EVALUATING COMMUNITY BASED PHYSICAL SOIL AND WATER CONSERVATION PRACTICES EMPHASIS ON TECHNICAL FITNESS AND ITS EFFECT ON SOIL PROPERTIES THE CASE OF LEMO DISTRICT, SOUTHERN ETHIOPIA

M.Sc. THESIS

BY

AMANUEL BEKELE

JULY, 2017

JIMMA, ETHIOPIA

EVALUATING COMMUNITY BASED PHYSICAL SOIL AND WATER CONSERVATION PRACTICES EMPHASIS ON TECHNICAL FITNESS AND ITS EFFECT ON SOIL PROPERTIES IN THE CASE OF LEMO DISTRICT, SOUTHERN ETHIOPIA

Thesis

By

Amanuel Bekele

Major Advisor: Abebayehu Aticho (Assistant *Prof*)

Co-Advisor: Endalkachew Kissi (Associate *Prof)*

Submitted to school of graduate studies Jimma University, College of Agriculture and Veterinary Medicine, Department of Natural Resources Management in partial fulfillment for Degree of Master of Science (M.Sc) Specializing in watershed management.

July, 2017

JIMMA, ETHIOPIA

DEDICATION

This thesis manuscript is dedicated to my mother Turnesh Erballo, Whom I lost with death on June, 2016.

STATEMENT OF THE AUTHOR

I declare that this thesis is my own original work. It is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate anywhere in the world. I submit it submitted to School of Graduate Studies of Jimma University for partial fulfillment of the requirement for a degree of Natural resource management in Watershed management.

The thesis can be deposited in Jimma University Library and available to borrowers under the rules of the library. Brief quotations from this thesis may be used without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from, or reproduction of the thesis in whole or in part may be granted by the Department of Natural resource Management or the School of Graduate. Studies when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the thesis.

Name: Amanuel Bekele

Place: Jimma University

Date of Submission: ___________________

Signature______________________

BIOGRAPHICAL SKETCH

The Author, Amanuel Bekele, was born on 4^{th} of December 1990 in Lemo District of Hadiya Zone, Southern Nation Nationalities and Peoples Regional state Ethiopia. He attended his primary education at Ambicho Junior, Secondary School at Yekatit 24/67 and secondary education at Wachamo comprehensive secondary school from (2006 to 2008).The author has joined Haramaya University department of Natural Resource Management in 2009. After graduation, he was employed in Lemo District Hadiya Zone and worked as expert of land and environmental register, Land administration office. September 2015, he joined the School of Graduate Studies at Jimma University, College of Agriculture and Veterinary Medicine in to pursue his M.Sc degree in Natural Resource Management specialization in Watershed management.

ACKNOWLEDGEMENTS

First of all I thanks' the Almighty God for his protection and provision and support since the beginning to the end of his postgraduate study.

I would like to expresses my deepest gratitude to my major advisor Abebayehu Aticho for his scientific support, and his patience for continuous follow up in every aspect of my work and encouraging me for all my success. I am also like to expresses my deepest gratitude to my co-advisor Endalkachew Kisi for he was kind scientific guidance in every aspects of my work up to Passover.

Further, I would like to extend my thanks to the local farmers for their cooperation, willingness to their response and patience during the household survey. I also thank my father Ato Bekele Buticho and mother W/o Turnesh Erballo but brought me to this end. I am also thankful to my sisters Tigist Bekele, EmabetBekele, Hirut Bekele, and Yohannis Bekele for their encouragement and endless praying for me.

Finally, I would like to acknowledge Lemo District for providing MSc sponsorship and Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) for funding my thesis and allowing using soil laboratory for sample analysis. I would like to thank Wolayita Sodo soil laboratory permission of to put soil sample of bulk density in their oven dry.

.

LIST OF ACRONOMY

ANOVA	Analysis of Variance
BD	Bulk Density
CEC	Cation Exchange Capacity
Das	Development Agents
FAO	Food and Agricultural Organization
FEPA	Federal Environmental Protection Authority
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GLM	General Linear Model
KI	Key Informant
LWARDO	Lemo Woreda Agricultural and Rural Development Office
m a.s.l	Meter Above Sea Level
MOARD	Ministry of Agriculture and Rural Development
NGOs	Non-Governmental Organizations
SBs	Soil Bund
SLM	Sustainable Land Management
SNNPR	Southern Nations Nationalities and Peoples Regional State
SAONREPA	Southern Agricultural office of Natural Resource and Environmental Protection Authority
SPSS	Statistical Package for Social Science
SSA	Sub-Sahara Africa
SWC	Soil and Water Conservation
WFP	World Fund Program

TABLE OF CONTENTS

LISTS **PAGE**

LISTS OF TABLE

LIST OF FIGURE

LIST OF APPENDIX

ABSTRACT

Soil erosion is revealed in the form of soil fertility reduction, a main environmental and agricultural productivity risk in Ethiopia. To overcome the problem of soil erosion soil bund was implemented in Lemo District, Hadiya Zone, SNNPRS. The general objective is to assess the technical fitness of community based conservation practice on selected soil physicochemical properties and this structure as a physical soil and water conservation practices. To achieve the objectives the Soil samples were collected from the selected croplands accompanied with soil bund situated at MSS, SS and GS with the sample distance between bunds of three replications from the depth of 0-15cm. To determine soil fertility status of cropland conservation practices, 27 composite soil samples were analyzed for soil texture, MC, Bd, pH, EC, SOC, TN, C:N ,Av.P and CEC. The laboratory analysis was conducted at Jimma University College of Agriculture and Veterinary Medicine and Wolaita Sodo soil laboratories. To assess technical fitness of graded soil bund conservation practices, field observation and measurements were conducted in nine fields in the three villages.Moreover, questionnaire survey was carried out for 129 household to identify the factors that affect farmers levels of participation of the conservation activities as a physical SWC practices in the District.Data analysis was conducted using SPSS software version 20. The laboratory results were tested for mean separation using LSD, for technical fitness used one sample t-test used to compare the observed means with the standards and information gathered through questionnaire analyzed using independent t-test and chi-square test.The result showed that cropland with soil bund had significantly ($P<0.05$) variation values at slope position except Av.P and C:N. Higher mean values Bd at MSS compared to the values for the rest slope positions. Mean pH a value at GS position was significantly higher compared to the SS and MSS. The trend was similar for EC,SOC,TN and CEC.In addition, result of interaction effects at slope positions with sample distance from soil bund has significant ($P < 0.05$) effect on clay content,SOC and CEC at gently sloping position whereas CEC at moderately steep slope.The technical fitness of implemented conservation practices were lack of the structures design association with standards. The survey results display that the majority of farmers were implementedsoil bund practices on their cropland.But, there were limiting factors such as land size, training, contact with extension agent and slope of cropland significantly influence farmers implementation of physical SWC practices. Take care of croplands with suitable maintenance and supervision of the soil bunds for long time could improve the soil properties thereby increasing soil productivity. More essentially inappropriate extension approach employed for the support of the SWC technology was recognized as reason for technical problems and non-participant of soil bund in the study area.Therefore, improve farmers involvement in soil conservation practice through facilitate good contact of DAs and SWC experts, continuing technical support and follow up is the better to reduce the loss of soil from cropland.

Keywords: Erosion, Physical, Bund, Slope and Participation

1. INTRODUCTION

Soil degradation is one of the global agricultural production and productivity challenges, particularly in developing countries. Almost all lands in Sub-Sahara Africa (SSA) are prone to soil and environmental degradation, Ethiopia is among the most affected countries (FAO, 2004; Vlek *et al*., 2008). Due to the problems associated with soil erosion, about 10 million hectare (ha) of cropland worldwide is abandoned every year (Pimentel, 2006),about 6.5 million ha of cropland in Africa affected every year (Scherr and Satya, 1996 cited in Mekonen and Tesfahunegn, 2011), and 12 tons/ha/year of soils in Ethiopia lost every year (USAID, 2000; Demelash and Star, 2010). Soil erosion affects soil physical conditions (reducing soil depth, water-holding capacity etc), chemical properties (removal of nutrient, organic matter, basic cations etc) and soil quality (Lemenin *et al*., 2005, Hurni *et al*., 2010), that limits agricultural production, poverty reduction and food security (Kassie andHolden, 2008).

Soil erosion is one of the most important risks to sustainable agricultural system (Hailu *et al*., 2012). In Ethiopia, loss of soil and essential nutrients due to unsustainable agricultural practices is costing $139 million (3-4%) of its agricultural GDP (Berry, 2009). About, 70% of Ethiopian highlands where most of the agricultural activates takes place have over 30% slopes, that favours soil erosion (Wood, 1990; Ali and Surur, 2012). In Ethiopia, about 32.1 million peoples are affected by soil erosion (Endalew *et al*., 2015), more than 30, 000 ha of the country's croplands were abandoned every year because cropping can no longer be support on the highly eroded areas (Endalew*et al*., 2015; Molla and Sisheber,2017).

In the middle of 1970's, soil conservation program is incited in Ethiopia with the collaboration of FAO to reduce soil degradation, improve agricultural production, enhance food security and reduce poverty (Hawando, 1997;Gashaw*et al*., 2014,Tamene and Vlek, 2008). Through this soil and water conservation technologies (e.g., terracing, bunds are introduced to farmers (Alemu and Kidane, 2014). In Ethiopian highlands soil bund is reduce soil erosion by 30.5%, improve infiltration, crop yields and change the conditions of the soil likepH, CEC SOC MC and BD (Ayalew, 2011), also in central highlands of Ethiopia soil bund is effective to reduce soil erosion and retain soil moisture (Adimassu *et al*.,2013).

However, soil conservation technologies are not equally successful or effective, and soil and water conservation technology implementation failure is indicated in many parts of Ethiopia. Farmers participant in soil and water conservation activities is influenced through several factors such as: development agents (DAs) awareness creation trends, landholding size and farmers technical skills limitation (Wolka and Negash, 2014). Farmers seemed to be participate in SWC technologies due to incentives or coercive pressures often dismantled the structures partially or completely from their cultivated land (Admassie, 2000). For instance, in East shewa about 73% of the farmers removed the structures, dismantled conservation structures than modified and maintained (Gebre *et al*., 2013); expert's and DA's inadequate follow-up and assistance in conservation practices (Mekonen and Tesfahunegn, 2011);lack of involvement of farmers at different stages of conservation (in the planning, implementation, monitoring and evaluation) and fail to consider local condition (e.g., farming system) and farmers need (Ali and Surur, 2012); lack of awareness of land users on soil erosion problem (Tadesse and Belay, 2004 ; Heyi and Mberengwa, 2012).

Currently in Ethiopia million hectares of lands are covered with soil and water conservation activities through mass mobilization of the community. Through this effort in most parts of the country successful stories are recorded however in some parts of the country (e.g., in southern Ethiopia Lemo District) the practices are less successful. But,no studies have been conductedon the evaluating community based physical soil and water conservation practices emphasis on technical fitness and its effect on soil properties. Therefore, such knowledge was essential to give information that can be used to develop conservation practices based on technical skill in Lemo District as well as in related areas in the country. The findings of this study will be good reference for Lemo District agricultural officials and other researchers, development agents and stakeholders to design strategies and projects that could help farmers in SWC measures and create awareness of better strategies on conservation technologies that may help in improving crop yield position.

1.1. Objectives of the Study

1.1.1 General Objective

- ❖ To assesstechnical fitness of community based physical soil and water conservation practices andits effects on selected soil properties in Lemo district.

1.1. 2 Specific Objective

- ❖ To assess effect of soil conservation structures on selected soil physicochemical properties.
- ❖ To assess technical fitness of physical soil conservation structures.
- ❖ To assess factors that affect levels of farmer's participation in physical soil conservation practices.

1.2 Researchquestions

The following research questions will be raised to achieve the designed objectives;

- How soil bunds influences soil physicochemical properties?
- Does the physical structures of the technical fitness is correct?
- What are the factors affect levels offarmers' participation in physical soil and water conservation practices in the study area?

2. LITERATURE REVIEW

2.1. The problems of soil erosion in Ethiopia

Ethiopia is one of the SSA countries most severely affected by the problem, and water erosion is prominent. Water erosion mainly occurs in the highlands, which have erratic rainfall generating erosive runoff (Hurni, 1993). Soil Erosion is one of the most important environmental problems among various forms of land degradation that poses serious challenge to the food security of the population and future development prospects of the country (Bekele and Drake, 2003; cited in Ertiro, 2006). It is a direct consequence of the past and the present agricultural practices in the highlands (Gebrehiwet, 2004). Densely populated and hilly countries in the Rift Valley area like Ethiopia has the most negative values because of a high ratio of cultivated land to total arable land, relatively high crop yields and soil erosion (Ketsela,2012). The SWC measures have been implemented to alleviate the problems of erosion and low crop productivity, which are symptoms of different extremes of rainfall conditions in Ethiopia since the 1970s, the effect of physical SWC measures can be effective against soil erosion (Morgan, 2005 cited in Mekonen and Tesfahunegn, 2011).

In Ethiopia the productivity of the agriculture sector of the economy which supports about 85% of the work force is being seriously affected by soil productivity loss due to erosion and unsustainable land management practices. The average crop yield from eroded of land in Ethiopia is very low according to international standard, mainly due to soil fertility decline associated with removal of top soil by erosion (MoARD, 2010).The occurrence of recurrent drought in Ethiopia has been attributed mainly due to land degradation (Yohannes, 1998 cited in Demeke, 2003). Because of the rugged terrain in Ethiopia, soil loss through water erosion is superabundant. According to Mena*et al*., (2011), from many factors that underlie these direct causes including population pressure, poverty, high costs of and limited access to agricultural inputs, low profitability of many conservation practices, high risks facing farmers, fragmented landholdings and insecure land tenure, and farmers' lack of information about appropriate alternative technologies.

In Ethiopia, the impact of soil erosion was recognized after the 1973 famine occurred in the country. Since the early 1980s the Ethiopia government with the aid from international governments or non government organizations has been actively involved in SWC programs. A package of SWC measures has been developed usually employing terraces, bunds, tree planting and closure of grazing areas (Eyasu, 2005). The SWC intervention in the high lands focused both on mechanical measures including construction of bunds, terraces, diversion ditches; check dams, micro basins and hill side terraces. The biological measures comprise enclosure degraded lands from human and animal interference, a forestation and reforestation (Nyssen, 2009;Getachew,2014).In Ethiopia however, where there are no significant of farm sources of livelihood, SLM approaches are top dawn, nearly 85% of population depend on subsistence agriculture literacy level are low and cultural barriers are many and population growth indeed negatively affect sustainable SWC and scaling up of land management practices (Pender, 2004). According to Getachew (2014) in Raya Azebo area of northern Ethiopia 62.5% of the farmers can be clearly understand that the technical problems were the major challenges in practicing the various soil and water conservation measures in these Village. Generally, Soil and water conservation technologies had the potential to improve land productivity and increase crop yields (Gebre*et al*., 2013).

2.2. Physical soil conservationpractices in Ethiopia

The major elements of the soil conservation activities were a range of physical structures such as cropland and hillside terracing, cut-off drains and waterways, micro-basins, check dams, water harvesting structures like ponds and farm dams, spring development, reforestation, area closure and management and gully rehabilitation (Nedasa, 2003; Heyi and Mberengwa,2012). According to Ertiro (2006) in Anna watershed Hadiya zone the majority of soil and water conservation measures introduced to the area are mechanical conservation measures on croplands include soil bunds, *fanya juu* terraces and cut-off drains. The biological conservation measures generally to improve soil fertility that consequently helps to reduce soil erosion (Gemechu and Kitila, 2015).

Besides, Physical soil and water conservation measures include like stone bund, soil bund, Fanya juu, water ways, cut-off drain, check dam, bench terrace (Tadesse,2010).Soil conservation activities can change the physical conditions of the soil like soil organic matter content, soil structure, water holding capacity, soil bulk density, soil pH and its workability (Jijo, 2005; Demelash and Stahr,2010). For instance,Ayalew(2011) reported as in Gununo area in the Southern Ethiopia the introduced soil conservation measures were physical structure (soil bund) and biological measures by integrating the two measures soil productivity was improved.

Physical SWC measures are moisture conservation is the primary purpose of SWC practices in areas, help to reduce soil erosion in highland areas where there is heavy rain fall and on sloping high lands, graded contour bunds or terraces reduce runoff velocity and extend the time span for water to infiltrate into the soil system (Gemechu and Kitila, 2015). The construction of physical structures to reduce overland flow thereby preventing removal of soil erosion and soil fertility improvement practices by compost application (Wolka*et al*.,2011).They are fundamentally a matter of determining a correct form of land use and management. The technologies (soil bund, fanya juu) are effective in arresting soil erosion, had the potential to improve land productivity and lead to increase in crop yields.

According to Getachew (2014) compared to other interventions; structures like soil bund are technically easy to implement and more important to arresting the soil erosion and its effects in the crop land. It can also maintain the soil resource, increase the soil moisture and increase yield production. They eventually constructed by throwing soil dug from basin down slope, used to control runoff and erosion from cultivation fields by reducing the slope length of the field which ultimately reduces and stops velocity of runoff(Atnafe*et al*.,2015). The farmers that believed conservation technologies are effective, but the conservation technologies to be less effective to improve the productivity of the cropland (Gebre*et al*., 2013). In fact, land degradation can be mitigated by various structural conservation practices chosen according to the site conditions.

Generally, physical conservation with biological conservation measures reduced soil losses and improved the availability of organic inputs for soil improvement (Amede, 2003).Moreover, among other soil and water conservation practice, physical conservation practice like; Soil bund is also the known land conservation mechanisms on the crop land in Lemo District.Aberha, (2008) also indicated that introduced soil and water conservation measures, soil bunds is widely acknowledged as being effective measures in arresting soil erosion and as having the potential to improve land productivity. In addition, physical SWC practices are important to stabilize the structural practices for long period and cost effective when we compare with biological structures but farmers that practices as an expected in Lemo District. A land treated with physical SWC Practice is generally believed that the soil resources will be protected from erosion. Physical and biological soil conservation measures and soil fertility improvement activities implemented in Wolaita conserved the soil and improved soil fertility (Safene *et al.,* 2006).A study made in the Galessa micro-Watershed in the central highlands of Ethiopia by Adimassu *et al*., (2012) reported that physical conservation significantly reduce nutrient losses and soil erosion. Ayalew (2011) pointed that in Gununo watershed, in the southern Ethiopia, physical conservation is made for maintenance of the structure, improvement of soil fertility, and observation of its effect on crop land and inputs for soil physical and chemical property improvement.

2.2.1. Graded soil bund

Soil bund is an embankment constructed from soil along the contour with water collection basin at its upper side, constructed by throwing soil dug from basin down slope and used to control runoff and erosion from cultivation fields by reducing the slope length of the field which ultimately reduces and stops velocity of runoff (Atnafe*et al*., 2015). According to WFP (2005), it is effective in controlling soil loss, retaining moisture and ultimately enhancing productivity of land.

According to Ali and Surur(2012), 10.8% of the farmers have constructed soil bund in the common eroded lands especially around the mountainous area, because of the cash they would earn from a safety net program. Furthermore, access to agricultural extension service increases the use of improved soil bundsand the significance of extension visits on the use of soil conservation technologies (Gebre*et al*.,2013).On moderately steep slope areas the farmers construct the soil and stone bunds for erosion control, but most of the time farmers of the study area used soil bund structures instead of stone bund, because of the shortage of stone is exist on their cropland area they were used soil bunds structures(Tegegn,2014).The farmers mentioned that ineffective designs by the development agents are responsible for causing gullies and mostly use soil bunds that are impermeable intended to maintain all rainfall but when overtopped at one location will cause gullies unless they have specially designed spillways and protected soils below(Mengstie , 2009).

2.2.2 Effect of SWC measures on soil properties

There are different kinds of SWC measures like terraces, check dams, soil bunds, cut-off drains, Fanya juu, trenches ,forestry, agro forestry, modify terrain through changing slope length and angle, which in turn reduce runoff velocity, enhance water infiltration, trap sediments washed down the terrain, improves the availability of water for irrigation, increased agricultural productivity and develop cropland efficiency through their ability to improve chemical as well as physical properties of the soil (Vancampenhout *et al*.,2006 ; Nyssen *et al*.,2007; Alemuand Kidane,2014). For instance, soil bunds, cut-off drain and *Fanya juu* are effective in controlling soil loss, retaining moisture and ultimately enhancing productivity of land in Goromti watershed(Atnafe*et al*.,2015).According to Beyene (2011), in the Denku micro watershed area study that crop lands through construction of variety of physical structures to reduce overland flow thereby preventing removal of soil, soil fertility improvement practices (compost application), and can raise the level of moisture in the soil ensuring better crop growth and crop production. In most of the time physical structure namely graded soil bund is barriers of soils are constructed along the contour to serve the purpose of slowing down the run-off as well as trapping eroded soil(Demeke,2003).

Terracing reduced soil erosion from upper to down-slope positions (Nyssen *et al*., 2007). Mekonen and Tesfahunegn (2011) reported that all respondents agreed on the point that farmers having crop land on flat plains in the watershed were more reluctant to use SWC measures compared to those on steep areas. If the SWC measures on the steep parts of the watershed were good enough to reduce run-off, waterlogged and related problems of erosion on flat areas could be minimized. Similarly, Nyssen *et al*., (2010), in northern Ethiopia reported that the construction of bunds at regular intervals reduces the rate of the downward runoff on slopes, which prolongs the time for water to infiltrate into the soil, and thus, improves water availability for crop production. Aberha (2008) also indicated that introduced soil and water conservation measure, soil bunds was widely acknowledged as being effective measures in arresting soil erosion and as having the potential to improve land productivity. The structures are designed to intercept and reduce runoff, improve land productivity and provide diverse ecosystem velocity,they compare the non-conserved measure is found to exhibit significantly higher mean bulk density with the conserved measure is the relatively lower bulk density could be attributed higher organic matter content improves the chemical properties of the soil is recognized to improve soil fertility that is why it plays a fundamental role on essential soil functioning(Amdemariam*et al*.,2011).

2.2.2.1. Effect of physical SWC on soil properties

According to Addisu (2011) the soil and water conservation is to facilitate optimum level of production from a given area of land while keeping soil loss below a critical value and protections of the life supporting capacity of soils such as soil quality, soil depth , soil structure, water holding capacity and soil productivity. For instance, soil bund is used to control runoff and erosion from cultivation fields by reducing the slope length of the field, which ultimately reduces and stops velocity of runoff. Usually, it was constructed in fields that have slope greater than 10% (Habtamu, 2014).The most widely used improved soil conservation technologies were improved soil bund, *fanya juu* and cut-off drain. They are established to conserve and keep the fertility of croplands like: to reduce and stop the velocity of runoff, increase the infiltration of rain water and stabilizing crop yields, so as to thus increase food security through increased food production/ availability. Improved soil bund was the most widely and most intensively used soil conservation structures in the area; 55.8% of the sample households and 60.1% of the cropland have improved soil bund in the Kachabirra area of the southern Ethiopia (Gebre and Weldemariam, 2013).

The physical soil and water conservation measures requires are labour intensive, more effective as compared to biological conservation and provide adoption decisions are effectiveness in controlling soil loss, benefits obtained from adoption, easiness to adopt and appropriateness to farming system circumstances. Therefore, the soil conservation technologies have the potential to improve land productivity and increase crop yields, but that benefit obtained may remain adequate with the structural work requires for their implementation in the area of east shewa (Gebre*et al*., 2013). According to Ayalew(2011), in the Southern Ethiopia reported that soil conservation technology(soil bund, fanya juu, cut-off drains) to all the technologies in the area very well perceived that the soil conservation measure protects the washing away of soil, seeds and fertilizer and thereby increases crop yield. There is no any sign of soil erosion observed on the field, the soil is built up, it became dark, retained moisture well due the construction of the soil conservation measures.

2.2.2.2Effects of graded soil bund on soil physico-chemical properties at different slope categories

A slope is the rise or fall of the land surface. It is important for the farmer to identify the slopes on the land. Slope position is one of the main topographic features that influence the process of drainage, runoff and soil erosion have an effect on soil physicochemical properties (Khan *et al*., 2013; Aytenew, 2015). Cultivation of the undulated topography and hilly slopes is common in Ethiopian highlands, it is also the same in the study area. Such activities enhance surface runoff and soil erosion. Although the effects and level of soil erosion vary with cropland position, decline of the physical and chemical properties of soil by loss of organic matter and loss of minerals containing plant nutrient.

Soil texture:- is used to determine crop suitability and to approximate the soils responses to environmental and management conditions. The study conducted by Aytenew(2015) revealed that the clay content showed an increasing trend as slope position lowers while sand content showed a decreasing trend down the slope position. This may be the fact that the position on the slope position which causes the variation in texture likely with moderately steep slopes the transportation and translocation of fine particles are expected (Hailu*et al*., 2012). However, the recent crop cultivation encroachment to the moderately steep slope of the land topography which brings less weathered sandy soil; and the intensive and continuous cultivation at the bottom of land which might cause compaction on the surface that reduces translocation of clay particles (Yeshaneh, 2015).

Soil bulk density:-are used to indicate the pore space available for water and roots. The variation of soil bulk density among the slope position might be attributed to the variation of soil particle size distribution and disturbance of soil particles with erosion (Aytenew,2015). In addition, Challa*et al*., (2016) investigated that the decrease in soil BD due to SWC practices at lower slope position would result in greater water infiltration rates which in turn minimize runoff velocity and organic matter accumulation. This improves a soil physical structure which promotes crop root abundance, crop production and better crop residues at the lower slope.

Soil pH and Electrical conductivity:-Soil pH refers to a soil's acidity or alkalinity that gives an indication of hydrogen ions (H+) in the soil while soil electrical conductivity is a measure of salinity and highly dependent on climatic conditions of the area in consideration. The variation in soil pH along with slope position, this could be due to the fact that the high rainfall joined with moderately steep slopes might have increased leaching, soil erosion and a reduction in soluble base cations leading to higher H+ activity (Hailu*et al*., 2012). In addition the study conducted by Aytenew **(**2015) the increase in soil pH at the gently sloping position could be attributed to the accumulation of bases that were presumed to have been eroded from the moderately steep and strongly sloping positions. However, the lowest pH value at lower slope can be due to intensive and continues cultivation that cause depletion of basic cations in crop harvest and depletion of basic cations drainage to streams in runoff generated from accelerated erosions (Yeshaneh, 2015). The electrical conductivity of the soil are low due to high amount of rainfall that results leaching of cations (Nigussie and Kissi, 2012).

Soil organic carbon:- is an important role in soil and influence on soil stability. The study conducted by Hailu*et al*., (2012) showed that soil organic carbon is inversely related with slope position; this may be due to the organic matter removal from the moderately steep slope to the gently sloping. The soil and water conservation practices that reduce surface runoff and soil loss, retain water that enhances crop growth and contributes to SOC input (Wolka *et al*., 2011). In addition, Yeshaneh (2015) studied that the lowest SOC in the lower slope crop land, this could be due to reduced inputs of organic matter, reduced physical protection of SOC as a result of tillage and increased oxidation of SOM.

Total nitrogen:- has a intense effect on soil fertility and essential to increase yield. The investigation carried out by Aytenew(2015) showed that total nitrogen revealed an increasing trend from moderately steep slope to gently sloping position, which might be due to their downward movement with runoff water from higher slope position and accumulation there at the lower slope position. The variation in TN was also significant with slope position, where TN was, higher in the lower slope than in the higher slope position due to the removal of organic matter from the moderately steep slopes as a result of soil erosion and leaching to the down slope (Challa*et al*., 2016). The C: N ratio was below 16.6 for all the soils in the studied area which indicates that there could be release of available form of N to the soil system through the mineralization process of soil organic matter which is suitable for crop growth (Terefe and Lemma, 2016).

Available phosphorus:- Phosphorus in soil is one of the most important nutrients in agricultural production that gives energy transformation. The variation of available P content among the slope position is paralleled with that of organic matter content, because of soil organic matter could contribute for the presence of available P in the soil system (Aytenew**,** 2015). The study also conducted by Hailu*et al*., (2012) showed that available phosphorous did not significantly different with slope position due to less availability of organic matter content in the area. On the other hand, Wolka *et al*., (2011) study showed that available P was different due to: the difference in the past land degradation resulting from continuous cultivation, extractive plant harvest and soil erosion.

Cation Exchange Capacity:- is a measurement of the magnitude of the negative charge per unit weight of soil, or the amount of cations a particular sample of soil can hold in an exchangeable form.Cation exchange is an important mechanism in soils for retaining and supplying plant nutrients, and for adsorbing contaminants. The investigation conducted by Selassie *et al*., (2015) showed that the variation of CEC content among the slope position due to the difference of clay and organic matter content of the soil, because of clay and organic matter content contributes for the presence of CEC. In addition, Challa*et al*., (2016) also studied that soil CEC showed an increment with decrease in slope position in cropland with SWC practices. The gently sloping area had very high CEC, which might be attributed to the high specific surface area of the clay and organic matter content (Aytenew**,** 2015).

2.3 Technical Fitness evaluation of Physical Soil and water Conservation Practices

In Ethiopia, efforts towards soil and water conservation have been carried out with limited success. The experience in Ethiopia showed that the practice of evaluation of the effectiveness of the soil and water conservation technology is not successful due to lack of political administrative commitment, insufficiency of budget allocated for monitoring and evaluation, and inadequacy of the institutional arrangements that underlie monitoring and evaluation (Wassie, 2000 cited in Meshesha and Birhanu, 2015). The study also conducted by Walie (2016) indicated that there was not observed any similarity between existing soil bund practice of spacing with the recommended one, the main reason for the failure to achieve SWC practice based on the standard is knowledge and skill gap on technologies. Soil and water conservation structures constraint of standards for spacing of bunds depending on rainfall and workable soil depth (Wolancho, 2015).

The evaluated performance of existing of level soil bund indicated that the majority of variables of layouts such as length of Bund, depth of Ditch, length of Tie ridge, height of Embankment, length of Berm and bottom width of embankment were significantly lower than the standards (Meshesha and Birhanu, 2015). The bunds will no longer be effective due to conservation a practice was out of the standards which had negative impact on erosion control.

2.5 Causes of Soil and water Conservation Efforts failures in Ethiopia

The physical soil and water conservation measures under implementation are willing to participate in construction bunds and it is mainly in the construction of these structural measures that the majority of the farmers professed their participation are not undertaken voluntarily, but there are no problems about land degradation. This shows that the problem is actually associated with the technology itself (Gebre and Weldemariam, 2013).Similarly, Tadesse and Belay (2004) in the Gununo area conducted that the major factors influencing implementation of physical soil and water conservation measures farmers perception of erosion problem, technology attributes, farm size, and family size. According to Wood (1990), conservation structures have not been as successful as they could be, because the farmers were not enthusiastic enough in accepting widely and maintaining the soil conservation technology. According to Tegene (1992) the failure of conservation programs partly emerge from the fact that planners and implementing agencies ignore or fail to consider socio-cultural factors as key determinants of the success or failure of conservation programs. Also the efforts to address soil and water conservation through food for work programs failed mainly due to minimum participation of farmers in planning and implementation stages. The approach followed is top down approach (Yohannes,1992 cited in Mazengia*et al*.,2007).

2.5.1 Factors influencing farmers' participation in the physical soil and water conservation practices

Participation is the action or state of taking part in something association with others in a formal basis with specified rights and obligations.Participation is generally presented as the active involvement of farmers in the planning, implementation, control and implementation programme by construction of soil and water conservation structures on their community land (Bagdi and Kurothe, 2014).

Age of the household: is essential for the general physical soil and water conservation hard work of the household. Age was one of the factors that influence the maintenance and participant decision of farmers' conservation practices (Demeke, 2003). The majority of the farmers age groups were not affect the conservation technologies, so there is no difference in age between the productive and non productive age (Gebre and Weldemariam, 2013). The age of the household head was negatively and insignificantly related to the implementation of SWC in watersheds (Wolka and Negash, 2014). This may be explained by the fact that older farmers resisted the participant of conservation technology.

Family size of households: is one of the important characteristics of household heads that determined the participation of a household in different socio- economic and conservation technologies activities. The majority of the farmers with a household size of large family sizes are less or no interest in participant of SWC practices (Gebre and Weldemariam, 2013) and the household with large family size are not likely to continue on participant of the conservation practices (Birhanu and Meseret,2013). The statistical analysis indicated no significant difference in the family size of participant versus non-participant of conservation practices (Demeke, 2003).

Educational status of farmers: is one of the important instruments to investigate the response of farmers to the application of conservation technologies by education level. The low level of education and high illiteracy rate is especially in developing countries like Ethiopia. However, the majority of the farmers have not enough educational qualification that is required for the participant of different new SWC technologies (Getachew, 2014). The majority of farmers that participant of conservation practices were those who attained the highest educational status, but the chi-square analysis indicates that there is no significant relationship between the participant and educational level of respondents (Gebre *et al*., 2013) and the education improvements appear to have contributed to several aspects of agricultural intensification and technological implementation (Atnafe *et al*., 2015).

Land holding Size of Farmers: Land is one of the most basic sources of production factor for rural areas of Ethiopia which depend on agriculture. However, the farmers having larger land size (>1.5 ha) showed interest in investing in conservation technologies, but also the farmers who have smaller land holding are less likely to participate conservation practices totally (Gebre *et al*., 2013). According to Tesfay (2015) the farmers who have smaller land holding due to increasing population pressure leads to fragmentation of the land, this also has its effect on soil and water conservation practices. Although Abebe and Sewnet (2014) reported that the size of land holding showed a significant association with the participation SWC of practices in their cropland.

Land tenure security: Land tenure is one of the key issues which the tenure organization encourages or discourages farmers to use the physical soil conservation practices and investment on land.The majority of farmers are owners of the land and secured right to use their cropland to invest conservation practices (Atnafe *et al*., 2015). On the other hand, about 90% of respondents believed that their cropland is secured of land tenure due to right to use conservation practices and there is no statically significance association between implementation of conservation technologies and land tenure security (Gebre *et al*., 2013). Even though, the majority of the farmers respondents about the current land holding policy of the country and this ownership did not had negative impact on their conservation activities (Tesfay, 2015).

Extension Services and Training on structural Soil and Water Conservation: Extension service is the most important to initiate better conservation technologies to smallholder farmers. The majority of the farmers have limited or no contacts with extension agents due to lack of enough training and limited extension support the conservation practice technologies are not successful (Gebre *et al*., 2013). The agricultural extension services is very crucial in the improvement of technology transfer since it improves farmer's knowledge about new technology which can further influence the approach of farmers towards participation of conservation practices (Atnafe *et al*., 2015). Agricultural extension service is principal value to introduce better agricultural practices and improved soil and water conservation technologies. However, extension service and contact of farmers with agricultural and rural development experts were limited, but access for information and contact with DAs has a role on the participation of soil and water conservation practices and having good relation with experts helps farmers in reducing connected with soil erosion problems and implement conservation practices (Tesfay, 2015).

Although training has important contribution on participant of soil and water conservation practices to improve conservation technology. Moreover, farmers that have better access to training on participant of soil and water conservation practices need to be provided to improve soil and water conservation efforts (Abebe and Sewnet, 2014). This may be due to its influence on farmers' decision to use conservation practices by facilitating them to get adequate information about the importance of SCW measures and create further awareness on natural resources conservation generally.

Slope of Cropland:- influences on soil and water conservation practices because of moderately steep slope is subject to more susceptible for water runoff and soil erosion. The slope of cropland also affects the sustainability of conservation structure because the moderately steep slope was further exposed to erosion. Therefore, it is believed that the participant of physical conservation practices tends to be likely on moderately steep slopes of sample respondents cropland is more participant than gently sloping (Birhanu and Meseret, 2013). On the other hand, among the respondents that found strongly sloping to moderately steep slope areas the farmers were more participant of soil and water conservation practices in their crop land (Gebre and Weldemariam, 2013). This is because on stongly sloping areas following moderately steep slope and long slopes, the problem of soil erosion is danger due to runoff from up lands and farmers constructed in response to this problem.

3.MATERIALS AND METHODS

3.1. Study Area description

This study was conducted in Hadiya Zone, Southern Nation Nationalities and People Regional State, Lemo District Ethiopia (Figure 1). The district is located in south of Addis Ababa the capital of Ethiopia and around Hossana- the administrative centre of Hadiya zone. Lemo District is 232 km away from Addis Ababa and 15km from Hossana.Geographically, Lemo District is situated between 7°22'00''- 7°45'00"N latitude and 37°40'00"- 38°00'00''E longitudinal.The district is border to Silte Zone in the North, Kembata Tembaro Zone in the South, Gombora district in the North West, Ana Lemo district in the North East and Shashogo in the East.

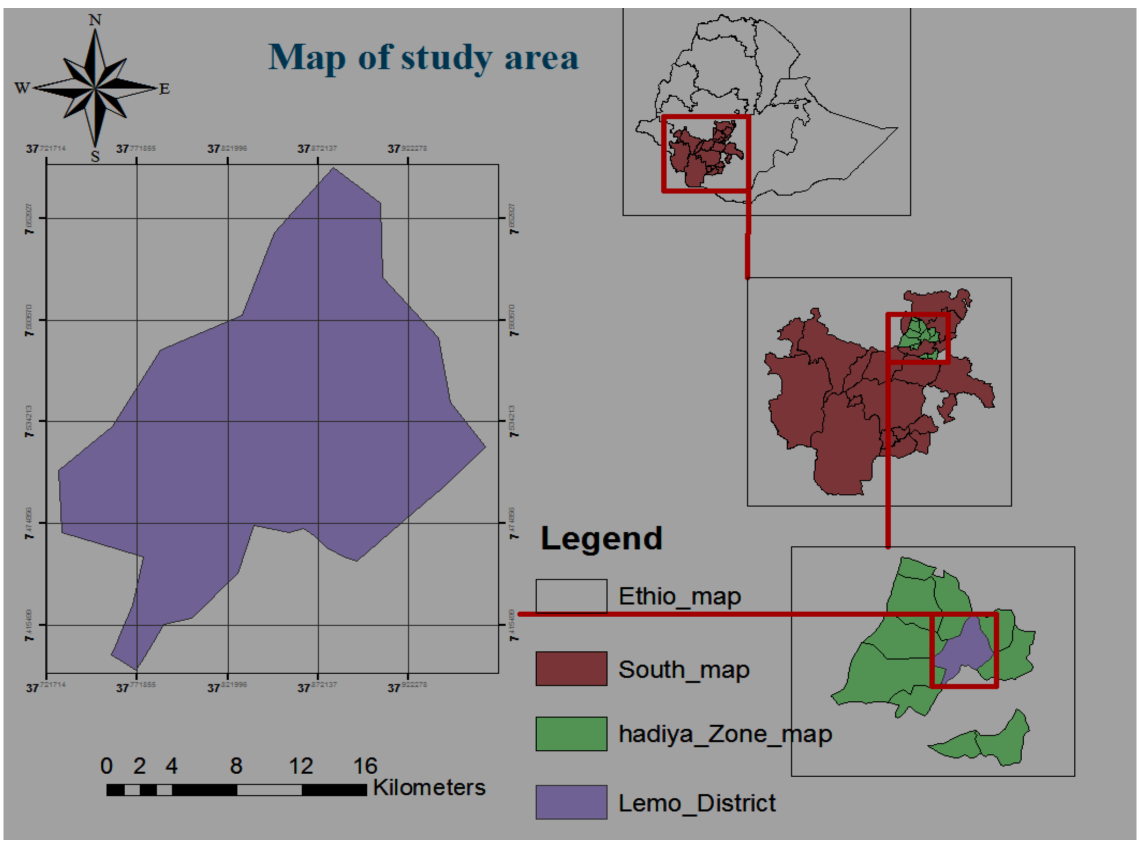

Figure 1: Map of the study site

The total land area coverage of the district is 38,140 hectare, of which 91% covers *Woina-Dega* (mid-altitude 1900 to 2500 m.a.s.l) and 9% *Dega* (high altitude 2501 to 2700 m.a.s.l). The mid-altitude area has flat 54.3%, hilly 5.4% and undulating 40% landscapes (LWARDO, 2009).It receives a bimodal rainfall distribution where the major annual rain season occurs in

Maher (May to end of September) and short rainy season occur in Belg (beginning January to April). The mean annual precipitation varies between 900 - 1400mm and temperature ranges 13 °C - 23°C (Lindqvist, 2005). The dominate soil types of the study area is Nitisol and Vertisol (FAO, 2006). These soils are characterized by local peoples differently. The main crops grown on these soils includes wheat, teff, sweet potatoes, barley, maize, faba beans, pea, cabbage, carrots, and onions including other perennial (e.g., enset, coffee, chat, sugarcane, avocadoes, mangoes). Most of lands are subjected to annual crops and followed by perennials (**Error! Reference source not found.**). Mixed agriculture (crop and livestock roduction) characterized as subsistence and rain-fed is the main livelihood bases of peoples.

Table 1: Major land use types of the study area

Major Land use types	Area (ha)	Area (%)
Annual crop land	25714.5	73.52
Perennial crop land	4349.5	12.44
Grazing land	1481.5	4.24
Natural forest	721	2.08
Cooperative and private forest	1443.5	4.12
Unproductive land	1262.5	3.6
	34972.5	100

Source: LWAO (2016)

3.2. Study design

Lemo District was purposely selected from 10 District of Hadiya zone based on the presence of slope classes and soil bund conservation practice in the cropland. The land of this area is 5.4% moderatelysteep slope, 40% strongly slopingand 54.3%flat to gently sloping (LWARDO, 2009).The gradients of moderately steep slope 15-30%, strongly sloping 10-15% and flat to gently sloping 1-5% (FAO, 2006).Lemo District hasdifferent slope position, of these moderately steep slope, strongly sloping and gently slopingpositions were selected using random sampling techniques.From these slope positions of croplands were purposely selected for technical fitness of soil and water conservation structures, and soil sampling. The soil samples were collected from croplands managed with soil bund since 2010 and technical fitness of conservation structures assessed from structures built in 2016.

Figure 2: Slope classes of the study area

3.3. Method of data collection

3.3.1. Soil sample collection

To assess effect of soil bund on selected soil physico-chemical properties such as texture, bulk density (Bd), moisture content (MC), soil reaction (pH,) electrical conductivity (EC), soil organic carbon (SOC), total nitrogen (TN), carbon to nitrogen ratio (C: N), available phosphorus (Av.P), and cation exchange capacity (CEC), soil samples were collected from the selected croplands accompanied with soil bund and situated at moderately steep slope (MSS), strongly sloping(SS) and gently sloping (GS). In croplands where the soil bund structures were implemented through mass community participation and sampling was did between the three consecutive structures.The soil samples were collected from 1m, 2m, and 4m away from soil bund using auger at 0-15 cm sampling depth.Five randomly collected samples were used to make a composite sample. In total 27 composite samples were collected from the three slope positions (3 slopes * three intervals from bund * three replications).Three undisturbed core samples also collected to determine soil bulk density and moisture content.

3.3.2. Field observation and measurement

To assess technical fitness of physical soil conservation implemented in the study area through mass community participation intensive field observation and measurements were conducted in nine fields in the three slope positions (three in moderately steep slope, three in strongly sloping and three in gently sloping). The field observation was made on the type of soil conservation structure implemented.Field measurements on design specifications (height of embankment, top width of embankment, bottom width of embankment, depth of ditch, size of ditch and length of Berm), vertical interval and space between bunds against the standards (Table 2). Tape mater was used to measure size and spacing between bunds and clinometers to measure slope (%).

Table 2: The recommended value for graded soil bund structures in the study area were compared based on this standard value

Bund components	Recommended standards	Sources
Height of embankment(m)	0.5-0.75	FEPA(2004)
Top width of embankment(m)	0.3-0.5	SAONREPA (2004)
Bottom width of embankment(m)	1-1.5	FEPA(2004)
Length of berm(m)	0.2-0.25	SAONREPA (2004)
Width of the ditch(m)	0.5-0.6	SAONREPA (2004)
Depth of the ditch(m)	0.5-0.6	SAONREPA (2004)
Vertical interval(m)	On slopes <15%=1	MOARD (2005)
	On slopes >15%=1.25	

Table 3: The recommended value for graded soil bund structures of spacing(m) between bunds at different soil types in the study area were compared based on this standard value(MOARD,2005)

Slope (%)		MOA recommendation		
		Sandy soils	Silt loam soils	Clay soils
1-7	Spacing between bund (m)	15-40	20-50	25-60
	VI (m)	1	1	1
7-15	Spacing between bund (m)	8-14	8-19	10-24
	VI (m)	1	1	1
15-30	Spacing between bund (m)	4-7	5-7	5-10
	VI (m)	1.25	1.25	1.25

Figure 3: Field measurement

3.3.3. Household survey

To assess the factors affect levels of farmers' participation in soil conservation practices in the study area, household survey was administered for 129 household heads. Structured questionnaire was used to collect information from households participated (implemented soil conservation practices on their cropland) and non-participant (not implemented soil conservation practices on their cropland). The total household sample size was determined using Cochran (1977) technique, and proportional sampling approach to draw sample households from the three slope classes (Table 4). The simple randomsampling technique was used to select 129 respondents from each slope classes for interview.

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

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) 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. (0.9)

N = total number of population

d =is degree of accuracy desired (0.05)

Table 4: The distribution of sample population in the three study area

Slope class	Total population	Population proportion	Sample population
Moderately steep	510	510/1897)*100	35
Strongly sloping	898	(898/1897)*100	61
Gently sloping	489	489/1897)*100	33
Total	1897		129

3.3.4 Soil Laboratory Analysis

The collected soil samples were transported to Jimma University College of Agriculture and Veterinary Medicine soil and plant analysis laboratory to determine the physical and chemical properties. These samples were air-dried, grinding and pass through 2 mm sieve for soil texture, pH, EC OC, Av.P, TN, and CEC. The core samples were transported to Wolayita Sodosoil laboratory within 24 hours to place in oven.

Hydrometer method was used to determine soil particle size distribution, hydrogen peroxide (H_2O_2) was used to destroy the soil organic matter, sodium hexametaphosphate $(NaPO_3)_6$ and sodium carbonate (Na_2CO_3) as dispersing agent, and amyl alcohol to reduce foam (Waling*et al.,* 1989). Bulk density of undisturbed soil sample was determined core method, mass of the solids and water content of the core measured through weighing the wet core, drying it to constant weight in an oven at 105°C for 24 hours (FAO, 2007).

Soil pH was measured using the glass electrode method with in a supernatant suspension of a 1:2.5 (soil: water on a mass to volume basis). The pH meter was calibrated with buffer solutions of pH 4 and 7. After 30 minute of stirring, the pH was measured in the suspension by using standard pH meter. Soil EC was measured by method in 1:2.5 (soil: water) suspension. Soil OC was determined by Walkley and Black (1934) wet digestion method. One gram of soil was reacted with a mixture of 10mL of 1N K2Cr2O7 solution and 20mL of 98 % H2SO4. The excess dichromate solution was titrated against 1M ferrous sulphate after addition of 200mL distilled water, 10mL of 85 % phosphoric acid and 1mL of indicator solution (0.16 % barium diphenylamine sulphate). TN was determined using Kjeldahl digestion procedure (Bremmer, 1996). The C: N ratio was calculated by dividing organic carbon to total nitrogen. Soil CEC was determined after extracting the soil samples by ammonium acetate method (1N NH4OAc) at pH 7.0 (Waling, *et al*., 1989). Soil Av. P was analyzed using 0.5M sodium bicarbonate extraction solution of Bray method (Van Reeuwisk, 1993).

3.4. Data Analysis

Two-way ANOVA (Analysis of Variance) was performed using Statistical Package for Social Science (SPSS) version 20 used to determine difference in soil bund practices at different slope positions and significance means were compared using LSD at 0.05 probability levels.General Linear Model (GLM) procedure at $P \leq 0.05$ level of significance was used to determine interaction effects of slope position and sample distance from bund on soil properties.Pearson's using simple correlation coefficient was used to determine degree of association between soil properties. Independent t-test was used to test respondent's age, family size,educational status and land holding size effects on soil conservation participation. Final, Chi-square test was used to determine the effects of land access means, extension services, training and cropland slope on farmer's participation in soil conservation practices. The measurement on height of embankment, top width of embankment, bottom width of embankment, depth of ditch, size of ditch, spacing between bunds, length of berm and vertical interval of soil bund was analysis using one sample t-test used to compare the observed means with the standards.

4. RESULTS AND DISCUSSIONS

4.1 Effect of graded soil bund on soil physico-chemical properties

4.1.1 Slope positioneffect on selected soil physical properties

Soil texture: According to USDA soil texture classification soils of the study area had clay texture at gently slopingand strongly sloping positions whereas clay loam at moderately steep slope positions. Statistical analysis showed significant ($P < 0.05$) differences in particle size distribution (sand, silt and clay) among the slope positions (Table 5).Cropland slope position has effect on erosion, the distinction of particle size distribution among the cropland might be due to the slope position difference since the removal of the finer particles (mostly clay particles) by erosion is increased on the moderately steep slope areas while deposition of these particles happen on the gently sloping areas. This agrees with the finding of Aytenew(2015)who reported that soil conservation practices at different slope position have significantly different in soil particles due to the meandering role in the processes of soil erosion and deposition at the lower cropland.This process might be during intensive rainfall has its effect on conservation practice. In addition, Selassie *et al*, (2015) reported that in the area of Zikre watershed north-western Ethiopia among slope classes there was significant differences of soil particles. On the other hand, Yeshaneh (2015) revealed early crop cultivation in advance of the slope position prevents the down slope transportation of fine particles.

Table 5:Graded soil bund effects at differentslope position, sample distance from bund and interaction effect of SP&SDFB on the selected physical properties of soils(mean ± MSD)

Slope position (SP)		Sand (%)	Silt (%)	Clay (%)	Texture	BD(g/cm^3)	MC (%)
GS		18.00±4.06^c	33.22±1.92^b	61.00±7.00^a	Clay	1.036±0.078^c	28.11±1.03^a
SS		18.78±3.23^b	39.00±2.34^a	41.00±3.46^b	Clay	1.08±.085^b	26.12±1.79^b
MSS		25.67±3.31^a	20.67±4.24^c	36.00±1.32^c	Clay loam	1.19± .081^a	25.79±1.11^c
p-value		0.000	0.000	0.000		0.001	0.003
Sample distance from bund (SDFB)							
GS	1m	18.67±1.52^a	33.67±2.08^a	58.33±4.61^a		1.09±0.069^a	27.67±0.57^a
	2m	16.33±3.05^a	33.00±2.64^a	67.67±3.05^a		1.00±0.037^a	28.33±1.52^a
	4m	19.00±6.92^a	33.00±1.73^a	57.00±8.00^a		1.01±0.11^a	28.67±0.57^a
P-value		0.739	0.912	0.113		0.401	0.501
SS	1m	17.67±4.16^a	40.00±2.00^a	42.33±2.30^a		1.07±0.060^a	26.00±2.64^a
	2m	17.67±3.05^a	37.33±3.05^a	41.00±5.29^a		1.03±0.055^a	26.33±1.15^a
	4m	21.00±2.00^a	39.67±1.52^a	39.67±3.05^a		1.13±0.12^a	26.33±2.08^a
p-value		0.396	0.361	0.702		0.377	0.974
MSS	1m	25±3.46^a	22.00±2.00^b	35.33±1.52^a		1.14±0.081^a	25.33±2.08^a
	2m	26.33±3.05^a	16.00±0.00^c	37.00±1.00^a		1.22±0.050^a	26.00±0.00^a
	4m	25.67±4.61^a	24.00±4.00^a	35.67±1.15^a		1.23±0.101^a	25.67±0.57^a
p-value		0.912	0.021	0.296		0.385	0.813
SPXSDFB							
GSx1m		18.67±1.52^a	33.67±2.08^a	58.33±4.61^b		1.09±0.069^a	27.67±0.57^a
GSx2m		16.33±3.05^a	33.00±2.64^a	67.67±3.05^a		1.00±0.037^a	28.33±1.52^a
GSx4m		19.00±6.92^a	33.00±1.73^a	57.00±8.00^c		1.01±0.11^a	28.67±0.57^a
P-value		0.620	0.870	0.008		0.202	0.311
SSx1m		17.67±4.16^a	40.00±2.00^a	42.33±2.30^a		1.07±0.060^a	26.00±2.64^a
SSx2m		17.67±3.05^a	37.33±3.05^a	41.00±5.29^a		1.03±0.055^a	26.33±1.15^a
SSx4m		21.00±2.00^a	39.67±1.52^a	39.67±3.05^a		1.13±0.12^a	26.33±2.08^a
p-value		0.196	0.162	0.570		0.178	0.961
MSSx1m		25±3.46^a	22.00±2.00^b	35.33±1.52^a		1.14±0.081^a	25.33±2.08^a
MSSx2m		26.33±3.05^a	16.00±0.00^c	37.00±1.00^a		1.22±0.050^a	26.00±0.00^a
MSSx4m		25.67±4.61^a	24.00±4.00^a	35.67±1.15^a		1.23±0.101^a	25.67±0.57^a
p-value		0.869	0.000	0.105		0.186	0.725

GS= gently sloping, SS= strongly sloping, MSS= moderately steep slope

Themain, sample distance and interaction effect means within a column followed by different letter are significantly different at p<0.05 level of significance and by the same letter are not significantly different at P>0.05 level of significance. MSD = Mean standard deviation, MC = Moisture content. BD = Bulk density, An interaction effect of slope position and soil sample distance from bund indicates, showed significant difference ($P < 0.05$) in clay and silt fractions at gently sloping and moderately steep slope positions, respectively. At gently sloping position, the highest amount of clay fraction (67.67±3.05) was recorded at 2 m away from soil bund and the lowest (57.00±8.00) at 4m from the soil bund. Similarly,at moderately steep slope highest amounts of silt fractions (24.00±4.00) were recorded at 4m away from the bund and the lowest (16.00±0.00) at 2 m from the bund. The difference of clay particles among slope position with away from bund might be due to attachment of soil particles and influence of soil bund practices.This agrees with Ademe *et al*.,(2017) who reported that the difference of soil particles may be due to soil particles resistance to attachment and effect of SWC measures.Furthermore, Bezabih *et al*.,(2016) reported that the slope position influences soil particles due to soil erosion affects cropland. But, sand was not significantly ($P>0.05$) different as one moves away from the bund (sample distance from bunds) and interaction effect of slope positions with sample distance from bunds.

Bulk density (**BD** g/cm3): the average values of the soil bulk density at gently sloping, strongly sloping and moderately steep slope position were 1.03, 1.08 and 1.19 g/cm3, respectively (Table 5). Soil bulk densities range for agricultural soils from values of 1 g/cm3 to 1.7 g/cm3 (Hillel, 1980; Buraka and Lelago,2016). Statistical analysis revealed that there was significant ($P<0.05$) difference in bulk density at different slope position. The lowest and highest bulk densities were recorded at gently sloping (1.03g cm-3) and moderately steep slope (1.19 g cm-3), respectively. The difference of soil bulk density among the slope position might be due to the interruption of soil particles with water erosion, difference in organic carbon and clay fraction. This agrees with Bezabih *et al*.,(2016) who reported that the soil bulk density has straight relationship with slope position as the slope increase the bulk density also increased and vice-versa. Moreover, Selassie *et al*, (2015)stated that high soil clay and organic matter content contributes for the low bulk density. The correlation matrix (Appendix 2) also showed a negative and significant relation of soil bulk density with clay ($r = -0.569^{**}$), and positively significant association of bulk density with sand ($r = 0.661^{**}$) faction. Besides, bulk density has negative and significant association with soil organic carbon ($r = -0.548^{**}$). In line with this,Hailu*et al*.,(2012) reported that soil organic carbon affect soil bulk density due to the soildeposition enhance clay content and accumulation of residues. But, bulk density was not significantly ($P>0.05$) different as one moves away from the bund (sample distance from bunds); the interaction of slope positions and sample distance from bunds also showed there was no significant difference.

Soil Moisture (MC %):the average values of the soil moisture at gently sloping,strongly sloping and moderately steep slope position were 28.11, 26.12 and 25.79, respectively (Table 5). Statistical analysis revealed there was significant ($P<0.05$) difference in soil moisture at different slope position. The difference of soil moisture among the slope position might be due to the variation of bulk density, clay content and soil organic matter content.In line with this, Challa*et al*., (2016) reported that the soil moisture has influenced by bulk density and soil organic matter content. The correlation matrix (Appendix 2) also showed a negative and significant relation of soil moisture with bulk density (r = -0.087*), and positively significant association of soil moisture with soil organic carbon (r = 0.334*) faction. But, soil moisture was not significantly ($P>0.05$) different as one moves away from the bund (sample distance from bunds); the interaction of slope positions and sample distance from bunds also showed there was no significant difference.

4.1.2 Graded soil bund effect on selected soil chemical properties

Soil reaction (**pH_**H2O): soil pH of the study area was within 5.3 to 6.0 ranges. According to Tadese (1991) soil pH rating in the study area was categorized asmoderately acid to slightly acid,which were suitable for the most crops (Aytenew, 2015). Statistically analysis showed, there was significant ($P < 0.05$) difference in soil pH between slope positions (Table 6). The highest pH was observed at gently sloping (6.0) and the lowest was at moderately steep slope (5.3). The highest soils pH at gently sloping might be due to the presence of high amount of SOC, CEC and clay fraction, and accumulation of basic cations moved through runoff and erosion from moderately steep slope positions. This agrees with finding of Yimer*et al*., (2006) who reported that high rainfall in moderately steep slope increased runoff, soil erosion and decrease soluble basic cations primary to increase H^+ activity and recorded a reduced pH. But, it contradict with finding of Yeshaneh (2015) who stated that lowest soil pH was recorded at gently sloping due to intensive cultivation that cause reduction of basic cation. In the current study area crop cultivation intensity was similar across slope position. Soil pH was positively and significantly correlated with SOC, CEC and clay fraction at r = 0.543**,r =0.363 and r = 0.637**, respectively. However, it correlated negatively with sand fraction r =-0.315 (Appendix 2). But, statistically non-significant difference was observed in pH as sample distance from bund increases. Also, interaction effects of slope position and sample distance from bund indicated revealed similar result.

Electrical conductivity (EC dS/m): according to Landon (1991) rating the soil in the study area was non saline. Statistical analysis showed, there was significant ($P<0.05$) difference in soil EC between slope positions (Table 6). The highest value (0.68 μs/cm) was recorded at gently sloping and the lowest (0.35 μs/cm) at moderately steep slope. This could be due to removal of basic cations (Ca, Mg, K, Na) eroded from moderately steep slope and accumulated at gently sloping areas associated to high rainfall of the area. In line with this, Nigussie and Kissi (2012) reported that electrical conductivity of soils reduced due to the high amount of rainfall which affect the basic cations. The correlation matrix (Appendix 2) indicated positive and highly significant association between pH and EC (r=0.374**).The value of pH and EC of crop lands decreased from gently sloping to moderately steep slope position might be due to the elimination of basic cations. The basic cations removal due to excessive soil erosion and deposited at the lower slope of cropland have reason to recorded high pH and EC. In line with this, Bezabih *et al*.,(2016) reported that the differences of pH and EC in the slope position due to runoff and soil erosion processes affects basic cations.Similar with soil reaction, non-significant difference was observed in soil electrical conductivity for sample distance from bund, and interaction effects of slope position with sample distance from bund.

Table 6:Graded soil bund effects at different slope position, sample distance from bund and interaction effect of SP&SDFB on the selected chemical properties of soils (mean ± MSD)

Slope position (SP)		pH(pH H_2o)	EC (ds/m)	SOC (%)	TN (%)	C:N(%)	Av.P (ppm)	CEC(meq/100g)
GS		6.00±0.00[a]	0.68±0.11[a]	3.21±0.46[a]	0. 29±0.08[a]	11.52±3.09[a]	5.61±0.18[a]	26.84±2.98[a]
SS		5.44±0.52[b]	0.43±0.19[b]	2.53±0.30[b]	0.19±0.050[b]	14.13±3.86[a]	5.46±0.38[a]	20.18±2.96[b]
MSS		5.33±0.50[c]	0.35±0.05[c]	1.98±0.52[c]	0.15±0.041[c]	12.75±2.30[a]	5.44±0.22[a]	19.07±2.23[c]
p-value		0.012	0.000	0.000	0.000	0.235	0.391	0.000
Sample distance from bund (SDFB)								
GS	1m	5.83±0.056[a]	0.79±0.12[a]	2.75±0.44[a]	0.27±0.067[a]	10.33±2.19[a]	5.48±0.11[a]	28.08±2.11[a]
	2m	5.72±0.15[a]	0.64±0.07[a]	3.39±0.22[a]	0.26±0.056[a]	12.97±2.38[a]	5.73±0.25[a]	23.88±1.08[a]
	4m	5.75±0.11[a]	0.62±0.036[a]	3.48±0.36[a]	0.34±0.12[a]	11.27±4.74[a]	5.62±0.085[a]	28.57±3.18[a]
P-value		0.505	0.100	0.091	0.544	0.635	0.279	0.087
SS	1m	5.33±0.57[a]	0.39±0.10[a]	2.58±0.04[a]	0.16±0.045[a]	16.30±4.07[a]	5.49±0.52[a]	18.80±3.03[a]
	2m	5.00±0.00[a]	0.55±0.32[a]	2.41±0.23[a]	0.20±0.053[a]	12.25±3.94[a]	5.37±0.34[a]	21.78±3.09[a]
	4m	5.67±0.57[a]	0.34±0.056[a]	2.61±0.54[a]	0.19±0.061[a]	13.83±3.87[a]	5.54±0.41[a]	19.95±3.09[a]
p-value		0.296	0.461	0.761	0.632	0.494	0.884	0.526
MSS	1m	5.33±0.57[a]	0.33±0.081[a]	2.09±0.10[a]	0.18±0.009[a]	11.60±2.62[a]	5.46±0.035[a]	17.05±1.16[a]
	2m	5.00±0.000[a]	0.35±0.056[a]	1.86±0.64[a]	0.13±0.013[a]	13.53±3.34[a]	5.41±0.37[a]	19.49±0.81[a]
	4m	5.33±0.57[a]	0.37±0.047[a]	2.00±0.79[a]	0.15±0.071[a]	13.11±2.62[a]	5.45±0.25[a]	20.67±2.78[a]
p-value		0.630	0.786	0.896	0.475	0.622	0.968	0.118
SPXSDFB								
GSx1m		5.83±0.056[a]	0.79±0.12[a]	2.75±0.44[c]	0.27±0.067[a]	10.33±2.19[a]	5.48±0.11[a]	28.08±2.11[b]
GSx2m		5.72±0.15[a]	0.64±0.07[a]	3.39±0.22[b]	0.26±0.056[a]	12.97±2.38[a]	5.73±0.25[a]	23.88±1.08[c]
GSx4m		5.75±0.11[a]	0.62±0.036[a]	3.48±0.36[a]	0.34±0.12[a]	11.27±4.74[a]	5.62±0.085[a]	28.57±3.18[a]
P-value		0.317	0.089	0.004	0.364	0.480	0.092	0.003
SSx1m		5.33±0.57[a]	0.39±0.10[a]	2.58±0.04[a]	0.16±0.045[a]	16.30±4.07[a]	5.49±0.52[a]	18.80±3.03[a]
SSx2m		5.00±0.00[a]	0.55±0.32[a]	2.41±0.23[a]	0.20±0.053[a]	12.25±3.94[a]	5.37±0.34[a]	21.78±3.09[a]
SSx4m		5.67±0.57[a]	0.34±0.056[a]	2.61±0.54[a]	0.19±0.061[a]	13.83±3.87[a]	5.54±0.41[a]	19.95±3.09[a]
p-value		0.105	0.266	0.652	0.475	0.303	0.827	0.342
MSSx1m		5.33±0.57[a]	0.33±0.081[a]	2.09±0.10[a]	0.18±0.009[a]	11.60±2.62[a]	5.46±0.035[a]	17.05±1.16[c]
MSSx2m		5.00±0.000[a]	0.35±0.056[a]	1.86±0.64[a]	0.13±0.013[a]	13.53±3.34[a]	5.41±0.37[a]	19.49±0.81[b]
MSSx4m		5.33±0.57[a]	0.37±0.047[a]	2.00±0.79[a]	0.15±0.071[a]	13.11±2.62[a]	5.45±0.25[a]	20.67±2.78[a]
p-value		0.472	0.687	0.845	0.282	0.462	0.952	0.009

GS= gently sloping, SS= strongly sloping, MSS= moderately steep slope

The main, sample distance and interaction effect means within a column followed by different letter are significantly different at $p<0.05$ level of significance and by the same letter are not significantly different at $P>0.05$ level of significance. EC = electrical conductivity, SOC = Soil organic carbon, TN = Total nitrogen, C: N= Carbon to nitrogen ratio, Av.P = Available phosphorous, CEC=Cation exchange capacity, MSD=Mean standard deviation.

Soil organic carbon (SOC %): according to Landon (1991) soil carbon rating, soil OC in the study area was categorized as high at gently sloping and strongly sloping whereas medium at moderately steep slope. There was statistically a significant ($P < 0.05$) difference in soil organic carbon content between slope positions, while non-significant ($P > 0.05$) difference was observed between sample distances from soil bund (Table 6). The highest amount of SOC (3.21±0.46) was recorded soils from gently sloping and the lowest (1.98±0.52) at moderately steep slope position.This might be due to the removal of organic matter through erosion and runoff from moderately steep slope land and deposition in flat land, good moisture content and low soil removal in gently sloping area. Hailu *et al*. (2012) reported that soil organic carbon content increases with soil moisture content and deposition at lower slope positions. Further it agrees with Wolka *et al*. (2011) who stated that soil and water conservation practices decreases runoff and erosion at upland to flatland, and increases soil moisture and SOC at the flat land. But, the current finding argues with finding of Yeshaneh (2015) studied showed that the lowest SOC was obtained in lower slope and highest obtained in higher slope due to continuous and intensive cultivation practices in lower slope positions which reduces organic matter.

The interaction effects of slope positions with sample distance from soil bund has significant ($P < 0.05$) effect on soil organic carbon content at gently sloping position. The highest (3.48±0.36) amount of SOC was recorded at 4 m away from soil bund and the lowest (2.75±0.44) at 1 m from bund. The might be due to the removal of organic matter and residue through erosion from 1m away from bund whereas reduced erosion influence at 4m from bund increased the accumulation.In line with this, Ademe *et al*.,(2017) reported that difference in SOC could be attributed due to the erosion reduction effects of SWC practices implemented and organic matter accumulation. The interaction of slope positions and sample distance from bunds showed there was no significant difference at strongly sloping and moderately steep slope position.

Total nitrogen (TN %):according to Landon (1991) soil nitrogen rating, soil N in the study area was categorized as high at gently sloping whereas medium at strongly sloping and moderately steep slope.Soil total nitrogen was significantly ($P < 0.05$) different between slope position, whereas not significantly ($P > 0.05$) difference between sample distance from soil bunds (Table 6).The average values of total nitrogen at gently sloping, strongly sloping and moderately steep slope were 0.29, 0.19 and 0.15%, respectively. The highest values at gently sloping (0.29%) and lowest at moderately steep slope (0.15%). This could happen due to the removal of organic matter through erosion from hilly slope and deposition at gently sloping position. Similarly, Aytenew (2015) reported that soil total N is low at moderately steep slopes as compared to gently sloping position.In addition, medium rates of soil N in the study area could associated with limited use of inputs containing nitrogen (such as commercial fertilizers, plant and animal residues), removal of N through biomass, medium level of organic carbon and continuous cultivation resulted from shortage of land. The total nitrogen had significant and positive association (r = 0.644**) with soil organic carbon, which agrees with Challa *et al.* (2016). The interaction effect of slope position with sample distance from soil bunds had non-significant effect on soil total N.

Carbon to nitrogen ratio (C:N) : According to Landon (1991) C:N ratio rating, soil C:N ratio in the study area was categorized as medium.Soil C:N ratio was non-significantly (P > 0.05) different between slope position (Table 6). The highest at stronglysloping (14.13%) and lowest at gentlysloping (11.52%).This narrow level of C: N ratios in the study area might be related with continued elimination of crop residues, cow dung, the presence of very fast oxidation and mineralization of previously existing organic materials. In line with this, Hailu *et al*., (2012) reported that the narrow stage of C:N ratio in the study soils does not indicate any significant different across conservation practices. In addition, medium rates of soil C:N ratio in the study area could associated with discharge of available N to the soil scheme through the mineralization sequence of soil organic matter.The obtained values of C: N ratios may propose that there was no problem of N immobilization which could considerably affect the presence of N for crop uptake. Also, statistically non-significant difference was observed in C:N as sample distance from bund increases and interaction effects of slope position with sample distance from bund.

Available phosphorus (AV.P): the average values of the soil available phosphorus at gently sloping, strongly sloping and moderately steep slope position were 5.61, 5.46 and 5.44 ppm, respectively (Table 6). According to Landon (1991) soil available P rating, available P in the study area was categorized asmedium.Statistical analysis revealed that there was non-significant (P>0.05) difference in available P at different slope position. The lowest and highest contents of available P were recorded at moderately steep slope(5.44 ppm) and gently sloping (5.61 ppm), respectively. The mean difference of available P content was slightly recorded with in the slope position. This could be due to the availability of soil organic matter content influenced the existence of further available P in the soil.This agrees with Hailu *et al.*,(2012) reported that the availability of organic matter content affect the existence ofavailable P within the soils. Moreover,Aytenew (2015) reported that the difference of available P content is match with that of organic matter content.In addition, medium rates of soil available P in the study area could associate with the deposit of the climate soil minerals, commercial fertilizers, the breakdown and mineralization of organic matter. Statistically non-significant difference was observed in soil available P for sample distance from soil bund and interaction effects of slope position with sample distance from soil bund.

Cation Exchange Capacity (CEC): the average values of the soil Cation Exchange Capacity at gently sloping, strongly sloping and moderately steep slope position were 26.84, 20.18 and 19.07 meq/100g, respectively. According to Landon (1991) soil CEC rating in the study area was categorized ashigh at gently slopingwhereasmedium at strongly sloping and moderately steep slope. Statistically analysis showed that there was significant ($P < 0.05$) difference in soil CEC between slope positions(Table, 6). The lowest and highest CEC were recorded at moderately steep slope (19.07 meq/100g) and gently sloping (26.84 meq/100g), respectively.The highest soils CEC at gently sloping might be due to the presence of high amount of clay and soil organic matter content, and the removal of organic matter and clay particles moved through runoff and erosionaffects moderately steep slope positions. This agrees with finding of Aytenew(2015) who reported in Dawja watershed of Enebse Sar Midir Abobo area in moderately steep slope runoff, soil erosion and decrease clay particles and organic matter content and recorded a reduced CEC. Furthermore, Challa *et al.* (2016) reported that CEC indicates an enhancement with decrease in slope position in cropland of SWC practices.

An interaction effect of slope position with soil sample distance from bund also showed significant difference ($P < 0.05$) in CEC at gently sloping and moderately steep slope positions.At gently sloping position, the highest amount of CEC (28.57±3.18) was recorded at 4 m away from soil bund and the lowest (23.88±1.08) at 2m from the soil bund. Similarly, at moderately steep slope highest amounts of CEC (20.67±2.78) were recorded at 4m away from the bund and the lowest (17.05±1.16) at 1 m from the bund. This variation might be due to elimination of clay particles through runoff and soil erosion. In line with this, Bekele *et al*., (2016) reported that the CEC differences may be the reduction of clay content through soil erosion.

Based on the evaluation the gently sloping slope area had high CEC, while all the other areas had medium CEC values, the difference might be recognized to the high accumulation organic matter and clay particles. The correlation matrix (Appendix 2) also showed a positive relation of CEC with clay content (r = 0.672**) and SOC (r = 0.536**). In line with this, Selassie *et al.*, (2015) reported that the presence of high soil organic matter andclay content contributes to record high CEC in the gently sloping. But, CEC was not significantly (P>0.05) different as one moves away from the bund (sample distance from bunds) and interaction effect of slope with sample distance between bunds at strongly sloping.

4.2 Evaluation of Technical Fitness of Physical Soil Conservation Practices

Among the total field assessed for technical fitness, graded soil bund was the common physical soil and water conservation structure used in the study area. Statistical analysis conducted for field measurements on the basic components of bund revealed; significant (P < 0.05) difference was recorded in bund embankment height, embankment bottom width, berm length, ditch width, ditch depth, space between bunds and vertical interval between field at the three slope position (Table 7). This because of the constructed graded soil bund components were different in contrast with the standard suggestion gave by ministry of agriculture. The problem was the implemented bunds did by community mobilizationforced by respective village leaders and DAs to participate in the conservation activities.Furthermore, community lack of enough technical support, lack of awareness, poor program participation and workable soil depth were some of the challenges during conservation practices that fail standard. In line with this, Meshesha and Birhanu (2015) revealed that in the area of Chena district in the south western Ethiopia the structure of level soil bunds component do not accordance with the standards. However, the embankment top width was only constructed by ministry of agriculture.

As compared to national standards stated for moderately steep slope, strongly sloping and gently sloping area most of the measurement on components of grade soil bund in the study area was quite different from the expectation.In moderately steep slope area, embankment height, embankment bottom width, ditch width, ditch depth and vertical interval components of bund were below standard, berm length and space between bunds were above standard, embankment top widthwas up to the standard.Similarly, for strongly sloping and gently slopingareas. However, it have some limitations such as lack of technical knowledge in designing,level of contact with DAs,lack of enough training on techniquesand poor coordination of District expert with village conservation expert. The poor design and supervisionof the soil bunds were easily damaged by flooding or livestock. This agrees with,Wolancho (2015) who reported that the effect of soil bunds are not successful due to technical support and structure embankment componentsbe engaged more lands for crops. Therefore miss management of croplandresults in a decline the productivity and food security.

The spacing of the bunds constructed by the community mobilization had showed in the field did not correctly applied according to the standard due to the bund spacing was decided by farmers interest (Table 8). A consequence of large spacing is the cause for the destruction of the constructed conservation practice, the formation of recent rills and gullies which hold enhances soil erosion. This finding is similar with; Masresha (2014) who reported that the area of Dejiel Watersheds in the northern Ethiopia the spacing of bund between successive fanya juuis wider than the standard value. In fact this failure of constructed conservation practices, there was impact on agricultural production. The present study area soil type was clay soil. Soils with clay content were less vulnerable to erosion than soil with sand or silt content (MOARD, 2005).According to the measurement conducted the mean of Vertical interval was significantly lower than the standard. The bunds supposed to show the surface runoff at the top where run reach an erosive speed and the bund not cause problem in agricultural process.However, vertical interval between bunds was decided based on the cropland slope of the area. This agrees with, Gizaw *et al*., (2009)who reported that in standard the spacing of bund decrease when slope position increases.

FGD and KI interview pointed out the main causes of errors observed in bund components, these were structure design and layout done through participation of local community who have no sufficient knowledge on the issue, lacks of sufficient knowledge and skills for properly implement bunds, most farmers' were bargaining the designer (foremen or watershed team leader) during construction of the structure by community mobilization because they think that closely constructed bunds reduce their cropland and near spacing may form difficult in ploughing activities.

Table 7: Assessment on the elements bunds constructed in the study area against national standard (MOARD,2005; FEPA, 2004 ; SAONREPA, 2004)

Slope position	Basic components of bund	MOARD standard	measurement Mean± SD
MSS (15-30%)	Embankment height (m)	0.5-0.75	0.41±0.05*
	Embankment top width (m)	0.3-0.5	0.31±0.04ns
	Embankment bottom width (m)	1-1.5	0.81±0.10*
	Berm length (m)	0.2-0.25	0.31±0.03*
	Ditch width (m)	0.5-0.6	0.39±0.06*
	Ditch depth (m)	0.5-0.6	0.40±0.05*
	Space between bunds(m)	5-10	41±8.04*
	Vertical interval (m)	1.25	0.89±0.50*
SS (7-15%)	Embankment height (m)	0.5-0.75	0.40±0.50*
	Embankment top width (m)	0.3-0.5	0.32±0.04ns
	Embankment bottom width (m)	1-1.5	0.77±0.09*
	Berm length (m)	0.2-0.25	0.28±0.04*
	Ditch width (m)	0.5-0.6	0.44±0.08*
	Ditch depth (m)	0.5-0.6	0.42±0.05*
	Space between bunds(m)	10-24	52±16.72*
	Vertical interval (m)	1	0.79±0.08*
GS (1-7%)	Embankment height (m)	0.5-0.75	0.35±0.06*
	Embankment top width (m)	0.3-0.5	0.31±0.04ns
	Embankment bottom width (m)	1-1.5	0.69±0.07*
	Berm length (m)	0.2-0.25	0.30±0.03*
	Ditch width (m)	0.5-0.6	0.38±0.06*
	Ditch depth (m)	0.5-0.6	0.42±0.05*
	Space between bunds(m)	25-60	99±19.04*
	Vertical interval(m)	1	0.86±0.05*

MSS=moderately steep slope, SS=strongly sloping, GS=gently sloping * significant at $P \leq 0.05$, ns non-significant at $P > 0.05$Source: Field measurement, 2016

Table 8: Assessment on spacing between bunds and vertical interval (VI) of soil bunds constructed in the study area against national standard (MOARD,2005)

Slope (%)		MOA recommendation			Actual measurement	
		Sandy	Silt loam	Clay	Clay	Clay loam
1-7	Spacing between bund (m)	15-40	20-50	25-60	99	
	IV (m)	1	1	1	0.86	
7-15	Spacing between bund (m)	8-14	8-19	10-24	52	
	IV (m)	1	1	1	0.79	
15-30	Spacing between bund (m)	4-7	5-7	5-10		41
	IV (m)	1.25	1.25	1.25		0.89

4.3. Demographic characteristics and Farmers' perception on soil erosion

Among the respondent household head selected for questionnaire survey 74.4% were male and 25.6% female (Table 9). These respondents have different socioeconomic status, for instance 88.4% were married, single 1.6%, divorced 4.7% and widowed 5.3%; 82.2% were protestant religion followers, 9.3% Muslim, 5.4% Orthodox, 3.1% Catholic and 80.6% have livestock 19.4% have no livestock. The common livestock in the study area includes; cow, oxen, mule, donkey, sheep and goats.

Table 9: Demographic characteristic of the sampled households (n=129)

Demographic characteristics	Category	Frequency (%)
Gender	Male	96(74.4)
	Female	33(25.6)
Marital status	Married	114(88.4)
	Single	2(1.6)
	Divorced	6(4.7)
	Widowed	7(5.3)
Religion	Protestant	106(82.2)
	Muslim	12(9.3)
	Orthodox	7(5.4)
	Catholic	4(3.1)
Livestock	No livestock	25(19.4)
	Livestock	104(80.6)

About 95.3% of the respondent households were acknowledged the presence of soil erosion (in the forms of rill, sheet and gully) problem in their croplands and the rest 4.7% of the respondents didn't recognized the problem (Table 10). The chi-square test revealed that there was non-significant difference between respondent farmers on the problems of soil erosion in their cropland. This has strong implication on farmer's engagement in soil and water conservation practices. Gebre *et al*. (2013) stated that farmers who have earlier understand soil erosion as problems in their cropland are makes more investment in soil conservation practices.

Concerning the severity of soil erosion, about 27.9% of the respondent household heads perceived soil erosion as severe in their crop land, 41% of the respondent perceived erosion as moderate and 26.4% of the respondent preserved erosion as minor (Table 10). The chi-square test showed there was no significantdifference between respondents perception on severity of soil erosion problems in their cropland. In addition, focus group discussion (FGD) participants and key informant (KI) revealed that, the rate of soil erosion (moderate, sever and minor) varies from place to place because of slope, uncontrolled grazing, lack of standard conservation practices, cultivation of steep slope, inappropriate farming, and nature of the soil differences.

Table 10: Effects of farmers' perception of soil erosion in the study area (n=129)

Farmers opinion on soil erosion		N (%)	X^2
Soil erosion as a problem?	Yes	123 (95.3)	
	No	6 (4.7)	0.620 Ns
Degrees of soil erosion?	Sever	36(27.9)	
	Moderate	53(41)	0.349 Ns
	Minor	34(26.4)	
	No problem	6(4.7)	

4.4 Factors affect physical soil and water conservation practices in the study area

As presented inTable 11, 93.5% of respondents participated in soil conservation activities were between 26 - 64 years old and the rest 6.5% were over 64 years old. In the non-participant category, 77% were between 26 - 64 age and 23% above 64 years old. The t-test on participant and non-participant revealed, age was not significantly (P>0.05) determining farmer's participation in soil conservation activities. Wolka and Negash (2014) reported that the age of the respondents is not determining community participation in soil and water conservation. Similarly, the educational levels of households were not significantly (P > 0.05) determined the participation of soil conservation in the study area. Most of the respondents participated in soil conservation were illiterate (56%) and few were secondary school completed (4%). Among the respondents not-participated in conservation, 46% of the respondents were able to read and write and 38% were illiterate. Studies reported, farmers an educational level is not significantly determine the implementation of soil conservation technologies in their cropland (Atnafe *et al.*,2015; Gebre *et al.*, 2013).

Table 11: Effect of farmers participation of SWC technologies by household age,level of education, family size and Land sizeof sampled households (n=129)

Variables	Category	Participant	Non-participant	t- value
		N (%)	N (%)	
Age(year)	26-64	72(93.5)	40 (77)	
	>64	5(6.5)	12 (23)	0.793 Ns
Educational	Illiterate	43 (56%)	20(38)	
Status	Able to read and write	19 (25%)	24(46)	0.272 Ns
	Elementary school	12(15%)	3(6)	
	Secondary school	3(4%)	5(10)	
	1-3	6(8)	3 (6)	
Family size	4-6	29(38)	13 (25)	0.099 Ns
(number)	7-9	35(45)	28 (54)	
	≥10	7 (9)	8 (15)	
Land size	≤0.5	4(5)	28 (54)	
(ha)	0.6-1	23(30)	10 (19)	
	1.1 to 1.5	25(32)	6 (11)	0.000
	1.6-2	19(25)	5 (10)	
	>2	6(8)	3 (6)	

Among the respondents participatedin soil conservation activities were 8%, 38%, 45% and 9% between 1-3, 4-6, 7-9 and ≥10 of the family size, respectively. In the non participant category, 6%, 25%, 54% and 15% were between 1-3, 4-6, 7-9 and ≥10 of the family size, respectively (Table, 11). The t-test on participant and non-participant revealed, family size was not significantly (P>0.05) determining farmer's participation in soil conservation activities.Birhanu and Meseret (2013) reported that the family a size of the respondent isnot significantlydetermine the implementation of soil conservation technologies in their cropland. Furthermore, Amsalu and De Graaff (2007) reported that the effect of family size on farmers' participation in soil conservation, which implies that households with large family sizes are not interest to practice conservation activities. But, the t-test on participant and non-participant revealed, land size was significantly (P<0.05) determining farmer's participation in soil conservation activities. Most of the respondents participated in soil conservation were participant,about 5% of the respondents have ≤ 0.5 ha, 30% of the respondents have 0.6-1 ha, 32% of respondents have 1.1-1.5 ha, 25% of respondents have 1.6-2 ha and 8% of respondents have > 2 ha. Among the respondents not-participated in conservation were 54% of the respondents have ≤ 0.5 ha, 19% of the respondents have 0.6-1 ha, 11% of the respondents have 1.1-1.5 ha, 10% of respondents have 1.6-2 ha and 6% of the respondent have >2 ha (Table11). Studies reported, farmers on land size is significantly determine the implementation of soil conservation technologies in their cropland (Abebe and Sewnet, 2014). But, it contradict with finding of Atnafe *et al*., (2015) reported that farmers on land size is not significantly determine implementation of soil conservation technologies in their cropland. Majority of the non-participant respondents that have land holding size (≤0.5 ha), this imply farmers who have small land sizes were less likely to invest in soil conservation activities, because of farmers opinion may reduce their cropland as it use further conservation practices. This could be due to less availability of knowledge and skill concerning the importance of conservation technology. The percentage of respondents and experts assured that participants, who have large land holding size (>1.5 ha) were interested in implementation of soil conservation activities. In line with this, Gebre*et a*l.,(2013) reported that farmers having larger farm sizes are interest to implement conservation technologies in their cropland.

As presented in Table 12, about 87% of the respondents participated in soil conservation activities had land and the rest accesses land through share cropping and rent. Whereas, 73.1% of the respondents not participated in conservation had land and the rest access land through share cropping and rent strategies.The chi-square test revealed, land tenure had not significantly (P >0.05) determines farmer's participation in soil conservation activities.Atnafe *et al*., (2015) reported, land ownership policy of the country has not affects the implementation of soil conservation technologies. Further, about 90% of farmers in Ethiopia believed they have the right to use their land for any interested investment resemble of conservation technologies (Gebre*et al*., 2013).

Table 12: Effects of land tenure security, slope category,DAs contact and training of the respondents onthe graded soil bund conservation activities (n=129)

		Participant	Non-participant	X^2
		N (%)	N (%)	
land access means	Own	67 (87)	38 (73.1)	
	Rent	4 (5.2)	6 (11.5)	
	Share	6 (7.8)	8 (15.4)	0.135 Ns
Slope category	MSS	25 (32)	10(19)	
	SS	38 (49)	23 (44)	0.044
	GS	14 (19)	19 (37)	
Contact with DAs in a month	Twice per month	19 (24.7)	7 (13.5)	
	Once per month	39 (50.6)	14 (27)	
	Rare per month	18 (23.4)	25 (48)	0 .000
	No contact	1 (1.3)	6 (11.5)	
Trained by	DAs	63(81.8)	29 (55.8)	
	NRM expert	8 (10.4)	7 (13.5)	
	NGO	1 (1.3)	5 (9.6)	0.010
	Media	2 (2.6)	5 (9.6)	
	Neighbors'	3 (3.9)	6 (11.5)	

As presented in Table 12, about 32%, 49% and 19% of the slope category respondents participated in soil conservation activities were moderately steep slope, strongly sloping and gently sloping, respectively. Whereas, 19%, 44% and 37% of the respondents not participated in conservation activities, respectively. The chi-square test revealed, slope category had significantly ($P < 0.05$) determines farmer's participation in soil conservation activities. Birhanu and Meseret (2013) reported, the slope position of cropland had significantly influence the participation of soil conservation technologies. The slope of a cropland also an influence the implementation of soil conservation practices due to the moderately steep slope was more vulnerable to soil erosion. This was because on strongly sloping areas following moderately steep slope and gently sloping, the risk of soil erosion was severe due to runoff from hilly lands and farmers implement in response this damage. Their results imply that a farmer who had cropland with moderately steep slope was more used implementation of conservation technologies. The farmers who had cropland with strongly sloping to moderately steep slope were more accept the implementation of soil conservation technologies. Gebre and Weldemariam (2013) have also found similar result. The farmers who had a cropland with moderately steep slope were needed further soil conservation activities than gently sloping. As the slope increases the probability of soil erosion problem also increases due to that the farmers use soil conservation technologies (Atnafe*et al*., 2015). This due to slope of the cropland was one of the features that aggravate soil erosion in particular and affect the productivity.

As presented in Table 12, about 24.7% of the respondents participated in soil conservation activities had got extension servicestwice a month and the rest got extension services as regards50.6% once a month, 23.4% rare in a month and 1.3% no contact with extension agent.Whereas, 13.5% of the respondents not participated in conservation had got extension services twice a month and the rest got extension services about 27% once a month, 48% rare in a month and 11.5% no contact with extension agent.The chi-square test revealed, extension contact had significantly ($P > 0.05$) determines farmer's participation in soil conservation activities. Atnafe*et al*., (2015) reported, extension contact is significantly determine the implementation of soil conservation technologies in their cropland.This due to the farmers had got good extension services showed more participation of soil conservation activitiesthan got extension services rare and not got extension services. Moreover, Birhanu and Meseret (2013) reported that in Farta District structural soil and water conservation activities relate with extension agent is significantly determine implementation of soil conservation technologies and sustainability of practices.

As presented in Table 12, about 81.8% of the respondents participated in soil conservation activities had trained by DAs and the rest of the respondents trained by District of agricultural NRM expert, neighbours, media and NGO. Whereas,55.8% of the respondents not participated in conservation trained by DAs and the rest of the respondents trained by District of agricultural NRM expert, neighbours, media and NGO.The chi-square test revealed,access to training had significantly ($P<0.05$) determines farmer's participation in soil conservation activities.Birhanu and Meseret (2013) reported that access of training has significantly determine the implementation of the soil conservation technologies. Furthermore, Getachew (2014) reported that farmers attend limit training is significantly a challenge on knowledge and skill to determine the implementation of soil conservation technologies in their cropland. This could be affects the implementationof soil conservation technologies in their croplands.

5. CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The investigation was carried out in three villages like Anna Bellessa, Ambicho Gode and shechana Roma, in Lemo District with objective of assessing the technical fitness of community based conservation practice on selected soil physicochemical properties and this structure as a physical SWC practices. Soil erosion critically limits land productivity in Lemo district areas. The composite soil samples were collected from three slope position of the cropland enclosed with conservation practice such as graded soil bund with the sample distance between structures. In the study area, the result showed that soil bund at different slope position the difference was significant for Bd,pH, SOC, TN and CECof the properties. However, the negative effects of slope positions were high at strongly sloping and moderately steep slope areas as compared to gently sloping area. The reason might be due to soil erosion and runoff effect that removed the clay contents, soil organic matter and other plant nutrients. Most of the soil parameters were higher at gently sloping position, except soil bulk density which was higher at moderately steep slope position due to interruption of soil particles with water and livestock.

The widely held of physical SWC practices were suitable for the area, but most of the essential conservation technologies were absent in thestudy area except graded soil bund. The fitness of conservation practices were assessed by measurement. The result revealed that implemented structure (graded soil bund) designs were not in agreement with the standards. The reason why that due to technical associated factors such as lack enough of knowledge and skill, lack of technical support and follow up, lack of regular coordination between DAs and District experts, limited training opportunities and lack of awareness for technologies. In addition, the schedule of soil conservation activities in the District was unsuitable. Regarding on the success of the SWC practices, the majority of the respondents revealed that physical conservation practices were less successful in the study area.

The survey results revealed that about 60% of the respondent were participant of graded soil bund conservation activities and 40% were non-participant graded soil bund in their croplands.According to the finding of the study, the dominated conservation practice had implemented on their cropland was graded soil bund. Farmers were recognize the benefit of soil conservation practices in protecting soil erosion so as to enhance soil productivity by arresting erosion.The participant of farmers whose cropland was found on moderately steep slopes had better participation on the implementation of soil conservation activities. The most important factors that influence farmers' judgment of physical soil conservation technologies were found to be related with land size, training, contact with extension agent and slope of cropland.

5.2 RECOMMENDATION

- Considering the importance of SWC practices route for improving the soil excellence and sustainable crop production, there should be a consistent supervision of the structures along slope position on soil physicochemical properties for getting better agricultural productivity.
- The physical SWC practices should be implemented in agreement with the standards.
  - ✓ Therefore, consistent maintenance and supervision of the structures should be in the position in right time of the conservation practices for the local condition is accepted to be determined and used for the sustainability of the structures.
  - ✓ The limitation of standards for spacing of bunds depending on rainfall and workable soil depth should be considered by MOARD.
- The levels of the problems should be solved through create awareness, facilitate good contact of DAs and SWC experts with farmers, training, continuing technical support and follow up ability of the community watershed team leader build up through concentrated technological activities.

6. REFERENCES

Abebe, Z.D. and Sewnet, M.A., 2014. Adoption of soil conservation practices in North Achefer District, Northwest Ethiopia. *Chinese Journal of Population Resources and Environment*,**12(3)**:261-268.

Aberha, E.T., 2008. *Continued Use of Soil and Water Conservation Practices: a Case Study in Tulla District, Ethiopia*. Sl: sn.

Ademe, Y., Kebede, T., Mullatu, A. and Shafi, T., 2017. Evaluation of the effectiveness of soil and water conservation practices on improving selected soil properties in Wonago district, Southern Ethiopia. *Journal of Soil Science and Environmental Management*,***8*(3)**:70-79.

Addisu, D., 2011. *Benefits and challenges of adopting soil conservation techniques in Goromti Watershed, Central Ethiopia* (Doctoral dissertation, aau).

Admassie, Y., 2000. Twenty Years to Nowhere: Property Rights, Land Management and Conservation in Ethiopia. *Red Sea Press*, Lawrenceville, NJ.

Adimassu, Z., Mekonnen , K., Yirga, C. and Kessler, A., 2012. Effect of soil bunds on runoff, soil and nutrient losses, and crop yield in the central highlands of Ethiopia. *Land Degrad. Develop*,**25**: 554–564.

Adimassu, Z., Gorfu, B., Nigussie, D., Mowo, J. and Hilemichael, K.,2013. Farmers' Preference for Soil and Water Conservation Practices inCentral Highlands of Ethiopia.*African Crop Science Journal*, **21** : 781 – 790.

Alemu, B. and Kidane, D.,2014. The Implication of Integrated Watershed Management for Rehabilitation of Degraded Lands: Case Study of Ethiopian Highlands. *Journal of Agriculture and Biodiversity Research*, **3(6)**: 78-90.

Ali, M. and Surur, K., 2012. Geographical Analysis of Soil Conservation in Silti Woreda, Southern Ethiopia. *International Journal of Environmental Sciences,***1(4)**: 206-223.

Amede, T., 2003. Restoring soil fertility in the highlands of East Africa through participatory research. *African Highlands Initiative: Kampala, Uganda*.

Amdemariam, T., Selassie, Y.G., Haile, M. and Yamoh, C., 2011. Effect of soil and water conservation measures on selected soil physical and chemical properties and barley (Hordeum spp.) yield. *Journal of Environmental Science and Engineering*, ***5*(11)**.

Amsalu, A. and De Graaff, J., 2007. Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Ecological economics*, **61(2)**: 294-302.

Atnafe, A.D., Ahmed, H.M. and Adane, D.M., 2015. Determinants of adopting techniques of soil and water conservation in Goromti Watershed, Western Ethiopia. *Journal of Soil Science and Environmental Management*, ***6*(6)**: 168-177.

Ayalew, A., 2011. Construction of soil conservation structures for improvement of crops and soil productivity in the Southern Ethiopia. *J. Environ. Earth Sci*, 1. pp.21-29.

Aytenew, M., 2015. Effect of Slope Gradient on Selected Soil Physicochemical Properties of Dawja Watershed in Enebse Sar Midir District, Amhara National Regional State. *American Journal of Scientific and Industrial Research*, **6(4)**: 74-81.

Bagdi, G. L. and Kurothe, R. S., 2014. People's participation in watershed management programmes:Evaluation study of Vidarbha region of Maharashtra in India. *Internationa soil and water coservation research,***2 (3)** :57-66.

Bezabih, B., Aticho, A., Mossisa, T. and Dume, B., 2016. The effect of land management practices on soil physical and chemical properties in Gojeb Sub-river Basin of Dedo District, Southwest Ethiopia. *Journal of Soil Science and Environmental Management*, ***7*(10)**:154-165.

Bekele, W. and Drake, L., 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecological economics*, **46(3)** :437-451.

Bekele, M., Lemenih, M. and Regassa, A., 2016. The Effects of Integrated Soil Conservation Practices on Soil Physico-Chemical Properties: The Case of Menesibu District, West Ethiopia. *Journal of Natural Sciences Research*, **6(23)**.

Beyene, K.K., 2011. *Soil erosion, deforestation and rural livelihoods in the Central Rift Valley area of Ethiopia: A case study in the Denku micro-watershed Oromia region* (Doctoral dissertation).

Berry, L., 2009. Land Degradation in Ethiopia: Its Extent and Impact. Global Mechanism and World Bank.

Birhanu, A. and Meseret, D., 2013. Structural soil and water conservation practices in Farta District, North Western Ethiopia: an investigation on factors influencing continued Use. *Science, Technology and Arts Research Journal*, ***2*(4)** : 114-121.

Buraka, T. and Lelago, A.,2016. Physico-Chemical Properties and Agricultural Potentials of Soils of Tembaro Woreda, Kembata Tembaro Zone, Southern Ethiopia.*Chemistry and Materials Research,***(8)7**.

Challa, A., Abdelkadir,A. and Mengistu, T.,2016. Effects of Graded Stone Bunds on Selected Soil Properties in the Central Highlands of Ethiopia. *International Journal of Natural Resource Ecology and Management,***1(2)**:42-50.

Demeke, A.B., 2003. Factors influencing the adoption of soil conservation practices in Northwestern Ethiopia. *Discussion Papers (Germany)*.

Demelash, M. and Stahr, K., 2010. Assessment of integrated soil and water conservation measures on key soil properties in South Gonder, North-Western Highlands of Ethiopia. *Journal of Soil Science and Environmental Management*, ***1*(7)** :164-176.

Endalew,B.,Muche, M. and Tadesse, S.,2015. Assessment of Food Security Situation in Ethiopia: A review. *Asian Journal of Agricultural Research*, **9(2)** : 55-68.

Ertiro, H., 2006. *Adoption of Physical Soil and Water Conservation Structures in Anna Watershed, Hadiya Zone, Ethiopia* (Doctoral dissertation, aau).

Eyasu, E. 2005. Farmer's Perceptions of Soil Fertility Changes and Management. Institute Sustainable Development. Addis Ababa, Ethiopia.

FAO .2004. Methodological framework for land degradation assessment in dry-lands.ftp://ftp.fao.org/agl/agll/lada/LADA-Methframwk-simple.pdf. Cited 12 Feb2011 Organization site.

FAO .2006. Guideline for Soil Description, 4th ed., ISBN:9789251055212, Stylus Publishing, LLC, Rome.

FAO. 2007. Methods of Analysis for Soils of Arid and Semi-Arid Regions. Food and Agriculture Organization of the United Nations Rome, Italy.

FEPA. 2004. Guidelines on Soil Conservation on Cultivated Land. Addis Ababa, Ethiopia.

Gashaw, T., Bantider, A. and Silassie, H.G., 2014. Land degradation in Ethiopia: Causes, impacts and rehabilitation techniques. *Environ Earth Sci*, **4(9)** :98-104.

Gebre, T. and Weldemariam, D., 2013. Farmers perceptions and participation on mechanical soil and water conservation techniques in Kembata Tembaro Zone: The case of Kachabirra Woreda, Ethiopia. *Int. J. Adv. Struct. Geotechn. Eng*, **2(4)**: 118-131.

Gebre, T., Mohammed, Z., Taddesse, M. and Narayana, S. Ch.,2013. Adoption of Structural Soil and Water Conservation Technologies by Small holder farmers in Adama *Wereda*, East Shewa, Ethiopia. *International Journal of Advanced Structures and Geotechnical Engineering,***(02)02**: 58-68.

Gebrehiwet, K.B., 2004. *Land use and land cover changes in the central highlands of Ethiopia: The case of Yerer Mountain and its surroundings* (Doctoral dissertation, AAU).

Gemechu, T. and Kitila, K. H.,2015.Assessment on Farmers' Practices on Soil Erosion Control and Soil Fertility Improvement in Rift Valley Areas of East Shoa and West Arsi Zones of Oromia, Ethiopia. *EC Agriculture,* **2 (4)** : 391-400.

Getachew, Z., 2014. *The Effectiveness And Challenges Of Soil And Water Conservation Practices In Raya Azebo Woreda Of Tigray, Ethiopia* (Doctoral dissertation, AAU).

Gizaw, D., Klika, A. and Hurni, H 2009. Assessment of soil erosion and soil conservation practices in Angereb watershed, Ethiopia: technological and land user context. Conference on International Research on Food Security, Natural Resource Management and Rural Development. University of Hamburg: 1-4.

Habtamu, O., 2014. *Challenges of Soil and Water Conservation Practices and Measure to be Undertaken The Case of Wuchale District North Shewa Zone, Oromia Regional State, Ethiopia* (Doctoral dissertation, AAU).

Hailu, W., Moges, A. and Yimer, F., 2012. The effects of 'fanya juu'soil conservation structure on selected soil physical & chemical properties: the case of Goromti watershed, western Ethiopia. *Resources and Environment*, **2(4)** :132-140.

Hawando, T., 1997. Desertification in Ethiopian highlands. *Rala Report*, (200).

Heyi, D.D. and Mberengwa, I., 2012. Determinants of Farmers' Land Management Practices: The Case of Tole District, South West Shewa Zone, Oromia National Regional State, Ethiopia. *Journal of Sustainable Development in Africa*, **14(1)** :76-06.

Hillel, D., 1980. Fundamentals of Soil Physics. New York. Boston. Sydney. Tokyo. Toronto. 413p.

Hurni, H., 1993. Land degredation, famine, and land resource scenarios in Ethiopia.

Hurni, H., Abate, S., Bantider, A., Debele, B., Ludi, E., Portner, B., Yitaferu, B. and Zeleke, G., 2010. Land degradation and sustainable land management in the highlands of Ethiopia.

Jijo, T.E., 2005. Land preparation methods and soil quality of a Vertisol area in the central highlands of Ethiopia.

Kassie, M. and Holden, S.T., 2008. Sharecropping Efficiency in Ethiopia: Threats of Eviction and Kinship, *Agricultural Economics,* 46: 4.

Ketsela B,H., 2012. The contribution of Eucalyptus woodlots to the livelihoods of small scale farmers in tropical and subtropical countries with special reference to the Ethiopian highlands.

Khan, F., Hayat, Z., Ahmad, W., Ramzan, M., Shah, Z., Sharif, M., Mian, I.A. and Hanif, M., 2013. Effect of slope position on physico-chemical properties of eroded soil. *Soil Environ*, **32(1)** :22-28.

Landon, J.R., 1991. Booker Tropical Soil Manual. A handbook for soil survey and agricultural land evaluation in the tropics and subtropics. JR Lndon (Ed.) Longman Scientific and Technical Copublished in the United States with John Wiley and Sons. *Inc., New York*.

Lemenih, M., Karltun, E. and Olsson, M., 2005. Assessing soil chemical and physical property responses to deforestation and subsequent cultivation in smallholders farming system in Ethiopia. *Agriculture, Ecosystems & Environment*, **105(1)**: 373-386.

Lindqvist,K.A., 2005. Managing land: a practical guidebook for development agents in Ethiopia. Ministry of Agriculture and Rural Development.

LWARDO (Lemo Woreda Agricultural and Rural Development Office), 2009.

Masresha, B., 2014. *Evaluation of Soil and Water Conservation Measures in Dejiel Watersheds, Choke Mountains, East Gojjam Zone of Amhara Region, Ethiopia* (Doctoral dissertation, AAU).

Mazengia, W., Gamiyo, D., Amede, T., Daka, M. and Mowo, J., 2007. Challenges of collective action in soil and water conservation: The case of Gununo Watershed, Southern Ethiopia. In *African Crop Science Conference Proceedings*, **8**: 1541-1545.

Mengstie, F.A., 2009. *Assessment of adoption behavior of soil and water conservation practices in the Koga watershed, highlands of Ethiopia* (Doctoral dissertation, Cornell University).

Mena, M. M., Tadesse, M. and Mamo, Y.,2011. Farmers' views of soil erosion hazards and Decision On Conservation Intervention Practices: Hawasa University Wondo Genet College Of Forestry And Natural Resource, Ethiopia.

Mekonen, K. and Tesfahunegn, G.B., 2011. Impact assessment of soil and water conservation measures at Medego watershed in Tigray, northern Ethiopia. *Maejo International Journal of Science and Technology*, **5(3)**.

Meshesha, Y.B. and Birhanu, B.S., 2015. Assessment of the Effectiveness of Watershed Management Intervention in Chena Woreda, Kaffa Zone, Southwestern Ethiopia. *Journal of Water Resource and Protection*, **7(15)** :1257.

MOARD. 2005. Managing land. A practical guidebook for development agents in Ethiopia. Ministry of Agriculture and Rural Development, Ethiopia.

MOARD. 2010. Sustainable Land Management Technologies and Approaches in Ethiopia. Published by the Sustainable Land Management Project, Natural Resources Management Sector, Ministry of Agriculture and Rural Development of the Federal Democratic Republic of Ethiopia. Addis Ababa, Ethiopia.

Molla, T. and Sisheber, B.,2017. Estimating soil erosion risk and evaluating erosion control measures for soil conservation planning at Koga watershed in the highlands of Ethiopia. *Solid Earth*, **8** : 13–25.

Morgan, R.P.C. 2005. "Soil erosion and conservation", 3rd Edn., Blackwell Publishing Ltd, Malden, pp.25–29.

Nedasa, B., 2003. Soil and water conservation program in the Amhara National Regional State.

Nigussie, A. and Kissi, E., 2012. Physicochemical characterization of Nitisol in southwestern Ethiopia and its fertilizer recommendation using NuMaSS. *Glo Adv Res J Agric Sci*, *1*, pp.66-73.

Nyssen, J., Poesen, J., Gebremichael, D., Vancampenhout, K., D'aes, M., Yihdego, G., Govers, G., Leirs, H., Moeyersons, J., Naudts, J. and Haregeweyn, N., 2007. Interdisciplinary on-site evaluation of stone bunds to control soil erosion on cropland in Northern Ethiopia. *Soil and Tillage Research*, **94(1)**: 151-163.

Nyssen, J., Poesen, J. and Deckers, J., 2009. Land degradation and soil and water conservation in tropical highlands. *Soil and Tillage Research*, **103(2)** :197-202.

Nyssen, J., Clymans, W., Descheemaeker, K., Poesen, J., Vandecasteele, I., Vanmaercke, M., Zenebe, A., Van Camp, M., Haile, M., Haregeweyn, N. and Moeyersons, J., 2010. Impact of soil and water conservation measures on catchment hydrological response—a case in north Ethiopia. *Hydrological Processes*, **24(13)** :1880-1895.

Pender ,J. 2004. Determinants of farmer's indigenous soil and water Conservation In semiarid India". Agricultural Economics, 19, 113-126. Final Report. Commission of European communities, STD3 project No. ts3-ct92-6049, 1992-1996. University ofTrieste, Italy.

Pimentel, D., 2006. Soil erosion: a food and environmental threat. *Environment, development and sustainability*, **8(1)** :119-137.

Safene, Ch., Abay, A., Waga, M., Tilahun, Amede. 2006. "Integrating various biological measures of erosion control and soil fertility management:The case of Gununo, Ethiopia.

SAONREPA. 2004. Farmers practical training manual on watershed development. Southern Ethiopia. 39: 28-29.

Scherr,S.J. and Satya,Y.N. 1996. *Land degradation in the developing world: Implications for food, agriculture, and the environment to the year 2020*. Intl Food Policy Res Inst.

Selassie, Y.G., Anemut, F. and Addisu, S., 2015. The effects of land use types, management practices and slope classes on selected soil physico-chemical properties in Zikre watershed, North-Western Ethiopia. *Environmental Systems Research*, **4(1)**:3.

Tadesse, F., 2010. Farmer's view and response to soil degradation and conservation interventions: a case of farta woreda, northern highlands of Ethiopia. M.Sc. Thesis Hawasa University wondo genet college of forestry and natural resource.

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

Tadese. T. 1991. Soil, Plant, Water, Fertilizer, Animal Manure and Compost Analysis. Working Document. *International Livestock Research Center for Africa (ILCA)*, Addis Ababa, Ethiopia. pp: 13.

Tamene, L. and Vlek, P.L., 2008. Soil erosion studies in northern Ethiopia. In *Land use and soil resources,* pp. 73-100. Springer Netherlands.

Tegene, B., 1992. Farmers' perceptions of erosion hazards and attitudes towards soil conservation in Gunono, Wolayita, southern Ethiopia. *Ethiopian Journal of Development Research*, **14(2)** : 31-58.

Terefe, R and Lemma, B., 2016. Effect of different conservation agricultural practices on soil Physical and chemical properties, in bako tibe district, West Shoa, Ethiopia. *Journal of Humanities, Arts, Medicine and Sciences*,**2(1)**: 49-56.

Tesfay, T. 2015. Soil and Water Conservation Practice in Lailay May Chew Woreda, Centeral Tigray, Tigray Region, Ethiopia. MSc Thesis Presented to the School of Graduates Students, Haramaya University.

USAID. 2000. Amhara National Regional State Food Security Research Assessment Report. USAID Collaborative Research Support Program Team, Addis Ababa, Ethiopia. p.143.

Vancampenhout, K., Nyssen, J., Gebremichael, D., Deckers, J., Poesen, J., Haile, M. and Moeyersons, J., 2006. Stone bunds for soil conservation in the northern Ethiopian highlands: Impacts on soil fertility and crop yield. *Soil and Tillage Research*, **90(1)** :1-15.

Vlek, P., Bao Le, Q. and Tamene, L., 2008. *Land decline in land-rich Africa: a creeping disaster in the making* pp 12-54.

Walie, D. S., 2016. Evaluate the Quality of Physical Soil and Water Conservation Structures in Wyebla Watershed, Northwest Ethiopia. *Journal of Environment and Earth Science*, **6(3)**.

Waling, I., VanVark, W., Houba, V.J.G. and Vanderlee, J.J., 1989. Soil and plant analysis, a series of syllabi. *Part*, 7: 712-717.

Walkley, A. and Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, **37(1)** :29-38.

Wassie, B., 2000. Project Planning, Implementation and Evaluation. *United Nations Center for Regional Development,* Africa Office, Kenya.

WFP. 2005. Report on the Cost-Benefit analysis and Impact Evaluation of Soil Conservation and Forestry Measurement. MERET. Addis Ababa. Ethiopia.

Wolancho, K.W., 2015. Evaluating watershed management activities of campaign work in Southern nations, nationalities and peoples' regional state of Ethiopia. *Environmental Systems Research*, **4(1)** :6.

Wolka, K., Moges, A. and Yimer, F., 2011. Effects of level soil bunds and stone bunds on soil properties and its implications for crop production: the case of Bokole watershed, Dawuro zone, Southern Ethiopia. *Agricultural Sciences*, **2(03)** :357.

Wolka, K., Moges, A. and Yimer, F., 2013. Farmers' perception of the effects of soil and water conservation structures on crop production: The case of Bokole watershed, Southern Ethiopia. *African Journal of Environmental Science and Technology*, **7(11)**:990-1000.

Wolka, K. and Negash, M., 2014. Farmers' Adoption of Soil and Water Conservation Technology: A Case Study of The Bokole and Toni Sub-Watersheds, Southern Ethiopia. *Journal of Science & Development*, **2(1)**: 35-48.

Wood. A. 1990. Natural resource management and Rural Development in Ethiopia, Insiegfried Pausewang, Fant Cheru, Stefan Brune and Eshetu Chole (eds) Ethiopia; Rural Development options. Zed books Ltd. London and New Jersey.

Yeshaneh, G.T., 2015. Effect of Slope Position on Soil Physico-Chemical Properties with Different Management Practices in Small Holder Cultivated Farms of Abuhoy Gara Catchment, Gidan District, North Wollo. *American Journal of Environmental Protection*, **3(5)** :174-179.

Yimer, F., Ledin, S. and Abdelkadir, A., 2006. Soil property variations in relation to topographic aspect and vegetation community in the south-eastern highlands of Ethiopia. *Forest Ecology and Management*, **232(1)**: 90-99.

Yohannes, G. M. 1992.Barriers of the adoption Fanya juu and contour bund soil conservation measures in northern Shewa.In: Institute of Agricultural research. Natural resource management for conservation and development proceedings of the second natural resource conservation conference. Pp:57-67.

Yohannes, G. M. 1998. The Use, Maintenance and Development of Soil and Water Conservation Measures by Small- Scale Farming Households in Different Agro-Climatic Zones of Northern Shewa and Southern Wello, Center forDevelopment and Environment, University of Berne, Switzerland in associationwith the Ministry of Agriculture, Ethiopia, Research Report 44.

APPENDIX

Appendix 1: Questionnaire survey

This questionnaire will be designed to collect data that are intended to investigate Evaluating community based physical soil and water conservation practices emphasis on technical fitness and its effect on soil properties in case of Lemo district. Thus, you are kindly requested to read and respond the following question clearly and genuinely.

Village: ________________question no_________ Date of interview_______________

Questionnaire Code No___________

Part I Households' Characteristics

1. Sex: A. Male [ ] B. Female [ ]

2. Ages: A. 18 – 25[ ] B. 26 – 35[ ] C. 36 – 45[ ] D. 46 – 60[ ] E. > 60[ ]

3. Religion: A. Muslim [ ] B. Orthodox Christian [ ] C. Protestant [ ] D. Catholic [ ]
   E. Traditional Believers [ ]

4. Marital status of the household: A. Married [ ] B. Single [ ]
   C. Divorced [ ] D. Widowed [ ]

5. Family size: A. 1 – 2 [ ] B. 3 - 4 [ ] C. 5 - 6 [ ] D. >6 [ ]

6. Educational status the of household: A. cannot read & write [ ] B. Read & write (1 - 4) [ ]
   C. Elementary School (5 - 8) [ ] D. Secondary School (9 - 10) [ ]
   E. High School (11 - 12) [ ] F. Certificate [ ]

Part II Socio Economic factor

1. Do you have animals /livestock? A. Yes [ ] B. No [ ]

1.2. If yes, state the types of animals/livestock? A. Ox/en [ ] B. cow/s [ ]

C. sheep/ or goat/s [ ] D. Mule [ ] E. Donkey [ ] F. If others ______

3. How many ha land do you have? A. <1 [ ] B. 1-2 [ ] C.2- 3 [ ] D. > 3 [ ]

4. What are the major crops types you have been using to your cropland? ____________

5. Do you think that your soil is fertile? A. Yes [ ] B. No [ ]

5.1. If yes, how do you keep the fertility of soil in your cropland by applying?

A. Manure [ ] B. Gay system (burning) [ ] C. Crop rotation [ ]

D. Compost [ ] E. Fallowing [ ] F. Fertilizer [ ]

G. soil and water conservation

5.2. If no, do you have plan to work on restoration of your soil's fertility?

6. If the fertility of your cropland is decreasing what is the indicator?

A. Decrease in crop production [ ] B. Soil fertility loss [ ]

C. Decrease soil moisture [ ] D. If others specify______________

7. Is understand soil erosion as a problem in your cropland? A. Yes [ ] B. No [ ]

7.1. How do you perceive the level of soil erosion problem in your cropland?

1. Severe 2. Medium 3. Minor 4. No problem

III .Institutional Factor

1. What are the factors that affect participation of physical soil and water conservation practice in your area? Rank them in the bracket

A. Lack of visits by development agent [ ] B. Lack of technical support [ ]

C. Lack of training [ ] D. Land tenure [ ] E. Less availability of technology [ ]

2. How the current landholding condition? 1. Own 2. Rent 3. Share

3. How do you describe the contact you have with soil and water conservation experts (DAs experts) A. Very good [ ] B. Good [ ] C. Limited [ ] D. No [ ]

3.1**.** How often development agents (DAs) visit you in a year? ____ (days in a year)

A. Weekly B. Three times in a month C. Monthly D. Twice in a year

5. Have you ever attended trainings related to physical soil and water conservation?

A. Yes [ ] B. No [ ]

6. Who is given that training? A. District agricultural NRM expert [ ] B. NGO [ ]

C. DAs D. If 0thers’--------------------------

7. What kinds of soil and water conservation train?

A. Physical SWC [ ] B. Biological SWC [ ]

7.1 If the guidance is physical SWC, what kinds of demonstration did you have been taken?

A. Soil bund [ ] B Fanya juu [ ] C. Cut-off drain [ ] D. waterway [ ]

IV. Technological and extension factor

1. Who provides SWC technology extension in your area? A. NGOs [ ] B. DAs [ ]

C. Community leaders [ ] D. Government organization [ ] E. From media [ ]

F. If other, specify ____________________________________

2. Does the extension system provide you much technology option? A. Yes [ ] B. No [ ]

2.1. If yes, which kind of technology you provide? A. Soil bund [ ] B. Fanya juu [ ]

C. Cut-off drain [ ] D. Waterway [ ] E. Terracing [ ] F. If others, specify _______________

3. What is the benefit of the soil and water conservation technology?

A. Decrease erosion [ ] B. Increase moisture content in the soil [ ] C. Increase yield [ ]
D. Protect land from erosion [ ] E. If others, specify __________________

4. What types of the physical Soil Conservation technologies are used in the area? ____

5. What technical and technological gap notice about physical SWC measures.
A. Poor efforts and design problem [ ] C. Limited appropriate technology [ ]
B. Lack of commitment of the expert [ ] D. Shortage of experienced expert [ ]
F. Other specify _________________

14. What are the reasons for the failure of different physical SWC technologies in your area? Rank them

A. Lack of people’s participation in SWC planning [ ]

B. Lack of people’s participation in SWC implementation [ ]

C. Lack of people’s participation in SWC monitoring [ ] D. farm size [ ]

E. The location of the farm land [ ] F. Slope [ ] G. Off-farm income [ ]

V. physical factors

1. How do you describe the slope of your cropland?

A. Gently sloping [ ] B. Strongly sloping [ ] C. Moderately steep slope [ ]

2. How do you perceive the rainfall amount in a year?

A. Heavy rainfall [ ] B. Moderate rainfall [ ] C. Low rainfall [ ]

3. Which is the physical factor affect physical SWC practice?

A. Rainfall intensity [ ] B. Cropland size [ ] C. Topography (slope) [ ]

D. Farm location [ ] E. Slope [ ] F. Soil type [ ]

The checklist will be prepared for key informant interview and focus group discussion.

Key informant interview

1. How physical SWC structures introduced and on what type land SWC method practiced in your area? Why the farmers use those methods?
2. How community participate in physical SWC in your village?
3. What are the technological problems face the farmers when they practice physical SWC?
4. What do you advise the farmer to improve the technological problems face them on physical SWC?
5. If there is technological problems of SWC in your area; what is the plan of DAs, experts, district agricultural office for the improvement of the problem that occurs in your area?

Points of discussion for Focus Group Discussion

1. What are the most commonly used physical SWC in your Village?
2. How physical SWC structures introduced?
3. What type of physical SWC practiced in your locality area?
4. Why the farmers use those conservation practices?
5. How do you look the extension workers condition in your village? Is that enough/ sufficiency?
6. Do you belief that the physical SWC practices are effective in maintain the soil and water conservation in your Village?
7. How do you evaluate the visit of development agents in giving technological support especially concerning physical SWC and what is the importance of giving the technological support to the farmers?
8. What is the role of development agent in your area regarding physical SWC?
9. What are the physical factors which affect the implementation of physical soil and water conservation practice in the Village?

Appendix 2. Pearson correlations of soil physicochemical properties

	PH	EC	SOC	TN	C:N	Av.P	CEC	Sand	Clay	Silt	BD	Mc
PH	1											
EC	0.37**	1										
SOC	0.54**	0.47*	1									
TN	0.49**	0.37	0.64**	1								
C:N	-0.13	-0.02	0.08	-0.63	1							
Av.P	0.18	0.23	0.34	0.10	0.21	1						
CEC	0.36	0.69**	0.53**	0.59**	-0.28	0.04	1					
Sand	-0.31	-0.45	-0.51	-0.15	0.23	-0. 17	-0.38*	1				
Clay	0.63**	0.61	0.71**	0.60	-0.19	0.24	0.67**	-0.64**	1			
Silt	0.20	0.23	-0.46	0.31	0.07	0.00	0.28	-0.62	-0.33**	1		
BD	-0.40*	0.36	-0.54**	-0.31	-0.04	0.02	0.40	0.66**	-0.56**	0.54	1	
MC	0.29	0.46	0.33*	0.43*	-0.23	0.55	0.47*	-0.13	0.51**	-0.11	-0.08*	1

** Correlation is significant at 0.01 levels

*Correlation is significant at 0.05 levels