FARMERS' PERCEPTIONS ON SOIL EROSION AND EFFECT OF CONSERVATION ON SOIL NUTRIENT STATUS IN KEDIDA GAMELA WOREDA, SOUTHERN ETHIOPIA

M.Sc Thesis

By

TAFESSE FORSIDO LOMBEBO

November, 2012

Jimma, Ethiopia

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M.Sc. Thesis

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
JIMMA UNIVERSITY COLLEGE OF AGRICULTURE AND VETERINARY MEDICINE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN WATERSHED MANAGEMENT

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November, 2012
Jimma, Ethiopi

APPROVAL SHEET

Jimma University College of Agriculture and Veterinary Medicine

Graduate studies

As thesis research advisor, hereby, I certify that I have read and evaluated this thesis prepared, under my guidance, by Tafesse Forsido, entitled Farmers' Perception on Soil Erosion and Effect of Conservation on soil nutrient status in Kedida Gamela Woreda, Southern Ethiopia. I recommend that it be submitted as fulfilling thesis requirement.

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As member of the Board of Examiners of the M.Sc. Thesis Open Defense Examination, we certify that we have read, evaluate the thesis prepared by Tafesse Forsido and examined the candidate. We recommended that the thesis could be accepted as the fulfilling thesis requirement for the degree of Masters of Science in Watershed Management.

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DEDICATION

To my beloved wife, Sr. Adanech (Michu) Hinsene and my three daughters: Betiel Tafesse Ruhama Tafesse and Ephirata Tafesse and Hana Hinsene(my sister in law) for their endless support and prayers for my success and in resisting all challenges of life in the course of this study. It is also dedicated to the Ethiopian Kale Heywet Church and to the people of Kambatta for their kind responses to my inquiries on information during my research work.

STATEMENT OF AUTHOR

This thesis is my original work it has never been submitted in any form to other university and it has never been published nor submitted for any journal by another person. This thesis has been submitted in partial fulfillment of the requirements of M.Sc. degree at Jimma University College of Agriculture and Veterinary Medicine and it deposited at university library to be made available to borrowers under rules and regulation of the library.

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BIOGRAPHICAL SKETCH

The author was born on March 30, 1970 at Duna district, Hadiya zone, SNNPR. He attended his elementary and junior secondary school education at Holy Cross in Wagebatta and secondary high school at Durame and completed in 1988 .He joined Dilla Theological college in 1991 and completed in 1993 with diploma in Theology.

After his graduation, he served as an evangelist and Bible school teacher for four years in one of Ethiopian Kale Heywet local church in Durame town, Kambata and Tembaro Zone SNNPR. In 1997 he joined Evangelical Theological College in Addis Ababa and graduated with Bachelor of Theology (B.Th) in pastoral ministry major in June, 2000. and After 6 years of service at Ethiopian Kale Heywet leadership and community development training college, he joined Jimma University, College of Business and Economics in extension program in 2006 and Graduated with B.A Degree in Business management in Feb, 2010.

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ACKNOWELEGMENT

Above all, I would like to praise and extend my unshared thanks to Everlasting and Almighty God, who is providing the opportunity and smoothening all aspects regarding my hardship throughout my study. « Through Him all things were made; Without Him nothing was made that He has been made. » John 1÷3

I would like to extend my heartfelt thanks to my major advisor Dr. Eyasu Elias for his valuable advice, insight and guidance starting from proposal development to the completion of the research work and his provision of reference material. I am again thankful to my co-advisor, Ato Abrham Benteyirgu for his willingness to advise me as well as his valuable guidance and support throughout my research work. Both have worked hard to keep me on the right track and accomplishment of the study. Their guidance and inspiration made this study a reality. I am also very grateful to assistant professor Yisehak Kechoro and Ato Abebayehu Aticho for their unreserved assistance and encouragement throughout my study period.

I would also like to express my sincere appreciation to Ethiopian Kale Heywet Churct for funding my research and other study expenses. I also pass my deeper appreciation for Ethiopian Kale Heywet Church spiritual ministry and theological section and Jimma leadership college board for giving me chance to pursue my post graduate study and paying my salary during my study program. I would like also to thank all management and staff members of Jimma Leadership and Community Development College and Western Kale Heywet Zone leaders for their hospitality and kind cooperation in all aspects. Though not to exclude others, my special thanks go to Ato Wondimu Abebe, head of Ethiopian Kale Heywet theological colleges for encouraging me morally and facilitating every arrangement required for my study.

I also remain thankful to all officials of Kambeta Tembero zone and Kedida Gamela woreda Agricultural and rural development that facilitated and assisted me in giving update information for my study. I would like also to thank EKHC training and urban ministry department for their financial support of my research.

I am grateful to all brothers and sisters in Jesus Christ who prayed and encouraged me morally for my study.

Last but not least my special thank go to my wife Sr.Adanech Hinsene and Hana Hinsene (my sister in law) for being with me all the time providing me a moral support, encouragement, prayer and carrying all family burden with patience and endurance. Finally, I express my heartfelt gratitude to the whole family and my children for their prayer and all inconvenience they have during my absence for academic and research work.

LIST OF ACRONYMS

CSA:	Central Statistical Authority
DA:	Development Agent
DAP:	Diammonium phosphate
EHRS:	Ethiopian Highland Reclamation Study
EPA:	Environmental Protection Authority
FAO**:**	Food and Agriculture Organization of the United Nations
FFW:	Food for Work
GDP**:**	Gross Domestic Product
GNP:	Gross National Product
ha:	hectare
HH:	Household Head
kg:	kilogram
km^2	Kilo meter square
KTZ	Kambata Tembaro Zone
KTZARDO:	Kembata Tembaro Zone Agriculture and Rural Development office
KGWARDO:	Kedida Gamela Wereda Agriculture and Rural Development office
masl:	meters above sea level
MoA:	Ministry of Agriculture
MoARD:	Ministry of Agriculture and Rural Development
MoFED:	Ministry of Finance and Economic Development
OM:	Organic Matter
PA:	Peasant Association
PADEP:	Peasant Agriculture Development Extension Program
PSNP	Productive Safety Net Program
SNNRP:	Southern Nations Nationalities Regional Peoples
SPSS:	Statistical Package for Social Science
SWC:	Soil and Water Conservation
USLE:	Universal soil loss equation
WADU	Wolayita Agricultural Development Unity
WFP	World Food Programm

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ABSTRACT

In Ethiopia, soil erosion by water constitutes to the most widespread and damaging process of soil degradation. Several studies indicate that soil erosion and the associated decline in soil fertility is developing into major constraint to agricultural production in Ethiopias. So far a lot of soil and water conservation practices have been employed in the study area. However, farmers' perception of soil erosion and participation in SWC practices and the effects of those practices on soil fertility have not been assessed and documented properly for the study area. Therefore, the aim of this study is to assess farmers' perceptions and participation in SWC practices and their effects on some key soil properties at Azedobo kebel, Kedida Gamela district, Southern Ethiopia.

A random sampling procedure was used to select the sample households in three slopes in the keble. Questionnaire survey was administered with 108 households to capture their perception of soil erosion and their asset holding in relation to implementing soil conservation practices. Also three farm fields were selected to conduct a detailed study on soil properties as affected by soil conservation practices. Each farm field was divided into upper, middle and lower slopes giving a total of 9 case farm sections. In each of the 9 farm sections, 4 composite soil samples were collected from the inter-bund space to compare difference in soil properties across farms down the slope. A total of 36 composite soil *samples were collected and analyzed for soil pH, soil organic carbon (SOC), total nitrogen (TN), available phosphorus (AP), available potassium (avail. K) and cation exchange capacity (CEC). The results showed that 55% of the farmers perceived soil erosion as a major problem on crop production. The most commonly used soil conservation structures include soil and stone bunds and fanayajuu on farm lands and terraces and area closures on hillside communal areas. Although farmers are aware of the impacts of erosion, land and labor shortage impinges up on the implementation of soil conservation measures. Many of the young people are moving away from farming opting to off- farm activities such as wage labor (in town) and petty trading.. Laboratory analysis of soil samples showed that fields closer to the conservation structure(0.5-1.0 m distance) had a better soil nutrient status than those away from the structures(>1.0m). This suggests that conservation structures combined with farmyard munuring and grass strips have positive effects on soil nutrients.*

1. INTRODUCTION

1.1 Background

Ethiopian economy is mainly dependent on rain-fed agriculture. The agricultural sector is the main source of employment, as it provides employment for about 80 % of the population (FAO, 1993). It also contributes to a very large proportion of the country's GDP (MoFED, 2002a). Smallholders dominate the agricultural sector of the country. These smallholders cultivate about 1 hectare of land, the average being 0.8 hectare. They produce over 90 percent of the agricultural output of the country (FAO, 1993). Although the contribution of agriculture to GDP has decreased in recent years, it remains the largest sector, estimated at about 40% in 2006, and generating about 88% of export earnings. However, the agricultural sector is characterized by small scale farming, highly fragmented landholdings, traditional farming technologies, heavy reliance on rainfall, low input and low productivity (Hassan, 2006).

Agricultural production has been at best low due to multitude of factors and soil degradation is among the most important ones (Woldeamlak, 2003). Such severe land degradation problems are emanating from the demands of the growing human and livestock populations. This environmental situation not only undermines the agricultural production capacity but also threatens the ecological sustainability of most regions. Decline in agricultural productivity in the highlands has largely been associated with high population density, deforestation and intensive cultivation of steep slopes without effective conservation measures (Shibru, 2010).

Most studies indicate that soil erosion and the associated decline in soil fertility is developing into major constraint to agricultural production in Ethiopia (FAO, 1986; Hurni, 1988; Bojo and Casselles, 1995; Eyasu, 2002). Erosion reduces rootable depth, removes soil organic matter and nutrients and decreases water holding capacities (Mulugeta and Karl, 2010). Ethiopia is often cited as one of the country's most seriously affected by soil degradation in the world (Bojo and Casselles, 1995). Out of the estimated agriculturally productive lands, about 27 million hectares are significantly eroded, 14 million hectares are seriously eroded and 2 million hectares have reached the point of no return, with an estimated total loss of 2 billion m^3 of top soil per year (FAO, 1986; Eyasu, 2002 and Bobe, 2004).

Of all the processes leading to land degradation, soil erosion by water is the most threatening. It accounts for about 56% of the total degraded land surface of the world (Oldeman *et al*., 1991). Population pressure, mismanagement of agricultural land, deforestation and overgrazing are among the major causes of soil erosion and environmental degradation (Descheemaeker *et al*., 2006). The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/hectare/year, and can be even higher on steep slopes with soil loss rates greater than 300 tons/hectare/year or about 250 mm/year where vegetation cover is scant (USAID, 2000). But more emphasize was the greater nutrient loss for crop production (Hurni and Tato, 1992). Hence land degradation in Ethiopia is becoming a matter of serious concern for its negative implications on the livelihood of the rural population and the environment which they largely depend. Soil erosion by water in the country is the major cause for the rapid degradation of the highlands (areas above 1500 masl) and undermines agricultural production and frustrates economic development in the country (Greenland et al., 1994).

Following the most alarming reports of the Ethiopian Highlands reclamation Study package of conservation measures has been developed usually employing hillside terraces, soil and stone bunds on cultivated fields, tree planting on communal areas (woodlots) and hillside closures (FAO, 1986)).

One of the big driving forces behind the soil and water conservation interventions was food-for-work (FFW) payments. Mechanical SWC appeared the ideal vehicle for the range of food and cash for work schemes that are popular components of food- aid distribution and employment-based safety-net program in areas suffering chronic food shortage (Scoones et al., 1996).

However, despite decades of soil conservation campaigns, there is largely increasing rate of soil degradation and relatively little has been accomplished in the area of resource conservation and environmental rehabilitation (Scoones *et al*., 1996). According to Eyasu (2002) and Scoones (1996), various factors contributed towards poor performance of the conservation measures including: top-down planning, the physical nature of the interventions that did not include vegetative measures, and poorly designed structures that resulted in production loss of about 10-20% in the short-run. The other major weakness of the SWC measures was the top-down planning of the schemes without considering the existing realities, farmers' knowledge and indigenous practices. As a result, farmers often view the conservation works as a government imposed task. They participate as a means to secure food grain or oil through food- for –work schemes (FFW) rather than to achieve the intended goal of resource -based conservation in sustainable manner (Eyasu, 2010).

The large-scale campaign approach to SWC was largely incompatible with locally generated technology. The major differences exist in the objectives, design features and, construction patterns and labour requirements. The problem is not laid on the necessity of externally driven technology but on the manner by which the technology is introduced.

1.2 Significance of the Study

There is a growing consensus that the poor adoption of SWC in Ethiopia can be attributed in part to the lack of appreciation of indigenous practices by soil and water conservation experts and policy makers. Traditional conservation measures can be considered as farming practices that have evolved over the course of time, without any known outside institutional intervention and which have some soil conservation effects. Various mechanical, biological and agronomic techniques are being used by farmers in various combinations and ways. These measures are the result of gradual learning process and emerged from accumulated knowledge of rural people by observation experimentation and thus, a process of handling over peoples 'experiences and wisdom through generation. Ethiopian farmers have long been aware of the problems associated with soil degradation and have traditionally been conservation-minded at a farm level. However, the community's indigenous knowledge on resource management, and coping mechanisms were not given due by local institutions attention (Scoone, 1996).

Hence, farmers' indigenous knowledge in soil conservation has not been documented properly, favoring the externally planned physical works through food-for-work (FFW) scheme payments. This undermined local capacity to conserve and manage the soil resources on sustainable manner.

Moreover, soil and water conservation measures have been implemented for more than ten years in the study area. However, farmers' perception of soil erosion was not assessed and soil samples were not taken to investigate the effect of conservation on soil fertility status (improvement on soil quality).

Therefore, this study was designed to document the existing practices of SWC and explore farmers' rational in local management decisions. By focusing on a selected kebele in one woreda in the southern region. The kebele purposely selected to carry out this study because of its hot spot to erosion and soil and water conservation measures have been implemented for more than ten years. Yet the effects of bunds on soil nutrients and assessments on farmers' perceptions have not been investigated. The study was intended to examine the effectiveness of SWC measures in addressing land degradation problems and improving the soil fertility status. In this study, attempt was also made to identify farmers' perception of soil erosion and explore the socio-economic factors that affect farmers' decisions on soil conservation practices. The study is also meant to identify.

1.3 Objective of the Study

General objective

The general objective of the study is to assess farmers' perception of soil erosion and to document different soil conservation practices and preferences in the case study kebele and to investigate the effect of soil conservation on some key soil chemical properties (fertility status of the soil).

The specific objectives are:

- To understand farmers' perceptions of soil erosion (i.e.. their visual images of soil erosion) in their fields and how these perceptions lead to soil conservation
- To document the soil and water conservation practices employed by farmers in their crop fields and communal areas
- To identify the socio-economic factors that affect farmers' decisions on soil and water conservation practices
- To explore the effects of soil conservation structures on fertility status of the soil.

1.4 Scope of the Study

The study mainly focuses on identifying preferences of farmers for different soil and water conservation practices and identifying the effect of soil and water conservation practices on selected soil chemical properties in a single kebele of the woreda. Therefore the results from this study may not apply to those kebeles which are different in their biophysical and socioeconomic settings in the woreda.

1.5 Limitation of the Study

Ignoring the effect soil physical properties and some micro nutrients, this study assumes that the effect of soil conservation on key soil chemical properties such as soil pH, OC, TN, avails. P, avail. K and CEC. However, the truth is that soil and water conservation have some effects on physical properties as well. On the other, because of time and budget constraints the effects of conservation measures on physical properties and micronutrients were not discussed in this paper.

2. LIRTURE REVIEW

2.1 Soil Erosion and Its Impacts

Soil is a vital resource, which demands paying attention to its use and management. Soil is the base for nourishment and provision of required needs for the whole of nature. The whole of creation depends on the soil and it is the ultimate foundation of our existence (Kibemo, 2001). Because soil is formed slowly, it is essentially considered as a finite resource. In many developing countries, land resources such as 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).

Soil erosion is the wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth to be deposited elsewhere (Jones,2007).

According to Eyasu (2005), the concept of soil degradation includes closely interlinked processes of deterioration of the physical, chemical and biological properties of the soil. All these forms of degradation lead to lowering of soil fertility and land productivity. Soil erosion by water is, however, the most widespread and serious form of soil degradation processes at work in the Ethiopian highlands. Soil erosion encompasses all types of degradation processes. It causes loss of soil water holding capacity and plant rooting depth (physical degradation), loss of organic matter and depletion of soil nutrient capital (chemical degradation) and decline in soil humus content and biological activity (biological degradation) . Along with soil movement large amount of organic matter, nitrogen, phosphorous, potassium and other nutrients that are necessary for agricultural production are lost every year. Together with the removal of surface soil, the loss of organic matter ranged from 15-1000 kg/ha/year which is equivalent to 1.17-78 million tons of organic matter per year from 78 million hectare of cultivated and grazing lands(Hawando, 1997 cited Ertiro, 2006).

According to Mulugeta and Stahr (2010), soil degradation is a process which lowers the current and/or the potential capability of the soil to produce goods or services. Six specific processes contribute to soil degradation: water erosion, wind erosion, water logging and excess salts, chemical degradation, physical degradation and biological degradation. Hence, the rate and extent of the damage made to the soil by water erosion is taken as the sole indicator of the present status of the soil resources (Hurni, 1988 and Eyasu, 2005).

Most soil degradation studies in Ethiopia largely focused on soil erosion while other forms of degradation have not been explicitly estimated in terms of quantitative significance and monetary costs. Soil degradation is defined as the temporary or permanent lowering of the productive capacity of land, assuming other factors such as technology, management and climate constant (Bojo and Casselles, 1995, Eyasu, 2002 and 2005).

In Ethiopia loss of soil resulting from soil erosion was estimated to be about 12 billion tons per year (EHRS, 1986), of which around 55% occurs on crop farmlands and 21 % occurs on overgrazed rangelands. This has resulted in loss of top fertile soils and land degradation with a third of the soils having less than 5 cm depth (FAO, 2003).

According to Eyasu (2005), different data sources report different estimates of soil loss due to erosion in the range of 42-300 tones/ha/year (Table 1). The wide range of estimates in soil erosion rate is indicative of the complex patterns of spatial and temporal variations and conceptual and methodological difficulties inherent in making such estimates.

Table 1. Rates of annual soil loss (t/ha/yr) from croplands in Ethiopia

Author	**annual soil loss (t/ha/yr)**	**Method used**
FAO / EHRS, 1986	130	USLE
Hurni,1988	42	Runoff plots
Belay, 1992	75	Runoff plots
Azene , 1997	100	Guess estimate
Tamire , 1996	300	Secondary data and estimates

Souce: Eyasu, 2005

The most comprehensive and the most influential report in terms of quantitative information on the rate of soil degradation and its economic cost in Ethiopia is that of EHRS (FAO, 1986) which made the following conclusions: About half of the Ethiopian highlands (27 million hectares) were significantly degraded in 1984, out of which 2 million hectares of agricultural land have degraded beyond restoration. The annual average net soil loss from agricultural lands is estimated at 130 t/ha, which would mean loss of 1,900 million tones of soil from the highlands annually. This results in annual soil depth loss of 8 mm. 14 million ha, which amounts 27% of the Ethiopian highlands are seriously eroded while some 6 million ha should be completely withdrawn from agricultural use and be afforested. The present rates of erosion, it is projected that 2020 will destroy the farmlands of about 10 million farmers. Soil erosion is particularly serious in the high potential cereal zones of the north-central highlands. In parts of Amhara and Tigray regions, 50% of the agricultural lands have soils with depth less than 10 cm, which make them unsuitable for farming (Eyasu, 2005).

The Ethiopian government, its development partners, and NGOs have been given attention for resource conservation and various innervations have been implemented at both national and local level to address development challenges in the country. However, the conservation efforts that were stated since 1970s and 1980s tried to introduce SWC measures in the areas where soil erosion is severe and food deficient is widespread (Alemayehu, 2007). Also many studies indicate that these conservations were only emphasis on physical conservation measures. Eyasu (2002) argued that in the case of construction of soil conservation measures in Ethiopia emphasis should be shifted from the construction of bunds alone to the use of vegetative and agronomic measures that are most effective in erosion control. Indeed, land degradation can be mitigated by various combinations of structural vegetative or biological and agronomic measures chosen according to the site conditions (Alemayehu, 2007). Increased vegetative cover of the soil with in cropping through mulching, cover crops and intercropping is effective at reducing the impact of rainfall and increasing the soil's resistance to erosion. Physical structures may still be necessary as they have an important role in reducing soil loss by runoff control, particularly for annual crops and no steeper slopes.

Despite all these efforts, many studies were indicated that the SWC campaign was neither effective nor sustainable. For instance, according to Aklilu (2006) reported that SWC activities in the highlands of Ethiopia are faced with several challenges. Despite extensive conservation interventions during the past decades, sustained adoption of the recommended measures by the farmers has not been as expected. Woldeamlak (2003) also noted that over the past few decades, the agricultural sector has failed to keep pace with growing demand for food. This is partly attributable to erosion induced degradation of croplands. On the other hand, efforts of SWC made over more than two decades ended up with disappointing results. The problem has therefore persisted and will persist as a serious threat to the food security and development envisioned in the country's policy documents (Alemayehu, 2007).

2.2 Causes of Soil Erosion

Soil erosion is a natural process and worldwide phenomenon. Nowadays 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.

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. Deforestation (clearing of vegetation), poor land management practices and lack of land use policy are the main factors that are accelerating soil erosion in Ethiopia (Lulseged and Paul, 2008).

2.2.1 Deforestation

The familiar theme of forest clearance is the most direct cause of land degradation through erosion. Poverty and high population pressure act more indirectly as driving forces for land degradation (Eyasu, 2002). Massive removal of vegetative cover of the soil through deforestation and overgrazing is the primary cause of land degradation in Ethiopia. Many forms of physical degradation such as erosion are secondary features emanating from this basic cause (Eyasu, 2005). 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 runoff, 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).

2.2.2 Poor land management practices

According to Eyasu (2005), inappropriate land management practices, and cultivation of marginal and more fragile lands and sloping areas are among the major causes of land degradation. Among the detrimental cultivation practices are: Overgrazing and removal of organic matter through crop residues and dung burning and continuous cultivation or lack of appropriate conservation measures and limited or no use of fertilizer inputs to compensate for nutrient losses. Specially, emphasis on small-seeded annual cereals crops that require fine fertile through repeated cultivation and vertical ploughing down slope to reduce water logging in Vertisols that lead to rill and galley erosion.

2.2.3 Lack of land use policy

Ethiopia lacks land use policy that regulates the allocation of land for appropriate activities (crop cultivation, grazing, forests, nature reserve etc). Currently, farmers cultivate hillsides sometimes with slopes more than 60%, leading to severe erosion (Eyasu, 2005).

Both Environmental and sociopolitical factors have contributed to this poor performance. Environmental factors include discrete terrain, cultivation of steeper slopes, erratic and erosive rainfall, and so on (Scoone and Toulmin, 1996; Campbell, 1991). Socio-political factors include the top-down approach adopted by bodies intervening to improve soil and water conservation (SWC).

2.3. Factors Affecting the Adoption of Soil and water Conservation Practices

Studies on the factors affecting adoption of soil conservation practices in most parts have begun since 1950s (Ervin and Ervin, 1982). Since then, several empirical studies evaluated the factors affecting the implementation of soil conservation measures by farmers. It is important to review some of them to lay a conceptual basis for identifying the relevant variables to be included in the analysis. Previous studies show that various personal, economic, socio-institutional and biophysical attributes have influential roles in farmers' decisions on the adoption of SWC measures in Ethiopia (Eleni, 2008).

According to Tenge *et al.* (2004), household variables, farming and economic variables and other external factors were identified as the major determinants of adoption. In the Ethiopian case, several household and socio economic factors that influence the decision of farmers to accept SWC measures have been reported. Amsalu and De Graaff (2007) found that, age, farm size, and livestock number as the most important factors with significant influence. Farmers' decisions to conserve natural resources generally and soil and water in particular are largely determined by their knowledge of the problems and the perceived benefits of conservation. Therefore, this study focuses on socioeconomic characteristics of the households. These include age, education, family size, livestock holding and farm size.

According to Eleni (2008), there were a positive and significant correlation between continued use of SWC measures and family size in Tulla district, southern Ethiopia. Lapar and Pandey (1999) have found a positive correlation between farmers' of educational level and their adoption of SWC measures. Birhanu (2003), has reported that adoption of SWC practices were not significantly influenced by age of household in the northwestern Ethiopia. Therefore, farmer's decision to adopt a given soil and water conservation practices at any time is influenced by the combined effect of socio-economic, such as age, education level, family size, farm size and like. Which are related to their objectives and constraints.

2.4 Soil and Water Conservation Efforts in Ethiopia

The serious implications of soil erosion and declining soil fertility have been recognized within Ethiopia particularly since the drought and famine of 1972–74. With the aid from international agencies, successive governments in Ethiopia have initiated strategies to cope up with soil degradation and to improve agricultural productivity. The various interventions employed to date can be grouped into fertilizer-based extension programes and physical soil conservation and afforestation measures (Eyasu, 2010).

2.4.1 Physical structure and afforestation measures

Soil conservation is any physical structure, biological, agronomical and soil management practice that is carried out on arable land in order to protect soils against erosion by water, wind and gravity. In Ethiopia, a package of conservation measures has been developed usually employing hillside terraces, soil and stone bunds on cultivated fields, tree planting on communal areas (woodlots) and hillside area closures (Table2). Between 1976 and 1988, food-for-work (FFW) programs funded the construction of 800,000 km of soil and stone bunds on cultivated land; 600,000 km of hill-side terraces ; and 80,000 hectares were closed for regeneration and afforestation of steep slopes (Eyasu, 2010).

Table 2. Soil and water conservation measures implemented by the Ethiopian government between 1976 and 1988

Conservation measures	Area covered	Remark
Soil and stone bunds on cultivated fields	800,000 km	level earth works and stone lines on 350,000 ha crop land on cultivated fields
Hill-side terraces and afforestation	600,000 km	mostly in the northern high lands
Check-dams on gullied lands	15,400 km	includes gully reclamation and plugging work
Area closures on communal lands(hillside)	410,000 ha	Area closure were meant for regeneration of natural vegetation most common in Tigray
Tree planting on communal area(woodlots)	465,000 ha of tree planting	500 million seedlings planted on community wood lots for conservation of communal lands

Source: Eyasu (2010). (Citing Wood 1990; and Tamire Hawando,1996).

To overcome the challenges, attempts have been made to introduce soil and water conservation (SWC) measures in a wide range of setting since early colonial era to present, yet many have failed. Global strategies, such as the desertification convention and environmental action plan and project documents are replaced with statement that exhorts to combat soil erosion (Scoone and Toulumin, 1996). Alarming about the potentially damaging consequences of soil degradation has prompted external intervention in SWC measures in Africa as elsewhere (Hurni and Kebede , 1992; Pretty and Shah, 1994). During the 1970s and 1980s ant- desertification projects were common in Africa and SWC measures were centered to their design (Scoone and Toulumin, 1996).

Despite the increasing pace of land degradation, the issue of conserving agricultural land was largely neglected by policy-makers until the early 1970s. The magnitude of the problem was fully realized and the problem attracted policy attention only after the devastating famine of Wollo in 1973/74 (Endris, 2006). According to Endris (2006), there was no government policy on soil conservation or natural resources management in Ethiopia prior to 1974. The 1974 famine was the turning point in the Ethiopian history in terms of establishing a linkage between degradation of natural resources, famine and soil conservation. Following the devastating drought of mid 1980s the Dergue regime, backed by international aid funds, relief initiated food program and SWC in the high lands. The influential High lands Reclamation study (FAO, 1986) provided justification and the familiar conservation measures providing technological solutions. However, these introduced technological measures were costly, lack of people participation, less suited to the local setting often poorly executed and maintained and disrupting the existing SWC measures.

For decades, soil and water conservation has traditionally been perceived as a physical problem caused by inappropriate farming practices. Conservation projects did not analysis the problem from the farmers' perspective. So, proposed solutions were often socially unacceptable, economically not viable or ecologically unsound (Fones-Sundell, 1989). However, indigenous conservation is now gaining popularity among scholars and policy makers, who concede that the farmers themselves have a better understanding of the processes of ecological change, slope dynamics and biological regeneration (Zunick, 1990).

2.4.2 Agronomic Practices for Soil and Water Conservation

2.4.2.1 Agro -forestry Practices

Concept definition: Agroforestry is an integrated approach to solving land-use problems by allowing farmers to produce food, fiber, fodder, and fuel simultaneously from the same unit of land. According to World Agroforestry Center(2003), it is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence (WAC,2003). In agroforestry system there are both ecological and economical interactions between the different components" (Lundgren and Raintree 1982). The concept of agroforestry is based on the development of the interface between agriculture and forestry. It is a sustainable multiple-production system whose outputs can be adjusted to local needs. The main components of agroforestry systems are trees and shrubs, crops, pasture, and livestock together with the environmental factors of climate, soil, and landform (Young

1989). The aim and rationale of agroforestry lies in optimizing production based on the interactions between the components and their physical environment. This will lead to higher sum total and a more diversified and /or sustainable production than from a monoculture of agriculture or forestry alone.

2.4.2.2 Some common agroforestry practices in Ethiopia

Among the countless and diverse agroforestry practices in Ethiopia, only few of them were reviewed for purpose of this study. Dispersed trees grown in farmlands characterize a large part of the Ethiopian agricultural landscape. Trees would be grown in a scattered form over a crop field, usually between 1–20 trees per hectare to minimize impact on the companion crop. For example, Cordia Africana intercropping with maize in Bako and western Ethiopia, Acacia albida-based agroforestry in the Hararghe Highlands and Debrezeit area (Hoekstra et al. 1990). The system has much potential for supplying fodder, poles, farm equipment, fuelwood, and agricultural improvements (Poschen 1986; Abebe 2000). Such practices also aimed to soil-plant interactions, soil fertility and N-fixation studies on wide range of species

2.4.2.3 Home gardens agroforestry practices in Southern part

Home gardens can be found in many parts of southern and southwestern regions of Ethiopia. Crops such as coffee, enset, pepper, and numerous kinds of vegetables are dominant components of the Ethiopian home gardens (Getahun 1988). Trees like Cordia Africana, Milletia fruginea, Albezzia gummifera, Ficus species, and Acacia species are among the species that form the upper storey of home gardens. The structural complexity in the Ethiopian home gardens is varied and ranges from complex and diverse forms containing numerous species and strata, as in Sidama, Gedio and others southern parts of the country, to the less complex forms, with one or two crop/tree mixtures. Home gardens supply much of the basic needs of the local population and help reduce the environmental deterioration. The beauty and quality of the landscapes of Sidama, for example, stand in stark contrast to the treeless farmlands of much of Ethiopian agricultural lands. Research on Ethiopian home gardens is at its infancy, with the exception of a few quantitative and descriptive studies (Getahun 1988; Abebe 2000; Negash et al. 2002). Multi-disciplinary biophysical studies, including soil-plant interactions and socioeconomic studies on home gardens, are needed for better understanding and use of these ecologically sound agroforestry systems.

2.5 Effects of Soil Conservation Practices on some Soil Chemical Properties

The most important chemical characteristics that influence soil fertility and plant growth are soil pH, OC, TN, available P and K, and CEC (Abayneh, 2001). This study was designed to point out the impact or effect of SWC on some soil chemical properties: pH, OC, TN, available P and K and CEC.

Soil pH is generally referred to as a “master variable” because it regulates almost all biological and chemical reactions in the soil (Brady and Weil, 1996). Distribution of soil pH may provide a useful index of the weathering status, potential nutrient holding capacity and fertility of soil types. Soil pH is mostly related to the nature of the parent material, climate, organic matter and topographic situation (Tamirat, 1992). The soil in high altitude area and at higher slopes had low pH values, probably suggesting the washing out of solutes from these parts (Abayneh, 2001; Mohammed et al., 2005). When eexcess rainfall passes through the soil, there could be leaching of basic nutrients like calcium and magnesium. Thus, these nutrients will be replaced by acidic elements including hydrogen and aluminum. Because of such condition, there will be an increase in the acidity of the soils (Olaitan *et al*, 1984; Glendinning, 2000). The finding of Alemayehu (2007) has shown that the mean pH value of both the terrace and non terraced farm plots along hill slope position is rated low (moderately acidic). According to Alemayehu (2007), the reason for its being acidity was related to the parent material of the sample soils.

Organic matter, existing on the soil surface as raw plant residues, helps protect the soil from the effect of rainfall, wind and sun. Removal or burning of residues exposes the soil to negative climatic impacts and deprives the soil organisms of their primary energy source (Bot and Benites, 2005). The finding of Alemayehu (2007) has suggested that the average organic matter value of terraced farm plots increases down a hill-slope position as well as relatively down individual terraces. The reason that the upper section has lower organic matter content than the lower section might be due to the fact that the nutrients washed away (eroded) from the upper part of individual terrace and accumulated at the lower section. According to Siriri *et al* (2005), organic carbon decrease down the terrace, but there is a higher organic carbon content at the uphill than in the downhill.

Nitrogen is one of the most essential elements that is taken up by plants in greatest quantity after carbon, oxygen and hydrogen, but it is the most frequent deficient nutrient in crop production. The total nitrogen content of a soil ranges from less than 0.02% in subsoil to greater than 2.5% (Abayneh, 2001; Mohammed *et al.*, 2005). There is a strong positive relationship between soil nitrogen and soil organic matter content. Low total nitrogen content and therefore, N deficiency is visible in highly weathered soils and sodic soils of arid and semi arid regions due to low organic matter content which is attributed to the general low biomass production and fast oxidation of organic matter in such climatic zones (Havlin *et al*., 2005). A study in Anjeni area shown, the mean value of total nitrogen content for both terraced and non-terraced farm plots is rated low. There is relatively slight change of total nitrogen content within individual terraced and non terraced plots as well as along a hill-slope position (Alemayehu, 2007).

Phosphorus is an essential element classified as a macronutrient because of the relatively large amounts of P required by plants. One of the main roles of P in living organisms is in the transfer of energy. Adequate P availability for plants stimulates early plant growth and hastens maturity. Although P is essential for plant growth, mismanagement of soil P can pose a threat to water quality. Variability of the level of available P is related to land use, altitude, slope position and other characteristics, such as clay and calcium carbonate content (Mohammed *et al*., 2005). According to the study conducted by Alemahyehu (2007), the mean available phosphorus values of both terraced and non terraced farm plots is recorded low. Howeve,r the values across a hill-slope position for both terraced and non-terraced plots have no clear trends, but there is higher value at the lower terrace section. The mean available phosphorus level in non-terraced plots is relatively better than that of the terraced ones. On the other hand, the finding of Mulugeta and Karl (2010), shows that the total available phosphorus is much higher in the conserved farm plot than in the non -conserved one. Thus, a significant difference was observed for conserved (24.7 ppm) and non-conserved (15.02 ppm) plots.

Available K exists in soils solution while exchangeable K is absorbed on the soil colloidal surface from where it is slowly released to soil solution so as to be available to plants. Plants then directly absorb K from soil solution where it is found in the most readily available form for plant absorption (Brady and Weil, 2002). The study conducted in Anjeni shown the average available potassium content of both the terraced (0.46) and the non-terraced (0.47) farm plots was to be found high (Alemayehu, 2007). It increases down the individual terrace and hill-slope position. There is also almost constant value of available potassium within non-terraced plots along hill-slope position.

CEC is the ability of soil solid phase to attract or store and exchange cation nutrients with the soil solution and render them available to plants through exchange reaction (Muller-Samann and Kotschi, 1994). CEC is an important parameter of soil because it gives an indication of the type of the dominant clay minerals present in the soil and its capacity to retain nutrients against leaching. CEC is strongly affected by the nature and amount of mineral and organic colloids present in the soil. Soils with large amount of clay and organic matter have higher CEC than do sandy soils which are low in organic matter. According to a study conducted by Million (2003) terraced area with original slope of 25 and 35% were found to have mean CEC value of 6 and 49%, respectively, which was higher than the average CEC of the corresponding non-terraced slope.

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

Kedida Gamela is one of the 77 woredas in the Southern Nations, Nationalities and Peoples' Regional State of Ethiopia. It is located in Kembata Tembaro Zone (KT) and bordered an exclave of Hadiya zone in the south, Kacha Bira woreda in the south west, Angacha woreda in the in the west, the Hadiya zone in the west and Bilate river in the east which separate it from Halaba Special woreda.(Fig. 1). The altitude of the woreda ranges from 1700 to 3028 meters above sea level. Its area is divided into 7% highland (*Dega*) and 93% *Weyna Dega* (sub-tropical climate) (CSA, 2008).

Within the woreda, the study site is located in Aze-Dobo kebele at 07^{o} 14.816'N Latitude and 037^{o} 54.341'E Longitude (KGWARDO, 2010), and is about 357 km away from Addis Ababa to the south and 120km from Hawassa (the capital town of SNNRP).

3.1.2 Population

According to Central Statistical Agency of Ethiopia (CSA) (2008), Kedida Gamela woreda has an estimated total population of 202,926, of which 101,032 were men and 101,894 were women. Also, 20,100 or 9.91% of its population are urban dwellers, which is greater than the zone average (8.8%). With an estimated area of 351.25 square kilometers, Kedida Gamela has an estimated population density of 577.7 people per square kilometer, which is also greater than the zone average (429.40). The study area is found in Aze-Dobo peasant associations (PA) with total land size of 558 ha and population of 1153HH. The average population density estimated to be 566 per km^2 which shows that the study area is densely populated (KGWARDO, 2010).

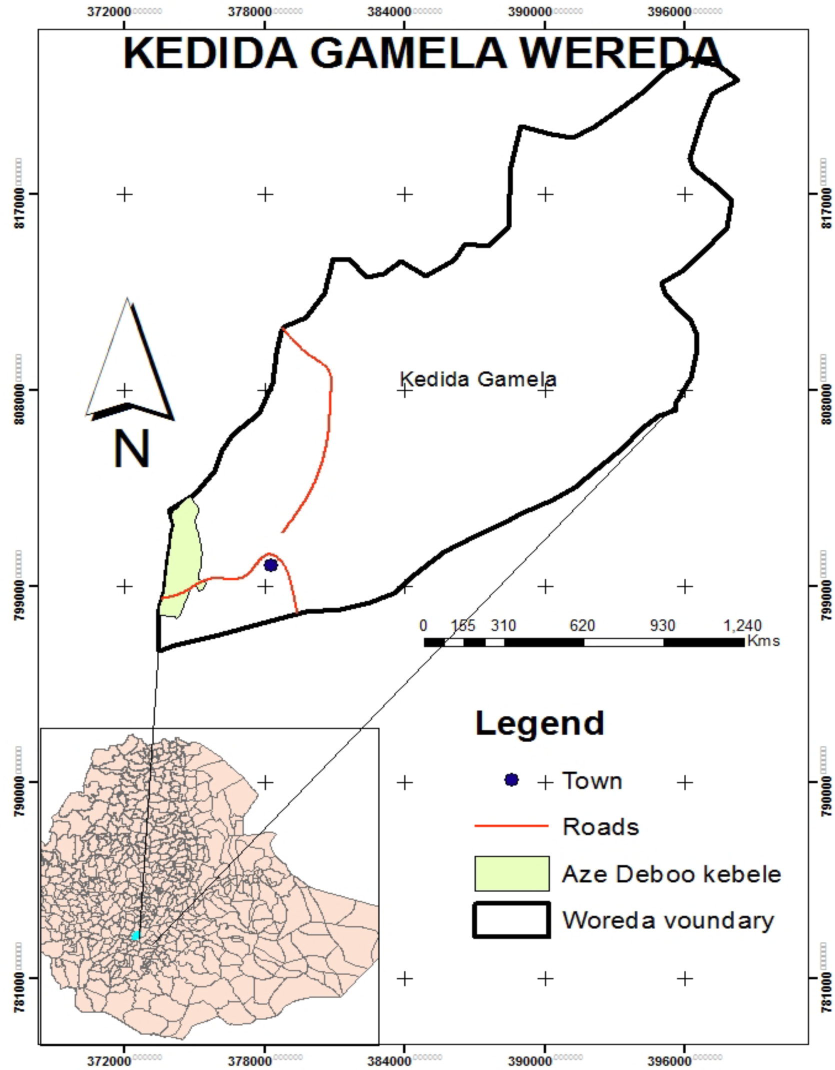

Fig 1: Location map of Kedida Gamela Woreda

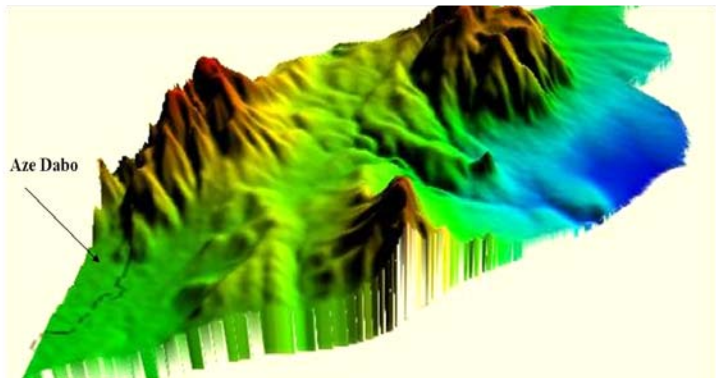

Fig 2: Satellite image of the study kebele

3.1.3 Land use

According to KGWARDO (2009), Kedida Gamela woreda covers a total area of 180.17Km^2. Out of this cultivated land accounts for 79.34%, uncultivated land for 0.8%, land that cannot be used for 3.8%, forest land 7.7%, grazing land 5.9%, and others 2.38%.

3.1.4 Topography

The land feature of Kedida Gamela woreda represents the central highlands of Ethiopia The topography of the woreda comprises uneven, mountains of high lands and with planes area coverage of 37%, 35% and 28% respectively. The chain of mountains surrounds the kebele (Ambarchoin the north,, the highest pick mountain, Chacha to the west and Denshe hills to the east). The Kebele has almost homogenous topography and is wet in summer and dry and hot in winter. Though the study area is surrounded by hills and located at the foot of these mountains and hills, there are no big rivers crossing it. However, there are some streams and seasonal flood flows (KGWARDO, 2011).

3.1.5 Climate, Soil and Vegetation

The average annual rain fall ranges from1000-1400mm and the average temperature ranges from18 - 26^{0}C. The rainfall pattern is a bi-modal. The short rains (Belg seasons) falls from March to May while the big rains (Kremt or Meher season) falls between June and October. In recent years, the area has experienced great variability in distribution and amount of rainfall causing crop failure (KGWARDO, 2010). Major types of soils identified in the study site are Cambisols at upper and middle slopes and Lithosols associated with Vertisols on flood plains. Some fruit tree species, such as Avocado, mango, banana and orange are common in the area. Coffee, Enset, Eucalyptus, Acacia species and some many shrubs and bushes are also among the common vegetation in the study area (Degalo, 2007).

3.1.6 Farming system

The agricultural system in the study site is typically an integrated mixed – farming system, which is characterized by two dominant perennial crops, Enset and coffee. These crops are categorized as cash and food crops. Perennial and annual crops such as cereals, vegetables and root crops are mixed in a multistory agro-forestry based system of home gardening. Field crops such as wheat and teff are planted on farm fields away from the homestead.

The other most important staple crops include maize, sorghum, cabbage, potato, yam beans, peas and sugar cane. Fruit trees such as orange, avocado and banana are also common. Enset is a food security crop being relatively drought tolerant and versatile plant. Major cash crops in the area are coffee, sugar cane, enset and fiber and different types of cereals (Degalo, 2007).

Food crops are grown not only for local/domestic consumption, but also as means of income generation. Enset is staple food crop mainly among the Kambata people. Culturally the existence of enset with in the farming system can also be considered as a pride. A hectare of enset can support many families for longer time. Currently, enset has become not only stable food but also means of income generation. Enset is also very useful for temperature and soil moisture regulation and conservation practices (Degalo, 2007). According to Degalo (2007), Kedida Gamel wereda is also one of the leading in coffee growing in Kambetta Tembaro Zone. Farming plots are usually small in size with the average being 0.5 ha per household. Each plot is divided in to sub plots for the purpose of multiple cropping. The settlement patterns are not widely scattered and thus, peasant homesteads are complex and continuous family plots form an extension of homestead. Areas devoted for communal grazing are mainly the planes and mountainous of high lands.

3.2 Methods

3.2.1 Sources and methods of data collection

3.2.1.1. Types and sources of data

The study used both quantitative and qualitative data collected from Primary and secondary sources through different techniques. Primary data were collected using semi-structured household interview questionnaires (Appendix 1), key informants interviews, focus group discussion and field observation. The qualitative assessment was made at village level to get a general overview of perceptions of problem of erosion and soil and water conservation practices, whereas the quantitative methods were used to get quantitative data like population number, education status, household age compositions, farm size, live stock ownership etc. of the villagers from three slopes, namely upper, middle and lower.

Secondary data relevant to the research work was collected from published materials such as office records and reports, journals, books and files from internet/web pages. Both primary and secondary sources were considered to collect qualitative and quantitative data that complement and/or supplement to each other and diverse information from different sources, so as to make the data and the results of the research reliable.

3.2.1.2. Methods of data collection

In the collection of the study, a combination of methods was used to collect relevant data. These include individual interviews, focus group discussions, key informant interviews, and field observation methods which were used to collect detailed information on soil and water conservation practices applied by farmers.

Household survey: primary data was obtained through structured questionnaire forwarded to various respondents. One hundred eight farm households operating in three slopes level were interviewed using focused questionnaire. The purpose of household interview was to capture household characteristics such as in asset ownership (e.g. land and livestock) and soil and water conservation practices.

The primary household data was collected at the village level. Primary data was also generated by interviewing local extension agents. In addition, direct field observations and a number of informal discussions with village elders, farmer groups, and extension workers were conducted to cross-check and verify some information of interest in this study.

An interview at the household level was conducted by going to each interviewee's homestead. The purpose of this interview is to obtain basic household data. Informal discussions with elders in each slope and farmers' group were conducted using a check list to guide the sessions. This interview was conducted to cross-check household data and to obtain aggregated information for the entire study.

Key Informants Interview: To complement the questionnaire and to have a detailed in sight in to soil conservation practices in the areas, in-depth interviews and discussions covering different topics were also held with district agricultural experts, DAs, better-informed farmers and opinion leaders to triangulate or verify the responses and to obtain additional information. This helped to capture some points that were not clearly obtained from household interview.

Focus group discussion (FGD): To complement the household survey, basic descriptive information was collected at different slopes levels in the study area. This technique helped to acquire useful and detailed information, which might be difficult to collect through the household survey. It is one of the most commonly used qualitative data collection approaches. Discussion was made with purposefully selected (7-9) farmers' respondents with the guidance of DAs. Checklist was prepared to guide topics for open-ended discussion with the group of farmers.

Fig. 3: Focused group discussion

Field observation

The extent of soil erosion was assessed in the case study farm fields following slope and land use type. The site was divided into upper, middle and lower slopes following the slope gradient. The aim is to explore differences in the extent of soil erosion across the slope and conservation measures employed. All types of soil conservation structures constructed within the slope were documented.

3.2.2. Sample and sampling procedure

3.2.2.1 Household Sampling

Sample size was determined based on proportion of total household population in the kebele following the procedure developed by Cochran (1977). Then number of household in each strata was proportionally calculated based on the total sample size (n1) (Corchran, 1977).

$$no = \frac{Z^2 * (P)(q)}{d^2} \longrightarrow n_1 = \frac{no}{(1 + no/N)}$$

Where;

n_{o} = desired sample size Cochran's (1977) when population greater than 10,000

n_1 = finite population correction factors (Cochran's formula, 1977) when total population is less than10, 000.

Z = standard normal deviation (1.96 for 95% confidence level)

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

q =is 1-P i.e. (1-0.1=0.9)

N = is total number of population (HH)

d =is degree of accuracy desired (0.05).

Based on Cochran's (1977), population correlation factors a total of 108 sample households' heads were selected using random sampling in each stratum for the study area. Allocation of the number of households of each level of slope was proportional to the number of household heads.

Farmers were also asked to rank the causes of soil erosion and its impacts on their farm land. Farmers' perception index on causes of soil erosion was computed by weighted perception index. Index=Sum of [(5 x number of household ranked first) + (4 x number of household ranked second) + (3 x number of household ranked third) + (2 x number of household ranked fourth 4) + (1 x number of household ranked fifth)] values given for particular causes of soil erosion divided by the sum of all values of causes of soil erosion. (Tsegaye and Bekele, 2010).

3.2.2.2 Soil sampling and testing

Three farm fields were selected and categorized in three slope categories, namely, the upper (13-20%), middle (6-12%) and lower (<6% flat areas) as determined using clinometers measurement. In each slope category three farm fields were selected thus giving a total of nine farm fields. In each the farm fields four composite soil samples were collected from the inter-bund space (i.e., plot immediately behind the bunds compared to plots further away from the bunds (i.e., about 3m) to compare differences in soil properties. Sampling were maintained in a parallel way at of 0.5m, 1m, 1.5m and 3m distance away from the bund and samples were collected from the upper (0- 20 cm depth) to compare differences in soil properties across different slopes of each replicated farms. This was repeated three times within each farm field representing upper, middle and lower farm landscape, thus giving a total of 12 composite samples per farm. Again to capture variability this design was replicated in three farm fields' making of a total of 36 composites (Fig 2). Also in each slope category, three composite samples were collected from three different farm fields near the conservation treated fields. This was meant to evaluate the effects of conservation structures on soil properties against untreated areas. The rationale for this exercises was to assess the effect of conservation structure on soil conservation and, therefore, on the fertility (i.e., nutrient dynamics) of the soil. The idea of comparing the upper and lower streams was to explore how the problem of soil loss and deposition varied across the landscape, thereby, identifying erosion hotspots for intervention.

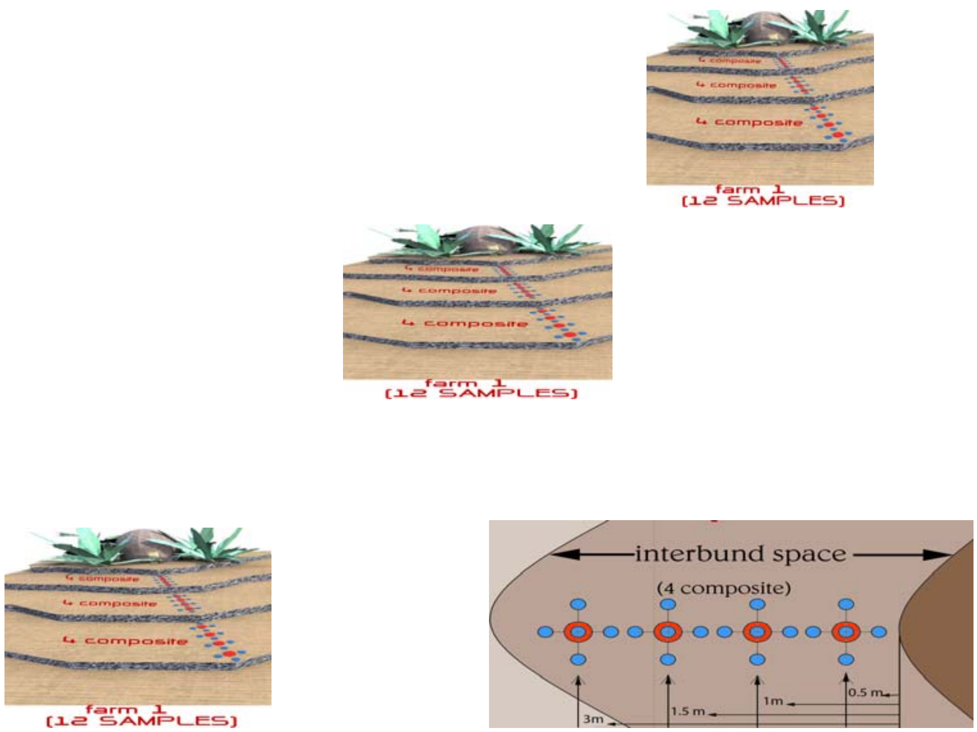

Fig. 4: Farm composite sample design across three slopes

The soil samples were taken to JIJE soil laboratory for analytical laboratory for analysis of key chemical parameters. Before conducting laboratory analysis the samples were air dried and passed through a 2-mm seive.

The pH of the soils sample was measured by digital pH meter water (1:2.5 soil to water ratio) using potentiometrically a glass-calomel combination electrode (Van Reeuwijk, 1992). The Walkley and Black (1934) wet digestion method was used to determine soil organic carbon content and percent Soil Organic Matter(SOM) was obtained by multiplying percent soil OC by a factor of 1.72 following the assumptions that OM is composed of 58% carbon. Total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by Bremmer(1965). Since the Olsen method is the most widely used for P extraction under wide range of pH both in Ethiopia and elsewhere in the world (Landon, 1991), available soil P was analyzed according to the standard procedure of Olsen *et al.* (1954) extraction method. Cation exchange capacity (CEC) was determined after extracting the soil samples by ammonium acetate (1N NH4OAc) at pH 7.0. Then it was estimated titrimetrically by distillation of ammonium that was displaced by sodium from NaCl solution (Chapman, 1965).

3.3 Data Analysis

Data was checked for some out layers and incorrect figure and entered into Microsoft office excel sheet to prevent loss of data and it was continually checked for precision reliability. All surveyed data was analyzed using statistical procedures for social science (SPSS) version 16 (SPSS Inc, Chicago, Illinois, USA, 2007). Statistical variations for categorical data was tested by means of chi-square with significant difference at $P<0.05$. The descriptive statistic for numerical data was subjected to analysis of variance (ANOVA) using the general linear model procedure of SPSS. Mean comparison was made using Duncan's multiple range tests. Level of significance was also considered at $P<0.05$.

4. RESULTS AND DISCUSSION

4.1. Demographic Characteristics and Educational Status of Households

Table 3 shows that the age structure of the household heads ranged from 22 to 85 years with an average age of about 45 years. It is hypothesized that age would influence farmers' decisions on soil conservation practices either positively or negatively as it affects the supply of labor for construction of conservation structures.

About 60% of the household heads interviewed were in the age group of 22-45 years, suggesting that there is a sufficiently large labor force (Table 3). These farmers have a better understanding of problems of soil erosion due to more access to information. As indicated above the proportion of old farmers is 9%, who are facing some serious problem of labor shortage to practice soil conservation. The result of one way ANOVA showed that there is no significant mean age difference among the three slopes.

Table 3. Socio-economic characteristics of households across slope (N=36)

	Slope			**Total**		**SE**	**P-value**
Age group	Upper (no)	Middle (no)	Lower (no)	(no)	%		
22-45	22	17	26	65	60		
46-64	13	13	7	33	30		
>65	1	6	3	10	10		
Total	36	36	36	108	100		
Mean	44.7	47.5	45.7			1.09	0.325 NS
Sex							
Male	28	32	30	90	83.3		
Female	8	4	6	18	16.7		
Total	36	36	36	108	100		1.0 NS
Educational level							
Illiterate	13	14	7	34	31		
read and write	11	6	7	24	22		
primary and secondary school	9	7	15	31	29		
high school	3	9	7	19	18		
Total	36	36	36	108	100		0.102 NS
Family size(mean)	6.81	6.42	7.11			0.2	0.19 NS

Note: NS, non significant

The result indicates that 83% of the head of households are male (Table 3). These male groups include the most influential people who are village elders, decision makers, older people, younger people, rich and poor farmers who are actively involved in soil and water conservation. During planning of soil conservation, it is important to consider the influential group but still care needs to be taken so that other groups are not marginalized. The data also shows that about 17% of the sample households were female-headed which are either widowed or divorcees (Table3). As would be expected these households have critical challenges of labor supply for soil and water conservation work. Gender difference was found to be one of the factors influencing the practice of different types of soil conservation. The reason for this is socio-cultural values and norms that allow males to have freedom of mobility and participation in different meetings and consequently have greater access to information.

With regard to the literacy status of households, the study has identified four categories of farmers namely, the illiterate, those who can read and write, those completed primary and secondary education and the high school completers (Table 3). This disaggregation is important because education affects farmers' level of understanding and interpretation of agricultural technology and extension information. As shown in Table 3, 31% of farmers were illiterate while 69% had some level of education and are literate. Literacy in that sense was extended from read and writes to attending regular school education. The majority of farmers in the area have got some level of education and thus having better access to information about soil and water conservation practices.

The family size of households plays an important role in the investment of soil and water conservation works. Family size in this study is considered as the number of individuals who permanently reside in the respondent's house, share the dwelling unit and other properties for common use (Eyasu, 2002). As shown in Table 3, the average household size was about 7 with no significant differences upper, middle and lower slopes. There a huge difference among households in terms of family size that ranged from 2 to 12. In general the family size observed in this study is much higher compared to the national average (5.15 per households) (CSA, 2008). This also coupled suggests that the area is one of the most densely populated areas in the country.

4.2. Land holding and Livestock Ownership of Households

In this crop-livestock mixed farming system, livestock ownership is one of the major assets of the households in general and oxen ownership in particular is critical as oxen provide the draught power needed for the farming. Sheep and goats are very important sources of cash and food (Table 4).

Table 4. Property ownership of household head across slope (N=36)

	Slope				
Properties	Upper	Middle	Lower	SE	P-value
Cattle (no)	2.36	2.53	2.06	0.13	0.314 NS
Goats/sheep(no)	0.25	0.39	0.22	0.06	0.431 NS
Equine	0.28	0.25	0.33	0.05	0.797 NS
Total livestock (no)	2.89	2.97	2.56	0.18	0.624 NS
Home garden(ha)	0.57a	0.52a	0.24b	0.04	0.000 ***
Outer field(ha)	0.01b	0.19a	0.21a	0.17	0.000 ***
Grass/wood(ha)	0.007b	0.85a	0.11a	0.13	0.002 ***
Total land (ha)	0.59	0.79	2.27	0.57	0.428 NS

Note: NS, and ***: non significant and significant at less than 1% level respectively.

Table 4 shows that the average livestock ownership of households is about 2 heads of cattle, 0.2 heads of goat (sheep and goat) and 0.3 heads of equine. This shows a very low asset ownership since considerable number of households (23%) owned no livestock at all. This is significant in terms of soil and water conservation practices, as livestock provide draught power and manure needed for soil organic matter enrichment. The one way ANOVA result indicated that there is no significant difference in the mean of total herd size among the slope at (SE =0.18) (Table 4).

Land availability often influences farming practice, and affects the land degradation process. Most of the agricultural land in the study area has so far been subdivided into the smallest land use type that is no longer economically viable for smallholders' subsistence.

The average land holding of sample households was 1.2 ha and the minimum and maximum holding per household was 0.13 and 2.5 ha, land respectively (Table 4). The total land ownership of upper, middle and lower slope households were 0.59, 0.79 and 2.27 ha, respectively with a standard deviation of 0.57 and P=0.428).

Out of the total sampled households, the majority (66%) possessed between 0.5 - 1 ha of land. Only 9% had more than 1 ha while about 25% had holdings of less than 0.5 ha. As would be expected, the richer households have relatively bigger farm size compared to poorer farmers across slopes. Those farmers who own less than 0.5 ha in the area are young and middle adults, since no redistribution of farm land was done in the study area. However, the younger household heads have owned very small plots of land from the holdings of their parents, as the *kebeles* do not have a land pool from which to give to newly forming families. In general, the overall mean of 0.65 ha of land holding per household in the study area is significantly lower than the national average (1.18 ha) (CSA, 2008). Again, this is a mirror image of the ever increasing population density in the area.

The Duncan's multiple range tests has been run to see mean comparisons which associate between land holding size among three slope types and land use type conservation structures. The result of Duncan analysis test shows that there is a significant association at 1% probability level of significance (SE = 0.04, P =0.000) for home garden, (SE= 0.17, P = 0.000) for outer field and for grass land (SE=0.13, P =0.002 (Table 4).

However, there is no significance different in total land holding size among slopes. This implied that the same land use type which was large at one slope became small in the other and the reverse is true this because steep slope is not appropriate for cultivation due to being exposed to erosion and thus, why farmers are used for home garden and planting trees while the middle and lower slope use for outer field crops. Farm size is also related to other economic factors. For instance, a farmer with a large farm size gets a high annual income from agriculture.

4.3 Farmers' Perception of Soil erosion

Table 5 presents the interview results of farmers' perceptions of soil erosion in their farm fields.

Table 5: Farmers perception of soil erosion at different slope position (N=36)

Erosion problem		Slope: Upper (no)	Slope: Medium (no)	Slope: Lower (no)	Total (no)	Total %	P-value
Do you face soil erosion problem	Yes	34	13	12	59	55	
	No	2	23	24	49	45	
	Total	36	36	36	108	100	0.000 ***
How severity of soil erosion in your farm	Severe	33	9	0	42	71	
	Moderate	1	4	12	17	29	
	Total	34	13	12	59	100	0.000 ***
On which farm section you face severe erosion	Homestead	3	0	0	3	5	
	outer field	31	13	12	56	92	
	Grass land	1	0	0	1	1	
	Total	34	13	12	59	100	0.000 ***

Note: *** significant at less than 1% probability level

As can be seen from Table 5, about 55% of farmers perceived soil erosion as a major problem on their cultivated fields. The remaining 45% indicated that there is no erosion problem on their farm fields. The indicators farmers used to assess the degree of erosion include the existence rills, change in soil color, and deposition of sediments in grass patches at the bottom of farm fields. These figures are less than to the findings of other studies who reported higher perception in other parts of the country. For instance, the study made in Gununo area of SNNPR (Wolaita) indicated that 74% of farmers perceived soil erosion problem on their cultivation field (Belay, 1992). Another study in Digil (Gojima area) indicated that about 98% of farmers perceive the problem of soil erosion on their own farms (Woldeamlak, 2003).

On the other hand, with regard to severity of soil erosion, out of the 55% who perceived soil erosion as major problem in the cultivated fields, 71% perceived sever while 29% perceived a moderate level of erosion. The majorities of farmers who perceived severe erosion were found in the upper slope while the least perception was found in the lower slope areas. This suggests that slope and farm landscape is significantly important for the occurrence of soil erosion. Again, within a farm landscape, severe soil erosion was observed in the distant outfields (as indicated by 92% of the respondents) respective to the huts while the homestead and grass land had no erosion incidence. This difference in erosion incidence across farm gradient is related to the difference in the land use pattern. That is to say, the home garden and grass lands which are planted to perennial crops such as enset and coffee (see Figure 2) that provide permanent cover and mulch material that protects the land from water erosion. On the other hand, the outer fields are planted to cereals crops (wheat, barley, teff) that are uprooted with no retention of organic matter and cover to the soil which predisposes it to erosion losses.

The Chi-square analysis computed showed there is significant difference in the perception of soil erosion as a problem among the upper, middle and lower slope (Table 5). This suggests that erosion incidence varies significantly with slope gradient and slope length >25% with steep longer slopes leading to high erosion incidence. That is why farmers in the upper slope or steep slopes areas indicates farms which far from homestead are less fertile and farms which are near to homestead become more and more fertile. This finding is similar earlier investigation of the nutrient content on enset field by Eyasu (1998).
The study also tried to capture farmers' perceptions of causes of soil erosion (Table 6).

Table 6: Major cause's soil erosion ranked by farmers frequency

	Rank					
Causes of erosion	1	2	3	4	5	Index
Population pressure	20	41	31	8	8	0.23a
Deforestation and over grazing	11	25	39	25	8	0.21c
Amount of rain fall	2	4	19	44	39	13d
Steep slope	42	12	12	14	28	0.21c
Poor farming	31	31	10	14	22	0.22b

Source: Own survey, 2012; Superscript: a, b, c, d, indicates 1^{st}, $2^{nd,}$, 3^{rd} and 4^{th} rank

The most commonly mentioned causes were population pressure, poor farming practices, deforestation/removal of vegetative over through overgrazing and steepness of slope, in their order of importance. This finding is in perfect agreement with the findings of Eyasu (2002) and Bojo and Cassles (1999).

Farmers indicated that they have to cultivate the land continuously due to increasing family size. The land holdings are getting smaller and diminutive due to repeated sharing among family members. Similarly, the ever increasing livestock population is causing complete removal of vegetative cover including crop residue left in the field (free range grazing is common on the outer fields). This predisposes the land to soil erosion by water.

Farmers are also aware of the impact of soil erosion on farming and their livelihood, although this awareness does not always lead to soil and water conservation practice. They believe that soil erosion reduces the depth of top soil, water holding capacity of the soil and ultimately leads to reduced crop yields. Productivity reduction is believed to have been caused by loss of soil fertility (due to removal of fertile particles) and reduction of effectively cultivated areas (farm size) through gully formation and washing away of the top soil.

Farmers were also interviewed to rank their perception on soil erosion impacts on their farm land. Sample respondents have ranked and mentioned five most important impacts as a result of soil erosion. These are reduction of crop production, reduction of farm land size, decline in soil fertility, expansion of gullies and shortage of animal feed, which were ranked as 1st, 2nd, 3rd, and 4th, with index value of 0.23, 0.20, 0.19, and 0.18, respectively (Table 7). This research findings was in agreement with some previous works which stated that demographic pressure, poor soil management along with climatic condition and other factors contribute to declining soil fertility (Gruhn *et al.*,2000).

Table 7: Impact of soil erosion ranking by household frequency

Impact of soil erosion	Rank					
	1st	2nd	3rd	4th	5th	Index
Loss of soil fertility	27	11	19	23	27	019[c]
Reduce of crop yield	32	21	32	14	9	0.23[a]
reduce of size of farm land	21	23	18	22	24	0.20[b]
Expansion of gullies	16	30	8	30	24	0.19[c]
Shortage of livestock feed	11	23	31	19	24	0.18[d]

Superscript: a, b, c, d indicate 1st, 2nd, 3rd, and 4th, rank position

The farmers' ranking is in some way in agreement with that of Sierra Leone farmers who associated the erosion problem on their land with high rainfall, steep slopes and lack of vegetation (Morgan, 2005).

4.4. Common Soil and Water Conservation Practices Employed by Farmers

Various types of soil and water conservation practices have been implemented by farmers in the study area for the last ten years with the objectives of conserving, developing and rehabilitating degraded lands and increasing food production. Based on the land use system in which they were constructed, soil conservation techniques introduced to the area can be categorized into two soil conservation measures on farm land and on degraded hillsides of the communal area.

4.4.1 Soil conservation measures on farm fields

The prominent soil conservation measures practiced in the area are summarized in Table 7.

Table 8. Frequency of common soil conservation measures practices across slope (N=36)

Types of practices	Slope					
	Upper	Medium	Lower	Total frequency	%	P-value
Do you have erosion control measure or did you implement them?						
Yes	30	25	20	75	70	
No	6	11	16	33	30	
Total	36	36	36	108	100	
Which type of SWC?						
Soil and stone bunds	22	18	13	53	49	
Terrace	7	5	2	14	13	
Biological measures	5	13	21	39	36	
Fayana juu	4	0	0	4	4	
Cut-off drain	2	0	0	2	2	
Flood diversion/diversion ditches	0	5	23	28	26	
Check dams	10	1	0	11	11	
Micro basin	4	0	0	4	4	
Significance						0.000***

Note: *** Significant at less than 1% probability level

As shown in table 7, the majority(70%) of respondents employed soil and water conservation and the most common soil conservation structures used on farm fields were soil and stone bunds and terraces combined with some biological measures (grass strips such as desho grass (Pennisatum) and vertiver (Vertiver zinanioides) are the most common grasses planted on soil bund and terraces. and fruit trees such as banana etc on structures). It is only in few places that fanaya-juu terraces have been practiced. The two most common conservation measures were soil/stone bunds supported by biological measures (e.g. planting fruit trees and fodder grass on bunds). Out of the total sample households interviewed 49% of farmers reported that they are using soil and stone bunds, while 36% are using biological measures such grass strips and fruit trees planted along the contour (see Fig.5).

Fig. 5: Grass and fruit trees (banana) and other trees species planted on soil bunds along the contour:

The other most common practice is use of flood diversion ditches (cut-off drain) to direct floods entering farm field into natural waterways. Also terraces are practiced by 13% of respondents (Table 7). It is less common because farmers preferred soil/stone bunds to terraces. Bunds are broken after several years of sediment accumulation and shifted to new construction site. On the other hand terraces do not led to implementation of this kind of flexibility in land management. After breaking the soil bunds, the silt/sediments accumulated behind bunds are used for crop production

The results of the present study indicate that there is a significant difference with types of erosion control among farmers in the three slopes. Soil and stone bunds and terrace were common between upper and middle slope while biological or agronomic measures were dominant in lower slope. This is because farmers use physical structure steep slope ingredients and longer slopes in the upper slope. Thus both soil/stone bunds and biological measures of soil and water conservation practices were preferred by farmers in the study area.

Soil bunds: These are narrow based channel terraces constructed by digging a ditch along the contour moving the soil down the slope to form a ridge. These structures are constructed along the contour when there is a need to retain both the runoff and sediments. By reducing the slope length of the farm land they are effective in controlling soil loss, retaining moisture and ultimately enhancing productivity of land (WFP, 2005).

Fig 6: soil bund practices on middle slopes

Stone bunds: These are barriers of stones placed at regular intervals along the contour. They have been used for generations in Ethiopia where they are locally known as "dhagga" and in some parts of South Africa. The size of the stone bunds varies between 0.5-2m and may be 5 to 10m apart, depending on the availability of stones and the topography. Stone bunds retain or slow down run off and hence control erosion. They also allow the accumulation of soil, which may be redistributed after the bunds are dismantled.

Fig 7: Stone bunds on steep farm lands

Stone-faced soil bunds: These are implemented in the area where abundant supplies of stone are available. The down side of stone faced bunds is that they harbor rodents such as rats that of damage filed crops (Fig. 6).

Fig. 8: Stone faced soil bunds on hill-side farm lands

Fanya juu: Fanya juu is a Swahili term which means of throwing up-hill (Mesfin, 1992; Woldeamlak, 2003). The fanya juu is constructed by digging a ditch along the contour and throwing the soil uphill to form a ridge of banks. Throwing soil uphill to make a terrace causes a reduction in slope, which in turn makes a better contribution to reduce and stop the velocity of runoff and consequently reduces soil losses. Fanaya juu was introduced to the area by the extension system over the past 15 years. The practice was introduced in the area to reclaim eroded fields on the higher slopes. But its adoption rate has been so slow and thus, only 4% of the respondents used the practice.

However, some of the problems mentioned by farmers, who implemented a number of physical/mechanical soil and water conservation measures are as follows:

- Conservation structures harbor rodents
- Structures occupy considerable area of arable land. This is a major disincentive given critical problem of land shortage
- Some physical measures such as terraces create inconvenience to operate with oxen-drawn implements
- Labor shortage: some respondents mentioned about labor shortage to construct structures such as terraces and stone/soil bunds as these are labor

intensive measures.

On the other hand, conservation adopted farmers believed that the benefits from conservation measures out weight the problems. This is reflected in terms of increased crop yields and enhanced soil fertility levels.

4.4.2. Agronomic practices for soil and water conservation

Farmers are using various types of agronomic practices for SWC in the study area. The common three practices are application of farmyard manure, mulching and crop residue, and agroforestry.

Table 9. Agronomic soil and water conservation practices across slopes (N=36)

Common agronomic SWC practices	Upper (no).	Medium (no)	Lower (no)	Total (no)	%	P-value
Application of manure	17	18	16	51	48	
Mulching and crop residue	10	6	8	24	22	
Agro forestry	9	12	12	33	30	
Total	36	36	36	108	100	0.000 ***

: ***= significant at less than 1% probability level

About 70% of the farmers apply farmyard manure, compost, crop residue and mulching on the areas prone to soil erosion as a barrier as well as enhancement of soil fertility (Table 9). Following manure application, enset is planted as a line barrier to erosion and provide on the soil through canopy cover. Hence, increasing the supply of farmyard manure is a vital option in the restoration of soil fertility and enhancing soil organic matter for protection smallholders in the study area.

Crop residues are also mulched in trash line to stop runoff. Sometimes they are laid on erosion tills as barriers of runoff. Mulching maintains surface residues on tilled land. Therefore, crop residues are useful in conserving the soil, controlling water runoff, improving soil physical condition and increasing fertility.

It was also found that dispersed tree planting (fruit, timber, and fuel wood trees) on the farm landscape is a common practice in the area (Figures 5 and 7). Agro-forestry is used as a means for both conserving the soil and enhancing its fertility. In the study site scattered trees are found on crop fields, especially on the outer fields in the upper slope.

About 30% of the interviewed farmers used agro-forestry practices (Table 9). The enset garden area represents a multistory system of agro-forestry involving fruit tress coffee associated with its shade trees. The farmers have a long experience of growing coffee under different shade trees. The most commonly used tree species for this purpose are *Cordia africana*, *Acacia* spp. Accecia abysinica *croton macrostrachyus* (e.g.Coodia Africa) forming the upper canopy. The middle layer is composed on annual crops such as maize while the lower canopy is formed of vegetable species and root crops. In these fields erosion does not occur due to canopy cover and mulch material on the surface of the soils through the leave fall and manuring. Thus this finding is agreed with findings that tell Agro-forestry could play a potentially valuable role in enhancing soil organic matter and improving land productivity. Soil organic matter helps retain essential nutrients, improves infiltration and water-holding capacity, and reduces erosion (Nair, 1993: Berkes, 1999 and Tesfaye, 2005). Even when inorganic fertilizer is available, a minimum amount of organic matter is required for its efficient use (Budelman and Zander, 1990).

Fig. 9: Agro-forestry practices on crop land and around homestead area

4.4.3. Soil conservation measures on degraded hillside

Soil and water conservation practices in communal areas especially on degraded hill-sides was introduced by extension intervention supported by local NGOs (i.e., Kembati Menti Gezima) through the food-for-work payments. This has been strengthened through the productive safety net program (PSNP) since the early 2000s.Conservation works on communal hill-sides focused mainly on constructing and maintaining conservation structures such as bunds and terraces.

While at the same time creating asset for participating households, PSNP contributed towards maintaining physical structures such as closures, check dams, hillside terraces; and micro basins. In the study area, it was found that 47% of the respondents are benefited from the PSNP while the other 44% participated in the FFW payment by an NGO working in the area. The local NGO called "*Kembati Menti Gezima*" has been engaged in SWC and environmental rehabilitation works on communal areas.

The communal area conservation and environmental rehabilitation works have focused on upper streams where soil erosion gets initiated and increased momentum down the slope damaging downstream farmlands. (Table7).

Area Closure

Among the important communal area rehabilitation activities implemented in the area includes area closures. In such a land management practices severely degraded lands are closed from the interference of livestock and human activities and left for nature to take care of the regeneration processes (Figure 10). These areas have been closed to improve land affected by severe erosion, limited vegetation and low fertility through natural regeneration. In order to facilitate the natural process, such areas have been planted with different low fertility and moisture level tolerant species, which is also called enrichment planting. According to the Woreda office of Agriculture (WoA), about 186 ha of land has been closed for human and livestock access. Trees planted for enrichment include Eucalyptus species (mainly E. globulos, and E. camaldulences), Graveilia robusta and various Acacia species (e.g., A. saligna and A. decurence). The enrichment planting is accompanied by construction of some physical conservation measures such as hillside terraces and micro basins to rehabilitate the degraded hill side.

During the group discussion with key informants and DAs, it was learned that the community has established bi-laws and regulations to protect and manage closures. The main responsibility of management and use of the rehabilitated area rests on the community leaders and local elders. The community has traditional rules and regulation to punish offenders or poachers of the closed area. The proceedings of the rehabilitated area is used by the community members including cutting grass, poles or construction materials following traditional system of resource administration.

Fig. 10: Area recently put under closure for rehabilitation

Hillside terraces

These are physical structures constructed in steep degraded slopes. These are constructed on communal land along the contour. The main objective of constructing hillside terraces is to control runoff, allow sufficient time for percolation of runoff water and maintain fertility of the soil. They also filter sediments and remove excess water. They are employed in combination with area closure for tree planting. According to MoARD (2005), they are effective in watershed rehabilitation, biomass production and recharging water table if combined with other moisture conserving measures

Micro basin

These are small structures constructed by excavating half circle shaped basins for tree planting. For the construction of micro-basin, soil is excavated in 1m diameter to conserve water for plantation. The spacing/ distance between basins along contour line and that along the slope (distance perpendicular to the contour line) is 2.5 m. The alignment of micro basins is made by line-level.

Cut-off drain (Artificial water ways)

A cut-off drain is a ditch dug across a slope to collect runoff water and divert it into natural or artificial waterway or to water storage structure. It protects cropland and other land down the slope. Cut-off drain has its own advantage and disadvantage. It takes excess water safely from cropland and helps prevent gully erosion. Some of the diverted water seeps into the soil, raising the water table and benefiting the crops. On the other hand cut-off drain can cause gully erosion unless it is carefully constructed. Out of total surveyed households only 11% used or practiced cut-off drain as SWC measures.

4.5 Correlation between Socioeconomic Characteristics of Household and Soil and Water Conservation Practices

Table 10. Correlation between socio-economic of HH and soil and water conservation practices

Variables	r^2
Age	0.47
Education level	0.20
Family size	-0.05
Livestock size	-0.13
Farm size	-0.30

Correlation between age of household and SWC was a positive and significant (r=0.47). This implies that with increasing of young age of households, soil and water conservation practices increasing by 47%. (Table 10). A possible explanation is that young farmers did practice soil conservation due to access to information about the importance of SWC. This finding is contradictory that of Birhanu (2003) who found to that adoption of SWC practices were not significantly influenced by age of household in the northwestern Ethiopia.

The Correlation between education and conservation was positive and significant (r^2= 0.20). This implies that with increasing education level soil and water conservation practices increased by 20%. Generally, the correlation test shows that better educated households have a better knowledge about soil erosion problems and land management. This finding is in agreement with the findings of Lapar and Pandey (1999) who found a positive correlation between farmers' years of education and their adoption of SWC measures.

With regard to the association between family size and SWC practices, person's correlation test implies that there is a negative and very weak correlation (r^2= -0.055 (Table 9). This implies that 5.50% of decrease in SWC was due to large family size. This findings is contradictory against the finding of Eleni (2008), who reported that there was that, a positive and significant correlation between family size and continued use of SWC measures in Tulla district However, the decrease in SWC with increasing family size in the present study could be due to high population pressure of the area and, thus the nature of physical conservation measures which reduce farm size.

There was a negative correlation (r^2= -0.13) and non significant correlation between livestock ownership and SWC practices (Table 9). This implied that those who have large size of herd less likely involve in SWC practices. That would mean by increasing livestock, conservation practices decrease by 13% over time. This finding is contrary to the findings of (De Graaff, J et al., 2004), who reported that a household that owned large number of livestock was assumed to adopt SWC practices better than those who have less number of livestock. This is due the fact that a farmer divides to farmer classified his small land size for various activities, such as grazing, construction and other related things.

On the other hand, farm size has a negative and significant correlation (r2= -0.30) with SWC. Hence with increasing farm size SWC practices decrease by 30%. This may be due to labour shortage as SWC is capital intensive. This is contrary to the findings of Amsalu and Graaff (2007), who reported that farmers who have a larger farm are more likely to invest in soil conservation measures. This implies that many young people were engaged in various activities and left their area because of education, instead of being involved in agricultural practices.

4.6. Effects of Conservation Structures on the Soil Fertility Status

As described in the methodology section the study explored some soil properties respective to the conservation structure. It was found that sites closer to the conservation structure a have better soil properties (in terms nutrients) and soil structure. The result of laboratory analysis of soil samples are summarized in Table 11, which is a mean value of the three replicates (i.e., three farm fields) in each slope category. The soil test results are interpreted on the basis of Booker Tropical Soil Manual (Landon, 1991).

Table 11. Some soil chemical properties with distance from bunds (mean of three farm fields as replication across farm sections)

Farm sections	Sampling distance(m)	pH H_2o 1:2:5	% OC	Total % N	Avail. P mg/kg	Avail.K cmol(+)/ kg)	CEC(cmol (+)/kg)
	0.5	6.26	1.31	0.17	9.15	0.74	11.64
Upper	1.0	6.31	1.17	0.15	8.25	0.73	12.56
	1.5	6.29	1.09	0.16	8.23	0.73	12.08
	3.0	6.29	1.17	0.15	6.33	0.73	12.07
	Mean	**6.29**	**1.18**	**0.16**	**7.96**	**0.73**	**12.09**
	Control	**5.86**	**1.01**	**0.10**	**12.23**	**0.69**	**11.58**
Middle	0.5	5.75	1.11	0.17	13.37	0.68	13.14
	1	5.70	1.16	0.13	17.16	0.56	12.54
	1.5	5.83	1.22	0.12	16.00	0.48	13.48
	3	5.80	1.21	0.12	20.24	0.49	12.35
	Mean	**5.77**	**1.17**	**0.21**	**16.69**	**0.55**	**12.88**
	Control	**5.72**	**1.12**	**0.15**	**17.80**	**0.62**	**11.82**
Lower	0.5	5.88	1.30	0.13	14.16	0.64	12.12
	1	5.93	1.29	0.10	12.37	0.71	13.00
	1.5	5.93	1.23	0.38	10.00	0.75	12.41
	3	5.90	1.33	0.16	6.13	0.76	12.42
	Mean	**5.91**	**1.29**	**0.19**	**10.66**	**0.71**	**12.49**
	Control	**5.78**	**1.22**	**0.08**	**18.50**	**0.69**	**12.42**

Soil pH (soil reaction)

As shown in Table 11, the pH of the soil is within a medium range with mean value of 5.91 in the lower slope to 6.29 in the upper slope. Higher pH values were observed in the upper slope perhaps due to some manure application as the area is located next to the homestead fields. When compared with the pH value for the control plot, the conservation treated fields had relatively higher pH across all slope categories. However, no significant differences were observed in soil pH within the inter-structure space. This finding is in agreement with the work of Mulugeta and Karl (2010), including that soil pH is associated with soil fertility as the mean pH value of control treatment is relatively lower when compare to conserved plots.

Organic Carbon (OC %)

The result shows a very low OC content with mean values of 1.18%, 1.17%, and 1.29% for the treated plots in the upper, middle and lower slope fields, respectively. The reasons for very low organic carbon content could be due to complete removal of crop residues particularly from the outer fields as feed for livestock, while farm yard manure is applied only in the enset-coffee gardens. But when compared with the control plots, the fields treated with conservation structures had relatively better organic matter content. The findings is in agreement with Siriri *et al* (2005) who reported that organic carbon decreased down the terrace, with a higher organic carbon content at the uphill than in the downhill.. On the other hand, there was no difference in organic matter content between fields closer to bunds and those away from them within inter-structure space. The pattern is the same across the three slope categories. This would mean that physical structures alone did not contribute to improve soil organic matter content and thus, crop residue retention and application of farm yard manure is also needed.

Total nitrogen (Total N %)

Following the trend observed in organic matter content of the soil, the N content is also in the low range with mean values of 0.16%-0.2%. This result is similar findings of Alemayehu (2007) in Anjeni area, west Gojam, where the mean value of total nitrogen content for both terraced (0.13) and non-terraced (0.17) a farm plot is rated as low. As would be expected, this is a mirror image of the low organic matter content of the soil. Although still in the low range, the treated fields had better N contents than the control fields particularly in the lower slope areas. However, Alemayehu (2007) reported that the non-treated farm plots had better N content. Furthermore, no distinct difference in N content was observed between plots immediately behind the structures (within 0.5-1.0 m range) with those far away (3 m range) and the inter-structure space. The results suggest that N content of the soil is more related to the organic matter content of the soil than the conservation structures. Therefore, for adequate supply of N, it is critical that farmers should properly manage the soil organic matter content.

Avalable Phosphorus (avail P mg/kg)

Unlike organic carbon and N, the P content of the soil is in the medium range with mean values of 7.96, 16.69 and 10.66 mg/kg for the treated plots in the upper, middle and lower slope fields, respectively (Table11). This finding is contrary to the findings of Alemayehu (2007), indicating that the mean available phosphorus values of both terraced and non terraced farm plots were low. This can be related to the continuous application of DAP (Di-Ammonium Phosphate) fertilizer (at an average rate of 150kg/ha) over the past 30 years, which might have resulted in P accumulation in the soil. The quantity of urea fertilizer applied is far too small compared to that of DAP. A closer look into the P content by distance from the conservation structure reveals that available P with considerably higher values at middle than at upper and lower slope position. At the same time that the P level increases as one moves away from the bunds. This is related to the fact that at middle slope position site closer to the bunds are planted to trees (banana or Grevillea) and DAP fertilizer application is targeted cereals. This is further substantiated by the fact that the control fields planted to cereals had significantly higher P values than the inter-bund space fields (Table 11).

Avalable Potassium (avail K cmol/kg)

Unlike N and P, the K contents of the soils is in the high range with mean values of 0.73, 0.55 and 0.71 cmol/kg for the treated plots the upper, middle and lower slope fields, respectively. This is in agreement with the general notion indicating that the Ethiopian soils are rich in K but deficient in N and P (Eyasu, 2002 citing Westphal, 1975 and WADU, 1976). As a result of this evidence, fertilizer containing K has not been supplied or recommended to farmers, which in the case study site. As far as conservation there was no difference between control and treated fields as well as with distance from the bunds, suggesting no positive effect of soil conservation structures on K. However, the level of K was relatively lower at upper slope position as compare to the middle and lower slope parts.

Cation Exchange Capacity (CEC cmol/kg)

Table 11 shows low levels of CEC following a trend similar to that of organic carbon and N content of the soil. The mean CEC values were 12.09. 12.88 and 12.49 for the treated plots in the upper, middle and lower slope fields, respectively. Also, there was no difference in the CEC levels across slope categories and fields across range of distance from the structures. The result suggests that conservation structures alone may have no contribution to enhance the fertility status of the soil unless supplemented by application of organic inputs. This is further substantiated by the fact that there was no obvious difference between the control and treated plots for CEC levels

Perhaps this can be explained by uniform application of mineral fertilizer in the outer fields to grow cereals.

In general it can be concluded that conservation structure combined with agronomic practices such as farm yard manuring and mulching are far better to restore fertility status of the soil than conservation structure alone. This is clearly reflected in the case of middle slope position farm section unit which is supplemented with biological measures. Also it is true for some upper slope position next to the homestead area. As it received treatment of both conservation as well as agronomic management the fertility levels are higher.

As we have move away from the homestead to the distant fields we noticed change in the fertility status with declining gradient. This is probably because these areas received only small quantity of minerals fertilizer (100kg/ha) which is contributing too little to maintain the fertility.

In general, conservation combined with organic manuring is better than construction of conservation structures alone. However, the CEC of the soils across farm sections was in the low range (11.6 -13.5 Cmol/kg) suggesting that the inherent fertility of the agricultural soils of the study area is low.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary and Conclusion

It was found that 71% of the farmers have perceived severe erosion in their crop fields. Indeed, farmers believe that soil erosion and thus, declining soil fertility is becoming a major constraint of crop production and declining soil fertility. The soil erosion problem is understood by the majority of the sampled households (55%) in terms of reduced productivity of land, gully expansion on arable land, decrease in top soil depth; decline in the water holding capacity of soils; and decline in crop yield from the farm. Various easily observable indicators are used by the farmers' to assess whether soil fertility is declining or not. The principal indicator mentioned was reduced crop yield.

Due to the existing knowledge and perception of the causes and effects of soil erosion, there is a widespread adoption of soil conservation practices. About 70% of farmers have implemented physical conservation structures on their crop fields, of which the dominant ones were soil/stone bunds, biological measures and diversion ditches. Among the socio-economic factors that have positive correlation with soil conservation decision were age, educational level and farm size, while livestock ownership was negatively correlated with SWC practices.

Several factors affect farmers' decision to invest on land management activities as well as their decision on the choice of land management measures. Land holding size, land fragmentation and, labor availability were found to be important land management related factors. Livestock size, and land ownership are the other factors that affect farmers' decision to invest on land management activities and/or their choice of land management measures. Unlike the general expectation, land tenure security was not mentioned by farmers as a disincentive to implement soil and water conservation practices. This is because in recent years farmers have received usufruct rights through land registration and certification process (secured rights to their holdings). Even before the land certification process, farmers had a possessive regard to their plot and this is related to the perennial homestead cropping nature unlike the annual cereal system in other parts of the country.

Some of the problems mentioned by farmers who implemented physical conservation measures involve: Conservation structures harbor rodents and structures occupy sizable area of arable land. This is a major disincentive given critical problem of land shortage. Some physical measures such as terraces create inconvenience to operate with oxen-drawn implements. Some respondents mentioned about labor shortage to construct structures such as terraces and stone/soil bunds which are labor intensive measures.

The PSNP interventions supplemented by the NGO food-for-work payments have resulted in increasing levels of conservation and rehabilitation of the degraded communal areas. Closures and community woodlots have been established but proper management and sustainable utilization mechanism has not been in place. So far, local elders and traditional leaders are managing these resources but they need to be backed by legal legitimacy.

Several of the young population is moving away from farming into off-farm activities including petty trading and wage labour.

With regards to the effects of soil conservation structures on soil properties, the study has revealed that conservation structures alone do not have any significant positive effects on the soil properties. Most the parameters studied including pH, N, aval. P and CEC seem to be related to the soil organic matter content than the physical conservation structures.

Therefore, it is very important that farmers should combine soil conservation with agronomic practices that would build the organic matter content of the soil. A crucial aspect in this regard would be the return of crop residues and application of farm yard manure to the soil. Currently, the farming practices in the outer fields of the farm section are resulting in soil mining with complete removal of crop residues for animal feed and household fuel.

Communal areas management was implemented through government FFW and NGO FFW program, whereas individual SWC practices were exercised by farmers own resources. However, such individual practices were insignificant.

5.2. Recommendations

1. It is important to create alternative sources of livelihood particularly in the light of increasing population densities and shrinking land holdings.

2. It is very important that farmers should combine soil conservation with agronomic practices that would build the organic matter content of the soil

3. Provision of alternative sources of feed for animals and fuel for households would be important.

4. Furthermore, it is recommended that fast growing leguminous trees and shrubs such as sesbania, leucaena and pigeon pea should be planted on the soil conservation structures to provide feed, and fuel wood as well as to improve fertility status of the soil.

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7. APPENDIX

Appendix 1. Questionnaires

I. Household Characteristics and Asset Ownership

1. What is your level of education?

a) illiterate b) read and write c) primary education d) high school complete

2. What is your family size (permanent members of the household)? _________________

3. What is your land holding (ha)?

a) Home garden area _______________ha

b) Fields away from homestead _________________ha

c) Grass/wood plots __________________ha

Total land holding __________________________ha

4. Do you own any animals?

a) Yes b) No

5. If yes, What is your herd size?

a) cattle ___________________

b) goat/sheep _______________________

c) equine /donkey /horses ________________

d) tropical livestock unit(TLU) ______________

6. Has the size of your cultivated land changed?

a) Yes b) No

If yes, indicate what has happened to your plot?

(a). Increased (b). Decreased

7. If it has decreased, what are the reasons? ___________________________________

____

8. What type of labor is used on your farm?

a) Family labor b) Hired labor c) Group labor

II. Crop Husbandry

9. What are the major crops you grow on your farm?

Table 1 major crops

Garden Crops	Field crops
Enset	Maize
Banana	Teff
Root crops	Wheat
Coffee	Barely

10. How do you prepare the land for planting?

a) Hoeing b) Oxen plough c) Others, specify ______________________

11. What is the major problems or constraints for crop production in your farm?

a) Land is too small b) land is too infertile

c) lack of oxen d) others, specify ________________________

12. What do you do with your crop residue?

a) Bun them b) Use them as feed

c) Use them for cooking d) others, specify ________________________

13. Do you plant trees on your farm lands?

a) Yes b) No

14. If yes, for what purposes? Put in rank)

a) Fire (Fuel) wood tree type b) Construction materials tree type

c) Fodder tree type d) Soil fertility maintenance tree type

e) Fruits or nuts tree type f) Shades tree type

g) Means of income h) Others, specify ______________________

15. Where do you plant tress?

a) around homesteads b)at the bounder of the plot

c) along streams and rivers d) others

III. Perceptions on Soil Fertility Change

16. Is there any change in the fertility status of your farm?

a) Yes b) No

17. If yes, in which plot type is more prominent?

a) Homestead b) Outer fields c) All fields

18. If fertility is declining, what are the causes for fertility loss?

a) Soil erosion

b) Lack of fertilizer application

c) Continuous cultivation for many years

d) Removal of vegetation covers

e) Negligence of SWC technologies

f) Others, specify ________________________

19. If soil fertility is declining, how do you cope with it?

a) Apply manure (farmyard) b) Apply fertilizer c) Apply SW measures

20. Do you use some kinds of practices to maintain or enrich soil fertility of your Cultivated land? a) Yes b) No

21. If yes, which of the following practices do you use?

a) Use of fertilizer b) Use of manure c) Intercropping

d) Mulch or compost e) Agroforestry f) Others (specify) -----------------

IV. Perception and practices of soil and water conservation

22. Do you have erosion problem in your farm? a) Yes b) No.

23. If yes, how is the severity of erosion on your farm plots at present?

a) Severe b) Moderate c) Insignificant d) No erosion at all

24. If erosion is exist on your farm, what are the major cause of soil erosion is your opinion (Rank them)

Causes	Rank
Soil being too erodible	
Deforestation and over grazing	
Rainfall intensity(too much and heavy)	
Slop of the land being steep	
Poor farming practices	
population pressure	
Other specify	

25. Which farm plot do you experiences erosion problem?

a) Homestead b) Out field

26. What is the trend of soil erosion on your farmland?

a) Increasing b) Decreasing c) No change

27. What measures did you take to control soil erosion?

a) Using introduced SWC technologies b) Using IWSC measures

c) Using both measures d) No need of SWC.

.

If yes, Which type of soil conservation measures do implement on your land?

a) Soil /stone buns b) flood diversion canal c) artificial water ways

d) Check dams e) Cut-off drains f) micro-basins

c) Plantation d) Mulching g) fanaya-juu

28. What are the advantages of ISWC measures over introduced SWC technologies?

a) They do not cover more cropland.

b) They do not consume more labor (money)

c) They are flexible

d) They do not need sophisticated skill.

29. Among the SWC measures you practiced which one do you prefer the most?

a) soil/stone bunds b) Flood diversion canal /cut-off drain c) artificial water ways d) check dams e) micro-basins f) fany juu terrace

30. Did you realize some advantages and disadvantages of introduced SWC measures?

a) Yes b) No.

31. What merits did you observe from them?

a) Reduced soil erosion, b) Increases crop yields

c) Maintains the land for future generation

d) Increases water availability (conserves moisture) stabilizes income and yield variability among the Society e) Regulates the ecosystem.

32. What are the major problems in using SWC practices?

a) They are suitable for rodents b) They reduce arable land

c) They are not suitable in ploughing d) They are expensive and labor consuming.

33. How do you evaluate the establishment and maintenance of SWC technologies?

a) It is much labor consuming b) It is too costly c) It reduces arable land

d) It creates difficulty for ploughing e) It reduces soil erosion

f) It increases soil fertility

34. What are the genera problems encountered in sustaining soil conservation technologies?

a) SWC technologies are area specific b) Extension education is not widely diffused.

c) SWC technologies labour land and capital intensive.

d) Lack of awareness about land degradation problems & importance of SWC technologies

e) Shortage of land f) Problem of land tenure security

g) Problems of free grazing (over grazing) h) Frequent drought and famine (poverty)

i) The negative impact of FFW and population pressure

Appendix 2: Person’s Correlation Matrix

	Slope	Sex	age	wealth status	education level	Family size	total herd size	total farm size	SWC practices
Slope	1	0.000	0.034	.000	-.207	-.060	.072	.028	.524
Sex	0.000	1	.013	.176	-.495	-.285	-.307	-.023	.087
Age	0.034	.013	1	-.258	-.293	.051	.237	.424	.47
wealth status	0.000	.176	-0..258	1	-.143	-.113	-.613	-.555	.357
education level	-0.207	-.495	-.293	-.143	1	.145	.190	.084	.202
Family size	-0.060	-.285	.051	-.113	.145	1	.182	.178	-.055
total herd size	0.072	-.307	.237	-.613	.190	.182	1	.394	-.131
total farm size	0.028	-.023	.424	-.555	.084	.178	.394	1	.301