly through Food-for-Work (FFW) program incentives.

The objective of the incentive emanate from the recognition that farmers do not have the necessary economic capacity to implement conservation measures, and therefore the FFW programs has been used to overcome the initial difficulties (HERWEG, 1993). And once established, a sustained or even improved production should be sufficient to persuade farmers to keep on protecting their land. However, this did not happen (HERWEG, 1993).

4.8. Methods of soil erosion management

According to the internationally approved categorization system (Liniger, *et al.,* 2002), the measures are grouped first according to land use where the technology is applied, secondly according to the degradation type addressed, and thirdly according to the conservation measures adopted. The common SWC measures have been discussed here under.

4.8.1. Biological soil-conservation techniques

According to Ministry of Agriculture (2001) biological soil conservation measures include; vegetative barriers, agronomic and soil fertility improvement practices, which help in controlling surface runoff, reduce soil losses and improve productivity.

4.8.1.1. Vegetative Measures

Vegetative measures such as grass strips, hedge barriers, and windbreaks involve the use of perennial grasses, shrubs, or trees, are of long duration, often lead to a change in slope profile, are often zoned on the contour or at right angles to wind direction, and are often spaced according to slope. Most common and widespread are vegetative strips and cover (mostly grass) and agro-forestry systems (intercropping trees with annual and perennial crops, often in a multistory system). These measures are common in humid tropical conditions where often no additional measures are needed due to good ground cover and protection of the vegetation. In semiarid conditions, where erosion as well as water stress occurs, vegetative measures also have very positive impacts such as reducing winds (wind erosion) and reducing water loss by evaporation (Humberto B. and Rattan L. 2008).

4.8.1.2. Agronomic Measures

Agronomic measures are practiced as the second line of defense in soil erosion control exercise while mechanical/physical measures are primary control measure and are often considered as reinforcement measures (MoA, 2001).

Intercropping is a practice of growing two or more crops at the same time on the same piece of land. While the principles and objectives of intercropping and mixed cropping are the same, the patterns are different. Intercropping follows specific arrangements. It is not difficult to distinguish the rows of the main crops from that of companion crops in intercropping. However, in mixed cropping, two or more crops are mixed up and broadcast over the field so that one cannot distinguish the rows of one crop from another. The aim of intercropping is to increase productivity of the land and to protect the soil against erosion. The intercrop stand makes better use of the available environmental resources. Intercropping reduces the problem of soil erosion. If properly applied intercropping could be a solution to low crop yield and soil erosion in row crops. Fodder legumes tend to produce more biomass than food legumes and the amount of nitrogen fixed is proportional to their biomass. The inclusion of forage legumes in intercropping increases the level of atmospheric nitrogen utilization. Nitrogen will be available to the main crop from root and nodule decay of intercropped leguminous crops (MoA, 2001).

Crop rotation is a practice of growing different crops one after another on the same piece of land, season after season or year after year. It is a valuable traditional practice, which plays an important role in maintaining ecological stability and improving agricultural productivity. If the same crop is grown on a piece of land year after year, the soil nutrient depletes sharply and as a result yield decreases. Nevertheless, if different crops are rotated, the depletion of soil nutrient and the decline in crop yields is minimized. Crop differs in their effect on soil. Some crops restore or build fertility of the soil, while others deplete its fertility. For instance, legumes fix atmospheric nitrogen and hence enrich soil fertility. Forage legumes and grasses provide good ground cover that protects soil erosion and enriches the soil with organic matter, which in turn improves the structure and biological activities. Cereals such as sorghum and maize deplete soil fertility (MoA, 2001).

Strip cropping refers to the practice of growing crops in alternate strips of row crops or forage/grass. This cropping system is an effective practice to reducing soil erosion because it breaks sloping landscapes in wide segments with diverse vegetative cover which intercepts runoff and promotes water infiltration, thereby reducing runoff and soil erosion. Strip cropping is often integrated with rotations where strips are planted to different crops each year. Hay, pasture or legume forages are also commonly used in strips in rotation with row crop crops. The sod or perennial grass is particularly effective at slowing runoff and filtering out sediment. Strip cropping established perpendicular to the dominant slope reduces soil erosion as compared to bare soil or up-down slope cropping or tillage. Crop yields between strip cropping and monocultures may not significantly differ in most cases, but the greatest benefit with strip cropping is to soil erosion control. Strip cropping may also be used in nearly flat terrains to reduce wind erosion. Risks of water and wind erosion increase with increase in strip width. Proper spacing of strips is important to effectively reduce soil erosion. Poorly designed strips may actually increase runoff and soil erosion if they concentrate runoff and have sparse and temporary vegetative cover (Humberto B. and Rattan L.2008).

4.8.2. Structural Soil Conservation Methods

Physical or structural measures include earthworks aimed at controlling and diverting the run off in the arable areas. Structural soil conservation methods control erosion by shortening the length and minimizing the gradient of the ground slope. This technique involves construction of tied ridges, bunds, *fanya juu* terraces, bench terraces, hillside terraces, diversified ditches (cutoffs) water ways and special water harvesting structures (MoA, 1986 quoted in Aklilu, 2001). Some of structural soil conservation methods have discussed below.

4.8.2.1. Stone bunds

Stone bunds are generally quite common in the dry zones of the tropics, since they are relatively easy to construct during the dry season. They are barriers of stones placed at regular intervals along the contour. They have been used for generations in Ethiopia where they are locally known as "*daagaa*". The size of the stone bunds varies between 0.5-2m and may be 5 to 10m apart, depending on the availability of stones and the topography. Stone bunds retain or slow down run off and hence control erosion. They also allow the accumulation of soil, which may be redistributed after the bunds are (Humberto B. and Rattan L. (2008)**.** Structural measures are very well recognized and have often been seen as the main measures in combating soil erosion.

4.8.2.2. Soil bunds

Soil bunds are constructed during the dry season that do not interfere land preparation for cropping. The construction is aimed on reduction and stopping velocity of runoff. It increases soil productivity by capturing moisture and crop yields over time. Soil bunds can easily be integrated with grasses, legume shrubs, growing cash crops such as tomatoes after their development. Grazing animals on bunds damage the structures. Construction of soil bunds is always started from the top of the watershed area/slope and from the waterway. If the bund construction is started from the bottom of the watershed area and if it is not completed in one season, then all water from the top of watershed area will destroy the lower one (Taffa, 1983).

4.8.2.3. Fanya juu

Fanya juu is an embankment constructed by throwing the soil dug from basin to uphill and the term was coined from Swahili language; meaning "throwing up-hill" (Woldeamlak, 2003). This conservation structure is also constructed during dry season. The aim is to reduce and stop erosion and increase water holding capacity of the soil so as to enhance crop yield. The main benefit of *fanya juu* is its capacity to become bench terrace within few years than soil bunds, yet it has overtopping and breakages (Lakew *et al.,* 2005).

4.8.2.4. Waterway

Waterways can be natural or manmade drainage channel to receive diverted runoff from cutoff drains in upper slope. The waterway carries the excess runoff to rivers, reservoirs, or gullies safely without causing more erosion damages. A vegetative waterway construction has better attention where the stone is absent. This is applicable in all agro-ecological conditions, especially in moist area and area prone to water logging (Lakew *et al.,* 2005).

4.8.2.5. Check dams

According to Lakew *et al., (*2005) check dams for the gully control may be made of stones, soils or brush-woods. In the study area stone is hardly enough to make check dams. Dominantly, the brush-woods and soil are used to construct check dams. Diverting runoff from cultivation field to the main and community road is very common in the study area. Nowadays, creation of awareness among community supported the gully rehabilitation and use of brushwood and stone check dams (if available) in the community roads and in farm fields. Tree branches and grassed soil are used traditionally, and effectiveness is constrained by erosivity of rainfall and size of channel.

4.8.3. Management Measures

Management measures (such as land-use change, area closure, and rotational grazing) involve a fundamental change in land use, involve no agronomic and structural measures, often result in improved vegetative cover, and often reduce the intensity of use. These measures often apply to grazing land management, where uncontrolled management has led to degradation, and where all other measures do not work without a major change in land management (Ademola and Paul 2007). As Hurni H., *et al.,* (2005) stated management measures can achieve remarkable results with low investments. For instance, badly overgrazed and degraded rangelands can recover rapidly after a reduction of grazing pressure and introduction of a rotational system of grazing and resting.

CHAPTER FIVE

5. RESULT AND DISCUSSIONS

5.1. Causes of Soil Erosion

A list top rank of causes of soil erosion by FAO (1996) shows about 35% of soil erosion is attributed to overgrazing, 30% to deforestation, and 28% to excessive cultivation. Forest resources play a major role in the social and economic development of many nations in addition to its protective function of the environment. Over 90 % the wood consumed in developing countries constitutes fuel wood, which accounts for about 90 percent of total energy consumption (EFAP, 1998). In the study area, forest is exploited for various purposes by local community. Among them exploitation for the purpose of fuel wood and making charcoal, construction material and furniture making took the leading. 95% farmers in group discussion and 129 of the respondent farmers believed that forests and woodlands are key components of the environment and provide essential services that are critical to combating soil erosion and climate change. On the contrary, deforestation is one of the major environmental issues that bring soil erosion problem.

Figure 5: Deforested land along Aleltu River (Field survey, 2014)

Figure 6: Photo shows deforested area in Warerso malima kebele (Field survey, 2014)

Almost all of the farmers believed that the land should rest for a period of time after some years of cultivation. To this extent 128 respondents (18.29%) argued that continuous cultivation or absence of fallowing is one of the reasons for the causes of soil erosion and repeated preparation of the land for cropping facilitates the soil easy for soil erosion. 17.71% of the responses indicated that the relationship between overgrazing and erosion as animal hooves expose soil by removing grass and other vegetation. What is clearly observed by farmers is that their land is less eroded when there is good plant coverage.

Figure 7: Photo shows overgrazed area in Lilo chebeka kebele (Field survey, 2014).

According to Gizaw *et al.,* (2009) soil erosion in association with inappropriate land management practices is one of the main factors causing degradation. Poor land and water management practices and lack of effective planning and implementation approaches for soil conservation are responsible for accelerating degradation on agricultural lands. In the study area 14% of the responses of farmer put lack or absence of sustainable land management as reason of soil erosion.

Insufficient supplies of fertilizer (cow dung) and farmers' inability to use were account 6.57% for the cause of soil erosion in the study area. Farmers do understand the severity of erosion on steep lands from their life experiences. 62 farmers were attributed the causes for soil erosion as slope steepness. Moreover, 9% and 3.86% of responses of the farmers considered the high intensity of rainfall (i.e. erosivity) and intensive cultivation as causes of soil erosion in their land. The other causes of soil erosion in the study area are the soil characteristics (i.e. erodibility) and desertification which account 1% and 2.29% of the responses respectively.

Table 5: Distribution of HHHs by causes of soil erosion.

Causes of soil erosion	Frequency of responses		Rank
	No	%	
Slope steepness of the cultivated land	62	8.85	6
absence of fallowing	128	18.29	2
Intensive cultivation	27	3.86	8
Soil erodibility	7	1.00	10
Intensity of rainfall	63	9.00	5
Absence or lack of SLM	98	14.00	4
Lack of fertilizers	46	6.57	7
Desertification	16	2.29	9
Deforestation	129	18.43	1
Overgrazing	124	17.71	3
Total	700	100.00	-

Source: Field survey, 2014

5.2. Types and severity of soil erosion

On focus group discussion not a single farmer mentioned any erosion risk on their farm plots and similar results are also from filled questionnaires by sample farmers. Severe erosion continues to affect the farmer's agricultural land and their livelihoods (Kibemo, 2011). The finding of the area shows severe soil erosion is about 52.7% of the farmers were responded. The number of households that identified the moderate degree of soil erosion was 52.7%. Only about 6.1% of farmers indicated that there is minor erosion problem on their farms. These variations in perception upon the degree of soil erosion among the farmers might be due to the topography setting of their farmland.

Table 6: Farmers' Perception of Soil Erosion by Degree of Severity.

Degree of erosion	Frequency	Percent
Severe	69	52.7
Moderate	54	41.2
Minor	8	6.1
Total	131	100.0

As Ann McCauley and Clain J. (2005) classified that there are three main forms of water erosion: - sheet, rill and gully erosion. Similarly based on the responses from the interviewed household's sheet erosion, rill erosion and gully erosion are the predominant forms of soil erosion in the study area. Wall (n.d.) said that rill erosion is the second most common pathway of soil erosion. According to the respondent from the area (45.8%) rill erosion occurred than the gully and sheet erosion. Gullies erosion was defined as erosion channels deeper than six inches (Peter, 2002) and the second (40.5%) types of erosion. Similarly, sheet erosion is account 13.7% in the study area.

Table 7: Farmers' Perception on types of soil erosion.

Types of erosion	Frequency	Percent
Sheet erosion	18	13.7
Rill erosion	60	45.8
Gully erosion	53	40.5
Total	131	100.0

5.3. Indicators of soil erosion

According to Mitiku *et al.,(*2006) visible erosion features, such as rills, gullies and concentrated accumulations are features that often indicate erosion of hot spots, those parts of an area that are most seriously affected by soil erosion. The evidence of the on-going soil erosion was demonstrated with identification of several onsite erosion indicators in the study area. 33.69% and 21.93% of the farmer's responses respectively suggested that poor crop productions and absence of fertile topsoil are the major indicators of the existence of moderate to severe soil erosion problems on their cultivated fields.

About 20.32% responses of the farmers were verified that exposed of underground rock on farmland area as indicators for soil erosion. Others described the existence of severe soil erosion problem by observing the rill and gully development (15.24%) and root exposure is 5.08%. From the indicator of soil erosion in the study area which accounts 3.74% of the responses is the slope of the plots greatly influences the rate of erosion by water. The slope is one of the observable indictor in the erosion process that prompts farmers to monitor erosion.

Table 8: Distribution of HHHs by indicators of soil erosion.

Indicators of soil erosion	Frequency of responses		Rank
	No	%	
Rill and gully development	57	15.24	4
Exposed underground rock	76	20.32	3
Slope steepness	14	3.74	6
Absence of fertile top soil	82	21.93	2
Root exposure	19	5.08	5
Poor crop productions	126	33.69	1
Total	374	100.00	-

Source: Field survey, 2014

5.4. Impact of soil erosion on the farm-land

The effect of soil erosion has serious social and economic repercussions for rural households relying on land cultivation. The impact of soil erosion are in line with what was reported by John Kerr and N.K. Sanghi (1992), the primary on-site effect of erosion is the reduction of topsoil thickness, which results in soil structural degradation, soil compaction, nutrient depletion, loss of soil organic matter, poor seedling emergence, and reduced crop yields. Based on the responses from the respondent households 21.75% identified losses of top soil and 18.96% of the responses stated that the consequence of soil erosion tends to be reduction of yield over time. Removal of the nutrient-rich topsoil reduces soil fertility and decreases crop yield. John Kerr and N.K. Sanghi (1992) reported that soil erosion reduces the functional capacity of soils to produce crops, filter pollutants, and store Carbon and nutrients. The number of households who responded the soil erosion led to loss of high input demand was 89. Mitiku (2006) gully erosion may result from rill erosion. It forms channels deeper than 50 cm, which causes additional processes destabilizing the gully walls; such as small landslips and 73 responses of the respondents were indicated soil erosion bring expansion gullies. About 10.22% of the responses approved that loss of vegetation cover was the impact of soil erosion in the study environment. Impact of soil erosion means a loss of land productivity with reduced farm income which directly affects the livelihoods of the rural population within the area. The finding of this study shows 7.62% of the responses or 41 people migrate out ward in line with land productivities reduced. Desertification supported by 38 of respondents as the impact of soil erosion and Ann Gobin *et al.,* (2003) reported soil erosion, in particular, is regarded as one of the major and most widespread forms of land degradation and, as such, poses severe limitations to sustainable agricultural land use. 4.28% of the responses in the study area identified the impact of soil erosion as loss of farm land and grazing land.

Table 9: Distribution of HHHs by their perception on impacts of soil erosion.

Impact of soil erosion	Frequency of responses		Rank
	No	%	
Loss of topsoil	117	21.75	1
Reduction of yield	102	18.96	2
Expansion of gullies	73	13.57	4
Loss of vegetation cover	55	10.22	5
Outmigration	41	7.62	6
High input demand	89	16.54	3
Desertification	38	7.06	7
Loss of farm and grazing land	23	4.28	8
Total	538	100.00	

Source: Field survey, 2014

5.5. Adoption and practicing of soil conservation technologies

The qualitative evidence from farmer in group discussion, key informant farmer and expert the government has implemented soil-water conservation activities, such as construction of physical structures to reduce overland flow thereby preventing removal of soil, soil fertility improvement practices (compost application), agro-forestry and reforestation of deforested hilly areas. Various major soil-water conservation practices have been identified by the local DAs in the study area within the previous five years. Direct observation and interviews with farmers indicated that there were some initiatives, but there was still a long way to go.

Most farmers are taking various measures to control soil-water erosion in the study villages. In the study area, the SWC technologies under implementation were physical structures: soil bunds, stone bunds, cutoff drains, check dam, waterway and biological measures.

Stone bunds are generally quite common in the dry zones of the tropics, since they are relatively easy to construct during the dry season (Humberto B. and Rattan L. 2008). The Stone bunds retain or slow down run off and hence control erosion. The result indicated that about 30.6% of the respondents prefer this type of structural soil conservation measures.

Figure 8: Photo shows stone bunds in Warerso malima (Field survey, 2014).

Soil bunds practicing by farmer in the study area account 24.4% and 22.1% of the farmers used other (agronomic soil conservation for instance contour plough and crop rotation) as effective methods of erosion control. 6.9% of the farmers' cutoff drains to prevent loss of seeds, fertilizers, manure and soil due to water flowing onto the plot from uphill. The excess water is disposed away from the field. However, Belay Teshome, an expert of land and resource management of sululta woreda Agricultural and rural development tells" a *cutoff drain causes several gullies between farm boundaries by effecting more and more erosion"*.

Figure 9: Cutoff drains in Kata Walele (Field Survey, 2014)

Check dams for the gully control may be made of stones, soils or brush-woods. In the study area stone is hardly enough to make check dams. Diverting runoff from cultivation field to the main and community road is very common in the study area. Nowadays, creation of awareness among community supported the gully rehabilitation and use of brushwood and stone check dams in the community roads and in farm fields. The study showed 5.3% of the farmers used this method.

Figure 10: Photo shows gully rehabilitation in Warerso Malima (Field Survey, 2014).

Other method of controlling soil erosion in the study area according to the farmers' response was waterways (10.7%). This method can receive diverted runoff from cutoff drains in upper slope. The waterway carries the excess runoff to rivers, reservoirs, or gullies safely without causing more erosion damages.

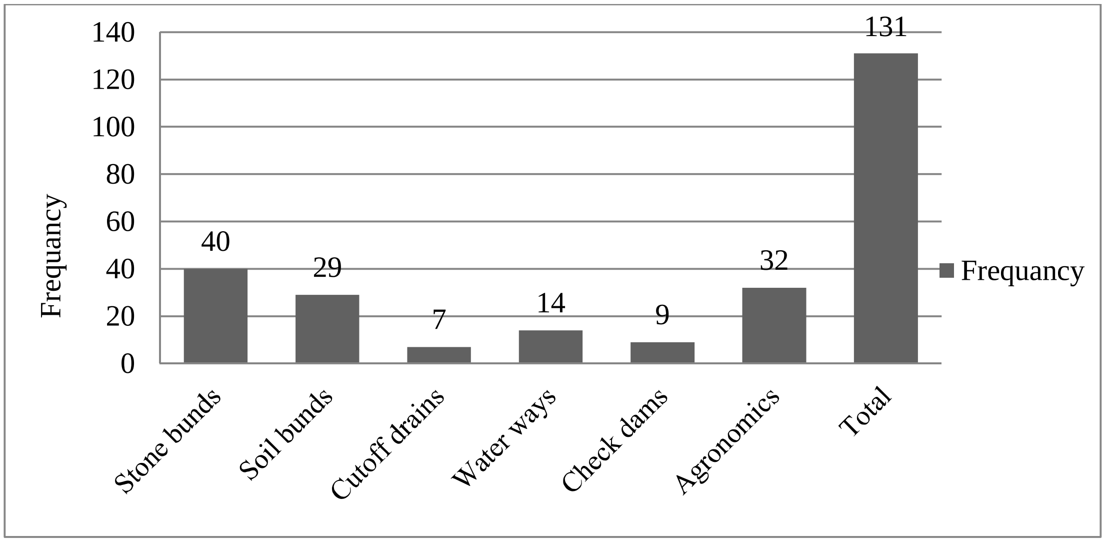


Figure 11: Distribution of soil conservation practices in the study area

According to the result 70.2%, 28.2% and 1.5% are respectively cultivation field, on both (cultivation and grazing) and grazing land needs specific types of conservation in the study area. The perception of the households as to the plot need specific types of conservation is in line with studies conducted by Yohanes and Dubale quoted by Kassu (2011) who reported that the erosion is most severe in cultivated lands with an average loss of 42 tons per hectare per year.

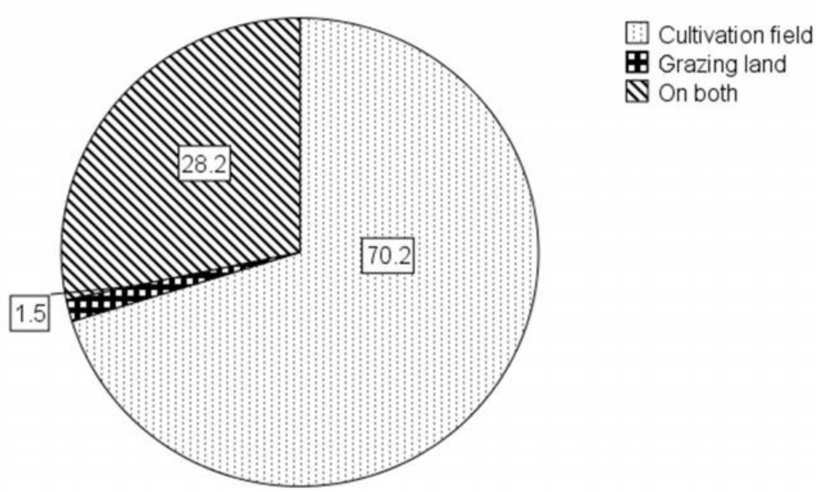


Figure 12: Plots need specific types of conservation

5.6. Factors affecting measures of soil-water conservation practices

Farmers' application of soil conservation techniques could possibly be influenced by different factor. Among major factors age, sex, household size, landholding size, slope of the land, educational attainment of the household heads and fertility and productivity of the soil were mentioned by many surveyed farmers. In addition, distance from the homestead, lack of information on soil conservation measures, level of contact with Development Agent (DAs) and training on soil conservation techniques into the area have as well significant influences the practices of soil conservation measures. The major factors affecting the measures of soil-water conservation have been widely discussed hereunder.

5.6.1. Age and sex characteristics of households

According to the data from the sample households the agricultural works are dominantly practiced by male headed farmers. Out of randomly taken 131sample households, 89.3% were male headed households while remaining 10.7% were headed by female farmers. Even in group discussion held with 10 farmers, there were only 2 female farmers. As per the respondents, females become head of households upon the death of their husbands.

Figure 13: Participants of group discussion with the farmers in Warerso Malima kebele.

Out of 131 sample household 94 (71.8%) of respondents suggested that there is a difference in soil-water conservation practices among male and female farmers. But 37(28.2%) of farmers argued that male and female farmers can equally practice the soil conservation measures. However, digging is very difficult in stony and steep slope land for females. A study conducted in Konso, Wolita and Wello, Ethiopia by Tesfaye (2003) reported that old age and heavy tasks were not suitable for female-headed households. Female farmers need support from male to construct soil-water conservation structures on their farming plot. The soil conservation measures by nature require much labor and are as well expensive in terms of equipment and time. For instance, designing and digging of soil bunds, stone bunds, *fanya juu* and check dams takes prolonged time, require large number of labor and resource.

The interviewed female farmers have an interest to construct soil-water conservation measures that need large number of labor, but they need the support from others. As a result, the majority of female farmers who depend on farming excluded the construction of soil bunds, *fanya juu,* check dam and trench digging. They have been practicing cutoff drains, waterways and biological and agronomic soil conservation techniques in combination and/or separately. As usual, females have much work load and home care in spite of involvement in farm activities that needs much effort and investment so as to increase production.

Farmers who are involved in share cropping and rented land did not construct permanent and effective conservation structures as they cultivate the land only for period of time depending on the agreement made with the land owner. Moreover, some farmers who are engaged on share cropping or leased the land refuse to maintain the existing structural soil conservation measures. Farmers in focus group discussion argued that family with large number of females in household tends to reject soil-water conservation practices especially soil bunds, check dam and trench digging than family with many male in the household. Instead, they prefer construction of cutoff drains with the combination of other agronomic measures.

According to data shown below about 90.2% of respondents are below 60 years while 9.2% are above 61 years and the average age of household heads is 44.06 years. Despite its role in accumulation of experiences and having deeper knowledge of the field, age is a factor of soil conservation. Age is believed to influence adoption decision because of its influence on planning horizon (Long L., 2003). Conservation measures such as terrace are long term investments (Lee and Stewart, 1983). But, the aged farmers have troubles with practicing soil conservation on their fields and usually have short planning horizon. Older farmers couldn't make soil conservation practices that require work hard which would not be accomplished by aged persons. On the other hand, aged persons practice less labor demanding technologies such as simple cutoff drains, contour ploughing, planting grasses and use of other agronomic conservation measures. This practice also reflects that aged farmers are practicing short-staying structures in their cultivation field which also allow free movement and take smaller pieces of land.

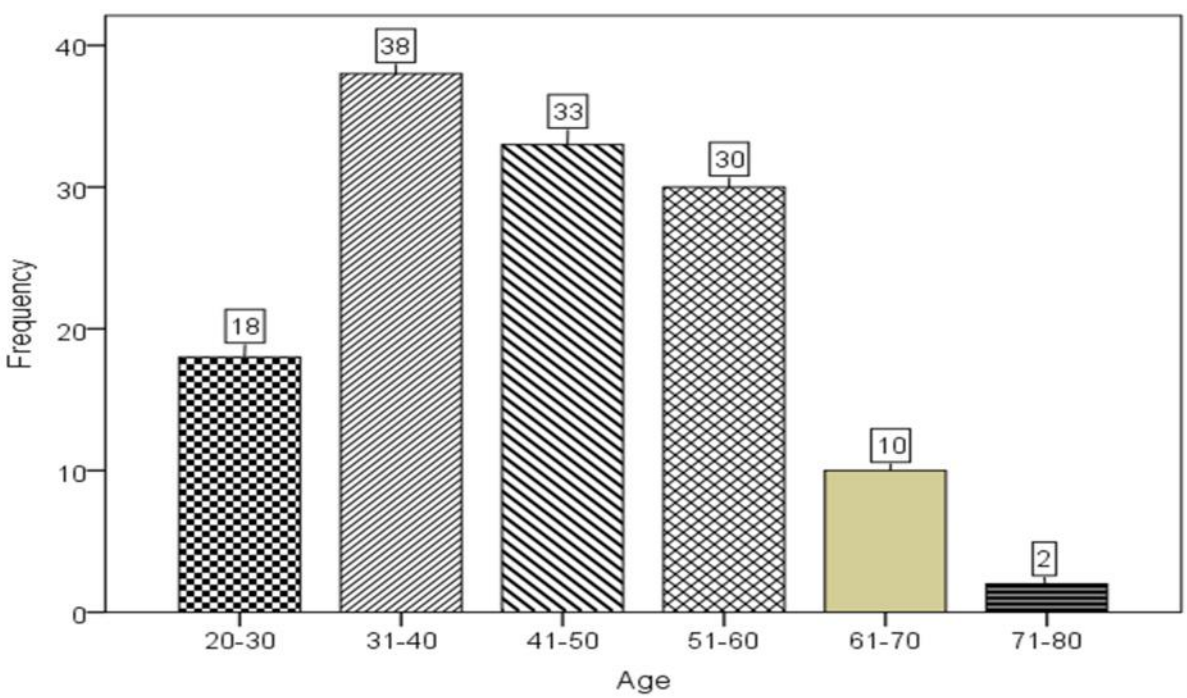


Figure 14: Distribution of sample HHHs by Age groups.

5.6.2. Educational status of respondents

Educational level affects the household decision which determines the fertility, productivity and the overall health of the land resources. It also enhances the knowledge and experience of the households. Out of 131 respondents more than half of sampled households (79.4%) reported that they have attended the literacy campaign launched by the previous government. Low level of education and high illiteracy rate is typical in developing countries like Ethiopia. In the study area 53.4 % of the sample household heads are unable to read and write and 26% can read and write. 13.7% completed primary education and 6.9% completed secondary education.

Table 10: Distribution of Educational levels of the household heads.

Education status of respondents	Frequency	Percent
Cannot read and write	70	53.4
Read and write	34	26.0
Completed primary education	18	13.7
Completed secondary education	9	6.9
Total	131	100.0

Source: Field survey, 2014

As a result, farming sector of the study area is dominated by illiterate farmers. Based on this fact, educational attainment of the farmers was examined whether it has significant impact on practice of soil-water conservation measures. In my study, the researcher assessed that farmers' perception on expression of soil erosion problems has shown difference among literate and illiterate farmers.

The effect of farmers' educational attainment on practicing of soil-water conservation was significant. Farmers on focus group discussion argued that higher literacy level of farmers could have brought differences among farmers in practicing soil-water conservation measures on their land and have soil conservation practices in general. Accordingly, from sample HHHs taken in the study, 13.7% of farmers who completed primary education level were much interested and have been practicing soil-water conservation techniques on their fields. 6.9% farmers who completed secondary education and engaged on agrarian sector well practicing soil- water conservation on the field. This result supported by the finding of Paulos *et al*., (2001) that explained educated farmers tend to be better at recognizing the risks associated with soil erosion and tends to spend more time and money on soil conservation.

5.6.3. Household and landholding sizes

Land availability often influences farming practice and affects the land degradation process. Most of the agricultural land in the study area has so far been subdivided to the smallest land holdings that are no longer economically viable for smallholders' subsistence. Farmers' responses also revealed the existing land shortage. Out of 131 sample household farmers, about 76.4 % of households reported that their present landholdings are too small (less than 1.5 hectare) compared to the land needs of the household and they are not in a position to inherit land to their children.

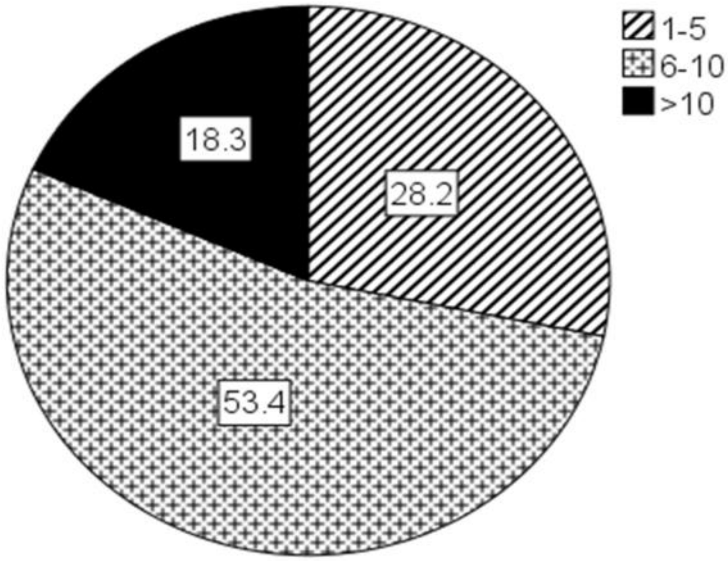


Figure 15: Distribution of Household size of the sample households.

Young male farmers used to inherit land from their parents when they get married. However, multigenerational households, with married children living with parents until their death, have become more common as household land holdings have decreased.

The size of family members can be seen from different angles. Firstly, if the household size is larger with many mouths to eat rather than to work, will have negative effect on practices of soil-water conservation measures. Secondly, the reality of soil-water conservation technique needs optimistically tied with higher labor forces in the household. In other words, when the majority of family members are capable of working (between the age of 15 and 64, CSA, 2007) soil-water conservation measures tend to positively correlate with large family sizes. Hence, interviewed farmers argued that soil conservation technologies are positively associated with large household sizes significantly. So that the possible clarification is that with the increase of household size, there is a rise on practice of soil-water conservation measures. In the study area, farmers who have small household size, require additional labor to construct and maintain soil conservation structures.

5.6.4. Average distance of farming lands away from the home stead

61.1% of farmer respondents had farmland that are more than 20 minutes walk distance away from their residence and only 2.3 % had cultivable land less than 5 minutes walking distance or near their residence. The average walking distance for all farmers to reach their plots is about 31.16 minute. According to interview with an expert of Natural resource management, Ato Belay Teshome said "If *the farmland is far away from the household's residence, it leads spending more time on journey to the parcel and discourages labor. Thus farmers prefer to conserve in the nearest plot. Therefore, the variable would have strong significant influence on the practicing decision and crop productivity of the plot"*. During the focus group discussion it was indicated that farmers having land far from their residence usually do not give visit to their cultivation field except during harvesting and planting season. During slack season, livestock roam on the field freely and destroy bunds. Hence, farmlands situated far from residence suffer from destruction of conservation structures and enhanced erosion.

Table 11: Ownership status and distribution of plot in terms of time consume to reach.

Average distance of farmland from home	Means of accessing farmland				Total
	Renting	Share cropping	Inheritance	Kebeles official allocation	
less than 5 minutes walk	1	1	0	1	3
6-10 minutes' walk	5	5	5	5	20
11-20 minutes' walk	8	4	8	8	28
21-40 minutes' walk	3	3	16	14	36
41 minutes- 1 hour walk	3	13	18	10	44
Total	20	26	47	38	131

Source: Field survey, 2014

The study also indicated that the farmers can obtain cultivation land from parents 47(35.9%) and 38 (29%), from kebeles official allocation. Sharecropping has become one of the means to augment food production when either land or labor/oxen is in short supply (Tesfaye, 2003). In the area through share cropping was 26 (19.8%) and the remaining 20 (15.3%) indicated that they can obtain land by renting. Although land is becoming scarce in the study area and the majority or 93.1% of the respondents indicated that land is not sufficient to support the livelihood of the household. Only 6.9% of respondents opted the farmland is sufficient to support their household members.

The farmers were also asked to categorize the causes for the scarcity of cultivable land. About 57.3% of them noted land degradation (loss of fertile soil due to erosion) as the main causes for the scarcity of cultivable land. The sharp increase of the population density in Ethiopia since the early 70ies pressure on landscape stability is extremely high (Stefan Thiemann *et al*., 2005) and 33.6 % of the cases reported that due to population pressure. 5.3% and 3.1% are because of the land taken by government and investors respectively.

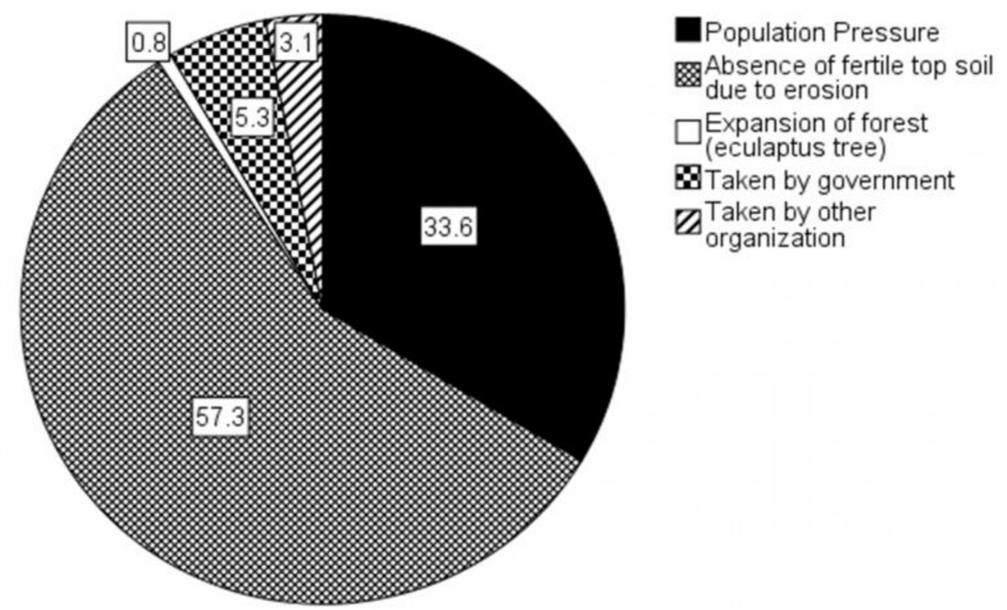


Figure 16: Distribution of major factors that contribute to agricultural land decreasing.

Also farmers suggested the possible solutions for this cultivable land scarcity to be resettlement (1.5%), migration to urban areas (9.2%), involvement in off-farm activities (small scale trading, daily laborers, etc (22.9%), increasing the existing land productivity by using soil conservation and improved seeds (65.6%). One (0.8%) of the farmers suggested expanding cultivable land by clearing forest and communal land. The interest of many farmers in this area was to reduce the pressure on their land by increasing the productivity of the land using modern technologies and providing access for non-farm activities.

Table 12: Means to overcoming shortage of farm-land.

Means of overcoming	Frequency	Percent
Going to resettlement area.	2	1.5
Migration to other area(urban area)	12	9.2
Involving in non-farm activities	30	22.9
Increasing the productivity of the land using modern technologies (inputs).	86	65.6
Increasing farmland through clearing forest and common land.	1	0.8
Total	131	100.0

5.6.5. Fertility and productivity of the farm-land

Farmers easily identify indicators of soil fertility. Commonly mentioned indicators are: decline of crop productivity, difficult workability and emergence of noxious weeds. For instance, the decline of crop productivity is further explained by stunted crop growth, a yellowish leaf color, and small head-setting. Almost all 123 (93.9%) of farmers have confirmed that productivity of farmland was decreasing overtime. In line with farmers' response Ato Belay Teshome, who is an expert on natural resource management in Sululta woreda, said that:-

> *The major indicators of fertility decline were yield decline, requires high fertilizer and management, changes in soil color, changes in texture and structures, absence of grasses and vegetation cover, and presence of exposed and bare abandoned land.*

It is also evident from the respondent farmers in the study area confirmed that low and very low fertility of the farmland are 72 (55%) and 43 (32.8%) respectively and 13 (9.9%) said fertility of soil is medium. Farmers possess a detailed knowledge of soil fertility they are cultivating. Farmers that attended on the focus group discussion also confirmed that less fertile land requires much fertilizer inputs in order to compensate deficit elements of the soil even, provision of chemical fertilizer was low and costly to apply. Moreover, they complained that application of natural manure was hindered by declining numbers of livestock owing to the shortage of grazing lands. Some major causes of soil fertility decline are similarly mentioned as major causes of soil erosion.

Table 13: Productivity of farmlands by fertility status.

Productivity of farm-land	Fertility of farm-land				Total
	very high	Medium	Low	Very low	
increasing over time	0	0	1	1	2
decreasing over time	3	12	69	39	123
Almost the same	0	1	2	3	6
Total	3	13	72	43	131

Source: Field survey, 2014

The yields of most farm-lands in the study area are affected by many factors. Of which absence of fallowing and continuous cultivation account 32.1%, and high cost of chemical fertilizer to apply on the field account 5.4%. Accordingly one farmer suggests:

> *Eshetu Tamirat said fertilizer and manure are negatively related to one another. Fertilizer is expensive in prices and inadequate in supply but less demanding of labor in its application. Manure in most of the cases is freely available but labor intensive in transportation and application.*

Prevalence of unreliable rainfall especially early end and late onset of the main rainy (*Kiremt*) season and failure of the smaller rainy (*Belg*) season with intensive rainfall washes away the top fertile soil account 16.25% of the responses, soil erosion 39.58% and over cultivation 6.67% are the reasons to yield decline.

Table 14: Distribution of responses of sample HHHs concerning causes of decreasing yield.

Probable causes of decreasing yield	Frequency of responses	
	No	%
Absence of fallowing	77	32.08
High cost of chemical fertilizers	13	5.42
Unreliable rainfall	39	16.25
Soil erosion	95	39.58
Over cultivation	16	6.67
Total	240	100.0

5.6.6. Information and training on soil-water conservation technologies from DAs

As the response from key informant farmers who have got information from DAs and in line with this respondent filled the questionnaires were 62.6 % of the respondents reported that they have training on soil conservation once in the year, 21.4% three times in five year and 9.9% twice in five years. But others (6.1%) there are the so called “model farmers “get more than two times training in one year. The major source of information concerning soil conservation is woreda agricultural office through their DAs which holds about 94.7%, 3.9% were from their neighbors’ and from NGOs were 1.5%. Access for information and contact with DAs has a role on the practice of soil conservation measures. Having good relation with DAs helps farmers in reducing hazard associated with soil erosion and conservation structures by providing information. Out of 131 sample house hold heads 93.9% have contact with DAs and 6.1% has no relation. In terms of relationship with soil conservation expert many studies pointed out that, the farther a village is from the place of residence of the extension agents, the less likely it is to be visited by the extension agents. The nearest reside peasant to the agent have more contact with the agents. The below data shows 47.3% have limited contact, 35.1% have good contact, 13% was very good and none relationship was 4.6% in the study area.

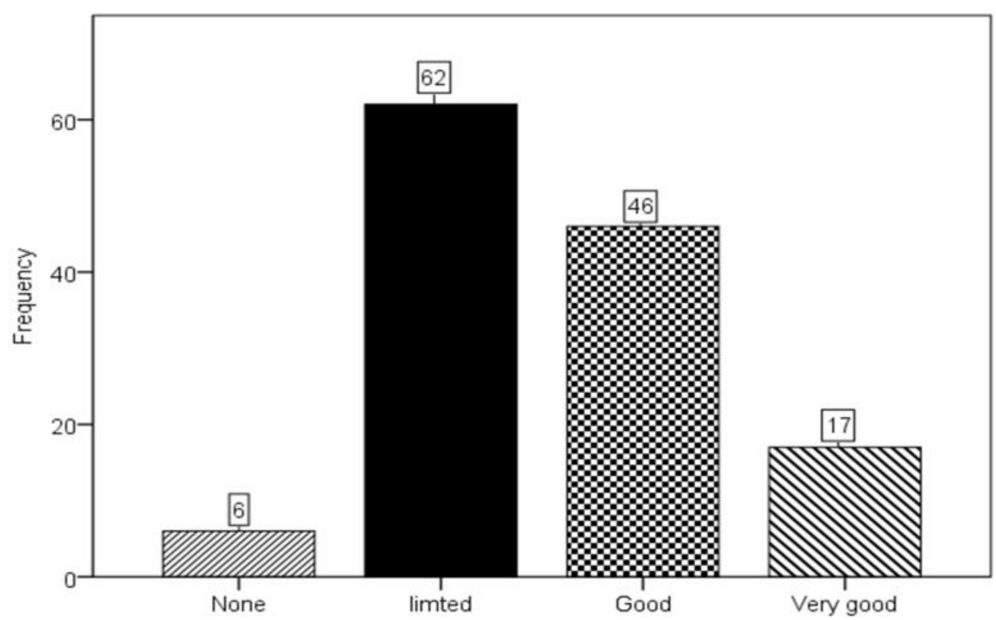


Figure 17: Distribution of sample HHHs by their frequency and magnitude of contacts with soil conservation experts.

As key informant said extension agent is one of the cabinet members at the kebeles level administration. Moreover, they gave attention for collecting, fertilizer and other credit services rather than for soil conservation. As survey result reveals, experts on soil fertility management and conservation measures were less effective and need special attention. Recent effort by the government to assign better trained and specialized DAs (compared to the existing ones).

5.7. Comparison of modern and indigenous soil-water conservation practices

Acceptance of the newly introduced soil conservation measures by the farmers is the decisive element for the success of controlling erosion. Acceptance depends more on the design characteristics of the measures as related specifically to effectiveness, also on several socio-economic and institutional factors. In the study area all of the farmers but one applied soil conservation technologies in the farm field. As the result, 21.4% applied but deserted completely, 27.5% applied but deserted selectively and 50.4% applied and maintained the conservation structures.

As noted by farmers, structural soil conservation measures sheltered rodents, increased grassed surface and decreased cultivation plot, restricted free movement, obstacle oxen plough, and expensive and labor intensive to maintain. Accordingly, they preferred to practice indigenous known soil conservation measures such as cutoff drains, waterways, and crop rotation. Because these are less expensive and demands few labors, might not obstacle oxen plough and make movement easier. Yet practice of indigenous known soil conservation tends to be influenced by some factors. For instance, farmers well know the importance of crop residues in enhancing soil fertility. But, crop residues and animal dung are used for energy and other home use.

Table 15: Distribution of sample HHHs by acceptance and non acceptance of soil conservation technologies.

Status of perceiving technologies	Frequency	Percent
Never applied any technology in the field.	1	0.8
Applied but deserted completely.	28	21.4
Applied but deserted selectively.	36	27.5
Applied and maintained conservation practice.	66	50.4
Total	131	100.0

Source: Field survey, 2014

The newly introduced soil conservation measures need to be evaluated not only for their technical effectiveness but also for the chances of their sustainable adoption and utilization by the land users. Farmers were asked to compare the traditional soil conservation measures with the introduced one. From 131 sample household heads about 88.5% farmers confirmed more productive than the traditional one. 8.4% respondent the same as the indigenous conservation practices. But 3.1% of the farmers suggested that the newly introduced soil conservation measures are less effective and less productive soil erosion than indigenous soil conservation.

Table 16: Distribution of sample HHHs by Effectiveness of newly introduced soil conservation measures as compared to indigenous one.

Status of effectiveness	Frequency	Percent
Less productive than the indigenous ones.	4	3.1
The same as the indigenous conservation practice	11	8.4
More productive than the indigenous ones	116	88.5
Total	131	100.0

Source: Field survey, 2014

CHAPTER SIX

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

Based on the major findings of the study made from the analysis, the following conclusions were drawn.

Soil is an important natural resource, and needs careful use and management. Soil erosion is one of the major contributors to the prevailing food insecurity in Ethiopia. The soil loss by erosion is severe in highlands and continues to threat the wellbeing of a large number of people reliant on agricultural production in the country. At the face of increased dependency on the agricultural sector for economic development, sustained use of the soil resource has become very important.

Farmers of the study area have awareness about the declining farm yields from year to year. In the present study area, the farming communities have no problem of perceiving the existence of soil erosion. They identify types and severity of erosion by water. Gully formation is the main work of intensive rainfall as slope of the area is ranged from gently sloping to very steep sloping. Soil erosion is one of the different components of land degradation. It poses key problems to livelihoods of the community members in the study area. Sheet, rill and gully erosion are the main types of erosion within the study area and the latter form of erosion, namely gully erosion, and is the most alarming problem removing huge quantities of soil and dissecting farmlands.

The majority of farmers experienced soil erosion, a phenomenon they related to the widespread onsite erosion indicators. They are well-informed of the water erosion processes and the consequent on-site erosion impacts. They have clear understanding of various forms of erosion indicators spread over the farmland and which adversely affect their soils. Rill and gully were most often mentioned indicators, followed by sheet erosion, root exposure, absence of fertile top soil and poor crop production are the major ones. They attributed the formation of these indicators to causes as high rainfall, overgrazing, absence of fallowing, steep slopes and poorly designed or ineffective soil conservation measures.

Combating soil erosion requires comprehensive and cost effective programme bottom-up participatory planning, implementation and monitoring by the real stakeholders. Conservation practices increase sustainable farm productivity and the incentives for rural households to construct and maintain effective conservation structures are well established with clear right of land ownership. There are conservation measures on farmlands, conservation measures on hillsides and conservation measures on degraded lands (to rehabilitate gullies). Majority of the conservation measures have been applied on cultivated fields. The structural soil conservation methods construct in the study area were stone bunds, soil bunds, check dam, waterway, cutoff and some agronomic soil conservation methods (crop rotation and contour plough). As per them, soil erosion is severe in cultivation field because the land is prepared several times before sowing the seeds.

Farmers' adoption of soil conservation measures can be influenced by different factors. Sex, age, education, household size, landholding size, and distance from homestead are the most main factors. According to the result of this study, the factors those influence farmers' practice of soil conservation measures considerably vary among farmers. Thus, the productivity and effectiveness of the plan and strategies to implement soil conservation measures in rural *kebeles* will depend basically on the extent to which such divergence allowed and then, the soil conservation plan must be flexible as much as necessary to consider diversity of farmers' conservation requirements.

Training, information and contact with development agents on soil conservation measures have role in gathering farmers' attention for practicing the conservation structures. Relation with development agents increases the interest of the farmers in practicing soil conservation measures by providing useful information in terms of where and when to construct them. However, as to the results of this study, farmers' contact with DAs is very limited and irregular. It will be productive if the woreda agricultural and rural development office follows up the effectiveness and efforts of DAs so as to improve closeness with farmers and enhance interest in soil conservation measures. Related to this, training on soil conservation measures and erosion controlling for the farmers provided rarely. The DA in respective *kebeles* should provide farmers with training and up to date information on soil erosion, conservation measures, and land management as a whole. Moreover, training on soil conservation methods should be directed to inform individual farmers on erosion related problems, the severity of erosion, types of erosion and the consequences of soil erosion vary from plot to plots.

The study founded out and assessed the impact of soil erosion on farmland and conservation practices in sululta woreda,oromia regional state, Ethiopia.

6.2. Recommendations

Based on the result of the study, the researcher has made the following recommendations.

- Alternative technologies to minimize soil erosion and improve agricultural productivity should be explored by national research institutes tested and disseminated taking in to account on the different agro-ecological zones of woreda.

- Policy makers need to be committed to making a difference and embarking on natural resource management instead of merely rehabilitating degraded lands which use up precious resources.
- The educational/training programme which was provided for farmers should be modified by considering the existing knowledge and practices in a particular area.
- There is a need for more publicity on land management practices which should be done mostly on mass media especially in radio and television. Creating awareness among the society concerning optimum use of natural resources, conservation systems, driving forces and their respective benefits is vital for sustainable soil resource management. Therefore, the local managers and responsible sectors in the Woreda should give emphasis in participation of the local communities in conservation activities and decision making.

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APPENDIXS

Appendix: I

ADDIS ABABA UNIVERSITY

COLLAGE OF SOCIAL SCIENCE

DEPARTEMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Dear farmers,

This questionnaire is meant to gather information for a study on assessing the impact of soil erosion and conservation practices. I hope that the research out comes contribute to the improvement of land management and increase crop productivities.

N.B. 1.The response you give will not have any negative impact on you.
2. No need of writing your name on the questionnaire.
3. Please respond for in feeling free wary on think is correct.

Yours faithfully,
Getachew Alemu.

Questionnaires filled by household heads.

Date of interview: Day ____ Month ____ Year 2006E.C
Region: Oromia Regional State.
Zone: Oromia special zone around Finfine.
woreda: Sululta Kebele: _________________

PART ONE

Respondents household characteristics.

1.1. Age ________.
1.2. Sex 1. Male ☐ 2. Female ☐
1.3. Household heads size: ____________.
1.4. What is the composition of the age and sex of the household heads member?

No	Age group	Male	Female	Total
1	1-5			
2	6-10			
3	>10			
	Total			

1.5. What is educational level of household heads?

1. Cannot read and write
2. Read and write
3. Completed primary education
4. Completed secondary education
5. Other specify_______________

PART TWO

Land and landholding characteristics of respondent

2. Questionnaires on landholding size and farmer's perception.

2.1. How many hectares of land do you own?

1. <0.5 ha
2. 0.5 ha-1.0 ha
3. 1.0 ha-1.5 ha
4. 1.5-2.0 ha
5. >2.0 ha

2.2. How did you get the land you have currently? (Multiple response)

1. Renting
2. Share cropping
3. Inherited from parents
4. Allocated by Kebele administrative officials

2.3. On average what is the distance of your cultivation fields from your home?

1. Less than 5 minutes walk
2. 6 to 10 minutes walk
3. 11 to 20 minutes walk
4. 21 to 40 minutes walk
5. 40 minutes-1 hour walk

2.4. How do you perceive the fertility of most of your farmland?

1. Very high
2. High
3. Medium
4. Low
5. Very low

2.5. How do you see the productivity of your farmlands?

1. Increasing over time
2. Decreasing over time
3. Almost the same
4. Do not know

2.6. If the yields of most of your farmlands are decreasing, what could be the reason behind? (Multiple response)

1. Absence of fallowing
2. High cost of chemical fertilizers
3. Unreliable rainfall
4. Erosion
5. Over cultivation
6. Others specify____________

2.7. What type of farmland is more productive?

1. Flat to very gently sloping (0-2%)
2. Gently sloping (2-5%)
3. Sloping to strongly sloping (5-15%)
4. Moderately Steeping (15-30%)
5. Steep to very steep (>30%)

2.8. How do you see the size your agricultural land over time?

1. Almost the same
2. Decreasing
3. Increasing
4. Do not know

2.9. If the agricultural land is decreasing, what could be reasons behind?

1. Population pressure
2. Land degradation
3. Expansion of forest
4. Taken by government
5. Taken by other organization
6. Other specify _________________

2.10. How do you think the size of your current landholding size to support your household members?

1. Insufficient 2. Sufficient 3. Excess

2.11. How do you overcome (minimize) the shortage of farmlands?

1. Going to resettlement area
2. Migrating to other areas (urban area)
3. Involving in non-farm activities
4. Increasing the productivity of land using modern technologies
5. Increasing farm land through clearing forest and common land

PART THREE

Soil erosion

3. Questionnaires on indicators, causes, severity and consequences of soil erosion

3.1. What are the indicators of soil erosion in your land?

No	Indicators	Order/Rank
1	Rill and gully development	
2	Stoniness of the soil	
3	Slope steepness	
4	Absence of fertile top soil	
5	Root exposure	
6	Poor crop productions	
7	Other specify	

3.2. What condition brings soil erosion in your land? (Put in order from most to least important)

No	Causes of soil erosion	Rank (1, 2…)
1	Slope steepness of the cultivation land	
2	absence fallowing	
3	Intensive cultivation	
4	Soil erodibility	
5	Intensity of rainfall	
6	Absence or lack of SLM	
7	Lack of fertilizers	
8	Desertification	
9	Deforestation	
10	Overgrazing	
11	Other specify	

3.3. What is the impact of soil erosion on your farmlands?

No	impact of soil erosion	Rank (1, 2...)
1	Loss of topsoil	
2	Reduction of yield	

3	Expansion of gullies	
4	Loss of vegetation cover	
5	Outmigration	
6	high input demand	
7	Desertification	
8	Other specify	
	Total	

3.4. How do you describe the degree of soil erosion in your farmland?

1. Severe 3. Minor
2. Moderate 4. No erosion risk

3.5. Which type of soil erosion is severe in your land? (More than one is allowed)

1. Sheet erosion 2. Rill erosion 3. Gully erosion

PART FOUR

Soil conservation practices

4. Questionnaires on adoption and practicing of soil conservation technologies

No	Items	Put(✓)
1	Structural soil conservation methods (soil bunds, stone bunds, *Fanya juu*, cutoff drains, check dams, waterways, bench terraces, …)	
2	Biological soil conservation methods (crop cover, mulching, afforestation, …)	
3	Agronomic soil conservation methods (contour plough, crop rotation…	
4	Both structural and Biological soil conservation methods	
5	Both Structural and Agronomic soil conservation methods	
6	Both Biological and Agronomic soil conservation methods	
7	Structural, Biological and Agronomic soil conservation methods	

4.1. Do you know that the yield can increase with soil conservation practices?

1. Yes 2. No 3.Donot know

4.2. If your answer for question '4.1' is 'Yes', which soil conservation practices are the most effective for your farmland?

No	Items	Rank
1	Soil bunds	
2	Cutoff drains	
3	Waterways	
4	Check dams	
5	Stone bunds	
7	Other specify,	

4.3. Where/on which plot do you practice specific type of conservation?

1. Cultivation field 3. On both

2. Grazing field 4. Other specify, _______________

4.4. Do you get training on soil conservation technologies?

1. Once in the year 2. Twice in five year

3. Three time in five year 4. Other, specify___________________

4.5. Where did you get information on soil conservation practices?

1. From neighbors 2. From DAs or experts

3. From other NGOs 4. Other sources specify__________

4.6. Do you have contact with DAs?

1. Yes 2. No

4.7. How do you describe your relationship you have with soil conservation experts?

1. None 2. Limited

3. Good 4. Very good

4.8. What factor do you think affect practice soil conservation measures?__________________

4.9. What have you done with the soil conservation measures?

1. Never applied the technology in the field

2. Applied but removed them completely

3. Applied but removed them selectively

4. Applied and maintained the conservation structures

4.10. Do you like trying new technologies whenever they are introduced to the area?

1. Yes 2. No

4.11. How do you know the productivity of soil conservation measures introduced to the area compared to the traditional ones?

1. Less productive than the traditional ones

2. The same as the traditional conservation practices

3. More productive than the traditional ones

THANK YOU!

Appendix: II

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Interview Guide

This interview guide is prepared to direct the interviews to be conducted with employee (environmental experts) of woreda Agricultural Office or any equivalent offices in the selected woreda. The purpose of this guide is to secure additional data that may not be clearly secured the questionnaires to be filled by respondents. It is also designed in such a way that it helps the interviews and the interviewees focus the discussion on issues related to the research questions. Thus, this interview is meant to secure only relevant data that could not be obtained through other means of data collecting tools.

1. What is considered as a major problem leading to soil erosion and degradation in Sululta woreda?
2. How do you perceive the types and severity of soil-water conservation on farm-land?
3. Do you believe that there are suitable and enough soil resources management plan? If yes, what are these guidelines?
4. What are the indicators of soil fertility on the land? And how do you compensate if the fertility decline?
5. How female farmers construct soil conservation practices on their farmlands?
6. What actions do you think need to be taken to reduce the risk of soil erosion and to minimize its environmental impact?
7. What is the role of the (DAs) experts in woreda office to increase soil-water conservation practices?

Appendix: III

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DEPARTEMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Focus group discussion

1. What is considered as a major problem leading to soil erosion and degradation in Sululta woreda?
2. How do you perceive the types and severity of soil-water conservation on your farm-land?
3. Do you believe that there are suitable and enough soil resources management plan? If yes, what are these guidelines?
4. What are the indicators of soil fertility on the land? And how do you compensate if the fertility decline?
5. How female farmers construct soil conservation practices on their farmlands?
6. What actions do you think need to be taken to reduce the risk of soil erosion and to minimize its environmental impact?
7. What is the role of the (DAs) experts in woreda office to increase soil-water conservation practices?

Appendix: IV

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DEPARTEMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

GAAFFILEE ABBAA WARRAAN GUUTAMU

Guyyaa gucni kun itti guutamee_____ji'a___waggaa 2006 E.C

Naannoo;-_Oromiyaa Godiina;- Aaddaa Naannawa Finfinnee Aanaa;- Sulultaa

Ganda;-________________

BOQONNAA TOKKO

1. Guca Gaaffilee eenyummaa Abbooti warraatin guuttamu

1.1.Umrii____

1.2.Saala 1. Dhiira ☐ 2. Dubartii☐

1.3.Baay 'ina maatii abbaa warraa______

1.4.Haala umrii fi saala maatii abbaa warraa(maatii hunda)

Lakk	Umrii	Dhiira	Dubartii	Baay'ina
1	1-5			
2	6-10			
3	>10			
Baay'ina				

1.5. Sadarkaa barumsaa abbaa warraa?

1. Dubbisuu fi barressuu kan hin dandeenye.
2. Dubbisuu fi barreessu kan danda'uu.
3. Barumsa sadarkaa 1[ffaa] kan xumure.
4. Barumsa sadarkaa 2[ffaa] kan xumure.
5. Kan biroo,_____________

BOQONNAA LAMA

GUCA LAFAA FI HAALA QABANNAA LAFAA ABBA WARRAATIN GUUTTAMU.

2. Gaaffilee hamma lafaa, haala qabannaa lafaa fi hubannoo qote bulaa ilaalchisee.

2.1.Yeroo ammaa kana lafa hektaara meeqatti fayyadamaa jirta?

1. Hektaara walakka gadi
2. Hektaara walakka- tokkoo
3. Hektaara 1-1.5
4. Hektaara 1.5-2
5. Hektaara 2 ol

2.2.Haala kamiin lafa argattan?

1. Kiraadhan
2. Hirtaadhan
3. Maatii irraa dhaaluun
4. Ganda irraa

2.3.Giddu galeessan iddoon lafa qonnaa kee mana jireenyaa kee irraa hagam fagaata?

1. Deemsa daqiiqaa 5 gadii
3. Deemsa daqiiqaa 21-40

2. Deemsa daqiiqaa 6-10
4. Deemsa daqiiqaa 41- sa'ati 1

2.4.Gabbina biyyee lafa qonnaa keetii akkamitti ilaalta?

1. Baay'ee gaaridha
2. Gaaridha
3. Giddu-galeessa
4. Xiqqaadha
5. Baay'ee xiqqaadha

2.5. Bu'aa qabeessummaa lafa qonnaa keetii akkamitti ilaaltaa?

1. Yeroo yeroon dabalaa jira
2. Yeroo yeroon hir'achaa jira
3. Haala walfakkatan adeema jira
4. Hin beekkamu

2.6.Baay'inaan callaan lafa qonnaa keetii kan hir'achaa deemu yoo ta'e sababni isaa maali jettee yaadaa? (deebii tokkoo ol ni danda'ama)

1. Osoo wal-irraa hin cinnee deddebi'anii qotuu
2. Daballii gatii xaa'oo
3. Rooba waqtii isaa hin eeganne irraa kan madde
4. Dhiqama biyyee
5. Hanga seeran oomishuu danda'anii ol qotuu
6. Kan biroo,___________________

2.7.Haala teessuma lafa kessanii kamtu irra caala qonnaf oola?

1. Diriiradha
2. Baay'ee halayyaa kan qabu
3. Xiqqoo kan dhundhule
4. Hallayyaa kan qabu
5. Tabba xiqqoo kan qabu

2.8.Hamma lafa qonnaa keessanii yeroodhaa yerootti akkamitti ilaaltu?

1. Walfakkaatadha
2. Hir"achaa jira
3. Dabalaa Jira
4. Hin beekamu

2.9.Hammi lafa qonnaa keessanii yeroodhaa yerootti yoo hir'achaa deeme sababni isaa maali?

1. Baay'ina uummataa
2. Sababa adda addaatin miidhama lafa
3. Babal'achuu bosonaa
4. Laftii mootummaan fudhatamuu
5. Lafti dhaaba birootin fudhatamuu
6. Kan biroo,_____________________

2.10. Hammi lafa amma of harkaa qabdan maatii keessan gargaaruf gahaadha jettanii yadduu?

1. Gahaa miti
2. Gahaadha
3. Gahaadhaa oli

2.11. Rakkina hir'achaa deemuu lafa qonnaa kana akkamitti dhorkuu dandeenya jettee yaadda?

1. Naannoo tokko safaruu
2. Hojii qonnaan alaa dalaguu

3. Lafti qonnaa bu’aa gaarii akka kennu teeknolojii haaraa fayyadamuu
4. Bosona ciruun lafa qonnaa babai’isuu

BOQQONNAA SADI

DHIQAMA BIYYEE

3. Gaaffilee mul’istuu, sababa, fi rakkoo dhiqamni biyyee fidu.

3.1.Lafa qonnaa kee irratti dhiqamni biyyee haala kamiin mul’ata?

Lakk	Mul’istuu dhiqama biyyee	Sadarkaa(cimaa gara laafattii)
1	Boroboraa’uun lafaa babal’achuu	
2	Dhakaan irra lafaati mul’chaa yoo deeme	
3	Lafti halayyaa ta’aa deemuu	
4	Gabbina dhabuu biyyee irra lafaa	
5	Hiddi biqilootaa mul’achuu	
6	Hir’inni callaa mul’achuu	
7	kan biro	

3.2.Haalonni(wantootni)dhiqama biyyee lafa qonnaa kee irratti fidan maal fa’a?

Lakk	Haalota dhiqama biyyee fidan	Mallattoo kana fayyadama “√”
1	Dhundhula lafa qonna	
2	Dhabamuu cifliqaa(boqonnaa dhowwuu)	
3	Lafa hanga oomishuu danda’anii ol qotuu	
4	Biyyee amalli isaa dhiqamaaf saaxilamu	
5	Rooba guddaa	
6	Haala ittifayyadama lafa walitti fufaa ta’e dhabamuu	
7	Dhabamuu xaa’oo	
8	Babal’achuu gammoojjii	
9	Ciramuu bosonaa	
10	Humnaa ol tiksuun lafa qoqorsiisu	

3.3.Naannoo keessanitti miidhaan dhiqamni biyyee fidu maali?

Lakk	Miidhaa dhiqamni biyyee fidu	Irra caala miidha isa Sadarkaadhan teessisi
1	Biyyeen irra lafa dhiqamuu	
2	Callaa quubsan dhabamu	
3	Babal’achuu boroborii	
4	Biqilttoonni lafa irra akka dhabamu taasisu	
5	Naannoo irra akka baqatan taasisa	
6	Baasii baay’ee lafaf nama gafata	
7	Lafti qonna akka dhabamu taasisa	
8	Lafti marga akka dhabamu taasisa	
9	Gammoojjin akka babal’atu godha	
10	Kan biro	
	Baay’ina	

3.4.Sadarkaa miidhama lafa qonna naannoo keeti akkamitti ibsita?

1. Baay’ee cimadha
2. Giddu-galessaa
3. Xiqqadha
4. Dhiqamni biyyee hin jiru

3.5.Gosoota dhiqama biyyee keessaa kamtu naannoo keessanitti sirritti mul’ata?

1. Bishaan bal’atee biyyee irra lafaa kan dhiqu (Sheet erosion).
2. Bishaan lafa kutuu yoo jalqabu ykn bo’oo baasu kan jalqabu (Rill erosion).
3. Bishaan lafa borobori godhee kan dhiqu ykn gadi kutee (Gully erosion).

BOQONNA AFUR

MALOOTA DHIQAMA BIYYEE ITTISAN

4. Gaaffilee Teeknolojii dhiqama biyyee hambisuuf nu tajaajilan.

Lakk	Terreeffama	Irra caala kan itti fayyadamtan (sadarkaan tarreessi).
1	Dhiqama biyyee ittisuu haala ijaarama biyyee irratti(daagaa biyyee, daagaa dhakaa, boraatii lolaa, daandii lolaa, hallayyaa hidhuu, …)	
2	Mala baayolojiitin dhiqama biyyee ittisuu(midhaanin lafa uwwisuu, bakka mukti hin jirree biqiltuu dhabuu, bakka irraa muramee deebisanii dhaabuu….)	
3	Mala agronomiitin dhiqama biyyee ittisuu(dalga qotuu, sanyii jijjiiruu…)	
4	Mala ijaarama biyyeeti fi baayolojiitin ittisuu	
5	Mala ijaarama biyyeeti fi agronomiitin dhorkuu	
6	Mala baayolojiiti fi agronomiitin ittisu	
7	Mala sadanuu fayyadamuu	

4.1.Mala dhiqama biyyee ittisuu haala ijaarama isa keessaa isa kam yeroo hunda fayyadamta?(deebi tokkoo ol ni danda’ama).

1. Daagaa dhakaa ijaaruu
2. Daaga biyyee ijaaruu
3. Boraatii lolaa(gulantaa) baasu
4. Daandii lolaa(boyii) baasuu
5. Hallayyaa hidhuu
6. Dalgee lafa qonnaa irratti booll’a dhedheero qotuu
7. Funyaa juu
8. Kan biroo________

4.2.Maloota eegumsa biyyee fi bishaanii keessaa kamtu irra caalaa bu’a qabeessa?

Lakk	Maloota dhiqama biyyee ittisan	Irra caalaa bu’aa kan qabuu sadarkaan teessisi
1	Daagaa dhakaa ijaaruu	
2	Daagaa biyyee ijaaruu	
3	Boraatii lolaa(gulantaa) baasu	
4	Daandii lolaa(boyii) baasuu	
5	Hallayyaa hidhuu	
6	Dalgee lafa irratti boll’a dhedheeroo qotuu	

7	Funyaa juu	
8	Kan biro	

4.3.Lafa qabdu keessaa addatti eegumsa kan gootuf isa kami?

1. Lafa qonnaa 3. Lamaanuu
2. Lafa margaa 4. Yaada biroo___________

4.4.Teeknolojii dhiqama biyyee ittisu irratti leenjii fudhattee jirtaa?

1. Waggaatti si’a tokkoo 3. Waggaa shanitti si’a sadi
2. Waggaa shanitti si’a lama 4. Kan biroo,____________

4.5.Odeeffannoo waa’ee dhiqama biyyee ittisuu, hojjiiwwan hojjataman eessaa argatte?

1. Ollaa irraa 3. NGOs)
2. Ogeessa qonnaa irraa 4. Kan biroo,___________

4.6.Ogeessa qonnaatin wal-qunnamtaa?

1. Eeyyee 2. Lakkii

4.7.Ogeessa dhiqama biyyee irratti hojjatu wajjin walitti dhufeenyi ati qabdu maal fakkaata?

1. Walitti dhufeenya hin qabu 3. Haala gaariin
2. Tasa tasa 4. Sirriittan wal-qunnama

4.8.Rakkoowwan akkamiitu hojjiiwwan dhiqama biyyee irratti hojjataman akka hin milkoofne taasisa jettee yaadda?____________________________________

4.9.Dhiqama biyyee hir’isuuf hojii hojjatamu maal maal fayyadamtaa?

1. Teeknolojii homaatuu qonna koo irratti hin fayyadamu.
2. Teeknolojii dhiqama biyyee hir’isu fayyadame ;garuu yeroo muraasa booda nan dhiise.
3. Teeknolojii dhiqama biyyee hir’isu fayyadame garuu muraasa keessayin dhiise.
4. Teeknolojii dhiqama biyyee hir’isu fayyadame ammas itti fufaan jira.

4.10. Teeknolojii haaran osoo naannoo kee dhufee isa irratti leenjii fudhachuuf fedha qabda?

1. Eeyyee 2. Lakkii

4.11. Bu’a qabeessummaa teeknolojii haaraa dhiqama biyyee ittisu kan amma hojiirraa oolee akkamitti kan durii wajjin wal bira qabdee ilaalta?

1. Akka kan durii bu’aa hin qabu 3. Kan durii wajjin wal-fakkaatadha
2. Bu’a qabeessummaan isaa kan durii caala

Galatoomaa!

Appendix: V

ADDIS ABABA UNIVERSITY

COLLAGE OF SOCIAL SCIENCE

DEPARTEMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Gaaffin afaanii kun kan qopha'ee hojjatoota qonnaa aanaa keessaa jiran fi namoota isaanin wal-fakkaatan wajiniin kan taasifamudha. Fayidaan isaa wantootaa gaaffii barreefaman guttamu irrattii hin kaanne fi wantoota dhoksaa ta'an yoo jirtan ibsuudhafi.

1. Aanaa sulultaa keessatti wantoonni dhiqama biyyee fidan maal fa'a?
2. Akaaku fi hanga dhiqama biyyee lafa qonnaa irratti mula'tu akkamittii hubataa?
3. Karoori mijataa fi gahaa wayee eegumsa biyyee irratti jira jettee itti amantaa?yoo jirate maal fa'a?seerri isa hoo?
4. Mul'istuun gabbina biyyee lafa qonnaa maal fa'a? Gabbinni biyyee lafa qonnaa yoo hirate maalin bakka bu'aa?
5. Qotee bulaa dubartonnii akkamitti lafa isanii irratti dhiqama biyyee dhorkuu?
6. Maaltu yoo rawwatame dhibbaa naannoo fi dhiqama biyyee hiri'isa jette yadda?
7. Aanaa keessatti gaheen hojjatonni qonna eegumsa biyyee irratti qaban maal fakkata?

Appendix: VI

Sululta woreda Rainfall and Temp. Distribution 2001-2013

Elements	Year	Md function	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PRECIP	2001	SUM	12.5	12.9	134.9	39.8	124.5	158.3	332.4	276.8	38.1	0.0	0.0	0.0
PRECIP	2002	SUM	38.4	49.4	134.0	56.1	48.5	315.8	720.0	499.5	61.5	3.5	0.0	39.1
PRECIP	2003	SUM	57.5	49.0	79.2	206.9	4.5	315.1	778.3	834.3	581.4	0.0	3.5	27.9
PRECIP	2004	SUM	68.2	0.0	27.2	79.8	21.7	694.3	1154.8	778.7	360.5	115.6	0.0	13.4
PRECIP	2005	SUM	5.3	71.4	0.0	38.7	76.6	196.4	263.6	312.6	351.3	1.5	0.0	0.0
PRECIP	2006	SUM	0.0	10.4	133.6	104.3	75.7	187.2	394.6	321.2	**	3.0	0.0	16.2
PRECIP	2007	SUM	12.5	46.5	26.1	50.4	105.9	154.0	325.1	276.7	124.2	14.8	0.0	0.0
PRECIP	2008	SUM	**	0.0	0.0	44.1	133.8	350.0	445.6	70.4	0.0	29.0	50.6	0.0
PRECIP	2009	SUM	33.5	23.9	39.9	2.3	6.2	**	491.3	**	**	**	**	**
PRECIP	2010	SUM	**	67.8	57.2	109.6	99.2	294.6	372.5	333.3	271.7	0.0	3.6	**
PRECIP	2011	SUM	16.0	3.3	29.0	40.4	77.7	**	422.3	526.7	304.9	1.2	**	**
PRECIP	2012	SUM	**	0.0	**	87.3	47.7	98.3	622.7	565.8	**	**	**	**
PRECIP	2013	SUM	**	0.0	24.0	86.1	3.0	264.0	343.4	273.7	235.4	6.2	5.9	0.0
TMPMAX	2001	AVG	**	23.6	21.8	22.4	22.6	21.1	20.9	21.2	19.8	21.6	20.7	20.8
TMPMAX	2002	AVG	22.0	22.9	21.9	21.5	21.3	21.2	21.6	20.3	21.1	21.6	22.3	22.1
TMPMAX	2003	AVG	22.6	21.6	22.1	22.3	22.7	21.7	22.0	21.5	20.6	20.2		18.9
TMPMAX	2004	AVG	21.6	21.0	22.5	20.8	21.7	20.6	**	**	**	**	**	**
TMPMAX	2007	AVG	23.4	23.0	24.6	23.1	24.6	21.2	18.8	19.1	20.1	22.1	23.3	23.5
TMPMAX	2008	AVG	**	24.4	25.9	24.0	23.8	23.2	19.3	21.2	22.8	22.2	21.9	22.4
TMPMAX	2009	AVG	20.6	22.8	23.4	22.5	24.0	**	20.5	**	**	**	**	**
TMPMAX	2010	AVG	22.2	22.6	22.6	22.9	23.0	22.7	21.3	20.1	20.7	22.5	21.5	**
TMPMAX	2011	AVG	22.4	23.2	23.9	23.7	23.2	**	21.0	19.5	20.9	22.1	**	**
TMPMAX	2012	AVG	21.8	21.6	23.4	23.3	21.9	22.5	22.1	21.0	21.7	**	**	**
TMPMAX	2013	AVG	23.5	25.0	25.1	24.4	23.1	25.0	20.7	20.7	21.5	21.6	23.1	24.8
TMPMIN	2001	AVG	**	3.9	8.7	8.7	9.5	8.6	9.9	10.2	8.4	7.7	9.5	5.7
TMPMIN	2002	AVG	6.6	6.8	9.7	10.1	9.6	9.4	10.3	9.3	8.6	8.6	9.0	8.6
TMPMIN	2003	AVG	7.5	9.0	9.3	9.6	9.8	9.6	9.9	9.5	8.9	7.2	4.9	6.0
TMPMIN	2004	AVG	7.3	6.4	8.0	9.0	9.0	8.7	8.5	9.2	8.6	9.4	7.2	8.9
TMPMIN	2005	AVG	8.0	8.7	9.2	9.1	10.2	9.9	10.0	9.9	9.7	7.0	4.5	4.5
TMPMIN	2006	AVG	7.1	8.6	9.4	9.9	10.3	9.5	10.3	10.1	8.3	7.8	5.4	5.9
TMPMIN	2007	AVG	7.3	8.1	8.5	9.8	10.2	9.7	10.0	9.7	9.4	5.9	5.5	3.6
TMPMIN	2008	AVG	**	6.5	7.8	9.2	11.4	10.0	9.9	8.5	7.1	8.2	6.5	7.5
TMPMIN	2009	AVG	8.4	7.9	9.0	8.8	9.7	**	9.7	**	**	**	**	**
TMPMIN	2010	AVG	7.7	10.0	9.9	10.6	10.5	10.1	10.6	10.4	9.3	7.4	8.2	**
TMPMIN	2011	AVG	9.1	8.3	9.3	9.6	9.7	**	10.5	9.3	9.7	8.1	**	**
TMPMIN	2012	AVG	9.4	9.8	10.1	10.3	10.2	9.5	10.6	10.6	9.7	**	**	**
TMPMIN	2013	AVG	8.2	7.5	11.2	10.7	10.5	10.2	10.4	10.5	9.6	9.6	7.8	3.2

Source: Ethiopia National Metrology Agency, 2014.

** No available data

Statement of the Author

I, the undersigned declare that the thesis is my original, and it has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

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This thesis has been submitted for examination with my approval as research advisor

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