FARMERS' PERCEPTION ON SOIL EROSION AND THEIR USE OF STRUCTURAL SOIL CONSERVATION MEASURES IN SORO DISTRICT, SOUTHERN ETHIOPIA

A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES, ADDIS ABABA UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTERS DEGREE IN GEOGRAPHY AND ENVIRONMENTAL STUDIES

BY: **KIBEMO DETAMO AGA**

ADVISOR: MOHAMMED ASSEN (PHD)

JUNE, 2011
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LIST OF ACRONYMS

CACC	Central Agricultural Census Commission
CFSCDD	Community Forestry and Soil Conservation Development Department
CSA	Central Statistics Authority
DA	Development Agents
EFAP	Ethiopian Forestry Action Plan
EHRS	Ethiopian Highland Reclamation Studies
FAO	Food and Agricultural Organization
FFW	Food for Work
FGD	Focus Group Discussion
FTC	Farmers' Training Center
GDP	Gross Domestic Product
IUCN	International Union for Conservation of Nature
MoARD	Ministry of Agriculture and Rural Development
PAs	Peasant Associations
SNNPR	Southern Nations, Nationalities and Peoples' Region
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
USD	United States Dollar
VI	Vertical Interval

ABSTRACT

The main objective of this study was to evaluate the farmers' perception on soil erosion and their use of structural soil conservation measures. The data for this study was collected via interviewees, key informants and field observations. Farmers perceived indicators of the existence of erosion and soil fertility loss differently. For many farmers, gully development and stoniness of soil were main indicators to soil erosion on their land. Others recognize by observing soil color. They also perceived well the causes of soil erosion in their lands as slope steepness of cultivation fields, ceaseless cultivation and absence of fallowing with many time preparations of soil for cropping; still other causes have great roles. Severity of soil erosion in the study area explained as severe, moderate, minor soil erosion and a few cultivation fields had no erosion risk. Consequently, farmers well understood the results of severe soil erosion on their farms and recognized as loss of topsoil, reduction of yield over time, loss of vegetation cover and grasses, change in soil color, requiring high input and management, formation of uncross-able gullies, lack of farm land and grazing field, and out migration.

Structural soil conservation measures practiced in the study area included cutoff drains, soil bunds, fanya juu, waterways, check dams, and trench digging. 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 DA and training provide a fertile ground for increased practice of structural soil conservation measures.

Soil conservation efforts need hand- in- hand cooperation with concerned experts while planning and implementation. To effectively plan for soil conservation measures application and introduce new techniques to manage resources in the right way, it is necessary to involve local farmers and have knowledge of local concepts such as that of soil classification, soil quality, soil fertility and soil erosion.

CHAPTER ONE

INTRODUCTION

1.1. General Background

Soil is an important resource, which needs much attention in its use and management. It is the soil which nourishes and provides with required needs for the whole of nature. The whole of creation depends on the soil which is the ultimate foundation of our existence (Fillou, 1862). Because soil is formed slowly, it is essentially considered as a finite resource. In many rural areas of the developing countries, land resources including soil, forest and water are under serious threat of degradation (Duraiappah, 1998). For the rural people, environment and natural resource degradation directly translates into a worsening of their means of sustenance (Yeraswork, 1995). As studies reveal (Hurni, 1986), high intensity of rain, extensive deforestation, improper farming practices, overgrazing and population pressure on resources have resulted in severe land degradation. One of the major factors of land degradation is soil erosion (Alemneh, 1990). As a result, the severity of the global erosion problem is becoming widely appreciated.

About 80% of agricultural land in the world is suffering from moderate to severe soil erosion, and 10% suffers slight to moderate erosion (Pimentel *et al*., 1995). Ethiopia is not an exceptional; it is facing severe and continuous soil erosion. Soil erosion is a root cause of land degradation and the most dangerous ecological process in the country (Ludi, 2004). In Ethiopia the impact of soil erosion was recognized after the 1973 famine occurred in the country. Since then, the Government of Ethiopia initiated a massive program of soil conservation and rehabilitation in the highly degraded areas, which involved the mobilization of over 30 millions peasants' workdays per year (Hurni, 1986).

In protecting soil erosion, as many studies indicate, soil conservation activities in Ethiopia are an old history (Gedeno, 1990). The indigenous soil conservation practices have been practiced in various parts of the country. An interesting example is the terracing activity of Konso farmers in Southern Ethiopia. Other soil conservation measures including fallowing, crop rotation, strip cropping, manuring, ditch building are practiced extensively.

As part of the mass mobilization efforts, between 1975 and 1989, terraces were built on 980000 hectares of cropland; 208000 hectares of hillside terraces were constructed and 310000 hectares of highly denuded lands were re-vegetated (Kruger *et al*., 1997; Teklu and Gezahegn, 2003). On the contrary to these considerable efforts and achievements, the country is still losing an appreciable amount of precious topsoil annually. Thus, the required level of conservation has not been met yet (Yohannes, 1994).

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).

Ervin and Ervin (1982) declared that farmers' perception affects positively the adoption and efforts of soil conservation. Farmers' perception to use soil conservation measures, especially in low-income countries, can be influenced by a complex set of socio-economic, demographic, technical, institutional and biophysical factors (Feder *et al*, 1985). Various studies (Ervin and Ervin, 1982; Bekele and Holden, 1998; Pender and Kerr, 1998; Lapar and Pandy, 1999; Makoha, *et al*., 1999) have identified the factors that affect farmers' adoption of practices that control erosion and enhance long-term production and productivity. For instance, 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 may control erosion but do not result in fulfilling the immediate needs of the farmers (Ervin and Ervin, 1982).

1.2. Statement of the Problem

Ethiopia is one of the most densely populated countries in Africa with over 90% of the population deriving their livelihood from agriculture and natural resource-based enterprises (Bekele and Holden, 1998). In Ethiopia, land degradation, low and declining agricultural productivity, and poverty are severe and interrelated insecurities that totally appear to feed off each other. Since the early 1980's, the donors and the government have supported large efforts to promote soil conservation and environmental rehabilitation in Ethiopia. More recent past soil conservation measures relied largely on Food for Work (FFW) programs as an incentive and emphasized on labor-intensive conservation activities such as terracing, building bunds and planting trees (Bekele and Holden, 1998).

But the consensus appears to be that many past soil conservation programs were disappointing for a number of reasons: they used an unsound "environmental narrative" to promote large scale, top-down interventions; gave inadequate consideration to farmers' perspectives, constraints, and local conditions; provided limited options to farmers; and in some contexts promoted options of very limited profitability (Bojo and Cassels 1995; Hoben 1996; Bekele and Holden 1999). "One- size-fits-all" approaches will not solve land management problems in the heterogeneous environment of the Ethiopian highlands (MoARD and World Bank, 2007). A more nuanced strategy involves identifying which land management options work, and where; providing farmers with an array of potentially effective options and combinations of options; identifying constraints to adopting appropriate options; and addressing those constraints through policies and investment programs.

Hadiya zone is one of the thirteen zones of the Southern Nations, Nationalities, and people's Region (SNNPR) of Ethiopia. A large part of the zone's land is exposed to severe soil erosion, land fragmentation, deforestation and land pressure. As a result, the soil becomes unable to satisfy the rapidly growing demands of population.   The Soro district of Hadiya zone has been exploited and degraded continuously. As a result, 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.

Although structural soil conservation methods are widely represented as having significant environmental, economic, social and political benefits for both individual landholders and the wider community, adoption of such measures is commonly perceived to be slow.
Consequently, severe erosion continues to affect the farmers' livelihoods. The rich top-soils have been washed off by runoff and the remaining sub-soils are exposed and generally deficient in available minerals.

Perceiving soil erosion as a problem by farmers is an important determinant of conservation practice. Moreover, the farmers' attitude towards the structural soil conservation and implementation of measures can be influenced by different issues. Yet, factors affecting practice of structural soil conservation measures by farmers have not been closely examined in the area and often poorly understood. This study, therefore, attempted to investigate farmers' perception on soil erosion and structural soil conservation measures.

1.3. Objectives of the Study

The main objective of this study is to evaluate farmers' perception on soil erosion and their use of structural soil conservation measures. More specifically, this study will attempt: -

A. To assess farmers' perception on the causes, extent and consequences of soil erosion;
B. To evaluate their perception on structural soil conservation measures;
C. To explain factors that influence farmers' use of structural soil conservation measures; and
D. To investigate the effectiveness of practiced structural soil conservation measures.

1.4. Research Questions

Understanding farmers' perception of soil erosion and its impact is a very necessary position in promoting structural soil conservation measures. Therefore, this study attempts to answer the following research questions:

1. How farmers perceive the causes, extent and consequences of soil erosion?
2. How farmers perceive structural soil conservation measures?
3. What factors influence farmers' practice of structural soil conservation measures?
4. Which structural soil conservation measures are dominantly practiced?

1.5. Significances of the study

The results of this study will have contributions in identifying implemented soil conservation practices by farmers and their effectiveness in controlling soil erosion. Secondly, it will be used as a stepping stone to examine farmers' perception on soil erosion and conservation measures in other study areas with modification to immediate issue. Moreover, it will help as a reference for other studies in the area with similar or other themes of study.

1.6. Delimitation and Limitations of the Study

In Soro district, farmers' perception on soil erosion and soil conservation, particularly structural measures to control soil erosion by water had not been investigated. This issue requires immediate solution in order to enhance agricultural productivity and soil fertility. The study is mainly focused in the issues mentioned above in Soro district because it is not promising to investigate other problems at the same time due to the resource inadequacy and constraints.

1.7. Organization of the Thesis

This study is organized into six chapters. The first chapter provides with an overview and the issues which attempted to address and achieve at the end of study. This is followed with related literature reviews in which the previous researches and thought related to farmers' perception on soil erosion and the use of structural soil conservation measures are reviewed. The third chapter describes the methodology used to collect relevant data and how collected data are analyzed. Chapter four illustrates the study area with its soil resources endowment, climate, water resources, land use, crop production, socioeconomic characteristics, and soil and water conservation activities in the study area. The fifth chapter presents the results of study. Finally, chapter six gives conclusion and possible recommendation based on the results of the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURES

2.1. Soil Erosion in the World

Much of the world has been facing increasingly serious soil erosion of various degrees caused by both natural and human factors as well as its consequent environmental deterioration. The loss of soil through land degradation processes particularly by erosion is one of the most serious environmental problems. Pimentel (2006) has argued that the reduction in water availability due to land degradation and soil erosion is a major global threat to food security and the environment.

More than 80% of land degradation is due to soil erosion out of which 56% is due to the water induced soil erosion (Oldeman, 1992). During the last few decades, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year (Pimentel *et al*, 1995). As to this study, with the addition of a quarter of a million people each day, the world population's food demand is increasing at a time when per capita food productivity is decline.

Erosion by water is a primary agent of soil degradation at the global scale, affecting 1094 million hectares, or roughly 56% of the land experiencing human induced degradation (Oldeman, 1992). Likely, soil from the world's croplands is being swept and washed away 10 - 40 times faster than it is being replenished. Even, one rainstorm can washes away several millimeters thick soil. When we consider a hectare, it would takes 10s tons of topsoil - or several decades and even centuries if left to natural processes - to replace that loss (Pimentel *et al*, 1995). Furthermore, the same study clarify that croplands are the most susceptible to erosion because of repeated cultivation and the continual removal of plant cover.

Since 1945 moderate, severe, extreme soil degradation has affected 1.2 billion hectares of agricultural land globally, an area size of China and India combined. Some 80 percent of this degradation has taken place in developing countries (Hawken *et al*, 1999, cited in Melville, 2006) and most countries lack sufficient resources to repair degraded land.

2.2. Soil Erosion in Ethiopia

Natural resource degradation is the main environmental problem in Ethiopia. The degradation mainly manifests itself in terms of lands where the soil has either been eroded away and/or whose nutrients have been taken out to exhaustion without any replenishment (Million and Kassa, 2004). The majority of the farmers in rural areas of Ethiopia are subsistence-oriented, cultivating impoverished soils on sloppy and marginal lands that are generally highly susceptible to soil erosion and other degrading forces.

Soil degradation is one of the most serious environmental problems in Ethiopia. The Ethiopian highlands have been experiencing declining soil fertility and severe soil erosion due to intensive farming on steep and fragile lands and other factors attributed to population pressure (Hurni, 1993). Soil erosion is a phenomenon, which mainly occurs in the highlands of Ethiopia (areas>1500 meters above sea level) which constitute about 46% of the total area of the country, support more than 80% of the population, and account for over 95% of the regularly cultivated land and about 75% of the livestock population (Bekele and Holden, 1999).

In Ethiopia, erosion averages 42 metric tons per hectare per year on currently cultivated lands and 70 metric tones per hectare per year on formerly cultivated degraded lands (Hurni, 1988). About 45% of the total annual soil loss in the country occurs from cultivated fields, which accounts for only 15.3% of the total area (EPA, 2003). The latest land degradation estimates indicate that out of the 52 million hectares of land making up the highlands of Ethiopia, 14 million hectares are severely degraded, 13 million hectares are moderately degraded and two million hectares have practically lost the minimum soil cover needed to produce crops (DCI, 1997). According to Girma (2001), Ethiopia loses annually 1.5 billion metric tones of topsoil from the highlands by erosion.

A study by Bekele and Holden (1998) shows that the problem of soil erosion is compounded by the fact that some farmers dismantled the conservation structures built in the past through food for work incentives. Consequently, in Ethiopia land degradation in the form of soil erosion and declining fertility is serious challenging agricultural productivity and economic growth (Mulugeta, 2004). Soil erosion by water is by far the greatest land degradation problem. As Johnson and Lewis (1995) stated that the most ubiquitous cause contributing to agricultural land degradation was soil erosion. EFAP (1994) also made clear that measures of land degradation usually focus on the severity of soil erosion.

Water erosion not only removes nutrients but also reduces thickness and the volume of water storage and root expansion zone (Abiy, 2007). Under extreme gully erosion, farm activities are extremely affected. The magnitude and rate of soil erosion continued to increase despite the considerable efforts made during the past three decades. Hence, many studies attribute water erosion, particularly on cropland, as a major cause for such a high level of soil erosion in Ethiopia (Hurni, 1988; Bekele and Holden, 1998). The role of overgrazing is significant in fueling soil degradation process since it is integrated into a smallholder farming system (Kibrom, 1999).

2.2.1. **Extents of Soil Erosion**

During the last 40 years, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year (Pimentel *et al*., 1995). The problem of soil erosion in developing countries is not as parallel as in so called developed countries. Although many countries of the world suffer from the problem of accelerated soil erosion, the developing countries suffer more because of the inability of their farming populations to replace lost soils and nutrients (Erenstein, 1999, Cited in Selamyihun, 2004).

Ethiopia is one of the third world countries affected by soil erosion severity and is one of the most environmentally troubled countries in sub-Saharan Africa (Fitsum *et al*., 2002). In Ethiopia, the largest proportion of the degraded land is situated in the *Woinadega* agro-climatic zone where about 72% of cultivated land of the country is concentrated (Zewdie, 1999). Moreover, in the Ethiopian highlands, soil degradation and desertification are major issues since agriculture and deforestation have been practiced here for over 2500 years (Hurni, 1991), combined with the insecure rainfall, low technology levels and an increasing population it poses a major threat to agricultural productivity (FAO, 1986; Tewodros *et al*., 2008).

The living conditions of the rural poor in Ethiopian highlands have been worsening because of drought and increasing deterioration of the quality and quantity of natural resources, which are the main basis of subsistence agriculture (Yitayew *et al.,* 2006). The same study predicted that serious soil erosion is estimated to have affected 25 per cent of the area of the highlands to the extent that they will not be economically productive again in the foreseeable future. The capacity of the highland farming communities to sustain production is, therefore, under serious pressure.

Wood (1990) described severity of soil erosion in Ethiopia and indicated that erosion reduces the countries food production by 1-2 percent annually. According to EFAP (1994), every year 20,000-30,000 ha of cropland in the highlands is brought out of production due to soil erosion and the consequent land degradation and by the year 2000 some 2.4-3.8 million people were expected to be affected. The same study also predicted that by the year 2010, some 10 million highland farmers' cultivation land would have been destroyed if land degradation continued by the same rate.

2.2.2. **Causes of Soil Erosion**

Soil erosion is a natural process and worldwide phenomenon. Today soil erosion has increased to the point where it far exceeds the natural formation of new soil. As the demand for food climbs, the world is beginning to mine its soils, converting a renewable resource into a non-renewable one (Brown and Wolf, 1984). The problem of soil erosion is not only the threat for the developing countries, but also it is the threat for agriculturally sophisticated world. For instance, Brown and Wolf (1984) describe that even in an agriculturally sophisticated country like the United States; the loss of soil through erosion exceeds tolerable levels on some 44 percent of the croplands. The ceaseless growth demand for agricultural products contributes to soil erosion in many ways. Thus, throughout the Third World, farmers are pushed onto steeply sloping, erosive land that is rapidly losing its topsoil. In other areas farming has extended into semiarid regions where land is vulnerable to wind erosion when plowed (Brown and Wolf, 1984).

In Ethiopia the severity of soil erosion can be attributed to intense rainfall and rugged and dissected nature of the topography with nearly 70 percent of highlands having slopes exceeding 30 percent. Rapid population growth, cultivation on steep slopes, clearing of vegetation, and overgrazing are the main factors that are accelerating soil erosion in Ethiopia (Lulseged and Paul, 2008).

In the highlands of Ethiopia, deforestation has reduced tree cover to 2.7 % of the surface area, About 50–60% of the rainfall is estimated to be lost as run off, carrying 2–3 billion tones of the top soil away annually (Hurni, 1988). The annual rate of soil loss in the country is higher than the annual rate of soil formation. Hence, the underlying cause for the excessive rate of soil loss is the unsustainable exploitation of the land resource which is manifested by extensive de-vegetation for fuel wood and other uses and expansion of cultivation and grazing into steep land areas (Kibrom and Lars, 2000; Woldeamlak, 2003; Aklilu and de Graaff, 2006).

Besides, despite the considerable efforts made to develop and promote different types of soil and water conservation technologies, acceptance, adoption and sustained use by the land users have not been widespread for various reasons (Bekele and Holden, 1998; Aklilu and de Graaff, 2006; Alemayehu, 2007; Woldeamlak, 2007). Soil erosion is as well caused by lack of efforts in conservation and largely remains a problem to be tackled at ensuring food security, poverty reduction and environmental sustainability. Soil erosion has led to the degradation of agricultural land and consequent reduction in agricultural production thus exposing the population to food insecurity (Paulos *et al., 2004*).

2.2.3. **Consequences of Soil Erosion**

According to Brown and Wolf (1984), the loss of topsoil affects the ability of land to grow food crop in some ways. It reduces the inherent productivity of land, both through the loss of nutrients and degradation of the physical structure. Erosion results in higher fertilizer requirements, and lower yields. When there is a loss of topsoil, they may increase land productivity by substituting energy in the form of fertilizer, or through irrigation to offset the soil's declining water absorptive capacity. A loss of topsoil may experience either a loss in land productivity or rise in costs of agricultural production and conservation.

Moreover, Brown and Wolf (1984) stated as the apparent increase in soil erosion over the past generation is not the result of a decline in the skills of farmers but rather the result of the pressures on farmers to produce more. Throughout the Third World Countries, increasing population pressure and accelerating loss of topsoil seem to go hand in hand. This is true to Ethiopia, particularly, in its highlands. As stated by Hurni (1993); Sutcliffe (1993); MoARD and World Bank, (2007), soil erosion by water constitutes a severe threat to the national economy of Ethiopia. To this end, Stoorvogel and Smaling (1990) reported that Ethiopia has among the highest estimated rates of soil nutrient depletion in Sub Saharan Africa which reduces productivity and increases vulnerability to drought. Moreover, FAO (1986) estimated soil erosion to cost Ethiopia on average 2.2 percent of land productivity annually from that of the 1985 productivity level. In addition, Sutcliffe (1993) also estimated that erosion costs Ethiopia 2 percent of its GDP between 1985 and 1990. Besides to these, Sonneveld (2002) discussed that the cost of erosion in Ethiopia is very high and it accounts more than anticipation per year. This shows that the trend of the impact of erosion is increasing from time to time rapidly in the country.

Increasingly, the economic cost of soil erosion is around USD 1.5 billion per year (Hurni, 1988). The MoARD and World Bank (2007) stated that the minimum annual cost of soil erosion ranges between 2 and 3 percent of the national agricultural GDP. This also clearly shows the extent to which soil erosion is a contributory factor to the country's structural food insecurity problem. The benefits of erosion control are sometimes difficult to understand, but the costs of erosion are real. Erosion reduces productivity by modifying soil properties and is more harmful to soils that are shallow, have poor quality subsoil, and do not have thick topsoil. Any combination of these characteristics greatly increases the damage from erosion (Hurni, 1993).

2.2.4. **Farmers' Perception on Soil Erosion**

In considering farmers' perception on soil degradation, it is necessary to evaluate whether they distinguish between indicators of erosion and fertility loss (Desbiez *et al*. 2004). For instance, studies conducted in different areas have shown that farmers have knowledge of soil conservation measures (Okoba and Graaff, 2004). The question to be asked is: 'if farmers have knowledge of soil erosion, why not apply conservation?' Identifying where implementation problems may arise is also very important (Awdenegest and Holden, 2006).

The study conducted in Awassa District by Awdenegest and Holden (2006) clearly shows that 92 percent of farmers in the catchments were aware of the problem of soil erosion and believed the severity of the problem had increased in recent years and 94 percent of farmers in the catchment were aware of the problem of soil fertility decline. The most important reasons suggested for soil erosion were: deforestation (66%), no terracing (47%), runoff (42%), no or scarcity of grazing land (17%), high rainfall rates (14%) and steep slopes (13%). From these, one can easily understand that the reason for soil erosion can vary in space (landscape) and time. Morgan, (1995) described that high rainfall in steeply sloped areas with poor vegetation and an absence of protective measures will result in high rates of soil erosion. In these area, farmers suggested indirect reasons that aggravate the problem, such as gullies and rills, high population, labor shortage and lack of soil conservation practices (e.g. terracing, cut-off drains) (Awdenegest and Holden, 2006). It is obvious that some crops facilitate soil erosion by water as wheat and teff have greater role on such manner. Crop production system widely practiced in the highlands of the country such as cultivation of teff and wheat which require fine tilled seed bed and single cropping of fields encouraged soil erosion (Belay, 1992; Woldeamlak, 2003).

2.2.5. **Adoption of the Soil Conservation Measures in Ethiopia**

Prior to the 1974 revolution, soil degradation did not get policy attention it deserved (Hurni, 1986; Wogayehu and Drake, 2003). The famines of 1973 and 1985 provided a momentum for conservation work through large increase in food aid (imported grain and oil). Following these severe famines, the then government launched an ambitious program of soil and water conservation supported by donor and non-governmental organizations (Hoben, 1996). The use of food aid as a payment for labor replaced voluntary labor for conservation campaigns (Campbell, 1991). Supporting this inspiration, Pender (2004) stated that soil conservation measures have relied largely on food-for-work programs as an incentive and have been oriented toward labor-intensive activities such as terracing, bund construction and tree planting.

With this, Ethiopia became the largest food–for-work program beneficiary in Africa and the second largest country in the world following India (Campbell, 1991). A total of 50 million workdays were devoted to the conservation work between 1982 and 1985 through food-for-work. Between 1976 and 1988, some 800,000 km of soil and stone bunds were constructed on 350,000 ha of cultivated land for terrace formation, and 600,000 ha of steep slopes were closed for regeneration (Wood, 1990). These conservation structures were introduced with the objectives of conserving, developing and rehabilitating degraded agricultural lands and increasing food security through increased food production/ availability (Adbacho, 1991).

Soil erosion poses a serious threat to national and household food security (Bekele and Holden, 1998) and therefore its management is essential for improving food security in seriously affected areas of Ethiopia (Awdenegest and Holden, 2006). Initially, most of the soil conservation works included construction of the stone and earth embankments, which the farmers believed took extra land from their small land holdings and sheltered rodents. Available evidence shows that the adoption of soil and water conservation measures has been very limited (Girma, 2001). A study by Bekele and Holden (1998) shows that the problem of soil erosion is compounded by the fact that some farmers dismantled the conservation structures built in the past through FFW incentives.

In fact, until the early 1990s farmers were not allowed to remove the conservation structures once built on their land. This shows that the conservation efforts have also neglected the pronounced regional disparities within the country and have frequently been implemented in a top-down manner, excluding the participation of the local community (Herweg, 1993). It is further clarified that some techniques such as terracing and other land management practices can increase productivity and thus profitable in some area like in low rainfall area, but the same techniques are much less profitable in other areas like in high rainfall areas because they can actually reduce farmers' yields by reducing the effective area of the plot, causing water-logging, or harbor pests. However, the introduction of economic reform program in 1990s and subsequent liberalization of the economy brought more freedom and hence conservation structures could be removed if the land users so wished.

Conservation practices have mainly been undertaken in a form of campaign and quite often farmers have not been involved in the planning process (Herweg, 1993). This shows that soil conservation projects implemented in the country failed to consider local people's economic, demographic, institutional and technical factors from their very inception. Obviously, the adoption of soil conservation technologies considerably is influenced by different factors. Among other influences, the characteristics of farmers such as age, education, household size, farm size and experience are some major influence for the decision of application of soil conservation. The age of a farmer is an important characteristic of a farmer that affects adoption of soil conservation technology. Relationship between age and application of soil conservation technologies has been seen from different point of views. Age of the farmers tends to influence negatively the conservation decision in that it decreases participation on environmental protection (Belay, 1998).

Correspondingly, a study conducted by Adesina and Zinnah (1993) revealed unenthusiastic relationship between age of a farmer and adoption whereas Hossain *et al*., (1992) in the case of Bangladesh acknowledged a positive relationship between age and adoption of conservation technology. Yet other studies carried out by Ntege-Nanyeenya *et al*. (1997) and Nkonya *et al*. (1998) found no relationship between age and adoption of a technology. According to Rogers (1983), exposure to education may enhance the awareness of a new technology and hence increase the capacity of the farmers to apply a given technology. Other case studies in Uganda by Ntege-Nanyeenya et al (1997) indicated that education had a significant effect on farmers' choice to adopt maize production technologies. Also to Ervin and Ervin (1982) education was found as significantly related to conservation efforts. For Saliba and Bromley (1986) education enhances farmers' willingness to adopt new techniques by improving the management capacity of farmer.

The size of the household has been recognized to positively influence the application of soil conservation technology by Woldeamlak (2003), which identified lack of interest in soil and water conservation measures to be explained by shortage of labor. Thus, household size influences the decision of farmers to undertake the conservation measures given household labor is the whole supplier of the required labor for undertaking the farming and soil conservation operation. In contrary to this, household size was identified to negatively impact the intake of the technology in the study carried by Wogayehu and Drake (2003) in which indicated that in the large families with greater number of mouth to feed, immediate food need is given priority and labor is diverted to off-farm activities that generate food rather than practicing the soil conservation technologies. In another study by Bekele and Holden (1998) in Andit Tid, Ethiopia, household size has been identified to have a negative and significant effect on adoption of soil conservation practices. Farming experience can also determine farmers' awareness of and interest to a given technology and their ability to implement it.

Besides to the farmers' socioeconomic characteristics, practicing soil conservation measures could also be influenced by land characteristics such as slope, soil color and moisture holding capacity, the distance of cultivation field from the homestead. Slope of the cultivation fields either motivates or de-motivates farmers towards decision to practice soil conservation measures. Hence, farmers located in steeper slopes tend to control soil erosion through use of appropriate measures whereas the counterparts delay in application of soil conservation methods owing to situated on flat slope. The study of Saliba and Bromley (1986) stated that farmers cultivating steep slope fields install more effective conservation measures than farmers that cultivate level fields. They detailed that soil degradation is better perceived among farmers of the highly degraded areas than their counterparts in less degraded areas. On the contrary, farmers in less erosion prone areas (level fields) do not employ conservation measures on their farmlands. Other study by Wogayehu and Drake (2003) and Bekele (1998) found positive association between existence of recommended type of conservation structures and concluded that slope affects farmers' decision to adopt conservation structures positively. Also Wu and Babcock (1998) observed frequent conservation practices installed on steeply sloping cultivation fields which reflect the desire of farmers to control soil loss from highly erodible soil.

Some farmers perceive the effect of soil erosion when it reaches some critical level, which is very difficult to reverse the degradation at the subsistence farmer level. Farmers will not be interested to invest in conservation and bear associated risks if they do not perceive significant threat posed on productivity due to soil erosion (Wogayehu and Drake, 2003). To Wu and Babcock, (1998) and Wogayehu and Drake, (2003) farmers that cultivate black soil invest on soil conservation more whereas farmers those cultivate other soil colors adopt conservation practices less frequently.

The distance of plot has role on farmers' decision to adopt soil conservation practices. Study by Wogayehu and Drake (2003) found significant and negative correlation between no conservation decision and distance of a parcel from the residence but positive correlation between homestead farms and adopting conservation decision. Farmers residing close to their cultivation land invest more on soil conservation measures than their counterparts living at distance. This is because cultivation land closer to the residences receives more attention and supervision than land that is situated at the farthest distance. Thus, farmers invest more in soil and water conservation in fields situated near to residences. Farmers' income level can also have influence on decision to practice soil conservation measures, specially, mechanical one.

2.2.6. **Farmers' Perception Towards Soil Conservation Measures**

Understanding farmers' perception of soil erosion and its impact is important in promoting soil and water conservation technologies (Chizana *et al*, 2006). Soil erosion is an insidious and slow process therefore farmers need to perceive its severity and the associated yield loss before they can consider implementing soil and water conservation practices.

Soil conservation in Ethiopia has a long tradition in Sub-Saharan Africa (SSA). Indigenous techniques, such as ridging, mulching, constructing earth bunds and terraces, multiple cropping, fallowing and the planting of trees, were performed starting from long decades and combined erosion control with water conservation (Igbokwe, 1996, cited in Fitsum *et al*., 2002). However, their effectiveness has been constrained by various means. For example, in Ethiopia, Azene-Bekelu, (1997) stated that lack of farmers' involvement in the planning and implementation of the programs, soil conservation measures were poorly executed and maintained.

Only 25% of the rehabilitation targets have been accomplished and most of the physical soil conservation measures and community forest plantations are destroyed (EHRS, 1984). Different farmers may have different attitudes towards soil conservation. Those attitudes may also affect the selection of soil conservation practices. Sometimes, farmers who have good attitudes also may not practice soil conservation due to the socio-economic failures (Bandara and Thiruchelvam, 2008). Lynne *et al*, (1988) has paid particular attention to attitudes towards conservation. They combined economic and psychology theories and found that conservation decisions were influenced not only by context variables, such as tenure, income and farm terrain, but also by attitudes.

On the report carried out by CFSCDD and FAO (1990) to identify the reasons for the success and failure of soil conservation programs, Hurni, (1991) described that world-wide, 500 million people live in subsistence agricultural systems on steep lands. Their survival directly depends on soil conservation to be implemented on an immense scale within the next few years. However, there are many constraints for soil conservation. Pereira, (1968) considered soil erosion as an outward symptom of unskillful agriculture, thus the first step in the halting of soil erosion must be the allocation of a higher proportion of national funds to the improvement of agriculture and forestry. In relation to this, other experts have also argued that awareness of the existence of the problem is the first step in the adoption process and is positively correlated with the adoption of soil erosion controlling mechanisms (Ervin and Ervin, 1982). Perceiving the soil erosion problem and positive effect of soil conservation measures also provides stimulus to and shapes opinions about to adopt conservation practices that stop the problem (Long, 2003; Habtamu, 2006).

However, Belay (1992) and Woldeamlak (2003) in their study found that in spite of high level of farmers' perception of soil erosion problems, the level of adoption of conservation structures was very limited. Thus, perception of erosion problem is not a sufficient condition for adoption of soil conservation practices though it is a necessary one (Woldeamlak, 2003). Practice of traditionally known soil conservation methods tends to be influenced by some factors. For instance, farmers well know the importance of crop residues in enhancing soil fertility. However, crop residues and animal dung is used for fuel energy and other home use. FAO (2005) described that removal of plant materials impoverishes the soil, as it is no longer possible recycle the nutrients present in the residue.

CHAPTER THREE

METHODOLOGY

3.1. Types and Sources of Data

Data for this study w as captured from two sources: primary and secondary sources. The main primary sources of data were farmers. Hence, field observation, focus group discussion, interviews with selected farmers and other informants were primary data sources. Zonal and district agricultural experts, *Kebele* administrators, soil and water conservation supervisors and DAs provided primary information. In addition, secondary sources of information used for this study.

3.2. Sampling Procedures

Soro district is divided into 46 *kebeles* (peasant associations) with total population of about 217,452 (CSA, 2009). Two-stage sampling technique was employed to select sample farmers. In the first stage, three (3) peasant associations (PA[1]) were selected as study samples, namely; Bonadibaro, Sigeda and Sundusa; with total population of 4105, 3708 and 5968 respectively (CSA, 2009). Selection was made through the use of topography/slope, adjacency/neighborhood, erosion severity (rough estimation made by district agricultural office) and implementation of soil conservation practices as criteria. Topographically, since most of the interviewees were not clear in quantification of slope in percent or gradient, rough field estimation and measurement of the slope classes was made as lower slope (flat to gently undulating land estimated to be 0 to7%), moderate slope (gently undulating to sloping land estimated to be 8%-15%), moderately steeping land (estimated to be 16-30%) and steep slope (estimated to be over 30%). This slope gradient estimation was cross checked and matched with calculated contour map of the district. Also discussion with DAs and District Agricultural Officers was made to acquire information on slope classification.

Hence, Bonadibaro *kebele* was selected due to its slope ranging from moderately steeping to steep slope and soil and water conservation practices are in use relatively better than other *kebeles*. Adjacent to this, Sigeda *kebele* is in northeastward with moderate slope landform. Here adjacency was taken as criterion in order to examine whether the farmers nearby sharing experiences on the

[1] PA- *peasant association that is equivalent to Kebele; meaning is lowest administrative division.*

strength and/or weakness of soil and water conservation practices from the other *kebeles*. And the two *kebele* are accessible as they are in the vicinity of district agricultural office. The third sample is Sundusa *kebele* that was selected again based on slope from gentle/flat area because the researcher assumed that the perception on soil erosion and soil conservation measures might differ by slope categories and as well the severity of soil erosion problems.

In the second stage, sample households from three *kebeles* were selected from the available list randomly. The criterion to select sample households was wealth status of farmers that includes landholding measured in hectare (provided by *Kebele* Administrators) and length of food secured months measured in month (provided by Safety-Net Program Officer or food for work). Based on the size of households head in each *kebele*; 30 household heads from Sundusa *kebele*, 28 household heads from Bonadibaro *kebele* and 26 household heads from Sigeda *kebele* were selected, respectively. The total sample size is 84 (5.5%) household heads (Table 3.1). Twenty-seven farmers were also selected for focus group discussion (six farmers were so-called 'model farmers').

Table 3.1: Distribution of Study Samples by *Kebele* and Landholdings in hectare

Kebele	Land size in Hectare	Number of Farmers	Sample Size	Percent
Sigeda	<0.5 ha	169	10	
	0.5 ha-1.0 ha	151	9	
	1.0 ha-1.5 ha	89	4	
	1.5 ha-2.0 ha	24	2	
	>2.0 ha	10	1	
	Total	443	26	5.9
Bonadibaro	<0.5 ha	183	11	
	0.5 ha-1.0 ha	162	9	
	1.0 ha-1.5 ha	96	4	
	1.5 ha-2.0 ha	39	2	
	>2.0 ha	31	2	
	Total	511	28	5.5
Sundusa	<0.5 ha	230	11	
	0.5 ha-1.0 ha	171	9	
	1.0 ha-1.5 ha	119	5	
	1.5 ha-2.0 ha	49	3	
	>2.0 ha	31	2	
	Total	600	30	5.0
Total		1554	84	5.5

Source: Field Survey, 2010.

3.3. Methods of Data Collection

The following data collection tools were employed to gather relevant information.

3.3.1. Field Observation and Informal Interviews

Field observation was started while writing the proposal and continued onto the whole process of data collection to make sure the validity of acquired information. It was aimed on understanding the local condition of local community in terms of their culture, farm practices and traditional way of resources utilization and application of conservation measures, etc. During the walk, the researcher took notes on the soil erosion severity, existing soil conservation measures, yield conditions, soil color, topography and land use and land cover. Accordingly, the three sampled peasant associations were observed purposefully.

Infrequently, informal interviews were carried out with farmers who were met along the path that was aimed on obtaining information to produce structured questionnaires which is the core instrument for collected information and were conducted in an informal and easy manner.

3.3.2. Structured Interviews

Largely used instrument for data collection was structured interview with carefully constructed questions. Based on information acquired from informal discussion with farmers and field observation, and from literatures reading; structured questionnaire (Appendix 1) was developed for randomly selected 84 household heads. Selected questions from the same structured questionnaire were used to focus group discussions. The enumerators were selected (one was college graduate and the other was high school graduate) for structured interviews. Since, farmers speak Hadiya language; the enumerators are fluent in speaking Hadiyisa and Amharic as well. Before the implementation of survey, enumerators were trained and tested for their clarity and understanding the questions. Unclear and unrelated questions to local people and enumerators were modified and additional questions were also included that was supposed to be necessary to capture relevant information. Henceforth, the survey questionnaire included household characteristics, landholding, soil erosion problems, and soil conservation techniques.

3.3.3. Focus Group Discussions (FGD)

Two ways of communication was conducted between farmers and interviewers in order to make the process of data collection more effective. In this way, farmers could also ask questions on problems of soil erosion and soil conservations. Focus group discussion was conducted in all three *kebeles* with 27 selected farmers. From Bonadibaro 7 farmers (two were so-called 'model farmer'), from Sigeda *Kebele* 8 farmers (two were so-called 'model farmer'), from Sundusa 6 farmers (two were so-called 'model farmer') and 6 farmers selected from three *kebeles* (two from each *Kebele*).

In additional to these primary data sources, some secondary sources of data collection methods were used in this study. Secondary sources of information used for this study include published materials such as reports, plans, official records, census records, project reports.

3.4. Methods of Data Analysis and Presentation

Both qualitative and quantitative methods were used in order to analyze collected data. The findings of the study were presented in tables, figures and charts. Some structured household survey data were analyzed using percentages, multiple response (frequency and cross tabulation), and descriptive statistics (frequency and cross tabulation) using the Statistical Package for Social Sciences (SPSS) for Windows 17.0.

Discussion held with DAs, key informants and selected local people on soil erosion problems, practices of structural soil conservation measures was also analyzed descriptively. Comparison between structural soil conservation measures and other conservation measures was made using descriptive frequency and multiple responses frequencies.

CHAPTER FOUR

DESCRIPTION OF THE STUDY AREA

4.1. Location, Topography and Soil Resources

Hadiya zone is located in South-central part of Ethiopia and topographically contained mountains, hills and plains. Soro is one of 10 districts in Hadiya zone which is located at $7^0$30'-7^0 43' North latitude and $37^0$35'-38^0 05' East longitude (Figure 4.1), in the Southern-tip of the zone and bordered by Gombora District in the North; Oromiya Region (Omo River) and Yem Special District in the West; Dawro Zone, Kambeta (KAT) Zone, and Duna District in South and Southeast; Lemo District and again Kambeta Timbaro Zone in the Northeast and East. The administrative center for Soro District is Gimbichu; 264 km far from Addis Ababa and 200 km far from Hawasa town, the capital of the SNNPR. With the highest proportion of area coverage of 57141 hectares; 35% is flat and 65% is undulating, moderately sloping and steeping lands. The altitude ranges from 840m to 2850m above sea level (Soro District Agricultural and Rural Development Office, 2010).

The wide diversity in climate, topography and vegetation cover in the study area has given rise to marked variations in soils, even within relatively small area. No detailed soil surveys have been carried out in Soro district. As farmers' classification, the dominant soil types are red-brown to red clayey soils on undulating land to steeping lands including the rolling plateau. These soils are relatively fertile and productive than grayish soil types which dominated the flat to undulating lands. The soils of this area are highly susceptible to erosion with gradually declining productivity. Whereas the soils of flat slopes are grayish to dark with leaning to water-logging during rainy seasons, yet less susceptibility to erosion. Thus, management of the soils of the area is likely dependent on soil types, fertility, slope, workability, water holding capacity, and susceptibility to erosion. Addition of nutrient through the crop residues and manuring was very rare and tends to rapidly increase in moisture depletion.

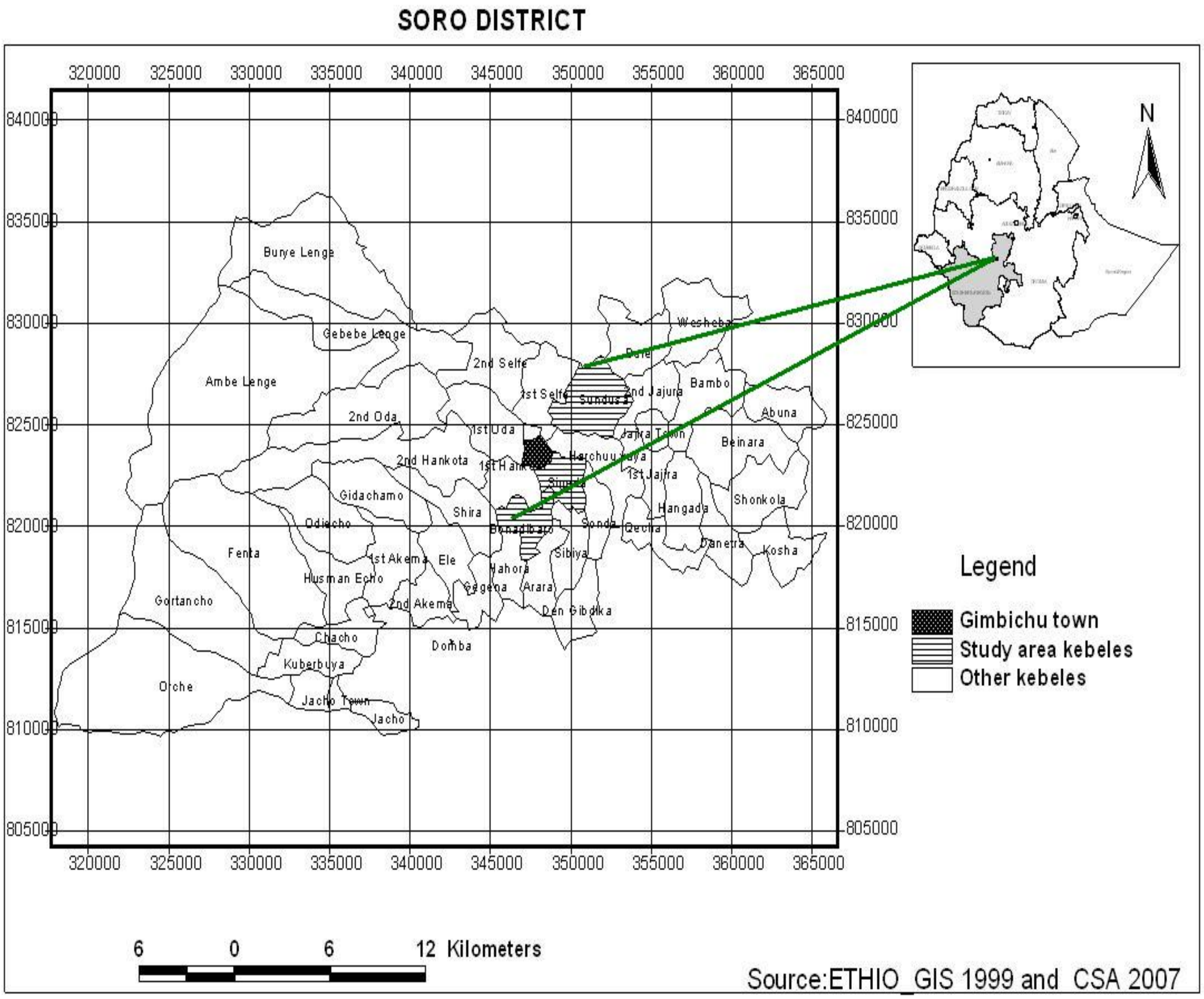

Figure 4.1: Map of the Study Area

4.2. Climate and Water Resources

The district is a typical of the moist *weyna-dega* agro-ecological zone (8% *dega*, 55% *weyna-dega* and 37% *kola*). The mean annual total rainfall is about 1260mm and has average temperature of 19^{o}C (Behailu, 2009).

Accordingly, it has two rainy seasons, *Belg* and *Kiremt. Belg* is the short rainy season and lasts between March and May. The *Kiremt* season, which is the longest rainy season, lasts between June and September. More than 75% of the total rain falls during this season and the highest rainfall occurs in July and August. Rain that occurs during the *Kiremt* season is very intensive and, hence, the severity of soil erosion is high during these two months.

Most of the crop production also takes place during the *Kiremt* season. Even though there were some variations with respect to cessation, amount and distribution, the *belg* rains were by large favorable in most areas of the district. For example, onset of the rain was timely in almost all *Belg* producing *kebeles* of the district and most districts of the Hadiya zone. Overall, although some positive aspects of rain were observed, there were damages caused by overflow and high erosion, particularly in the area of steeping landscapes. In *Kiremt* season excessive rain causes large amount of soil loss and crop damages. Accordingly, there was a decline in amount and distribution of rainfall from year to year.

Altitude and humidity have significant impact on temperature condition in Ethiopia. The warmest months of the area are between February and May. On the contrary, the coldest months of the study area range between June and August. October and November are windy months (Behailu, 2009).

In the district about 63.9% populations were accessed to adequate water supply. About 93.2 % of water supply comes from streams and springs and only 6.8% comes from tap water sources. The entire area drains towards the Gibe River in the west direction. In the study area, there are three main streams (namely, Lintala stream that separates the two adjacent study *kebeles*, Sigeda and Bonadibaro, Ajacho and Gamunna streams). There are also permanent springs which are used as source of drinking water for the town and rural community.

4.3. Land-Use and Vegetation Cover

The study area has an old history of land use with high erosion damages, especially with increasing slopes. As the remnants of tree species (scattered here and there) depict the area has once been covered by dense forest. However, the vegetation cover has been removed, and replaced by cultivation fields and plantation of exotic species such as eucalyptus species mainly *Eucalyptus globules* and *E camaldulensus*. As per the trend analysis of forest coverage by watershed management experts, particularly in Sigeda and Bonadibaro kebeles, forest covered area was 53% before 1974. Between 1974 and 1991, the forest coverage declined to 32% and rapidly went down to 15% between 1991 and 2008. Major reason for this rapid decline of forest coverage was extensive deforestation due to the population growth and expansion of cultivation land. Thus, like other parts of the country, natural vegetation of the area has been influenced by human activities.

The remnant tree species in the study area witness the land cover/ land use change that occurred because of the impact of human activities. Like forestland, grassland and bush land overgrazed and then gradually changed into farmland. Common grazing land exists in pocket areas and farmers graze their animals near to homestead. Because of this shortage of grazing field, farmers have owned small numbers of animals. As result, accelerated soil erosion and fertility decline become the main problem of the area once the forest cover was lost.

4.4. Landholding Size of Respondents

The landholding of farmers in the study area is very small, as in most of the highlands of the country. Landholding among households varies significantly where the household per capita landholding being 0.10 ha. Minimum and maximum size of landholding were 0.12 ha and 5.70 ha, the average being 0.85 ha. This seems to lend evidence for what was projected by IUCN (1990). According to this report, the per capita landholding of the country is expected to decline from average of 1.76 ha in 1985 to 1.1 and 0.66 ha in years 2000 and 2015 respectively (IUCN, 1990). Despite this fact, the per capita landholding of the study area is by far less than what was reported even for the year 2015.

4.5. Crop Production and Economy

Dominantly growing crops in the study area include wheat (*Triticum sp.*), *teff* (*Eragrostis sp.*), sorghum (*Sorghum bicolor*), Oat (*Avena sativa*), bean and peas (*Vicia fabia* and *Pisum sativa*), barley (*Hordeum sp.*), maize (*Zea mays*), potato (*Solanum tuberosum*) and enset (*Enset ventricosum).* None of these crops could be grown without chemical fertilizer application since natural fertilizer of the soil is insufficient, except Enset. Enset is the staple food in the area and almost always grown for consumption and also for sale. Major crops such as teff and wheat and others are grown once in a year during the long rainy season. Some crops such as maize, barely, enset, and potato are also grown during the small rainy season. Crop productivity is declining from year to year. Economically, agriculture serves as the main economic foot and means of livelihood to the majority of the people and characterized by traditional mixed farming as it includes both crop and livestock production. More of it is rain-fed with gradual prevalence of drought and crop failures.

4.6. Socio-Economic Characteristics

4.6.1. Demographic, Ethnic Composition and Religion

Based on National population and housing census reports of 1994, estimation made in 2005 about the total population of the district was about 233,058. The four largest ethnic groups reported in Soro were the Hadiya (89.57%), the Kembata (1.67%), the Timbaro (1.49%), and the Amhara (1.23%); and all other ethnic groups made up 6.04% of the population. Hadiya was spoken as a first language by 93.13%, 2.17% (Kembata), 1.14% (Timbaro), and 0.75% (Amharic); the remaining 2.81% spoke all other primary languages. In terms of religion, 60.15% of the population was Christians (Protestants), 19.04% embraced Ethiopian Orthodox Christianity, 11.39% were Catholic, 4.46% practiced traditional religions, and 0.95% was Muslim.

The CSA (2007) reported the population of the Soro District to be 196,693. This has shown a decline by 36365 people from the population size of 2005 (CSA, 2005). It was mainly because of inclusion to adjacent district and out migration. The District Finance office and population and housing annual report also recorded the population for the year 2009/10 was 217,452. Male populations account about 108,271 (49.8%) and females were about 109,181(50.2%). About 95.9% of populations of Soro District are involved in agriculture and reside in rural areas experiencing declining food security (Table 4.1).

Table 4.1: The Population of Soro District by the year 2008 and 2009/10

No	Kebeles	Population by years						Remark
		2008			2009/10			
		Male	Female	Total	Male	Female	Total	Increase/yr
1	Sigeda	1800	1806	3606	1851	1857	3708	102
2	Bonadibaro	2017	1975	3992	2074	2031	4105	113
3	Sundusa	2849	2956	5805	2929	3039	5968	163
Total		6666	6737	13403	6854	6927	13781	378
Gimbichu Town		4685	3869	8554	4816	3978	8794	240
District /Woreda		105322	106207	211529	108271	109181	217452	5923

Source: Soro District Finance and Statistic Office, 2010.

The minimum and maximum sizes of households were 2 and 25 respectively, the average being 8.2 (Table 4.4). This is the same to the average of the district, but by far greater than 5.7 that have been reported for Hadiya Zone (CACC, 2003I).

Table 4.2: Household Size of the Sample Respondents

Household sizes	Frequency	Percent
1-3(small size)	1	1.1
4-6(Medium size)	21	23.1
7-9(Large size)	50	54.9
Above 10(Very large size)	12	13.2
Average size for Sample Household		8.2
Average size for Soro District		8.2
Average size for Hadiya Zone		5.7

4.7. Soil Conservation Activities

Primarily, conservation structures were introduced with the objectives of conserving, developing and rehabilitating degraded agricultural lands and as well increasing food security through increased food crop production (Adbacho, 1991). As a result, most of the conservation structures were practiced to protect soil erosion on the farmlands. Some widely used structural soil conservation measures are described in the following few sections.

4.7.1. 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).

Since the beginning of introduced soil conservation measures in 2004, there was a continuous construction of soil bunds, yet there is delay in implementation. In 2004, 2005 and 2006 the length of constructed soil bund in the study area was 779.42km, 815 km and 970 km, respectively. However, the trend of constructing soil bunds declined as of 2007. Between 2007 and 2009, the district's agricultural and rural development office planned to construct 369km of soil bunds in each year. But around 254 km, 325 km and 274.6 km soil bunds were accomplished in 2007, 2008 and 2009, respectively. Although maintenance was planned for 540 km soil bunds for the year between 2007 and 2009 at district level, only about 325 km, 401.3km and 445km were completed (District Agricultural Office, 2010).

In Bonadibaro, Sigeda and Sundusa Kebeles, 5 km, 4.5 km and 3.7 km soil bunds were constructed in 2009, respectively. Also 15.2 km, 15.2 km and 12 km soil bunds were maintained and preserved in Bonadibaro, Sigeda and Sundusa, respectively. In the year 2010/11, the districts' agricultural and rural development office plan to construct 369 km soil bunds in degraded area and claimed to maintain 540 km soil bunds (Soro District Agricultural Office, 2010).

4.7.2. *Fanya Juu*[2]

This 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). *Fanya juu* is usually applied in cultivation land with slopes above 3% and below 16% gradient. It can also be constructed in uniform terrains with deep soils. Moreover, it has a potential to increase/sustain soil productivity and environmental protection.

Integration with grasses and composting is suitable in *fanya juu* soil conservation measure.

To increase the efficiency of *fanya juu*, a group of 5-20 households work together. *Fanya juu* is commonly practiced in Ethiopia in several areas following its introduction over 2 decades ago.

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[2] *Fanya juu- is a term coined from Swahili language; meaning "throwing up-hill"*

The construction of *fanya juu* takes less space than soil bunds and accelerate bench development, thus, complaint about space can be greatly reduced with *fanya juu* terraces (WFP, 2005). But the great similarity rises from that embankments of soil bunds and *fanya juu* terrace are laid following contour of fields. The district's agricultural and rural development office merged the soil bunds and *fanya juu* structures in its plan and claimed to construct 1000 km structure (soil bunds and *fanya juu*) and maintenance of 500 km of various conservation structures in 2010/11. Specifically, 3.5 km *fanya juu* was constructed in Sundusa Kebele in 2007. No maintenance was made for these structures rather some structures were destroyed and changed into cultivation fields.

4.7.3. Cutoff Drains

As many of other structural soil conservation measures, cutoff drains are constructed during dry season to avoid impediment to land preparation for main cropping season. This structure is a graded channel constructed mainly in moist area to intercept and divert the surface runoff from higher slopes and protect downstream cultivated land or village (Figure 4.2). On the contrary, cutoff drains in dry area are used to divert runoff and additional water into cultivated fields to increase soil moisture.

Figure 4.2: Cutoff Drains in Cultivated Fields (Field Survey, 2010)

Between 2004 and 2006 the district agricultural and rural development office constructed 55.38 km, 60.5 km and 76.5 km cutoff drains on erosion prone areas. In 2009 the construction of 27.67 km was completed and 30 km of cut-off drains were constructed in 2010. The construction was also made by traditional way through the use of oxen and digging by hand.

4.7.4. Waterways

Waterways can be natural or man made 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 (Figure 4.3).

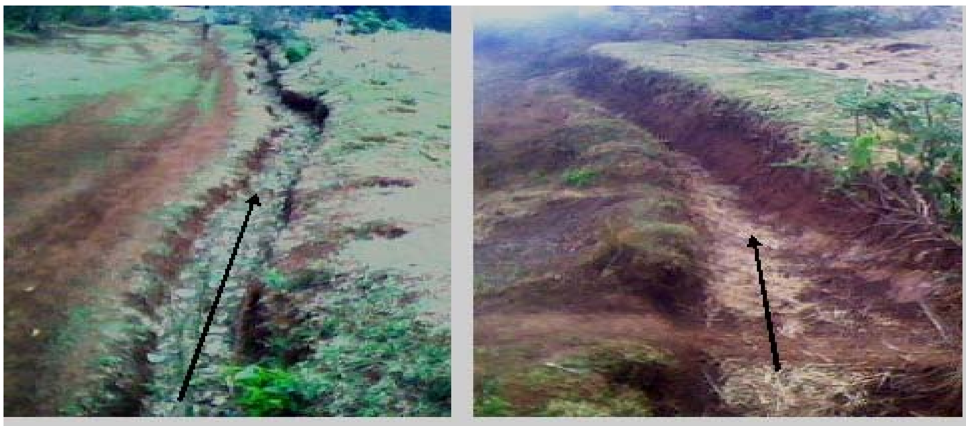

Figure 4.3: Waterways above Cultivation Fields (Field Survey, 2010)

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).

4.7.5. Check Dams

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.

CHAPTER FIVE

RESULTS AND DISCUSSIONS

5.1. Farmers' Perception on Erosion Problems

5.1.1. Land size, Soil Fertility and Land Productivity

Of interviewed farmers, 97.6% indicated that the land they cultivate is insufficient to support their households. They were asked to categorize the causes for the scarcity of cultivable land. About 30% of them noted population growth as the main cause and for 28 % of the farmers, land degradation (loss of fertile soil due to erosion) was the main cause for the scarcity of cultivable land, yet 6% of them lost their land due to the expansion of town and main roads. For example, the expansion of the Gimbichu town converted much of the agricultural land to urban land.

Farmers suggested the possible solutions for this cultivable land scarcity to be resettlement (26%), migration to urban areas (14%), involvement in off-farm activities (small scale trading, daily laborers, etc (28%), increasing the existing land productivity by using soil conservation and improved seeds (32%). None 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 sending their children to schools and providing access for non-farm activities.

Farmers possess a detailed knowledge of soil fertility they are cultivating. Discussions with the groups provided qualitative evidence to support that farmers perceive relative soil fertility in terms of crop yield although other aspects like rainfall patterns and soil characteristics noticeably matter the yield. Also they relate yield to the position of the slope suitable for cultivation. As noted, maximum yield is obtained from flatter and gentler slopes. A few farmers preferred undulating slope for high yield, because they fear of water-logging in a flat slope.

Farmers have good acquaintances of identification of soil fertility and classify soils based on their fertility, consistence, color and moisture using local language, such as; '*harsha* or *sham bucha'* (very dark and fertile soil), '*lambe'anch bucha'* (heavy gray and moderately fertile soil), *'qottala* or *goggal bucha' (light* gray and infertile soil), *'borbora* or *kashar bucha'* (very infertile and red soil) and '*dora'* (sticky grayish to reddish clay soil that is mainly used for pottery and ceramics).

About 54.8% and 40.5% of the farmers described the color of their soil as grayish and reddish, respectively. Only 4.8% of farmers' land was described as dark to grayish in color (i.e. relatively fertile soil). Hence, farmers perceived as dark soil is very fertile and provides high yield unlike the grayish and reddish soil. When the soil becomes structure-less and much clayey, it would become vulnerable to runoff. Also other characteristics such as texture, depth, and drainage are used in the soil fertility evaluation. Farmers' identification of soil fertility and color considerably deviate from what researchers and scientists do followed. If the soil yields consistent overtime, they could consider the soil fertile but they couldn't explain the detailed requirement and deficiency of soil.

Almost all farmers have confirmed that soil fertility was declining from year to year. In line with farmers' response, 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.

Group of farmers also confirmed that less fertile land requires much fertilizer inputs in order to compensate deficit elements of the soil. However, fifty-seven percent of farmers noted that 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. Animal dung was used as source of energy for cooking. Removal of crop residues was mostly common practices for animal feed and other home use. The removal of crop residues impoverishes the soil, as it is no longer possibly recycle the nutrients present in the residues (FAO, 2005). Farmers noted management and conservation level increases when the soil losses its fertility. Absence of grasses and vegetation cover were mentioned as other indicators for the soil infertility by forty-five percent of the farmers. Currently, the soil hardly grows grasses and becomes bare and rock outcrops were common.

Farmers perceived some major causes for soil fertility decline, yet there is difference in level of importance based on slope. Some major causes of soil fertility decline are similarly mentioned as major causes of soil erosion. For 85.7% of farmers soil erosion by water was a major problem responsible for the declining soil fertility in upslope *kebeles* whereas many farmers in flatter slope attributed declining soil fertility to continuous cultivation and absence of fallowing.

Also farmers in upslope attributed soil fertility loss to topography of the cultivation fields and unreliable rainfall, yet other causes like introduction of eucalyptus trees, low level of soil conservation measures, deforestation, insufficient supply and delay of chemical fertilizer have better role on fertility decline throughout every slopes (Table 5.1). Intensive rainfall washes away the top fertile soil whereas the shortage causes drought and facilitates the processes of wind erosion. In flatter slopes, prevalence of unreliable rainfall does not form a major problem of soil fertility loss but forms in upslope positions. On the other hand, continuous cultivation and absence of fallowing accelerates soil fertility loss in flat slope, whereas it is second or third cause in upslope positions. This suggests the spatial variability of soil erosion and its associated impacts within the study area as it is caused by topographic factors of soil erosion and thus, majority of farmers are able to relate causes of soil fertility loss to factors of soil erosion.

Table 5.1: Farmers' Perception on Some Major Causes of Soil Fertility Decline

Causes of Soil Fertility Loss	Respondents Residence		
	Sigeda	Bonadibaro	Sundusa
	Percent	Percent	Percent
Continuous cultivation and absence of fallow	21.4	22.6	33.3
The topography of the land	23.8	26.2	9.5
Severity of Soil Erosion	28.6	29.8	9.5
Unreliable Rainfall	28.6	33.3	13.1
Deforestation and Desertification	10.2	11.4	9.4
Introduction of Eucalyptus Trees	13.1	12.0	20.2
Insufficient and Fertilizer Supply	19.0	22.6	14.3
Low level of soil conservation measures	9.5	15.6	1.1

Land has been cultivated frequently to produce food crop for rapidly growing population. Particularly, owning small size and increasing demands for food crop production forced farmers to cease long-stayed traditional ways of soil fertility management such as fallowing, manuring, terracing, and leaving crop residues on the fields. Fallowing was nearly absent due to land shortage and manuring was rare as it is used as source of energy. Crop residues were used for other purposes like forage, construction, and otherwise some farmers burn immediately after harvest.

Moreover, insufficient and inappropriate timing of supply of chemical fertilizer has role on soil infertility. More than half of the farmers argued obtaining of required fertilizers is delayed and in the mean time the land is repeatedly plowed that makes soil ready for runoff. Also when the fertilizer was insufficient, farmers again mix the soil repeatedly to uniformly distribute the fertilizer and this in turn causes the soils easy for detachment and transportation.

Introduction of Eucalyptus trees and deforestation have a great role on soil fertility loss. As per the responses, there were considerable amount of indigenous forests before a decade. But due to high demand for arable land by the growing population, the forested area were cleared and changed into farm lands. This expansion resulted in soil erosion particularly on steeper slopes and there by causes soil fertility decline. This supports the works of Aklilu and de Graaff, (2006); Woldeamlak, (2003); Kibrom and Hedlund, (2000) which all stated the underlying cause for the excessive soil loss is unsustainable exploitation of land resource via clearing of natural vegetation for fuel wood and other uses and expansion of cultivation and grazing lands onto steepy land areas.

Eucalyptus globules and *E. camaldulensus* are introduced to the area long years ago. These tree species are laterally and deeply rooted in searching for available moisture and minerals. It thus over exploits the moisture and fertility of soil although it is the source of income, firewood, materials for construction to many of the local people. Moreover, leaves of the eucalyptus species laid on the ground take longer time to decay and shield the infiltration of water thereby increasing the risk of runoff and erosion.

5.1.2. Indicators, Causes, Extents and Consequences of Soil Erosion

As recognized from group discussions, farmers perceived soil erosion as a problem of farming. Of course, farmers acquaint with soil erosion from observations of their surroundings, accumulated experiences and by pressures from experts. Environment lends them with traditional knowledge that could be experienced through the passage of time and shared with each other that could either strength or weakness of farmer's practices.

Farmers in this area mentioned the some similar indicators for both soil fertility loss and existence of severe soil erosion with varying level. Those farmers who choose the severity level as high understood and related the existence of soil erosion on their plots to development of gullies and rills in their farms as well as the truncated topsoil. Hence, 79.8% and 78.6% of the farmers suggested that, respectively, rills and gully development and absence of fertile topsoil to be as major indicators of the existence of moderate to severe soil erosion problem on their cultivated fields. About 72.6% farmers verify that poor crop and grass growth as indicators for soil erosion. Others describe the existence of severe soil erosion problem by observing the stoniness of soil (71.4%) and color of soil (59.5%) changing from dark/black to red one.

Still 63.1% of the farmers explained the occurrence of soil erosion in the study area in general and their farms by the presence of accumulated soil at the bottom of conservation structures and lower positions. When the runoff lacks the capacity to transport the uploaded soil, it tends to unload it at the middle or end of the channel as sediment. If the deposit is black in color, farmers consider it as removal of fertile soil from some elsewhere in the watershed. In addition to these, farmers also mentioned slope steepness and root exposure (observation of roots of trees on the surface) as indicators of existence of soil erosion on their lands (Figure 5.1).

Figure 5.1: Gully development and Root exposure by water erosion (Field Survey, 2010).

A land that is poorly fertile couldn't give yield as expected and gradually turns to bare land and lacks any form of vegetation cover. In this area, it was observed that nearly 41 hectares of arable land has been left uncultivated and became rock outcrops with un-crossable gullies. The slope of these degraded lands ranges from 25% to 33% creating difficulty for construction of soil conservation. Historically, these degraded areas were covered by natural forest before few decades. Due to increasing need for cultivable land, deforestation had taken place. However, after using the lands for only 4 or 5 years without appropriate conservation methods, farmers left uncultivated because the land became infertile and rock outcropped. The degradation is increasing by increasing the proportion of rock outcrop and stoniness that forced farmers to abandon arable land.

The responses of many farmers on the causes and extent of soil erosion in their fields were nearly comparable. Some causes of soil erosion are as the same time causes for soil fertility decline. Larger proportion of surveyed farmers in Bonadibaro and Sigeda PA declared the severity of erosion resulting in the formation of gully, but few farmers assumed presence of severe erosion in flat Sundusa site. As noted by many farmers, the two most important causes of soil erosion in the area are slope steepness of the cultivation fields and ceaseless cultivation and absence of fallowing, yet other causes have better scope in paving the way for erosion (Table 5.2).

Table 5.2: Farmers' Perception on Major Causes of Soil Erosion

Causes of Soil Erosion	Frequency	Percent	Percent of Cases
I. Slope steepness of the cultivation land	64	13.5	76.2
II. Ceaseless cultivation and absence of fallowing	63	13.3	75.0
Types of soil and erodibility	51	10.8	60.7
Intensity of rainfall	61	12.9	72.6
Absence and delay of Soil conservation measures	51	10.8	60.7
Insufficient and delayed fertilizer	48	10.1	57.1
Deforestation and desertification	46	9.7	54.8
Overgrazing	38	8.0	45.2
Terms of land preparation for cropping	51	10.8	60.7
Total	473	100.0	563.1
Dichotomy group tabulated at value 1.			

Among interviewed farmers, 76.2% and 75% farmers attributed the causes for soil erosion as slope steepness and unceased cultivation in steep slope areas, respectively. As the study area is more susceptible and relatively populated than neighboring districts, absence of fallowing period and repeated preparation of the land for cropping makes the soil easy for soil erosion. This clearly provides support for the conclusion of Bekele and Holden (1998) who stated that vast areas of the highlands of Ethiopia could be classified as suffering from severe to moderate soil degradation. Increasing intensification and continuous cultivation on sloping lands without supplementary use of soil amendments and conservation practices poses a serious threat to sustainable land use. In addition, Brown and Wolf (1984) stated that the apparent increase of soil erosion over the past generation is not the result of a decline in the skills of farmers but rather the result of the pressures on farmers to produce more. Hence, farmers of the study area were aware of soil erosion but they are forced to intensify and produce more food crops for their basic livelihood.

Moreover, 72.6% and 60.7% of the farmers considered the high intensity of rainfall (i.e. erosivity) and the soil characteristics (i.e. erodibility) as causes of soil erosion in their land. Deforestation and overgrazing were mentioned as causes of soil erosion by 54.8% and 45.2% of the farmers of the study area. Over grazing has received relatively less attention as a cause of soil loss/erosion in highlands because the number of livestock is limited there than in the lowland parts of the study area. However, keeping livestock in flat sloped areas results in soil erosion by destruction of soil conservation measures.

Farmers described existence of soil erosion on their land as severe, moderate, minor, and no erosion risk (Table 5.3)

Table 5.3: Farmers' Expression of Soil Erosion by Degree of Severity

Soil Erosion Severity Level	Frequency	Percent	Cumulative Percent
Severe	21	25.0	25.0
Moderate	34	40.5	65.5
Minor	25	29.8	95.2
No Erosion Risk	4	4.8	100.0
Total	84	100.0	

Table 5.3 shows that 29.8% of interviewed farmers mentioned erosion on their farm-field is minor and about 55 (65.5%) of the farmers interviewed opted that there is moderate to severe degree of soil erosion problem on their lands. Only about 4.8% of farmers indicated that there is no erosion problem on their farms. Some farmers speak about soil fertility loss, still they have mentioned as no soil erosion on their land. In contrary, other farmers, however, able to identify clearly the soil type, causes extent and overall result of soil erosion. What brought the difference among the farmers in expressing soil erosion problems?

The impact of educational attainment on farmers' perception on soil erosion problems was examined whether it has significant role on the perception and identification of erosion problems as presented in Table 5.4.

Table 5.4: Farmers' Educational level and Perception of Soil Erosion

Educational Status	Farmers' perception of soil erosion as a problem					
	Always		Sometimes		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cannot read and write	34	40.5	7	8.3	41	48.8
Read and write	20	23.8	4	4.8	24	28.6
Secondary level	11	13.1	1	1.2	12	14.3
above grade 10	7	8.3	-	-	7	8.3
Total	72	85.7	12	14.3	84	100.0

The level of expression of soil erosion problem shows difference among the educated and uneducated farmers. This shows that illiterate farmers differ in perceiving soil erosion problem compared with educated farmers and with an increasing level of educational attainment of farmers, there is higher perception of soil erosion problem. For instance, almost all farmers who attained education above secondary level have perceived the existence of soil erosion well and practicing soil conservation measures on their land. Therefore, as result of their educational level, uneducated farmers are likely to differ in practicing soil conservation measures compared with educated farmers. In conclusion, educational attainment of farmers supports them in identification of indicators, causes, extent and consequences of soil erosion risk on their land. However, decision to practice soil conservation measures demands the consideration of other aspects of perception.

Farmers acknowledged the effects of soil erosion on their lives. Most of the farmers stated the overall consequences of soil erosion tends to be loss of topsoil, reduction of yield over time, loss of vegetation cover and grasses, change in soil color, require high input and management, and formation of gullies, lack of farm land and grazing field and out migration. When the land becomes rock outcropped, there would be shortage of cultivable and grazing land. The consequences of soil erosion were mentioned as main indicators of soil fertility decline in famers' land.

Moreover, surveyed farmers well understood even where effects of soil erosion tend to be severe. Accordingly, soil erosion is severe in cultivated fields because the land was prepared several times before planting. About 87% of the farmers approved that the croplands are vulnerable to soil erosion from other lands. This is explained by the growing of some crops which require repeated plowing for adequate seed bed preparation and hardly allow intercropping.

As 60.7% farmers responded, crops such as *teff*, wheat and barley require fined soil seed bed and also land has been prepared for prolonged times while waiting for chemical fertilizers; which makes it succumb to soil erosion. In view of that, 97.6% of farmers suggested that *teff* and wheat are the two crops that require fined soil and repeated preparation of soil. For *teff* cultivation, for example, the land should be prepared six times and for wheat and barley 4 to 5 times, and for other crops at least 2 to 4 times land preparation is needed.

The cultivation of *teff*, wheat, barley and some other crops hardly allow intercropping and this exposes the land for the effects of erosion (Table 5.5).

Table 5.5: Types of Crop Produced in the study area and terms of Land Preparation

No.	Types of Crop	Scientific Names of Crops	Terms of Land Preparation for Cropping
1	*Teff*	*Eragrostis tef.*	5-6 terms
2	Wheat	*Triticum aestivum*	4-5 “
3	Barley	*Hordeum*	4-5 “
4	Maize	*Zea mays*	3-4 “
5	Sorghum	*Sorghum bicolor*	3-4 “
6	Potatoes	*Solanum tuberosum*	3-4 “
7	Sugar beat	*Beta vulgaris*	2-3
8	Beans	*Phaeolus*	2-3 “
9	Peas	*Pisum sativum*	2-3 “
10	Oat	*Avena sativa*	2-3 “
11	Lentil	*Lens culinaris*	2-3 “
12	Taro	*Colocasia esculenta*	2-3 “
13	Chickpea	*Cicer arietinum*	2-3 “

As farmers noted, repeated land preparation has been done to enhance soil moisture and fertility. This in turn encourages soil erosion and lends evidence for the conclusion of Belay (1992) and Woldeamlak (2003) that illuminated the type of crop grown has important implication on soil degradation.

5.2. Practices of Structural Soil Conservation Measures

The costs and benefits related to the structural soil conservation measures have role on farmers' decision to practice them. Relatively, structural soil conservations are widely used in arresting soil erosion by water in the area. The practiced structural soil conservations include soil bunds, *fanya juu*, cut-off drains, check dams, waterways and trench digging (Table 5.6).

Table 5.6: Major Practiced Structural Soil Conservation Measures

Types of Practiced Structures	Responses		
	Frequency	Percent	Percent of Cases
Soil bunds	40	25.8	55.6
Fanyaa juu	14	9.0	19.4
Cutoff drains	52	33.5	72.2
Check dams	14	9.0	19.4
Waterways	19	12.3	26.4
Trench digging	16	10.3	22.2
Total	155	100.0	215.3
Dichotomy group tabulated at value 1.			

The dominantly used structural soil conservation measures are cutoff drains and soil bunds. About 72.2% and 55.6% of the farmers have used these two conservation structures, respectively. However, there is some confusion between the use of soil bunds and cutoff drains in terms of their merit and demerit. Some farmers in high slope positions mostly practiced cutoff drains with integration of waterways in preference to soil bunds. Those farmers perceived cutoff drains as more important structure than soil bund in arresting soil loss.

Soil bunds create difficulties when increased in height and construction is costly and labor intensive whereas cutoff drains are easy to construct and maintain as required. However, cutoff drains transport fine soil from farm fields and favor gully formation in cultivated fields. In the study area, farmers with small landholding mostly preferred construction of cutoff drains and waterways because it would be easy to construct more cutoff drains within small farm size whereas construction of soil bunds take more land and increases grassed top, time consuming, requires more labor as well as its maintenance is expensive.

In addition, farmers in hillsides practiced check dams and trench digging to control excessive runoff. Construction of check dams within farm land was uncommon in past years, even though there were large numbers of gullies. Diverting runoff from cultivation fields and home yards through waterways was common. Nowadays, creation of awareness among community supported the gully rehabilitation and use of brushwood and stone check dams (if stone available) in the communal roads and farm fields.

The interest of farmers in trenches digging showed less curiosity, particularly in flat area because of fearing water-logging and gullying, yet it has role on controlling soil erosion by water. A few farmers have well recognized the importance of trench digging as to harvest rain water so as to increase permeation. Planting temporary crops around the trench benefit farmers by controlling damage of trench and provide fruit.

The practice of *fanya juu* is limited and the importance is merged with soil bunds despite their differences. Most farmers in the study area have not been clearly informed on the unique benefit of *fanya juu*. For instance, soil from *fanya juu* is thrown up and facilitates bench development and construction requires lesser land than soil bunds. In contrary to this, throwing the soil from *fanya juu* structures is difficult for aged farmers and shifted the decision towards the practice of cutoff drains and other soil conservation measures or leaves the land without any conservation measure.

5.3. Factors Affecting Practices of Structural Soil Conservation Measures

Farmers' application of structural soil conservation techniques could possibly be influenced by different sides. Among major factors age, gender, household size, income, soil type and depth, topography, education status of farmers and land size were repeatedly mentioned by many surveyed farmers. In addition, lack of information on benefit and cost of structural soil conservation measures, distance from the homestead, level of contact with DA's, training on soil erosion and soil conservation techniques and length of food secured months have significant influences on practicing structural soil conservation measures. Among these factors some have influence practice of structural measures negatively whereas other factors affect the practice positively.

5.3.1. Gender

The agricultural works are dominantly practiced by male farmers. From randomly drawn 84 sample households, 83.3% were headed by males and the remaining 16.7% were headed by females. Even in group discussion held with 27 farmers, female farmers were only 4 and as per inclusion, hardly found so-called 'model' female farmers. As per the respondents, females become head of households upon the death of their husbands. In this study gender was seen from two angles; firstly considered as household head and constraints related to structural soil conservation practice and secondly, as existence of large number of females in the family than male.

About 57% of the respondents suggested that there is a difference in practicing structural soil conservation measures among male and female farmers. But 42.9% of farmers argued that male and female farmers equally can practice and benefit from structural soil conservations, but digging is very difficult in stony land for females. As Lakew *et al*. (2005) reported that older and female farmers face difficulties in constructing structural soil conservation, but they could manage and maintain the already constructed one. In the present study, maintenance of older soil bunds by female farmers was found to be difficult.

Female farmers need support from male farmers near to them or elsewhere to construct structures on their plot. The structural soil conservation measures by nature require much labor and expensive in terms of equipment, labor and time. For instance, designing and digging of soil bunds, *fanya juu*, check dams, and waterways takes prolonged time and needs large number of labor.

One thing that indicates the difference was that male farmers begin construction of soil bunds either individually or in group before the reach of soil conservation experts, but inclusion of female farmers in group was uncommon. The interviewed female farmers have an interest to construct soil bunds, but they need help from elsewhere. As a result, in majority of female farmers' farm land, the practiced soil conservation methods excluded construction of soil bunds and *fanya juu* (Table, 5.7). They have been practicing cutoff drains, waterways, check dams; 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.

Table 5.7: Practiced Structural Soil Conservation Measures by Sex

Practiced Structures	Male		Female		Total
	Yes	No	Yes	No	
Structural Soil Conservation Measures	46	24	11	3	84
Soil bunds	40	30	-	14	84
Fanya juu	14	56	-	14	84
Cutoff drains	42	28	10	4	84
Check dams	11	59	3	11	84
Waterways	19	51	1	13	84
Trench digging	13	57	3	11	84

Among the female farmers' land, some portion of fields which necessitate the construction of soil bunds or *fanya juu* become vulnerable to severe soil erosion due to rejection by them. Hence, either withdrawal of female farmers from farm activities or renting/share cropping is a common practice in the area understudy. This in turn influences the practice of structural soil conservation.

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 short term as long as the agreement with the owner exists. Moreover, some farmers who are engaged on share cropping or leased the land destroy and refuse to maintain the existing structural soil conservation measures. Beside to this, a family with large number of females in household tends to be rejecting practice of structural soil conservation measures (soil bunds, *fanya juu*) than family with many male in the household. Instead, they prefer construction of cutoff drains with combination of other agronomic measures.

5.3.2. Age

Despite its role in accumulation of experiences and having deeper knowledge of the field, age as a factor of soil conservation was mentioned by 59.5% of farmers. The aged farmers have troubles with practicing structural soil conservation on their fields. Older farmers couldn't make *fanya juu*, soil bunds and check dams as these require hard work 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. In conclusion, age and practice of soil bunds and *fanya juu* are negatively associated whereas age is positively associated with practice of cutoff drains and other agronomic soil conservation measures. More precisely, the younger the farmers the higher the number of soil bunds and *fanya juu* constructed in their fields. This directly lends evidence for finding of Long (2003) that stated as age influences farmers' adoption decision because of its influence on planning horizon. Although conservation measures such as terraces are long term investments, aged farmers usually have short planning horizon and they may be less interested in long term negative effects of resources depletion (Saliba and Bromley, 1986).

5.3.3. Educational attainment

Out of the sampled 84 household heads, 48.8% were illiterate (cannot read and write), 28.6% can read and write (attended elementary or junior school), 14.3% attended secondary school (9-10) and the remaining 8.3% completed grade 12. From this, one can easily value that agricultural sector; especially farming is dominated by illiterate farmers in this area. Based on this fact, educational attainment of the farmers was examined whether it has significant impact on practice of structural soil conservation measures. In present study, farmers' perception on expression of soil erosion problems has shown difference among educated and uneducated farmers.

The effect of farmers' educational attainment on practicing of structural soil conservation was significant. In fact, higher literacy level of farmers could have brought differences among farmers in practicing structural soil conservation measures on their land and has effect on soil conservation practices in general.

In the study area, among the illiterate, 62.5% have been practicing structural soil conservation measures whereas from those who can read and write, 63.4% have been practicing. Further more, farmers who attained secondary level education showed increasing use of structural soil conservation measures on their farm. Thus, 83.3% of farmers who attained secondary level education have been practicing structural soil conservation measures on their land and 85.7% farmers who attained education above grade 10 were much interested and have been practicing structural soil conservation measures on their farm. This result supports the finding of Paulos *et al*. (2004) that explained educated farmers tend to be better at recognizing the risks associated with soil erosion and tend to spend more time and money on soil conservation.

5.3.4. Household Sizes

The size of family members can be seen from different angles; in the first place, if the household size is larger with many mouths to eat rather than to work, will have negative effect on practices of soil conservation measures in general. In relation to this, the study conducted by Wogayehu and Drake (2003) indicated that in the large families with greater number of mouth to feed, immediate food need is given priority and labor is diverted to off-farm activities that generate food items. However, the reality in terms of structural soil conservation reverses the conclusion of Wogayehu and Drake (2003), because the practice of structural soil conservation is optimistically tied with higher labor forces in the household (Table 5.8). In other words, when the majority of family members are capable of working (between the age of 15 and 64), structural soil conservation measures tend to positively correlate with large family sizes. Hence, in the present study, physical soil conservation technologies are positively associated with large household sizes significantly. So that the possible elucidation is that with the increase of household size, there is a rise on practice of structural soil conservation measures.

In the study area, farmers who have small household size, require additional labor to construct and maintain soil conservation structures. To this end, some farmers pay about 8.5 birr per 10m soil bund when they face shortage of labor. Shortage of working forces, especially for construction of structures will immediately forces farmers to shift their decision towards implementation of less labor demanding soil conservation measures.

Table 5.8: Household Size and Use of Structural Soil Conservation Measures

Household Size	Conservation Structures											
	Soil Bunds		Fanya Juu		Cutoff Drain		Waterway		Check Dams		Trench Digging	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Small(1-3)	-	1.2	-	1.2	-	1.2	-	1.2	-	1.2	-	1.2
Medium(4-6)	9.5	15.5	3.6	21.4	14.3	10.7	6.0	19.0	3.6	21.4	4.8	20.2
Large(7-9)	31.0	28.6	9.5	50.0	38.1	21.4	14.3	45.2	9.5	50.0	8.3	51.2
Very large(>10)	7.1	7.1	3.6	10.7	9.5	4.8	2.4	11.9	3.6	10.7	6.0	8.3
Total	47.6	52.4	16.7	83.3	61.9	38.1	22.6	77.4	16.7	83.3	19	81

Besides; farmers who have faced labor shortage and no money to pay, reject construction of structural soil conservation measures and then shifted their decisions towards the practice of biological soil conservation measures that might not compensate the benefit of structural soil conservation measures in controlling soil loss. This indicates that even the construction of a single soil bund can cost much money and needs large number of labor forces and give better role for large family members. This suggests that there will be lack of interest in soil and water conservation measures when there is a shortage of labor (Woldeamlak, 2003). Thus, household size influences the decision of farmers to undertake the type of conservation measures as household is the supplier of the required labor for undertaking the farming and soil conservation operation.

The household's size links to the age of farmers in affecting the practice of structural soil conservation measures. Farmers reported that the aged farmers and those who have small work force face difficulties in practicing structural soil conservation measures.

5.3.5. Land Size

As land is further fragmented, it becomes uneconomical in size and left with little room for implementing structural soil conservation measures. Land size and practice of structural soil conservation measures have strong positive relationship. The small farm-size holders have negative attitudes towards structural soil conservation measures. These farmers lack trust on structural soil conservation measures as they were poorly participated in the planning and designing of soil conservation program. Hence, farmers perceived structural soil conservation methods as described here under.

Firstly, farmers fear loss of land for construction of soil bunds. Almost all farmers who have land below 0.5 hectares consider this as major reason to reject structural soil conservation measures. The loss of farm land by constructing soil bunds increase when the number of bunds and years it stayed increase. In connection to this, the following is stated by an aged farmer of the study area.

> *A farmer, who is 59 years old, has 0.85ha of farm land and constructed soil bunds six years ago. The slope of his plot ranges 20-23% and the numbers of soil bunds constructed were 8 bunds at the vertical interval of 8 meters. The severity of soil erosion is high and soil is very susceptible to runoff. These all soil bunds have an average height of 1.56m and the grassed top surface of 1.68m with an average length (horizontal distance) of 60m. Thus, this grassed top surface of each soil bund has not been cultivated for three years and used for grazing. Collectively, this farmer lost at least 13.44m (8×1.68m) pieces of his plot, yet grass has its own uses (Figure 5.2). The farmer said that, if cultivated each grassed top of the soil bund yields at least 3kg of wheat or teff and 24kg from all soil bund tops per year. Due to its height and inconvenience after three years, ploughing by oxen near to it is difficult (personal interview).*

On a plot of 20% slope, the area of productive land lost due to structures could reach up to 20% and the proportion quickly increases with increase in slope gradient (Bekele and Holden, 1998). As result, farmer preferred construction of cutoff drains instead of soil bunds. Cutoff drains are easy to construct and maintain when needed. Therefore, destruction of soil bunds and replacing these by cutoff drains and waterways were observed in the study area.

Figure 5.2: Soil Bunds Constructed Six Years Ago

Secondly, the discussion with other farmers supported the aforementioned opinion and they argued that structural soil conservation measures restrict free movement in the field (Figure 5.3). Before the introduction of structural soil conservation measures, there had no problem of moving up and down in the field and farmers used to plough without any obstacle. However, with the introduction of these structures there is division of plot into small pieces mainly because of the increasing height of the bunds which cannot be crossed easily. This was a main problem of aged farmers in the study area.


Source: Field Survey, November, 2010.

Figure 5.3: Soil Bunds Constructed Five Years Ago

Thirdly, almost all the Ethiopian farmers plough their lands by pair of oxen. Soil bunds created difficulties when the interval between the bunds become narrower while turning back the oxen and fatigue of the work increased to farmers, especially for the aged farmers (Figure 5.3)

The constructed soil bunds have been mismanaged in some farm lands and maintenance is difficult. For instance, some farmers planted permanent crops such as coffee and fruit plants on the relatively aged soil bunds. Stabilizing soil bund with grass planting and some other short-staying plants is advisable that does not hinder light maintenance as needed.

5.3.6. Length of Food Secured Months

In the study area, food insecurity problem is a widely spread problem. The declining land productivity is among the causes for food crop shortage. This in turn affects the efforts of soil erosion control by farmers. Farmers attributed yield decline to soil erosion and loss of soil fertility and clearly explain which are destroying their survival, yet other causes playing their role significantly. Out of the sample households, 51.2% mentioned that the produce from their farm can support for less than three months, 29.8% could be supported for three to five months, 15.5% is secured for five to eight months and the remaining 3.6% is food secured for eight months and above (Figure, 5.4). According to farmers, food insecurity is not only attributed to soil erosion but also to the small size of farm farmers owned.

Since there is a positive association between practicing of structural soil conservation and land size rises, the relationship between application of structural measures and length of food secured months may partly attribute to size of landholding. Those farmers whose farm size is larger tend to be food secured for longer months and practice structural soil conservation on their field than those farmers whose farm size is smaller. Moreover, farmers having large farm size prefer the use of soil bunds and *fanya juu* whereas farmers whose land is small prefer the use of cutoff drains and simple waterways. Thus, as stated by Aklilu (2006) ‘resource-poor farmers utilize their resources rather for making a living today than investing for tomorrow’. Hence, poor people have a short time horizon and cannot afford to invest for the future. Farmers who are food secured for a year have larger farm size and effectively practicing structural soil conservation measures on their land better than those who have small size of land. Thus, the risk of food insecurity is mainly resulted from the farm size they owned and this has an influence on the practice of structural soil conservation measures.

Discussion with model farmers revealed that the secret to be food secured, especially in erosion prone area, is the effective management of the soil through use of soil conservation measures. The use of structural soil conservation measures on the cultivation field has a paramount role on arresting soil erosion by water in this area.

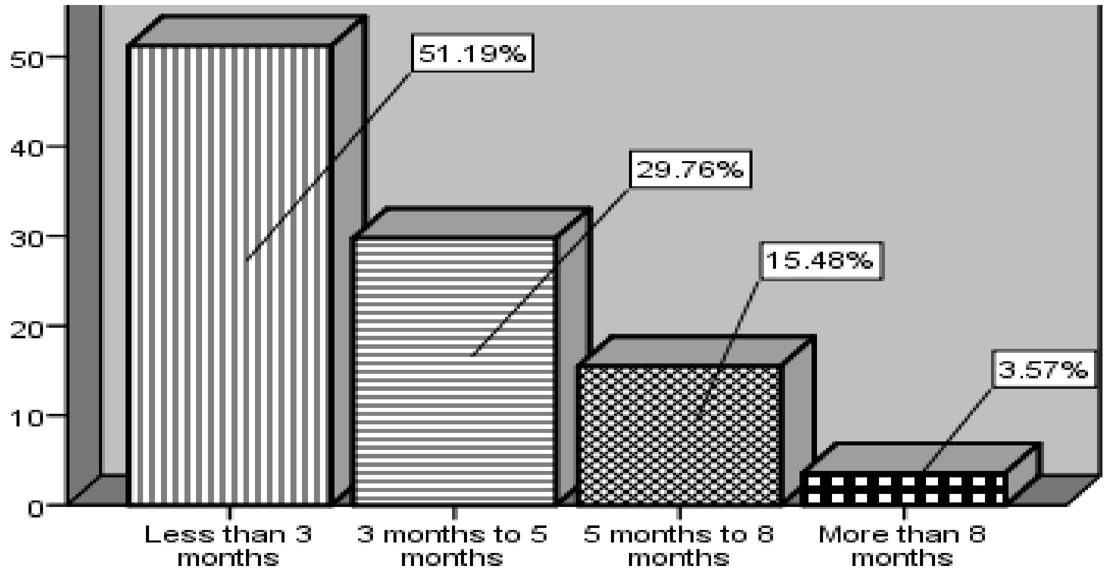

Figure 5.4: Length of Food Secured Months of Sample Households

5.3.7. Off-farm Activities

Involvement in off-farm jobs is common in the study area. Some are engaged in handicrafts, daily labor work, selling of firewood, small scale trading and brewing local beverages ("*Arake*" and "*Shámeta*"). These off-farm activities have served farmers as sources of additional income to purchase food crops mainly in the scarcity of agricultural produces. Involvement in selling firewood and petty trading accounted for about 25% and 22.6% of additional employment opportunities. Handiwork, daily jobs and brewing played a considerable role in supplementing the farmers with additional incomes (Figure 5.5).

On the contrary, involvement in off-farm activities has negative effect on the decision and implementation of soil conservation measures (Bekele and Holden, 1998). However, in this study area the fact is hardly support the aforesaid conclusion. In the present study, practice of structural soil conservation measures is positively associated with involvement in off-farm activities and was found significant. A family having large working household tends to involve in different economic activities so as to increase household income. A household with considerable income from off-farm jobs could possible invest more in structural soil conservation measures. Farmers who secured money from off-farm activities can possible pay for construction and maintenance of structures.

Hence, discussion with informants revealed that the benefit of involvement in other activities stippled the negative impact in the construction of structural soil conservation measures.

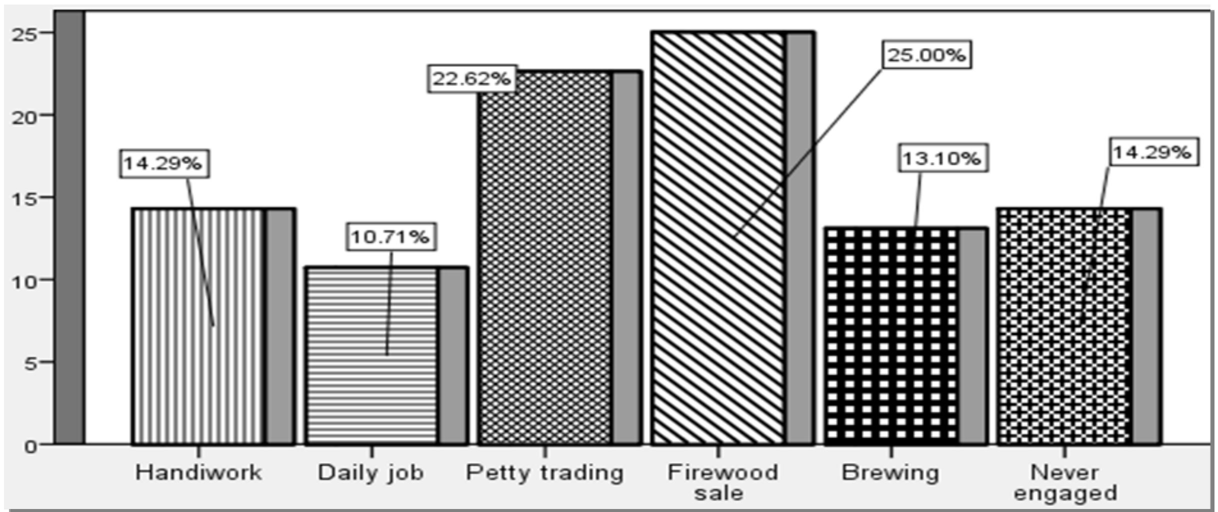

Figure 5.5: Types of Job Farmers involved other than Farming

As to the results of the study, farmers were forced to involve in off-farm jobs mainly because of food crop shortage. Yet among the food insecure farmers, some farmers are not engaged in additional jobs owing to age, distance, shortage of labor force and lack of access. Discussion reveals that some model farmers who have been engaged in off-farm jobs were well aware and practice structural soil conservation measures on their land. Although some farmers have interest to involve in off-farm activities, they have no extra time and access for such activities due to long distance to commute from their residence to town or working area where off-farm activities could be available. Distance from off-farm job area restricted some farmers' migration and pushed them to practice soil conservation measures on their land.

5.3.8. Land Tenure Security and Source of Land

Farmers in the study area are contented and optimistic with the right to their land. Their willingness for resources conservation and transferring to their sons increases when the land possession is secure. The relationship between land tenure security and practice of structural soil conservation measures is positively associated. This is in accord with the study of Wogayehu and Drake (2003), Bekele and Holden (1998) and Lakew *et al*. (2005).

Seventy five percent of accessed farmers suggested that secured landholding encourages farmers in planning and implementation of relatively permanent conservation structures on their plots. They started to rehabilitate even the rock outcrop area after land ownership certification, because that belongs to them and will become the land of their sons in the future. Thus, many studies in Ethiopia found that land tenure insecurity has negative effect on farmers' decision to practice soil conservation structures (Bekele and Holden, 1998). Since stable land tenure is very important for adoption of major investments especially terrace construction, the low level of retaining conservation structure throughout the country is attributable to land tenure insecurity (Wogayehu and Drake, 2003; Bekele and Holden, 1998). Lakew *et al* (2005) described that the certification of the land owned by farmers has great relation with and importance on investing on soil conservation and it is best reinforcement to rehabilitate the degraded land. He added that each farmer has to conserve and manage his/her land as per the watershed development program. Share cropping and land leasing from the land owners have considerable impact on practice of permanent structures and increases unwise resource exploitation by landless farmers.

In the study area, farmers get the farmland by either inheritance from parents (and in some cases parents give a portion of their land to sons) or allocated by *Kebele*. Those who have no their own land (i.e. landless farmers) tend to cultivate others land through share cropping/lease system arrangements. Of 32 farmers whose land is less than 0.5ha, 20 (62.5%) farmers have inherited land from their parents whereas the remaining farmers have got their land through *Kebele* allocation. This indicates that parents could give small portion of land for their sons. The perception on soil erosion and soil conservation considerably differs according to their landholding systems. Farmers who leased land from others have shown reluctance to practice soil conservation measures, especially the permanent structural conservation measures. As to farmers, this was mainly related to avoid the loss of a tract to conservation structure and being shelter for rodents.

5.3.9. Distance from Homestead

All respondents suggested that for a frequent observation and construction of conservation measures distance to farm fields would be advantageous. About 91% of respondents indicated that their cultivation fields exist close to residences. For 9% of the farmers their land is distant from homestead. Distance to cultivation land from homestead was found to influence negatively the practice of structural soil conservation measures. The feasible elucidation is that the nearer the cultivation fields to the homestead, the frequent the management and the higher will be the protection of soil from erosion. When runoff comes, farmers are ready to protect soil and maintain the damaged bunds and check dams in the nearer fields. Moreover, if the farm field is near to them, farmers used to practice variety of soil conservation measures. As all respondents perceived, leaving crop residues on the cultivation field enhances soil fertility. But, when the cultivation land exists away from residences, other people take residues away for home use (fuel energy); for animal feed, for fencing and even for sell. Thus, if the farm field is located near the farmhouse, it becomes easier to be managing and receives better attention. This is attributed to the location factor that increases the labor cost due to time spent on travel. In other side of these, there were few farmers whose land is here and there, but the field that exists far from homestead has been given for share cropping and left for grazing mostly without soil conservation measures. This shows to somewhat adaptation to the situation in which farmers tried to minimize the cost of travel.

5.3.10. Training on soil erosion and conservation practices

According to interviews, farmers have knowledge on causes, extents and consequences of soil erosion on their living with varying level. Training and education on soil erosion and conservation need to be provided to create further awareness on resources conservation. Farmers require training on soil and water conservation, crop production and yield maximization, yield storage system, enhancing soil fertility and land tenure and land use. The construction of structural soil conservation requires relatively frequent training and appraisal. Although the training on controlling soil erosion has significant contribution on application of structures, the level of training is very low.

Farmers who have not accessed to training have gained experience from their neighbors and traditionally from their elders. Farmers adjacent to each other can acquire experience in either strength or weakness of specific soil conservation measures from nearby farmers and neighboring *kebeles*. However, most of the farmers didn’t get training on soil conservation. About 51.2% of surveyed farmers never get training on soil conservation applications and 45.2% have got only a limited training and only 3.6% have received adequate training (Table 5.9).

Table 5.9: Training and Practice of Structural Soil Conservation Measures

Training	Practicing structural soil conservation measures					
	Yes		No		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Always	3	3.6	0	.0	3	3.6
Sometimes	30	35.7	8	9.5	38	45.2
Never	24	28.6	19	22.6	43	51.2
Total	57	67.9	27	32.1	84	100.0

Table 5.9, shows that out of 51.2% surveyed farmers who didn't get training, 22.6% farmers have not been practicing structural soil conservation measures. Farmers need training not only on the benefits and costs, but also on the methods of construction. Moreover, giving training on soil conservation measures improves the relationship between farmers and DAs and encourages them to implement new conservation measures. As the model farmers stated that the training must not be only on newly introduced conservation measures, but also the experts should provide awareness on traditionally practiced ones because the latter one served as the ground for the effectiveness of the former one in terms of creating awareness and addressing the importance of soil conservation measures in controlling erosion and enhancing soil moisture.

5.3.11. Productivity and Effectiveness of Structural Soil Conservation

As expected the effectiveness and productivity of structural soil conservation was found to have significant positive influence on farmers' decision to install. Hence, it possibly explained that when a specific structural soil conservation measure is effective and productive in the view of farmers, it tends to be practiced by farmers widely. Thus, for twenty-five percent of the respondents, structural soil conservation measures are more productive and they noted as 'more effective' than non structural conservation measures. Likewise, structural soil conservation measures are 'effective' for 52.4% farmers (Table 5.10). But, 22.6% farmers didn't recognize the effectiveness and productivity of structural soil conservation measures because they have hardly put in structures on their land. Thus, farmers have averaged the productivity of structural soil conservation measures more effective than other measures in general. Specifically, in the point view of some farmers, cutoff drains have received better attention than other structures owing to its convenience to implement and maintenance. Construction of soil bunds and *fanya juu* was constrained by their negative impact in harboring rodents, take away a piece of land, need large labor force and considerable time, restrict movement and so like. This result supports other study noted that the decision to practice soil and water conservation measures tends to be influenced by farmers' attitude on effectiveness of conservation structures (Long, 2003; Bekele and Holden, 1998; Ervin and Ervin, 1982). For their importance, the frequently used structural soil conservation measures were cutoff drains, soil bunds, waterways, *fanya juu*, check dams, and trench digging.

Table 5.10: Productivity and Effectiveness of Structural Soil Conservation Measures

Structural Soil Conservation Measures	Frequency	Percent	Cumulative Percent
Effective	44	52.4	52.4
More Effective	21	25.0	77.4
Don't Know	19	22.6	100.0
Total	84	100.0	-

In most cases in order to make the structural soil conservation measures effective, farmers used to plant grasses, temporary crops and make periodical maintenance. In the lands of many farmers, the conservation measures are combination of structural soil conservation measures and agronomic measures, yet biological soil conservation is used to control erosion and as source for forage. As noted by respondents, agronomic soil conservation measures are cheap in terms of cost and labor; easy to construct, maintain and change through time than structural one.

5.3.12. Potential to Install

Installation of structural soil conservation measures requires considerable labor and material. As noted by many farmers, structural soil conservation measures require much cost and work load. Materials such as shovel, pick axes, field level, and wooden compactor are needed, particularly while making of soil bunds and *fanya juu*. Therefore, lack of enough labor force and material tends to shift farmers decision from installing structural soil conservation measures to other compatible conservation measures that demand less labor force.

5.3.13. Perception of Soil erosion problems and Benefits of Structural Measures

Perception of soil erosion problems and benefit of soil conservation measures was positively and strongly associated with farmers' practice of structural soil conservation measures. In fact, farmers' perception is one limb that influences farmers' decision to practice structural soil conservation measures on their land. In relation to this, Belay (1992) and Woldeamlak (2003) in their study found that in spite of high level of farmers' perception of soil erosion problems, the level of adoption of conservation structures was very limited. Thus, perception of erosion problem is not a sufficient condition for adoption of soil conservation practices though it is a necessary one (Woldeamlak, 2003). Long (2003) noted that perceiving the problem provides stimulus to adopt conservation practices. Moreover, perceiving negative effect of soil erosion shapes opinion about conservation measures and their adoption.

Although farmers know the negative impact of soil erosion, some of them removed structural soil conservation measures partially or completely. Among those who installed structural soil conservation measures, 7 (12.3%) farmers removed the structures completely and 17 (29.8%) farmers removed it partially. However, 33 (57.9%) farmers have introduced and maintained conservation structures on their land. The removal of structures was related to some negative impacts of soil 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 traditionally known soil conservation measures such as cutoff drains, waterways, strip cropping, and other fertility enhancing methods like manuring, mulching, leaving crop residues on field, because these are less expensive and demands few labor, might not obstacle oxen plough and make movement easier. Yet practice of traditionally 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.

5.3.14. Farmers' Contact with Development Agents (DAs)

Access for information and contact with DA has a role on the practice of soil conservation measures. Having good relation with DA helps farmers in reducing hazard associated with soil erosion and conservation structures by providing information. Among assessed farmers, 70.2% have contact with development agents. Of these farmers, 67.9% have practiced structural soil conservation measures on their land and 2.4% of farmers didn't. Nine (10.7%) farmers have practiced soil conservation measures on their fields without the assistance of DA. However, 19% of farmers have no contact with development agents and other soil conservation experts and failed to practice soil conservation measures (Table 5.11).

Table 5.11: Farmers Contact with DA and Practice of Structural Soil Conservation

Contact with Development Agents	Practicing Structural Soil Conservation Measures					
	Yes		Not		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	57	67.9	2	2.4	59	70.3
No	9	10.7	16	19.0	25	29.7
Total	66	78.6	18	21.4	84	100

The time which development agents stay on their respective working area/*kebele* was very limited. The longer they reside with peasants in the rural *kebele*, the more have contact with farmers. But they work only 2 or 3 days per week with farming people. In the selected *kebeles* there were 13 DAs and three supervisors. As noted, majority of them were involved in other administration duties and serve as cabinet member. Moreover, they gave attention for collecting tax, fertilizer and other credit services rather than for soil conservation. As survey result reveals, the current experts on soil fertility management and conservation measures were less effective and need special attention.

5.3.15. Soil Color and Moisture level

Farmers perceive the effect of soil erosion when it reaches some critical level, which is very difficult to reverse the degradation. Farmers used soil color as indicator of soil fertility. As interviews with sample farmers indicated, decision to practice structural soil conservation measures considerably influenced by the color and moisture level of soil. Farmers in the study area classified the color of soil typical as "*hemach bucha*" (black fertile soil) and "*kashar bucha*" (red soil).

As noted by 66% respondents, construction of soil bunds makes it out of production. When the soil is black and fertile, farmers reject construction of soil bunds and *fanya juu* rather they prefer to install cutoff drains and waterways outside the cultivation fields. Hence, one can see from this that the color of the soil influences negatively the construction of soil bunds and *fanya juu*, but positively associated with cutoff drains and waterways. Similarly, farmers are interested to construct the soil bunds where soil has moisture stress. About 51% of the respondents suggested that rather than construction of structures on the fertile land, it is better to do in dry and moisture stressed land so as to enhance fertility and arrest further soil erosion. This result reverses the conclusion made by Wu and Babcock (1998) and Wogayehu and Drake, (2003) who stated as farmers that cultivate black soil invest on soil conservation more whereas farmers those cultivate low quality land adopt conservation practices less frequently.

5.3.16. Topography

Pertaining to the slope of cultivation fields, farmers' decision to construct structure differs significantly. Farmers in flat area tend to practice more cutoff drains due to the low erosion risk coming from up slope whereas farmers whose farms are located in steeper slopes have been practicing different types of structural soil conservation measures. Among 54 farmers whose farms are located in slope of moderate to steeping land, 77% have been practicing soil conservation measures on their land whereas out of 30 farmers whose farms are located in flat area, about half (50%) have not practicing structural soil conservation measures on their land (Table 5.12).

Table 5.12: Topography and Practice of Structural Soil Conservation Measures

No.	Respondents Kebele and Structural Soil Conservation Practice by Slope							
	Sample Kebele	Slope*	Practice of Structural Soil Conservation Measures					
			Yes		No		Total	%
			Frequency	%	Frequency	%		
1	Bonadibaro	Steep slope	24	85.7	4	14.3	28	100.0
2	Sigeda	Moderate	18	69.2	8	30.8	26	100.0
3	Sundusa	Flat	15	50.0	15	50.0	30	100.0
Total	3		57	67.9	27	32.1	84	100.0

Source: Field Survey, 2010. ***(* = simple assumption while taking sample kebeles)***

However, in terms of construction, the rising topography creates difficulty because the number of structures increases with rising slope. Hence, results indicate that slope of the cultivation land has positive association with installation of structural soil conservation measures by farmers. To this end, Saliba and Bromley (1986) observed that farmers cultivating steep slope fields install more effective conservation measures than farmers cultivating level fields. Also Wu and Babcock (1998) observed frequent conservation practices installed on steeply sloping cultivation fields which reflect the desire of farmers to control soil loss. As well, Wogayehu and Drake (2003) and Bekele and Holden (1998) concluded that slope gradient affects farmers' decision to adopt conservation structures positively.

5.4. Expected Reward from Structural Soil Conservation Measures

More than half of the surveyed farmers confirmed that the perceived benefit of using soil conservation measures include arresting soil erosion and enhancing soil fertility, and an increase in productivity of land. Farmers were also asked to compare the traditional soil conservation measures with the introduced one. From 84 sample farmers, about 65 (77.4%) farmers have been practicing soil conservation measures in general. Out of 65 farmers who practice soil conservation measures, 57 (87.7%) farmers have been practicing introduced structural soil conservation measures. However, farmers were not clear with difference between traditional soil conservation measures and introduced one. But 78% of the farmers suggested that the newly introduced soil conservation measures are more effective and productive in arresting soil erosion than traditional soil conservation. However, the installation and maintenance of the introduced structures are expensive, time consuming, require large labor and expert support.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Soil is an important resource, which needs much attention in its use and management. Because soil is formed slowly, it is essentially considered as a finite resource. Soil erosion is a major contributor to the prevailing food insecurity in Ethiopia. The soil loss by erosion is severe in highlands and continuous to threaten man's wellbeing as bulks of country's people are reliant on agricultural production. Farmers are aware of declining yields from their farms from year to year, but often unable to regain productivity because of climbing soil erosion. In the present study area farming community 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 undulating to steeply sloping.

Farmers can differentiate various indicators of soil fertility loss using their experiences of identification of associated severity of soil erosion. Furthermore, they are able to distinguish different causes of soil erosion in their land based on knowledge they have through farming conditions. Some indicators of soil erosion on their lands include rills and gully development, root exposure, poor crops and grasses grown, stoniness of soil, color changes, slope steepness, absence of topsoil and accumulation of sediments/dump.

The main recognized causes of soil erosion in the area include slope steepness of the land, ceaseless cultivation without fallowing, erodibility of soil, intensity of rainfall, deforestation and desertification, absence and delay of soil conservation practices, insufficient and delayed supply of fertilizer, overgrazing and terms of land preparation until cropping. As farmers noted, slope steepness is a vital cause for soil erosion and followed by ceaseless cultivation that was resulted from the pressure of population growth and forced farmers to give up land fallowing.

As the area exists in *weyna dega* agro-ecologic zone, the intensity of rainfall is among the major causes of soil erosion and results in heavy loss of topsoil. Natural vegetation cover was victimized by expanding demand for agricultural land. Expansion of eucalyptus trees seriously affected the fertility of soil, yet supporting as main source of fuel energy. Practice of soil conservation measures, especially, structural methods is delayed and the existing were removed by farmers when they are considered as less effective, restricted free movement and land taking. Moreover, they practice cutoff drains in preference to soil bunds and *fanya juu.* Delayed and insufficient fertilizer results on preparation of land for many times. This results on making the soil ready to erosion.

The extent and consequences of soil erosion have been explained by farmers comparatively. They acknowledged the effects of soil erosion as loss of topsoil, reduction of yield over time, loss of vegetation cover and grasses, change in soil color, requiring high input and management, and formation of uncross-able gullies, lack of farm land and grazing field, desertification, and out migration. When the land becomes rock outcrop, there would be shortage of cultivation and grazing land. Due to the negative effects of soil erosion, people tend to migrate searching for land and food. Moreover, farmers have well understood even where does soil erosion tends to be severe. As per them, soil erosion is severe in cultivation field because the land is prepared several times before sowing the seeds.

Some crops are recognized as to aggravate soil erosion by water. *Teff* and wheat are the repeatedly mentioned facilitators to soil erosion as they need more preparation of land until seeding. This is done mainly to make fine seed bed and enhance fertility by preparing at least *four times.* Good soil conservation leads to enriched lands, better crop yields, good financial returns and a balanced environment. Less erosion means the better soil quality, with the soil retaining the nutrients and chemicals added to it, and this naturally leads to better and more improved crop yields. People are well recognized the importance of soil conservation measures in controlling erosion so as to enhance soil fertility. Soil conservation measures were practiced on either cultivation land or grazing lands or on hillsides and degraded lands or to rehabilitate the gullies. Due to work load, crop cover and other reasons, the conservation structures were constructed most probably in a dry seasons. Most of the conservation structures were practiced in order to protect the soil erosion on the farmlands.

Dominantly, farmers practice structural soil conservation measures such as cutoff drains, waterways, soil bunds, *fanya juu, and* check dams. Besides, other agronomic soil conservation measures have been practiced in the area. Based on the types of soil, slope, farm size, and training on conservation the width and length of structural soil conservation tends to vary. For example, the farm size has a great influence in practicing soil bunds as it takes away parcel of plot in its construction. Likewise, training on soil conservation measures is limited because there is poor contact with development agents and extension services. The dominantly used structural soil conservation measures are cut-off drains and soil bunds. Majority of farmers in the study area have not been clearly informed on the unique benefit of *fanya juu*. Besides, practice of *fanya juu* is limited and the importance is merged with soil bunds despite of their differences. The soil from the *fanya juu* is thrown up and helps in making the slope flat gradually whereas the soils from the soil bunds thrown down the bund.

Farmers' perception to practice structural soil conservation measures can be influenced by different factors. The most important and considered factors include gender, age, education, household size, land size, length of food secured months, off-farm activities, distance from homestead, farmers perception on soil erosion and soil conservation measures, topography, effectiveness and productivity of structural measures, potential to install measures, contact with DAs, training on measures, color and moisture of soil and land tenure security and source of land.

When the slope gradient increases, the practice of structural soil conservation measures becomes more important. However, in terms of construction, the rising topography creates difficulty because the number of structures increases with rising slope. Higher educational level brings difference among farmers in practicing structural soil conservation measures. Farmers who attained secondary level education have shown increasing practice of structural soil conservation measures than farmers who cannot read and write. Involvement in non farming job supports farmers in practicing structural soil conservation measures by equipping materials required for construction of soil bunds, *fanya juu,* etc. Food secured famers perceived soil conservation structures as important and have been practicing them as well.

As labor force is vital for construction of structures, large family size has a great role in initiating farmers in construction of conservation measures. Farmers having larger farm size show more interest for construction of structural soil conservation measures than farmers who have small farm size. Related to this, farmers who inherited their land from parents have small farm size than farmers received their land through *kebele* allocation. Landless farmers are involved in share cropping and they have less interest to construct structural soil conservation measures and even they occasionally removed the existing one because they perceived it as land taking, restricts free up and down movement and shelter rodents.

When the distance of farm field from homestead increases; the practice of structural soil conservation tends to decreases by far. Aged farmers preferred practice of cutoff drains and biological and agronomic soil conservation measures than soil bunds and *fanya juu,* because it needs more labor and materials to install. Training on soil conservation measures and contact with development agents have role in gathering farmers' attention for practicing the conservation structures. The more effective and the productive the structural soil conservation measures, the more the farmers tend to practice and maintain the structures.

The effectiveness and productivity of structural soil conservation measures can be seen either on their own land or on the land next to them or on the adjacent *kebeles*. Thus, if the specific conservation measure is more effective in controlling erosion and productive than other existing, farmers decide to install or familiarize it. Land tenure certification has a paramount role in shaping the farmers' attitude towards soil conservation measures, particularly long-term structures. Farmers who have cultivating their own land could practice structural soil conservation with confidence from farmers who practice share cropping.

Considerable numbers of farmers have removed structural soil conservation measures from their plot. Some were partially removed, yet others were completely destroyed. This was happened because of its inconvenience for plowing by oxen and restricted movement, expanding with grassed tops and height. Still there are some structures which become steeper with increasing height.

6.2. Recommendation

It is fair to say that the severity of soil erosion in this area is worsening the wellbeing of community, yet considerable efforts have been made to arrest soil erosion. Although farmers have awareness regarding the soil erosion and its effect on their live, it needs hand- in- hand cooperation with concerned experts while planning and implementation of soil conservation measures.

To effectively plan for soil conservation measures application and introduce new techniques; to manage resources in the right way, it is very necessary to involve local farmers and have knowledge of local concepts such as that of soil classification, soil quality, soil fertility and even soil erosion. This provides a fertile ground for researchers, development agents, and other concerned one to further investigate the farmers' perception on soil erosion and the use of soil conservation measures.

Many of the farmers in the study area have been practicing structural soil conservation measures as well as biological and agronomic measures. However, the integration of structural measures with biological one has better economic importance; because grasses on the top of the soil bunds used for livestock feeding and for sale. Farmers distinguished soil conservation measures that benefit them within few years or to restructure seasonally. For example cutoff drains are easier to maintain and reconstruct frequently than soil bunds and *fanya juu*. Hence, soil conservation experts ought to be able to consider the preference of local farmers while planning and implementing measures.

Cutoff drains transport soil while forming enough flow-ways, but preferred by farmers for its easy to construct and maintain. Thus, this implies that training on benefits and costs; and contact with DAs is limited. Creation of awareness on soil erosion, soil conservation measures and benefits of a specific soil conservation measure is required.

Although farmers have been practicing structural soil conservation measures on their land, the slope inclination and soil types rarely were taken into account. The interval between structures varies regardless of slope and soil type. And while construction of soil conservation measures in this area, easily erodible soil types and sloping area should be prioritized because there was delay in launching the conservation measures.

By its nature, the construction of structural soil conservation measures is labor intensive and expensive. Practice of this measure by aged farmers and female farmers have shown slow progress, although they perceived as important in arresting soil erosion. Henceforth, construction of structures become easy, if there is cooperation among farmers and make by groups of people.

As the result of this study indicated, soil erosion is severe in cultivation field than in the other fields, more specifically, where *teff*, wheat, barley, cultivated fields. These crops make the land erodible as they require fine seed bed preparation. To reduce soil erosion gradually from cultivation land; strategies to construct structural soil conservation methods, like soil bunds, *fanya juu*, cutoff drains should first be directed to the most severely degraded areas.

Farmers of large farms are likely to spend more on structural soil conservation, because in many cases, larger farm size is linked with more food secured months of farmers and increased access of wealth that makes purchasing of equipment for construction of physical soil conservation measures more available. To this end, the agricultural and rural development office should provide farmers with variety of conservation measures so as to diversify the choice of farmers appropriate to their farm size.

Relation with development agents surely increases the interest of the farmers in practicing structural 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 district agricultural and rural development bureau 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. Farmers training center (FTC) in the study area was built, yet training is hardly provided. In some FTC, there is no conservation structure to show farmers as illustration and even the land near to FTC was severely eroded. The DA in respective *kebeles* should provide farmers with training and up to date information on climate, slope, soil erosion, conservation measures, and land management as a whole. Moreover, in this study area, training on soil conservation methods should be directed to inform individual farmers on erosion related problems, because the severity of erosion, types of erosion, the consequences of soil erosion, farm slope, soil types and depth vary within the watershed.

Successful long-term practice of structural soil conservation measures require land tenure systems that secure continued ownership of land. There are still farmers without certification of their land ownership. The land tenure policy of the country should be integrated with rewarding farmers those who invested more in soil conservation measures, especially, for those investing in long-term structures. Besides, development agents and other concerned organizations should create awareness even for the farmers who are landless and practicing share cropping, because these people showed reluctance to practice structural soil conservation. Otherwise, when the landowners lease their land to others, they might reach at agreement to practice necessary conservation measures.

Finally, according to the result of this study, and other findings, the factors those influence farmers' practice of structural soil conservation measures considerably diverge widely 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 discrepancy endorsed and then, the soil conservation plan must be flexible as much as necessary to consider diversity of farmers' conservation requirements.

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APPENDIX: QUESTIONNAIRES

Date of interview: Day ____ Month ____ Year ______
Interviewed by: ______________________________
Region: _____________________________________
Zone: ______________________________________
District: ____________________________________
Kebele: _____________________________________

Part-I: Respondents Household Characteristics

1.1. Age of household head: ______________________.
1.2. Sex of household head: 1. Male
2. Female
1.3. Size of household: ________________________.
1.4. What is the composition of the household by age and sex group?

No.	Age Group	Male	Female	Total
1	0-14			
2	15-64			
3	>64			
	Total			

1.5. What is educational level of household head?
1. Can not read and write
2. Reading and writing
3. Attended secondary level
4. Attended above grade 10

1.6. For how long do you use the produce of your land?
1. For at least 3 months
2. For 3 months to 5 months
3. For 5 months to 8 months
4. For more than 8 months

Part- II: Land and Landholding Characteristics of Respondent

2. Questionnaires on land size, landholding, and farmers' perception

2.1. How many hectares 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
5. >2.0 ha

2.2. How did you get the land you have currently? (More than one choice is possible)

1. Through renting
2. Through share cropping
3. Inherited from parents
4. Allocated by Kebele

2.3. What is the distance of your cultivation field from your home?

1. Less than 5 minutes walk
2. 5 to 10 minutes walk
3. 10 to 20 minutes walk
4. 20 to 40 minutes walk
5. Over 40 minutes walk

2.4. How do you perceive the distance of cultivation field from your home?

1. Near
2. Moderate
3. Far
4. Very far

2.5. What is the color of the soil in your cultivation field?

1. Grayish
2. Reddish
3. Dark/black
4. Other color specify___________.

2.6. How do you perceive the fertility of your land?

1. Improving
2. Constant
3. Declining
4. Do not know

2.7. If the fertility of your land is declining what is the indicator?

____

____.

2.8. If the fertility of your land is declining, what could be the cause?

____

____.

2.9. How do you perceive the productivity of your land?

1. Increasing
2. Decreasing
3. Constant
4. Do not know

2.10. If the yield from your land is decreasing, what could be the reason behind? (More than one answer is allowed)

1. Absence of fallowing

2. High cost of chemical fertilizers
3. Unreliable rainfall
4. Erosion/runoff
5. Over cultivation
6. Other reason___________

2.11. How do you describe the slope of your land?
1. Flat
2. Gently undulating
3. Moderately steeping
4. Steeply sloping

2.12. Do you perceive that the slope has impact on productivity of your land?
1. Certainly
2. Never
3. Uncertain

2.13. Which land do you perceive more productive?
1. Flat
2. Gently undulating
3. Moderately steeping
4. Steeply sloping

2.14. What is the share of different land uses?

No.	Crop type	Land allocated in hectare
1	Crop production	
2	Enset production	
3	Fallow land	
4	Grazing land	
5	Reserved land	
	Total	

2.15. How do you see agricultural land over time?
1. No change
2. Becoming scarce
3. Increasing over time
4. Do not know

2.16. If the agricultural land is becoming scarce, what could be reason behind?
1. Population pressure
2. Land degradation
3. Expansion of forest
4. Taken by government
5. Taken by other organization
6. Other reason_________

2.17. If the agricultural land is increasing, what could be reason behind?

1. Expansion to the marginal land
2. Expansion to the forested area through deforestation
3. Gift from relatives or parents
4. Other specify________

2.18. How do you think that current landholding to support the household?

1. Insufficient
2. Sufficient
3. Excess

2.19. What do you do if the land scarcity is a problem?

1. Going to resettlement area
2. Migration 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
6. Other option specify_______

Part-III: 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	Orders/ranks
1	Rills and Gully development	
2	Observing the color of soil	
3	Accumulation of dump near to valleys	
4	Stoniness of soil	
5	Slope Steepness	
6	Absence of fertile topsoil	
7	Root exposure	
8	Poor crop and grass growth	
	Total	

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	Ceaseless cultivation and absence of fallowing	
3	Types of soil and erodibility	
4	Intensity of rainfall	
5	Absence and delay of SCM	
6	Insufficient and delayed fertilizer	

7	Deforestation and desertification	
8	Overgrazing	
9	Terms of land preparation for cropping	
	Total	

3.3. What is the effect of soil erosion on your land?

No.	Effects of Soil Erosion	Rank (1, 2…)
1	Loss of topsoil	
2	Reduction in yield over time	
3	Reproduction of gullies	
4	Loss of vegetation cover and grasses	
5	Change in soil color	
6	Require high input and management	
7	Lack of farm land and grazing field	
8	Desertification, and out migration.	
9	Other	

3.4. How do you know the loss of topsoil in your land? (more than one answer is possible)

No	Items	Put (√)
1	By the yield decline	
2	By the gully formation	
3	By the loss of vegetation	
4	By the absence of grass	
5	By the change of color	
6	By the need of much input	
7	By the level of management required	
8	Other means	

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

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

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

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

3.7. What crop does facilitate soil erosion?

____

____.

Part-IV: Soil Conservation

4. Questionnaires on adoption and practicing of soil conservation technologies

4.1. Do you perceive that the yield be increasing with soil conservation practices?

1. Yes
2. Never
3. Do not know

4.2. If your answer for question ‘4.1’ is ‘Yes’, have you been practicing soil conservation?

1. Yes
2. No
3. Do not Know

4.3. If your answer for question ‘4.2’ is ‘No’, what is the reason behind?

____

____.

4.4. If your answer for question ‘4.2’ is ‘Yes’, what kinds of soil conservation methods do you apply? (More than one answer is allowed)

No	Items	√
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	

4.5. If your answer for question ‘4.4’ is ‘structural soil conservation methods’, what is the reason behind?

____

____.

4.6. Which structural soil conservation measures do you practice regularly? (More than one is allowed)

1. Soil bunds
2. Fanyaa juu
3. Stone bunds
4. Cutoff drains
5. Waterways
6. Check dams
7. Bench terraces
8. Trench digging
9. Others

4.7. If you do not practice structural soil conservation methods in your land, what is the reason?

____

____.

4.8. How do you perceive structural soil conservation methods?

1. Very cheap and easy
2. Cheap
3. Expensive
4. Expensive and labor intensive
5. Do not know

4.9. How do you perceive the effectiveness of structural methods to control soil erosion?

No	Items	√
1	Less effective	
2	Effective	
3	More effective	
4	Do not know	

4.10. Which types of structural soil conservation measure is more effective? (Rank from more effective to less effective)

No	Items	Rank
1	Soil bunds	
2	Cutoff drains	
3	Fanya Juu	
4	Waterways	
5	Check dams,	
6	Bench Terraces	
7	Trench digging	
8	Stone bunds	

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

1. Cultivation field
2. Grazing field
3. On both
4. Other

4.12. Do you get training on soil and water conservation technologies?

1. Always
2. Sometimes
3. Never
4. Do not know

4.13. Where did you get information on soil and water conservation practices?

1. Traditionally
2. From neighbors
3. From DAs and experts

4. From other non-governmental organizations
5. Other sources specify__________

4.14. Do you have contact with DAs?
1. Yes
2. No
3. Do not know

4.15. How do you describe the contact you have with soil and water conservation experts?
1. None
2. Limited
3. Good
4. Very good

4.16. What factor do you think affect practice of structural soil conservation measures?

____

____.

4.17. What have you done with the structural 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

4.18. Do you like trying new technologies whenever they are introduced to the area?
1. Yes
2. No
3. Do not know

4.19. How do you perceive the productivity of structural soil conservation measures introduced to the area compared to the traditional ones?
1. Less productive that the traditional ones
2. The same as the traditional conservation practices
3. More productive that the traditional ones

4.20. If you have made any form of destruction of terraces, what is reason for the destruction?
1. Search for fertile soil
2. Planned to construct a new one
3. To avoid rodent and other pests
4. Reducing the bunds height
5. Need to avail more land
6. Lack of values from the bunds
7. To construct house
8. Other specify_________________

Declaration

First, I declare that this thesis is my bona-fide work and that all sources of materials used for the thesis have been duly acknowledged. I solemnly declare that this thesis has never been presented to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Name: - Kibemo Detamo Aga

Signature: - --------------------------------

This Thesis has been submitted for examination with my approval as university advisor

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Date: - June, 2011.