EFFECT OF SOIL BUND AND FANYA JUU ON SELECTED SOILPHYS ICO CHEMICAL PROPERTIES AND FARMERS ADOPTION TOWAR-DS THE PRACTICE: THE CASE OF DALE WABERA DISTRICT WEST ERN ETHIOPIA

MSc THESIS

BY

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Effect of Soil bund and fanya juu on Selected Soil Physicochemical Properties and Farmers Adoption towards the Practice: The Case of Dale Wabera district Western Ethiopia

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DEDICATION

I dedicated the work to my beloved grand Mother Baye Bira, although she is no longer of this world, her memories continue to regulate my life. Thank you so much I will never forget you. Lastly I dedicated the work to my advisers, friends, and classmates who shared their words of advice and encouragement to complete this work.

BIOGRAPHY OF THE AUTHOR

The author was born from his father Gadisa Denu and mother Kusate Regassa in Dale Wabera district, KelemWolega zone 585 km western from Addis Ababa and 74 km to the East of Dembi Dollo in October 25/1986 G.C. He attended his elementary school at Mekidimbar and Kake junior secondary school and completed his secondary school at Alem Teferi senior secondary school. Then he joined Alage agricultural technical and vocational education training collage (ATVET) in November 2004 G.C and graduated with diploma in natural resource in July 2006 G.C. Following his graduation, he was employed by Dale Wabera agriculture and natural resource office as development agent and worked until he joined his upgrade at Jimma University in October 2009 and graduated with B.Sc degree in natural resource management in July 2010. After he graduated from JUCAVM, he served at different level in Dale Wabera office of agriculture and natural resource until he joined JUCAVM for a second time to follow master degree in Natural Resource Management (specialization in watershed management).

STATEMENT OF THE AUTHOR

I hereby declare that I am the sole author of this master thesis and that I have used those sources listed in the bibliography and identified as references and other reports and documents from woreda office of agriculture and natural resources. I further declare that this thesis is my original work and never been submitted by others to any higher institutions in order to obtain a degree.

Name: Sirna Gadisa Denu

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Submission date: __________________

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TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

Page

LIST OF FIGURES

Page

LISTS OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AV.P	Available Phosphorous
BD	Bulk Density
CEC	Cat ion Exchange Capacity
CSA	Central Statistics Agency
DA’s	Development Agents
DWFEDO	Dale Wabera Finance and Economic Development Office
FGD	Focus Group Discussion
GLM	General Leaner Model
HH	Households
LSD	Least significant difference
NGO	Non Government Organization
OM	Organic Matter
PD	Person-day
pH	Potential Hydrogen
PSWCS	Physical Soil and Water Conservation Structures
RCBD	Randomized Complete Block Design
SAS	Statistical Analysis System
SB	Soil bund
SOC	Soil Organic Carbon
SPSS	Statically package for Social Sciences
STN	Soil Total Nitrogen
SWC	Soil and Water Conservation
SWCP	Soil and Water Conservation Practice
USDA	United States Department of Agriculture
WOCAT	World Overview of conservation approaches and Technologies

ABSTRACT

*Soil and water conservation practice (SWCP) plays a major role in reducing soil losses and improves soil properties that enhance the agricultural production and productivity. In the Dale Wabera district, soil bund and fanya juu have been widely implemented since 2011via community based watershed development approach. However, in the study area the effect of the structural practice was never been evaluated yet. Therefore the objective of this study was to evaluate the effect of the physical SWC structures and slope gradients on soil properties and to identify factors affecting farmer's adoption of the SWC practices. Cultivated fields treated with soil bund, fanya juu and control plots adjacent to these structures were considered along the three slope gradients. A total of 27 soil samples were collected from the top 20 cm soil depth in '**X**' design square plot with length of 10 m x 10 m and replicated three times. 120 HH were randomly selected among which 48.3% were adopter and 51.7% were non-adopters of SWC structures. A total of 10 variables were fitted in the logistic regression model. Results showed that most soil physical properties were not significantly affected by soil bund (SB) and fanya juu s' of seven years age compared to control plot. However, sand showed significant different ($P \leq 0.05$) between the structures which might be due to inherent soil property derived from the parent material. SOC, TN, CEC and pH also showed significant differences between structures and control plots, but available P did not showed variation which might be due to soil acidity in the study area. With regard to slope gradient soil texture showed significant different ($P \leq 0.05$) but BD and MC were not significantly different along the slope. Except for CEC which showed highly significant different with slope gradient the other soil chemical properties did not showed variation along the slope. With regard to carbon stock concentration of the two selected structures, soil bund showed highly significant different when compared with fanya juu and control plots. The results of the model also showed that the explanatory variables: age, education level, family size, land holding, farm experience, availability of labor shortage and extension service were significantly affecting the adoption of SWC practices by the farmers. On the other hand; sex, marital status and livestock holding were not significantly affecting farmer's adoption of SWC practice. Therefore, increasing the quantity and quality of development agents, providing training and experience sharing tour for farmers and bottom- up planning initiation were recommended for the study area. Moreover, further research need to be conducted on socioeconomic aspects of SWC practices for a better understanding of the sustainable use of the land.*

Key Words: *Adoption, Fanya Juu, soil bund, Slope*

1. INTRODUCTION

Soil is an important resources that provides a number of important ecosystem services and it is the medium to produce crop, fodder, fiber and raw materials, among other functions Bilotta *et al(*2012). However, soil erosion has become a serious problem in many countries including Ethiopia (Degraaff *et al.*, 2008). Studies suggested that high rates of soil erosion in Ethiopia is mainly caused by extensive deforestation, population growth, overgrazing and use of marginal lands intensify erosion, topography, soil type and the intensification of the agriculture production also results in high erosion rates (Temesgen *et al.,* 2014). Several studies also reported that annual soil loss show spatial and temporal variations, even if the national average soil loss was estimated to be12tons/ha/yr (Gashaw, 2015). At Koga catchment north western Ethiopia it was found to be 25 mg/ha/year(Yeshaneh *et al.*, 2015), 91.6 mg/ha/year in Fincha watershed western Ethiopia (Tefera and Sterk, 2010), 23.4 mg/ha/yr in Modjo watershed central Ethiopia (Gessesse *et al.,* 2015). Soil erosion by wind and water and subsequent sediment transport and depositional processes may lead to soil organic carbon (SOC) loss especially from a sloping agricultural land unit. Conversion of native or natural ecosystem soil to conventional agriculture use can result in 30% loss of the original SOC stock and 70% of the SOC is subjected to wind and water erosion and transported as SOC rich sediment (Olson *et al.*, 2016). Several research findings confirmed that soil degradation, especially soil erosion and associated soil nutrient depletion, is the major cause of the decline of agricultural production in Ethiopia (Nyssen *et al.*, 2004).

The soil removed by erosion is 1.3 to 5 times richer in organic matter than the soil left behind (Lal, 1990) as cited by Pimentel (2006). For example, the reduction of soil organic matter from 0.9% to 1.4% (assuming a soil organic content of 4 to 5%) lowered the crop yield potential for grain by 50% (Sundquist, 2010). The government of Ethiopia first recognized the impact of soil erosion following the 1973-1974 famine which occurred in the highly degraded parts of the country, particularly in Tigray and Wello (Meshesha *et al.*, 2012). At that time, far mers were mobilized through their peasant associations, mainly in food for work program and about 116 watersheds covering about 1.5 million hectares were treated by different soil and water conservation practices (Bewket, 2007).

In 2010, the Ethiopian government launched a land restoration program that was aimed to double agricultural production and productivity through improving the management of natural resources and agricultural lands. Following the launch of the program, the regional bureaus of agriculture, district agricultural offices, and other local administrative bodies mobilized farmers to help with the construction of SWC practices. Since 2010, more than 15 million people have contributed free labor equivalent to US$750 million each year. Physical and biological SWC measures have been introduced in more than 3,000 watersheds managed by local communities nationally (Mekuria, *et al.,* 2015). As reported by many authors, soil physical and chemical properties had significant variations with regard to physical soil and water conservation practices. According to Hailu *et al.*(2012), the soil organic carbon content under the farm plot where conservation structures were not build was significantly lower than in the cultivated land of under 5 and 10 years of aged fanya juu structures. Farm land with physical SWC practices has high TN as compared to the non conserved land (Selassie *et al.,* 2015). In Dale Wabera district, by recognizing problem of land degradation, and soil erosion several SWC structures have been implemented by the efforts made by government and non-government in all rural Kebeles starting from January 2011.The principal aims of the interventions were to reduce soil erosion, restore soil fertility, rehabilitate degraded soils, improve micro climate, and enhance agricultural productivity (Desta *et al.,* 2005).

Statement of the problem

Physical soil and water conservation structures (PSWCS) are not equally successful or effecti ve in many parts of Ethiopia. In the study area SWC practices have achieved considerable suc cess in coverage. Impacts of the PSWCS on soil properties were evaluated in different parts of Ethiopia, for instance in Wyebla watershed northern Ethiopia Simeneh and Getachew (2015). Similarly at Anjeni watershed north western Ethiopia, it was evaluated by Teshome *et al.*(2014). At Bokole watershed southern Ethiopia it was evaluated by Wolka *et al.* (2013). Generally, up to 2014, 258 studies have dealt with either soil erosion or SWC in Ethiopia, of which 162 focus on the Ethiopian highlands and 112 in the northern Ethiopian highlands (Haregeweyn *et al.,* 2015).

The most important reason for limited use of SWC technologies is farmers' low adoption behavior. According to Mengstie (2009) SWC measures fully adopted only when their executi on is sustained and fully integrated in the household's farming system.

Previous studies show that various personal, economic, socio institutional and biophysical as well as political attributes have influential roles in farmers' decisions about the adoption of SWC practices in different areas of Ethiopia. However, these attributes are not yet studied in Dale Wabera districts of western Ethiopia. A major conclusion that can be drawn from a review of previous studies showed that, soil response to SWC interventions is site specific, which apparently depends on complex and interacting site specific factors such as the local geology, geomorphology, topography, and climate and land use history. This suggests the need for site specific studies to assess the effects of SWC practice on the soil properties. Therefore, this study aimed to evaluate the effect of two selected PSWC practices in improving soil properties and to identify factors affecting farmers' adoption of the practices.

1.1 Objectives of the study

1.1.1 General Objective

To evaluate the effect of soil bund, fanya juu and slope gradient on soil properties and to identify factors that determine the adoption of farmers 'on soil and water conservation practices.

1.1.2 Specific objectives

1. To evaluate the effect of soil bunds, fanya juu conservation structures and slope gradients on soil properties.
2. To estimate soil carbon stock accumulation of the two selected physical soil and water conservation structures.
3. To identify factors affecting farmers' adoption of soil and water conservation practices in the study area.

1.2 Research Questions

1. Is there any difference between conserved and non-conserved farm plots with regard to soil properties?
2. Is there any difference between soil bund and fanya juu regarding soil carbon stock accumulation?
3. What are those factors affecting the adoption of soil and water conservation practice in the study area?

2. LITERATURE REVIEW

2.1Types of soil and water conservation practices

Soil and water conservation (SWC) are activities at the local level which maintain or enhance the productive capacity of the soil in erosion prone areas through prevention or reduction of erosion, conservation of soil moisture, and maintenance or improvement of soil fertility. According to world overview of conservation approaches, SWCP classified as agronomic, veg etative, structural and /or management practices that prevent and control degradation and enhance productivity in the field (Liniger *et al.,* 2007).

2.1.1 Physical soil and water conservation practices

Physical or mechanical conservation include a wide variety of practices and structures in most cases are aimed to decrease slope of the land so as to stop or slow down the velocity of water that will cause erosion (Moges and Holden, 2008). Moreover, physical structure is implement ed to control runoff and soil erosion in fields where biological control practices alone are insufficient to reduce erosion. According to Alemu and Kidane (2014),Gemechu and Hunde (2015), mechanical structures such as terraces, check dams, stone or/and soil bunds, trenches and micro basins modify terrain through changing slope length and angle, which in turn reduce runoff velocity, enhance water infiltration and trap sediments washed down the terrain. However, these conservation applications depend on climate, soil type and vegetation covers.

Fanya juu: fanya juu means "throw the soil up the hill" in Kiswahili. The terraces formed are ideal for fodder grasses and help prevent soil erosion. Fanya juu terraces are constructed by digging ditches and heaping the soil, forming bunds in the upper sides of the ditches. Spacing depends on slope and soil depth (Asnake and Elias, 2019).

Soil bunds: soil bund is an embankment along the contour, made of soil and with a basin at its upper side. The bund reduces or stops the velocity of overland flow and consequently soil erosion. Soil bunds are about 50–75 cm high and have a bottom width of 100–150 cm and a water retention basin on their upper side.

Usually, tied ridges, placed in the basin about every 10 m help to prevent runoff from flowing sideways and to concentrate overflow at one point along the bund and it is applicable for slopes of 3-50 %, soil of greater than 50cm depth (Hurni *et al.*, 2016).

2.1.2 Biological soil conservation practice

Beside the physical structures, implementation of biological soil conservation practices (e.g., vegetative barriers, agronomic, alley cropping, grass strip establishment), and application of farmyard and green manures in degraded lands become immerse practices across the country (Desta *et al.*,2005). It can help to reduce soil erosion as it reduce the impact of rainwater droplets hitting the soil, increasing water infiltration and slow down the speed at which runoff flows through the field (Abebe, 2018). Biological practices are enhancing the overall soil health; improve soil organic matter content, physical properties and nutrient status. Further, it is quick and cheaper than physical structures, compassionate to rehabilitation lands, protect land from further degradation, and stabilize physical structural for long period (Abinet, 2011).

Vetiver grass: Vetiver grass (*Vetiveria zizanioides* L. Nash) was first developed by the World Bank for soil and water conservation in India in the 1980s. Vetiver contour hedges reduced runoff (as percentage of rainfall) from 23.3 to 15.5%, soil loss from 14.4 t/ha to 3.9 t/ha and sorghum yield increased from 2.52 t/ha to 2.88 t/ha over a four year period in India (Truong and Loch 2004). According to Babalola et al. (2003), Soil loss and runoff water were 70% and 130% higher on non-vetiver plots than vetiver plots. Vetiver grass is a very simple, practical, inexpensive, low maintenance and very effective means of soil and water conservation, sediment control, land stabilizations and rehabilitation (Terefe, 2011).

2.2 Effects of physical soil and water conservation structures on soil properties

1. Soil texture

Soil texture determines a number of physical and chemical properties of soils. It affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, tillage and irrigation practices(Ladha *et al.*,2004). It is considered as a basic property of a soil. Soil processes such as erosion, deposition, elevation and weathering can alter the textures of various soil horizons.Wakene and Heluf (2004) reported that, intensive cultivation contributed to the variation of particle size distribution at the surface horizons. In general, sandy soils have low water and nutrient holding capacity, low organic matter (OM)content, little or no swelling and shrinkage and high leaching of nutrients and pollutants(Deckers and Nachtergaele, 1998).It was reported in different parts of Ethiopia by several authors that, soil textural classes were influenced significantly by physical SWC practices.

For instance, Bewket *et al,* (2018) reported higher proportion of sand and silt fractions for conserved micro watersheds than that of not conserved. However, as reported by Ademe *et al.(*2017), for sand and clay there was no significant difference when compared between conserved and not conserved land. The lowest sand content was observed in the terraced hillside which is the effect of conservation practices to accumulate better organic matter and clay materials (Hishe *et al.,*2017). In other study, sand showed significant variation along the treatments and none was observed with clay (Hailu, 2017). According to Wolka *et al.*(2011), silt and clay fractions showed significant difference in croplands under level soil bund aged 6 year when compared with adjacent not terraced croplands. Assefa (2007) reported that soils sampled from the middle of the individual terrace as well as from the middle slope of the terraced sites have a clay loam textural class. The silt content was higher in the conserved landscape than in the non-conserved landscape Bezabih *et al.(*2016); Hishe *et al.(*2017), but Mengistu et al.(2016) found that the silt content was higher in non-conserved rather than conserved land.

2. Soil bulk density

Soil bulk density (BD) is an important soil parameter directly related to a number of soil properties and processes including porosity, soil moisture, water infiltration rates and erodibility (Arya and Paris, 1981). It is an important parameter to predict soil hydraulic functions such as water retention, hydraulic conductivity or surface runoff (Rawls *et al.*, 1982). Hailu (2017) reported significant variation with treatments for bulk density that higher mean value was observed in control farm land compared to the stone bund and stone faced soil bund structures and slope gradients. Wolka (2011) reported that soil under non-conserved farm plots was found to have higher bulk density than those under SWC structures. Lower mean value of BD was recorded in farm plots with SWC practices compared to non terraced farm plots. This is due to the presence of higher OM as a result of conservation measures (Challa *et al.*, 2016). However Ramos *et al.*(2007) reflected what is in contrast with this that the soil BD of terraced land was higher than that of non conserved land. A relatively higher bulk density in non-conserved plots could be related with washing out of fine organic matter rich soils by erosion and thereby exposed slightly heavier soil particulates.

3. Soil pH

Soil reaction (usually expressed as pH value) is the degree of soil acidity or alkalinity, which is determined by the concentration of hydrogen ions (H+). Soil pH is influenced by both acid and base-forming cations (positively charged dissolved ions) in the soil such as hydrogen (H+), aluminum (Al3+), and iron (Fe2+ or Fe3+) and calcium (Ca2+), magnesium (Mg2+), potassium (K+) and sodium (Na+) (Ann McCauley, 2017). Soil reaction affects nutrient availability and toxicity, microbial activity, and root growth (Rahman *et al.,*2018). Although there are plants that thrive in acid or alkaline media, most crops perform best in a slightly acidic soil to neutral (pH 6.0-7.0).The values of pH less than 5.5 may lead to aluminum toxicity, and hence unavailability of phosphorus and some of the soil micronutrients such as molybdenum and reduced biological activity (Githae *et al.*, 2011). When soils have pH>8, some of the micronutrients and phosphorus become unavailable to the plants, biological activity is reduced and soil becomes saline.

According to Bewket *et al.* (2018) the pH of soils at the conserved micro-watershed was lower than the non-conserved mean that there were higher mean values for conserved micro watersheds. Bezabih *et al.*(2016) reported the soil pH was significantly varied within land use types, slope gradients and the soil depths and the significant variation was observed between the slopes categories. The mean value of pH was lower in steep slope and higher in gentle slope. But, according to Challa *et al.(*2016) and Hailu (2017), The soil pH did not show significant variation between treatments, slope gradient and slope-treatment interaction effect at ($p \leq 0.05$).

4. Soil organic carbon and Total nitrogen

Soil organic carbon (SOC) is the carbon associated with soil organic matter (Chan, 2008). SOC and TN contents play a crucial role in sustaining soil quality, crop production, and environmental quality due to their effects on soil physical, chemical, and biological properties. It is estimated that there is a 1-2% reduction of soil productivity annually from the crop lands in the Ethiopian highlands due to land degradation (Hurni, 1993). One aspect of land degradation leading to such decline of soil productivity is loss in SOC and TN due to erosion, intensive decomposition, or leaching. In countries like Ethiopia where there is serious food insecurity due to impoverished soils, the importance of soil organic matter maintenance need not be overemphasized (Itanna *et al.,* 2011). The knowledge of SOC and

TN concentrations and stocks is indispensable for improving soil quality, food production, and mitigating carbon emissions (Yimer *et al.,* 2006). Due to the existence of SWC practices, the highest TN was observed in silluh valley northern Ethiopia (Hishe, 2017). Aseffa (2007) and Demelash and Stahr (2010) stated that SWC supplemented with rehabilitated vegetation cover had positive impact in improving the total nitrogen of the soil. The overall TN content of soils under control farm plots was significantly lower than that of soils under stone bund and stone faced soil bund structures, but no variation was observed along the slope gradient (Hailu, 2017). However, the variation in TN was also significant with slope gradient, where TN was, higher in the gentle slope than in the higher slope gradients which might be due to the removal of OM from the higher or steep slopes as a result of soil erosion (Challa *et al.,*2016). According to Landon (1991) cited by Anbessa and Dereje (2018), TN was rated as greater than 1% as very high, 0.5 to 1%as high, 0.2 to 0.5% as medium, 0.1to 0.2% as low and less than 0.1% as very low. If OM input from crop residues, manure and any other sources were not equal to the rate of decomposition, without taking into account the rate of output, the TN depletion is faster. These in turn make the situation more problematic along with soil erosion (Challa *et al.,* 2016).

5. Available phosphorus

Phosphorus is a major essential plant macro nutrient which is needed for plant growth and development. Plants grow slowly when the level of available P in the soil is low (Silva *et al*., 2015; Hishe, 2017). According to Tanto and Laekemariam (2019) integrated SWC established for 5 years had 2.13-fold more available P content than non-cultivated land. The result clearly depicted that the longer the establishment of SWC practices and its integration with biological measures positively influenced available P content of cultivated lands. But, Belayneh *et al (*2019) reported that available phosphorous of the soil was not significantly affected by conservation measures ($p > 0.05$). Furthermore, Hailu (2017) also reported that available phosphorous did not significantly varied (*P > 0.05)* both with the treatments and slope gradients. According to Bezabih *et al* (2016) available P was significantly affected by land use types.

6. Cation exchange capacity

The Cation exchange capacity (CEC) of soils is defined as the capacity of soils to adsorb and exchange cations (Brady and Weil, 2002). CEC is an important parameter of soil because it gives an indication of the type of clay minerals present in the soil, its capacity to retain nutrients against leaching and assessing their fertility and environmental behavior. According to Tugizimana (2015), the maximum mean value of CEC was observed in conserved farm plots with physical soil and water conservation practices. However, Hailu (2012); Hishe (201 7) found a non-significant variation in CEC among different soil and water conservation practices. CEC was significantly different due to land uses ($p \leq 0.05$) but conservation practices did not show any variation (Bezabih *et al.*,2016).

2.3 Attitudes of farmers on soil and water conservation practice

2.3.1 Farmers' adoption of Soil Erosion as a problem

According to Miheretu (2014), perception of soil erosion as a hazard to crop production and sustainable agriculture is the most important determinant factor for adoption of conservation measures, and he further asserts that understanding and recognition of soil erosion as a problem in own farm plots, and its’ causes and impacts on crop yields is the first step towards searching for and adoption of remedial measures. Farmers reflect due to loss of soil from farm fields decreased the thickness of topsoil and hence reduction in crop productivity (Meshesha and Tripathi, 2016). On the other hand, when farmers do not accept soil erosion as a problem, they cannot expect benefits from controlling the erosion process and it is highly that they will be by the side against adopting any conservation technologies (Zerssa *et al.*, 2017). Biratu and Asmamaw (2016) reported that all the interviewed farmers perceived soil erosion as a problem on their own farm that constraining soil productivity. Concerning indicator of erosion and degradation, yield reduction and poor crop performance, dissection of field and gully was repeatedly mentioned by the respondents (Nigussie *et al.*, 2017). There was over flow of constructed ditches and it damages their crops when there was siltation in and out of their field mostly at the lower field border (Zerssa *et al.*,2017). A study on different parts of the country confirmed that, farmers have a general awareness of soil erosion and soil fertility problem (Madalcho, 2017). Other study by (Tadesse and Belay, 2004) and (Biratu and Asmamaw, 2016), indicated that, about 74% and 92% of surveyed farmers perceived the problem of soil erosion on their farms, respectively.

2.3.2 Farmers participation of SWC activities

In Ethiopia where almost everybody survival is related to soil SWC participation and conservation has not be seen separately. Conservation measures are in the interest of both in individual and community participation. Thus the support and cooperation of community are needed whenever and where conservation measures applied (Abebe, 2018). Aticho *et al.(*2018) reported that, farmers participated in soil and water conservation activities were 26–64 years old while 6.5% were over 64 years old, this indicated that household head age, was not have significant influence on farmers' participation in soil and water conservation activities. Most of the farmers performed soil and water conservation activity on their croplands had frequent contact with extension workers (DAs), and attends training provided by different stakeholder (e.g., NGO). Other studies indicated, contact with local extension workers, and access to training on soil conservation technologies improve farmers participation in soil conservation practicesBirhanu and Meseret (2013); Sinore *et al.(*2018). The knowledge and skills obtained from extension workers and training improves farmers' decision and execution of SWC technologies. Several studies on farmers' participation in developmental projects have reported that highly educated respondents participate to a vaster extent than their lesser educated counterparts (Agidew and Singh, 2018).

2.4 Factors affecting the adoption of physical SWC practices

2.4.1 Political factors

In the past three to four decades, although more attention was given to rehabilitation of degraded lands, the government has given priority to low potential areas. For example, the governments financial contribution for soil and water conservation activities in Tigray, Amhara and Oromia regions from 2000-2004 were identical. At that time, even though the three regions are different in total area coverage and total population, 95.396 million Ethiopian Birr was uniformly contributed for these regions to perform SWC activities (Dejene, 2003). More over the government has encouraged NGOs to work in the low potential areas. Mekuriaw (2017) reported that, farmers in the low potential areas, for example Tigray were mobilized and supported by local and international NGOs in applying SWC practices. The implication is that in the low potential areas, NGOs and multilateral organizations delivered the necessary equipment, trained farmers and DAs on how to construct and maintain SWC structures, to improve their livelihood which is not the case in the high potential areas, as a result, SWC measures have effectively been implemented in the low potential areas such as Tigray since 1991 (Hurni *et al.,* 2015).

Mekuriaw *et al* (2018) reported that in Tigray and Wello, 94% of the interviewed farmers had built and were maintaining SWC structures to keep the soil on their cultivated land and to improve productivity. However, in the case of high potential areas only 56% of the interviewe d farmers had built SWC structures on cultivated land. He also reported that, lack of awareness and strict enforcement and limited access to knowledge and lack of technical support were the main reasons for the low adoption and performance in the high potential areas. Even though the governmental bodies declared that they were following bottom up approach the reality was the reverse (Amdihun *et al.,* 2014). Ignoring farmers' knowledge of local problems and their inputs in participating in SWC measures could be another reason for the failure of SWC programs. The implementation and success of SWC structures are constrained by application of top-down approaches, insufficient institutional supports and general failures to enable farmers genuine participation in key SWC practices (Tefera and Sterk, 2010).

2.4.2 Biophysical and socio economic factors

According to Mekuriaw *et al.* (2018) physical factors such as topography and slope of farm land did not emerge as important factors, according to the respondents. However, Belay, (201 4) reported that, biophysical factors such as, low level of economy, farm size, topographic con dition of the land, distance between home area and farm plot, high intensity of rainfall and uncontrolled or free grazing affects level of adoption of SWC measures on their own farm plot. A slope situation of cropland determines farmers adoption of soil and water conservation technologies (Birhanu and Meseret, 2013). Atnafe et al (2015) also reported as the slope gradient of cropland increases the probability of soil erosion risk increases and farmers use soil and water conservation practices. This indicates that SWC alternatives must be promoted based on farmers' preferences and specific agro-ecological conditions such as slope. Thus, in order to facilitate the perception of SWC practices, a blanket recommendation approach must be avoided (Teshome et al. 2014). According to Zerssa *et al.* (2017) farmers had an intention for incentives to adopt conservation measures from government and concerned body. This shows the use of incentives in promoting adoption of soil and water conservation practices under the condition of the Ethiopia high land was necessary. Educational level, land security, extension contact, and soil and water conservation training Variables were found significant to affect adoption of soil and water conservation practice(Erkie, 2016).

Concerned organizations and government bodies involved in soil conservation should shift emphasis to give greater attention in conserving soils before the land lost all the fertile soils rather than targeting land that has been already exhausted and degraded. But other study report, SWC structures are more likely to be implemented and maintained on low fertility and steep sloping farmland by giving the priority for it rather than fertile lands, because labor and other resources are scarce (Mengstie, 2009).

2.5 Problems of soil and water conservation structures

2.5.1 Decrease in total cultivable land

In the developing world where the livelihoods of population directly depends on cultivable land the total decrease of cropping land as a result of SWC structures become challenge (Wolka, 2014). In Ethiopia it was recommended that fanya juu occupies 2-15% of the land area for a slope of 3-15 %, stone bund occupies 5-25% for a slope of 5-50% and soil bund occupies 2-20% for the slope of 3-30% (Teshome *et al.,*2013). Stone bund occupies about 8% of the farm land in northern Ethiopia. In experimental plots established in the central high lands of Ethiopia soil bunds occupy 8.6% of cultivable land (Admassu*et.al,* 2012).

2.5.2 Labor requirement

The construction and maintenance of physical SWC structures require intensive human labor for which machinery has not been developed or introduced in most developing countries (Wolka, 2014). A guide by Ethiopian ministry of agriculture estimates 150-250PD for the construction of one kilometer of commonly practiced SWC structures, such as soil bunds stone bund, fanya juu etc (Desta *et al.,*2005).

Generally, according to Demissie (2009) the most important problem mentioned by most farmers for soil and water conservation measures was the competition of much labor with other farm activities especially during plowing and weeding time, the difficulty of ploughing by oxen, the expansion of pests, weeds and rats on the constructed structures.

3. MATERIALS AND METHODS

3.1. Description of the study area

1. Location

Dale Wabera is one of the districts of the Oromia region of Ethiopia; it is part of the KelemWolega zone located at about 585 km from Addis Ababa. The administrative center of this district is Kake. geographically, Dale Wabera falls between latitude 08° 41' 92''-08°55'92'' N and longitude of 035° 00' 38''- 035° 07'65''(Ayele *et al.,* 2012) (fig 1).

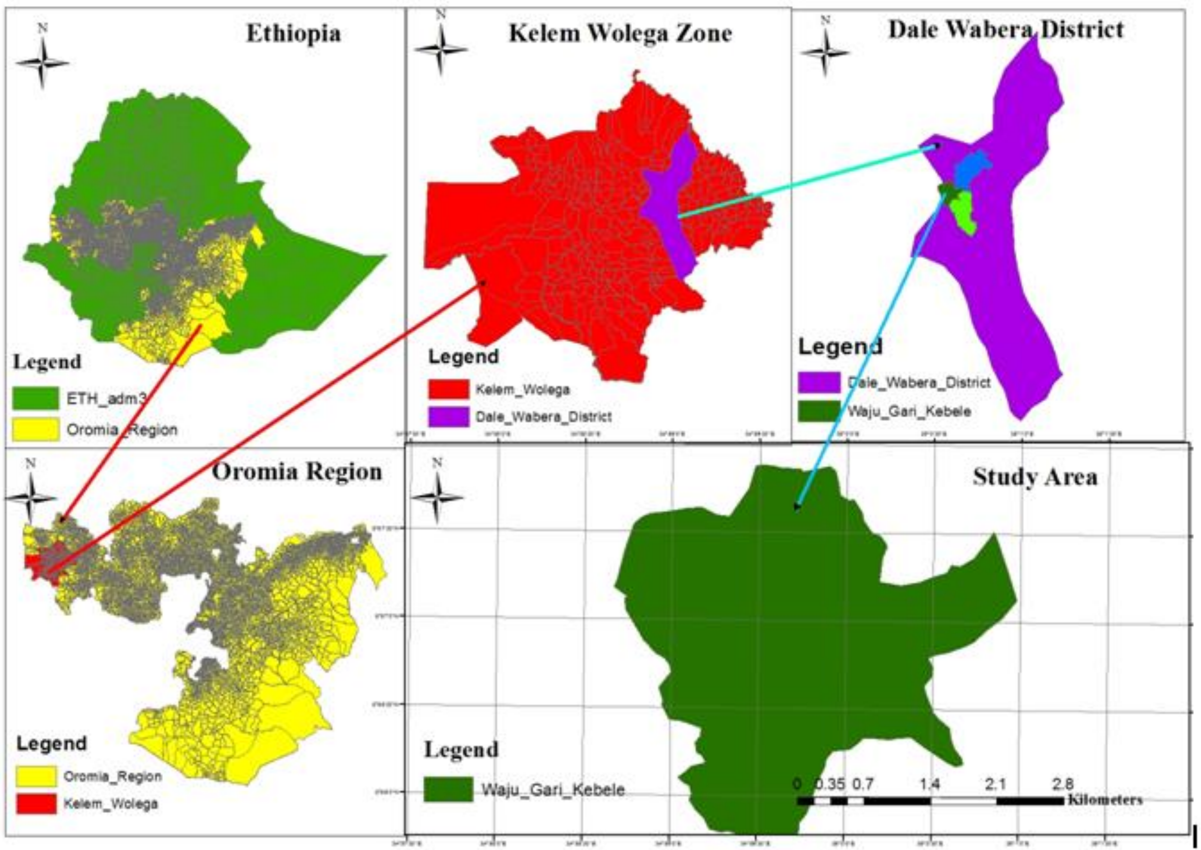

Figure 1 Map of the study area

2. Population

The 2007 national census reported a total population for this district was 105,708, of whom 53008 were men and 52,700 were women; 14,105 or 13.51% of its population were urban dwellers. The majority of the residents were protestants, followed by Islam and Orthodox Christianity (CSA, 2007).

3. Climate

Annual rainfall varies from 1200 mm in the extreme south low land to 1800 mm in the high land with the average being 1500 mm. Daily temperature in the district varies from21^{o}C to 29^{o}C with an average daily temperature of 25^{0}C(Gemtessa and Dera ,2017).

4. Economy

The economic base of Dale Wabera district is agriculture. The sector is rain-feed and is characterized by low productivity. The agro climatic condition is favorable for growing diversified crops including annual and perennial crops. Barley (*Hordeum vulgare)*, Teff (*Eragrostisteff*), Sorghum, Maize (Zeamays), and finger millet are major cereals grown by the farmers. Fruits and vegetables are grown by some farmers for food and income. Irrigated agriculture using streams and springs is limited and practiced by a few farmers to grow vegetables and maize for house hold consumption and for local market. Livestock is an integral part of the farming system of the district. The more source of power for land cultivation is oxen and equines for transportation. The major animals species kept are cattle, small ruminants and equines. In the district, livestock production is constrained by shortage of feed and poor genetic potential of local breeds (DWFEDO, 2018).

5. Elevation and soil

The elevation of the Dale Wabera district is lying between 1200 to 2200m.a.s.l with an averag e elevation of 1700m.a.s.l (Gemtessa and Dera 2017). Although detailed soil description is not available in the study area, two major soil types are dominant in the district: Nitisols covering about 80% of the district and vertisols covers 17% and others 3% (DWFEDO, 2018).

6. Infrastructure

Dale Wabera district has about 30 km gravel surfaced all-weather road and about 72km dry weather road. As to financial service in Dale Wabera district there are commercial bank of Ethiopia, Oromia International Bank and Oromia saving and credit organization. The district has primary hospital, 4 health centers and 20 health posts, and also 2 senior secondary school, preparatory school and technique school (DWFEDO, 2018).

3.2 Experimental design and sampling procedures

Two stages sampling techniques were employed for study site selection. First Dale Wabera di strict was purposively selected from the 11 districts of KelemWolega zone and then Waju Gar i Kebele was selected purposively from 22 Kebeles of the district as this, kebele provide us an opportunity to find out different SWC practices and the researcher was familiar with the area, experience to the problem of soil erosion and low adoption of physical soil and water conserv ation practices. This kebele is included under the project sites of an NGO known as Menschen fiir menschen NGO.

3.3 Soil sample data collection

Before the start of experimental data collection, a field survey was conducted in consultation with key informants, local development agents and Kebele leaders to harmonize with the area and locate representative sample plots within the selected slope gradients. Data were collected by selecting sampling sites from both farm plots where soil bunds and fanya juu bunds conser vation structures were practiced and in plots with no SWC practice as a control adjacent to the structure in the watershed of the study area. Judgment sampling method was used to take representative soil samples from conserved and non-conserved sites based on the assumption that it can represent for the purpose it was required (Landon, 2014). Samples were taken between the two successive conservation structures. Soil samples were collected from the top 0-20cm depth at four corners and center of a plot of 10m x 10m size using “X” sampling design (Margesin and Schinner, 2005),with sharp edged and closed, circular auger pushed manually down the soil profile from the three slope classes Namely, gentle sloping (5-10%), medium sloping (10-15 %) and steep sloping (15-30) according to FAO soil description(Jahn *et al.*, 2006).

The total soil samples were sated as three types of treatments; three slope gradients and each of these were replicated three times. Totally 27 composite samples were collected by using ra ndomized complete block design (RCBD) for soil analysis at micro watershed level (fig 2).

Each time after sampling from both treated and non treated sites, soil clods in samples was thoroughly broken to make a uniform mix in clean plastic bucket. For BD determination after clearing the top surface crop residues and others, undisturbed soil were taken from the center of each sampling plots at depth of 0-5 cm topsoil with a core sampler of $98cm^{3.}$

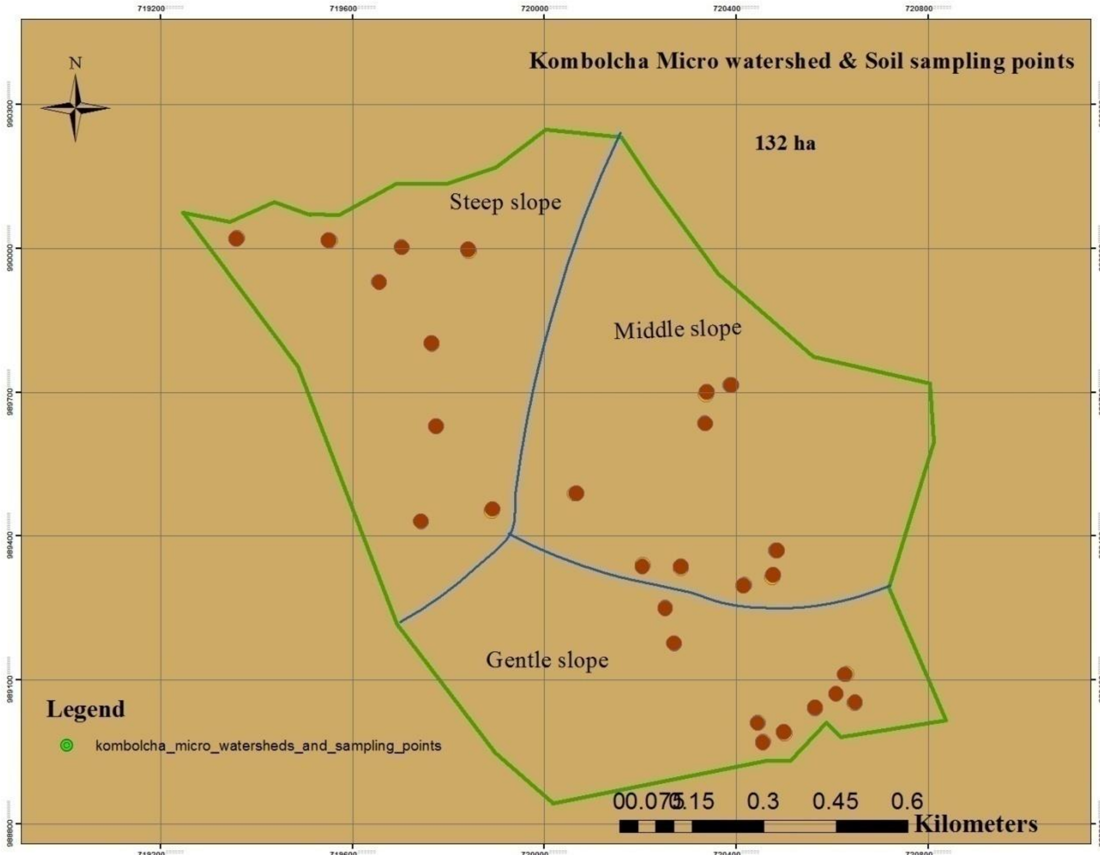

Figure 2 Soil sampling points at the study watershed

3.4 Soil laboratory analysis

Samples were air dried at room temperature, homogenized and passed through a 2 mm sieve. Soil texture, bulk density, soil Moisture content, Soil Organic Carbon (SOC), Total Nitrogen (TN), available phosphorous (Av.P), Cation exchange capacity (CEC) and Soil (pH), of the prepared samples were analyzed following standard laboratory procedure. Soil organic carbon (SOC) was determined by the wet combustion procedure of Walkley and Black method (Van Ranst et al., 1999). One gram of soil, previously ground to pass a 0.2mm sieve, was reacted with a mixture of 10 ml of 0.17 M potassium dichromate and 20ml of 96% sulphuric acid. The excess dichromate solution was titrated against 1M ferrous sulphate after addition of about 150 ml distilled water, 10 ml of 85% phosphoric acid and 1ml indicator solution (0.16% barium diphenylamine sulphate). Soil TN was measured after sulfuric digestion following Kjeldahl distillation process (Kjeldahl, 1992). Soil bulk density was determined by the soil core method which is the ratio of oven dried mass of soil to core volume, and soil texture (sand, silt, and clay contents) were obtained by sieving and decantation procedures according to Blake and Hartge (1986). Soil pH was determined by using the glass electrode and hydrometer method as suggested by VanReeuwijk (2002). Available phosphorus was determi ned using the Bray II method (Bray and Kurtz, 1945) as the experimental soil is acidic. Cation exchange capacity (CEC) of the soils was determined by ammonium acetate (pH 7) method using the percolation tube procedure (van Reeuwijk, 2002). Except the soil bulk density and soil moisture content which was determined at Nekemte soil research center, the rest parameters were analyzed at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) soil laboratory.

3.5 Socio economic data collection

Structured questionnaire, direct field observation and focus group discussion were employed to collect socio economic data across transect of the study area (fig 3). Development agents were trained on techniques of data collection. After they were made aware of the objective of the study and content of the questionnaire, pre-test had been conducted under the supervision of the researcher. Some adjustments were made to the questionnaire and the data were collected under continuous supervision of the researcher. Key informant interview was used to collect in depth information about soil and water conservation practice of the district.

The information gathered via key informant interview was used to complement the data collected from household survey via structured questionnaire and other sources. Accordingly 8experts 4 from woreda office of agriculture and natural resource and 4 from Dale Wabera integrated rural development project (Menschen fiir Menschen) were selected and interviewed in depth about SWC practice of the district. Direct field observation was conducted through transect walks within the watershed (Annex3.5) to obtain information about the physical background of the area, conditions of soil erosion, condition of the present soil and water conservation practices status.

Figure 3 Field observation and key informant interviews

The FGD was held with 10 women and men to assess farmers' adoption of SWC practices. These farmers were selected based on their adoption level of soil erosion, plot location, main soil and water conservation practices on their farmlands. The discussion was focused on identifying which types of physical SWC practice were more determine soil properties. A check list was prepared to guide the open ended discussion with the identified FGD members. The data collected from the FGD were qualitative and general which reflects causes of soil erosion, consequences of soil erosion, and practices of soil and water conservation on their farm land. Questionnaire survey was applied to collect primary data from sample households using structured questionnaire (Annex, 2). An explanation those included in the HH survey was demographic and socio economic characteristics of households; farmers' adoption on different SWC practices and its impacts on determining soil properties. Waju Gari has a total of 314 households (DWFEDO, 2018). From this total sample size for household interview was determined according to(Cochran,1977).

$n_{o}= \frac{z^2 * pq}{e^2}$............. (1),

$n_1 = \frac{n_o}{1+(\frac{n_o(}{N})}$........... (.2)

Where:

n_0 = desired sample size according to Cochran (1977) when population greater than 10,000

n_1 = Finite population correction factors (Cochran, 1977) population less than 10,000

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

P = 0.15 (population variability i.e. 15%)

q= is 1-P i.e. (0.85)

N = is total number of population

e= is degree of accuracy desired (0.05);

Accordingly,

$n_{o}= \frac{1.96^2 * 0.85*0.15}{0.05^2}$…………Eq. (1)

$n_1 = \frac{195.9}{1+\frac{195.9}{314}} = 120$…………Eq. (2)

Accordingly, 120 sample households were randomly selected from the three zones of the kebele using random number sampling technique and they were interviewed (fig 4).

Figure 4 Household interview

3.6 Methods of data analysis

The effect of SWC practice and slope gradients on soil physical and chemical properties were subjected to analysis of variance using the general linear model (GLM) procedure of the statistical analysis system (SAS, version 9.3). The GLM model was used because it can generalize multiple linear regressions for more than one dependent variable. The model is given as: $yij= \mu + \alpha i + \beta j + (\alpha\beta)\, ij + £\, ij$

Where; *yij*= dependent variables (soil properties) μ = sample mean, αi = effect of slope βj = effects of treatments *(αβ) ij*= interaction effect of slope and treatments. *£ij*= random error

The significance difference of soil property due to SWC practice and slope gradient were tested using analysis of variance (ANOVA) procedure at $P \leq 0.05$ level of significance and mean separation were made using least significant difference (LSD).

To identify soil organic carbon stock under the two selected SWC practice, organic carbon stock for each 27 soil samples were calculated by using the following formula: Organic C stock t/ha (ton per hectare) =organic C content (%)*ds*the

Where, ds is the soil bulk density (g/cm^3) and

th is the thickness of the soil layer (cm) (Pereira *et al.*, 2006). Then the comparisons among soil bund and fanya juu were conducted by using SAS version 9.3 software packages for analysis of variance (ANOVA). When the analysis of variance (ANOVA) showed significant differences ($P<0.05$) a mean separation for each parameter was made by using LSD (least significant difference) test.

The data collected from the HH survey were coded, edited and entered in to Microsoft excel and imported to the statically package for Social Sciences (SPSS) version 20 software, where descriptive statistics, mean, standard deviations and binary logistic regressions were conducted. The data which were obtained from interview, focus group discussion and field observation was analyzed qualitatively to supplement the survey questionnaire.

4. RESULTS AND DISCUSSION

4.1 Effect of SWC practices on soil physical properties along slope gradients

The analysis revealed a significant variation of top soil texture with regard to soil bund and fanya juu of seven years of age in percent of sand content. The maximum sand content was observed at fanya juu (37.44%) and control (35.22%), however minimum sand contents (31.22 %) were observed for soil bund (Table 1). However, there was no significant differenc e with regard to silt and clay content. The variation with sand content was estimated to be due to inherent soil property derived from the parent material since soil texture is not affected by SWC practices within such a short period of time. The maximum sand content at the fanya juu was due to the fact that in the fanya juu the bund was formed at the upper side of the ditch, high rain fall in the study area removed fine particles under the bund and the graveled materials left behind which might increase the sand contents at the upper side of fanya juu structures. This result confirmed the finding of Hailu (2017) who reported the same result for Gondar zuria district. Soil textural fraction sand, silt and clay showed significant difference with regard to slope gradient. The mean of sand content was higher (37.88 %) and lower (29.22 %) at steep slope (15-30 %) to gentle slope (5-10 %) respectively. The clay content was higher at gentle slope (44.88%) and lower at steep slope 35.11% (Table 2). Looking at the particle size distribution, it was observed that the clay content showed an increasing trend as slope gradient lowers while sand content showed a decreasing trend down the slope gradient. The variation may be due to the steep slope; transportation and translocation of fine particles are probable, the high annual precipitation over the study area might have selectively transported and/or leached fine fractions leaving behind the coarser fraction. This result confi rms the findings of Ademe *et al.(*2017; Tugizimana(2015). The highest silt content (27.66) was observed at steep slopes. This result also confirms the findings of Hailu (2017) who reported that, on the steep slope, the most noticeable changes were a decrease in clay and a corresponding increase in sand and silt fractions as the slope gradient increases.

Table 1: Physical soil properties as influenced by SWC practices

SWC Practices	Physical soil properties				
	Sand	Clay	Silt	BD	MC
Control	35.22^{ab}	39.33^{a}	25.44^{a}	1.26^{a}	19.85^{a}
Soil bund	31.22^{b}	41.77^{a}	27.00^{a}	1.22^{a}	20.45^{a}
Fanya juu	37.44^{a}	36.00^{a}	26.11^{a}	1.17^{a}	19.15^{a}
CV	13.4	13.6	9.2	9.58	9.75
P. Value	0.03	0.09	0.41	0.23	0.38
Interaction	0.0069	0.0034	0.032	0.95	0.88

Table 2:Physical soil properties as influenced by slope gradient

Slope gradient (%)	Physical soil properties				
	Sand	Clay	Silt	BD	MC
Gentle	29.22^{b}	44.88^{a}	25.00^{b}	1.22^{a}	20.53^{a}
Middle	36.77^{a}	37.11^{b}	25.88^{ab}	1.26^{a}	18.98^{a}
Steep	37.88^{a}	35.11^{b}	27.66^{a}	1.16^{a}	19.93^{a}
CV	13.4	13.6	9.2	9.58	9.75
P. Value	0.0069	0.0034	0.032	0.94	0.88

Even though higher mean value was observed in control plot (1.26grams/cm^3) and middle slope gradient, the soil bulk density didn't show a significant variation with treatments and slope. Which is similar with the finding of Bahilu *et al (*2014). The conserved and non conser ved farm lands were still under cultivation and with increased proportions of farmland cultivat ed the soil bulk density decreased and soil of the study area showed no significant different with SWC practice as well as slope. However, lower soil bulk density was observed at fanya-juu (1.16grams/cm^3) and soil bunds (1.21grams/cm^3) respectively. This could be attributed to the presence of significantly higher organic matter as a result of conservation measures. This study is similar to that of Demelash and Stahr (2010) who reported that, non-conserved micro-watershed was found to exhibit significantly the highest mean value of soil bulk density than the micro-watershed treated with SWC practices.

Regarding to the slope higher soil bulk density was recorded at middle slope, which is disagree with the findings of Challa *et al (*2016) who reported that lower soil bulk density for the middle slope gradient. But Khan *et al (*2013) reported the highest mean (1.51grams/cm^3) values of bulk density on steep slope position.

Even though there was no significant different between slope and SWC practice regarding the view of moisture contents, the higher mean value (20.53%) was recorded for gentle slope and for soil bunds structure (20.44) respectively. This might be due to the high quantity of clay soil and organic matter content at the gentle slope which have major implication to retain water in the soil. Clay soils are fine textured and have large surface area which allows a soil to hold more water. The results were supported by Easton and Petrovic (2005) who found that the areas near the bottom of the slope had higher soil-moisture content than areas near the top of the slope. Nevertheless the result was in contrast with the findings of Challa *et al (*2016) who reported the highest moisture content for middle slope rather than gentle slope.

4.2 Effect of SWC practices on soil chemical properties along slope gradients

The result showed that SWC practice has statistically affected soil pH ($P \leq 0.05$). The pH of the soils sampled from the treated and untreated plots of all the locations ranged from 4.76 to 5.99. This could be categorized as strongly acid to moderately acid ranges according to USDA (1998). The higher mean values of pH (5.35) and (5.18) were recorded for farm land conserved with soil bunds and fanya juu bunds, respectively (Table 3). The mean values from soil bund and fanya juu may be explained by the difference in the extent of soil loss between the conservation treated and untreated plots. The result confirmed the finding of Ademe *et al (*2017) who reported highly significant variation between soil pH and conservation practices in Wonago district southern Ethiopia. The mean pH at the control plot was lower than those of the treated plots (4.86). The low pH reflected in the control plot might be related with high rainfall, associated with leaching and removal of important soil nutrients due to the absence of SWC structures.

Along the slope gradient no significant difference was observed in soil pH, but the highest mean value (5.23) was found in the gentle slope compared with steep and middle slopes, which was (5.02) and (5.14) respectively (Table 4). The lowest pH in soils of steep slope gradient could be attributed to the loss of basic cations through runoff and erosion. This in turn increases the activity of H^+ ion in the soil solution and reduces soil pH. In line with this result Khan *et al (*2013) also reported the highest pH (8.25) at the bottom slope. Moreover Teressa (2017) reported that soil in steep slope had significantly lower pH than those on other slope positions due to the accumulation of soluble cations on the lower slope.

Table 3: Soil chemical properties as influenced by SWC practices

SWC Practices	Soil chemical properties				
	SOC	TN	AVP	CEC	PH
Control	1.18[b]	0.101[b]	1.51[a]	23.73[b]	4.86[b]
Soil bund	1.78[a]	0.15[a]	1.83[a]	26.69[a]	5.35[a]
Fanya juu	1.57[a]	0.13[a]	1.74[a]	23.43[b]	5.18[a]
CV	19.27	19.24	22.6	10.83	4.24
P. Value	0.0016	0.0015	0.55	0.03	0.0008
Interaction	0.69	0.69	0.0064	0.0018	0.48

Table 4:Soil chemical properties as influenced by slope gradients

Slope gradient (%)	Soil chemical properties				
	SOC	TN	AVP	CEC	pH
Gentle	1.63[a]	0.14[a]	1.93[a]	27.15[a]	5.23[a]
Middle	1.54[a]	0.13[a]	1.87[a]	23.89[b]	5.14[a]
Steep	1.36[a]	0.11[a]	1.27[a]	22.82[b]	5.02[a]
CV	19.27	19.24	22.6	10.83	4.24
P. Value	0.17	0.17	0.08	0.0090	0.16

Soil organic carbon (SOC) showed significant variation with respect to treatment. The soil organic carbon content under the control plot was significantly lower than in the cultivated land under soil bund and fanya juu structures. The average SOC content for soil bund was higher (1.78 %) than that of fanya juu (1.57%) and control (1.18%). This might be due to the SWC practice of soil bund (SB) and fanya juu that reduce surface runoff, soil loss and retain water that enhances crop growth and contributes to SOC input. It might be related also to higher biomass production in conserved farm land. SOC did not show significant variation regarding to slope gradient. However, maximum mean values were observed at gentle slope (1.63%) and the minimum was at steep slope (1.36%) (Table.4). This result was similar with Siraw*et al (*2018) who reported that, the highest SOC content (1.04%) for conserved micro-watershed than that of non conserved (0.75%) in the Northwestern Highlands of Ethiopia. Sig nificant variation in SOC between treated and control sites were reported by many authors in different parts of Ethiopia, for instance,(Challa *et al.*, 2016; Teressa, 2017; Amare *et al.*,2013)

Table 3 depicts a significant variation between the treatments ($p \leq 0.05$). The farm plots treate d with soil bunds and fanya juu within the kombolcha watershed was found to reveal higher TN than the non-conserved control plots.

Reduced soil erosion and increased soil organic matter partly explain the higher TN in the con served watershed. Likewise, Demelash and Stahr (2010) reported that farmland with physical SWC practices have high TN as compared to the non-conserved land. Moreover (Bewket *et al.,* 2018) reported TN at the conserved micro-watershed (0.12%) was higher than at the non conserved (0.09%) with the difference being statistically significant at $P<0.05$ level Hailu *et al (*2012) reported that, the overall TN content in soils under control farm plots was significantly lower than the content under fanya juu of 5 and 10 years old. Furthermore Bezab ih *et al. (*2016) reported variation in TN contents due to land uses and conservation difference in Gojeb sub river basin of Dedo district, Southwest Ethiopia. Total nitrogen content did not showed statistically significant variation with regard to slope gradients. However, the maximum mean value (0.14) was observed at gentle slope which were larger than that of steep slopes (0.11) (Table 4). TN of all the slope gradients in the present study area was in the range of Low to medium based on the rating suggested by Tadesse *et al (*1991).

The descriptive statistics of available P is shown in Table 3 and 4. The result confirmed that available phosphorous was not significantly affected under different SWC practices and slope gradients. With regard to SWC practice the maximum mean values (1.83ppm) were recorded for level soil bund and the minimum (1.51ppm) were observed at control site. The maximum mean values (1.93ppm) of available phosphorous were observed at gentle slope and the minimum (1.27ppm) was at steep slope. Results of soil lab revealed that, the available phosphorous for the study site was very low. These were perhaps due to the difference in the past land degradation resulting from continuous cultivation and soil erosion, also it might be due to the fact that soil of the study area was within the acid range of 4.76 to 5.99 that soils with a pH of less than 6 commonly have deficiencies of phosphorous. This study is in line with the findings of (Alemu *et al.,* 2016; Fanuel *et al.,* 2016a and Kehali *et al.*, 2017) who reported that most of Ethiopian soils are deficient in available phosphorus concentr ation due to low pH (acidic), the intensive cropping system, imbalanced use of fertilizer and nutrient mining. The result was in contrast with the finding of Taressa (2017) who reported significant different of available P with regard to treatments and slopes.

The outcome of the soil lab result showed that there was significant difference in CEC (meq/100gm of soil) between the treatments and with regard to slope gradients at ($p \leq 0.05$). The CEC of the soil was lower (23.73) in control, (23.43) for level fanya juu and higher (26.69) in farm plots with soil bunds. Soil of the study area was dominated by clay loam and Soils with a higher clay fraction tend to have a higher CEC. This is in line with research conducted by Alemayehu (2003) where conserved area was found to have mean CEC value of 6 and 49%, respectively, higher than the average CEC of the corresponding non conserved. Teressa, (207) reported the soil CEC illustrated significance difference with treatments and slope position. Soil under terraced farm plot showed higher CEC than none terraced farm land. With regard to slope gradient the highest CEC (27.15) was observed in the gentle slope which might be attributed to the accumulation of clay particles at the gentle sloping with highest surface area due to down ward movement of fine particles because of erosion. The lowest value was observed in the steep slope positions (22.82) (Table 4). The result confirmed the findings of (Aytenew, 2015) who reported the lowest and highest CEC values for strongly sloping and gently sloping areas respectively. The differences among control and fanya juu bunds were very small. This result is indifference with (Bewket, 2003; Hailu, 2017) who reported not significant variation with CEC between SWC practice and also among the relative locations.

4.3 Soil organic carbon stock in different SWC practices and slope position

Soil organic carbon stock was significantly influenced by SWC structures. Similarly,(Amare *et al.,* 2013; Hailu *et al.,* 2012) reported that soil organic carbon content in soils under three terraced sites were higher compared to the corresponding non-terraced sites of similar slopes. Soil organic carbon stock of soil bund structure was significantly higher (43.56t/ha) than fanya juu (38.80 t/ha) and control (30.07t/ha) sites. The maximum soil organic carbon content at level soil bund structure was due to high clay content. In that high clay content may lead to more organic C molecules being absorbed by clay surfaces owing to the larger surface area (Zhong *et al.*, 2018). The declining soil organic carbon stock at the control plot might be due to absence of SWC practice that reduces the removal of organic matter and enhances SOC accumulation. Topographic position did not showed statistically significant variation with respect to carbon stock in the study area. However, maximum mean values were obtained at gentle slope gradient. This result is in line with (Mengistu *et al.,* 2016). The result revealed that SOC stock was significantly decreased from gentle to steep slope positions. This might be due to deposition of eroded materials from upper slopes. The average mean value of soil organic carbon stock was 39.88, 38.9 and 31.6 t/ha for gentle, middle and steep slope positions respectively (Table 5).

Table 5: The influence of topographic position and SWCP on soil C stock concentration

Slope gradient	OC (%)	ρ (g/cm^3)	Cs (t/ha)	SWC Practice	OC (%)	ρ (g/cm^3)	Cs (t/ha)
Gentle	1.63^a	1.23^a	39.88^a	Level soil bund	1.78^a	1.23^a	43.56^a
Middle	1.55^a	1.26^a	38.90^a	Level fanya juu	1.57^a	1.17^a	38.80^{ab}
Steep	1.36^a	1.17^a	31.60^a	Control site	1.18^b	1.27^a	30.07^b
CV	19.27	9.58	19.94	CV	19.27	9.58	19.94
P. Value	0.1748	0.2467	0.0524	P. Value	0.0016	0.2354	0.0031

Generally the effect of SWC practices on soil properties was higher on soil bunds and gentle slope gradients in all the study watersheds. This is because the mostly adopted and practiced types of conservation structures in the study area were soil bund compared to others. According to Getnet and Quraishi (2014) the soil conservation measures adapted well to the local conditions and local community were protected the soil from being eroded and improve soil productivity. Steep slopes generally have shallow soils because soil that does develop is regularly washed down the slopes into the gentle slope prior to the construction of SWC structures, due to this gentle slope gradients have nutrient deposition than steep slope, when SWC practice was added the rate of nutrient regeneration was by far more rapid than that of at steep slopes.

4.4 Farmers Adoption of SWC practices

The following section presents the survey data and interpretation of the analytical findings. All the 120 sample respondents reported that they have participated in mass mobilization soil and water conservation practices since 2011.

4.4.1 Basic household characteristics

The basic household characteristic refers to the general characteristics of the sample populatio n, including composition by age and sex, household size, education, and etc. Majority of the sample household (90%) were male headed households while 10% respondents were female headed households (Table 7). The dominance on male respondents revealed that they were dominant in the participation of SWC practices. The average age of sampled farmer was 40 with a minimum age of 20 and maximum of 64(Table 6). Of the total respondents, 94.2% were married, 5.8 were singles. Out of the 120 households questioned, about 12.5% were not able to read and write, 18.3% had attended up to grade 4, about 55% were attended their school up to grade 8 and the remaining 14.2 % were attended their secondary school (Table 7). Household family size and characteristics are directly related to the supply and demand conditions for basic human needs such as food, shelter, health and educational facilities which in turn directly or indirectly influence the decision for watershed management or soil and water conservation activities (Fikru, 2009). The average family sizes for the sampled household were 4 with the largest family size 15 and the smallest 0 (Table 6).

Table 6: Demographic and socio economic HH characteristics

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	120	20	64.00	40.66	9.89
Education level of HH	120	0	12.00	5.83	3.20
HH Family size	120	0	15	4.74	2.69
Land size	120	0.25	5.00	2.17	1.168
Farm experience	120	2.00	45.00	21.47	11.07
Livestock holding	120	0	37.00	4	4.76

The overall mean family size of 4 persons per household were below the average family size of 4.9 persons per household (CSA, 2007). This result disagree with (Atsbaha and Reddy, 2014) who reported the average family size of 5.88 which is above average. Farm size and ownership are the two critical' rural livelihoods issue for farmers of Ethiopia in general and the study area in particular. The landholding size of the respondents ranged from 0.25 to 5 ha with an average of about 2.17 ha. The majority of the respondents (29.2%) however possessed 0.25 to 0.5 ha, only 5% of the respondents were possessed more than 1.5 ha of land. This result is similar with the finding of (Tamiru *al.*, 2018) who reported that about 28% of the sample households have a farm size of 0.1-0.5 hectare. However, (Alemu *et al*, 2019) reported an average land holding size of 3.37 ha, which is by far larger than the 2007 national average of 0.85 ha. In addition to crop production, livestock rearing is the other major agricultural activity undertaken predominantly in the study area. Livestock is used for various purposes in the study area including plough power, milk, meat, eggs, transport and other purposes. The maximum livestock holding for the respondents were 37 and the minimum was 0 with an average livestock holding 4 per HH (Table 6).

Table 7: Demographic characteristics of HHs

Item description	Option	Frequency (N= 120)	percent
sex	Male	108	90
	Female	12	10
Marital status	Married	113	94.2
	Single	7	5.8
Education level	Not read and write	15	12.5
	1-4	21	18.3
	5-8	66	55
	9-12	18	14.2

4.4.2 Farmers perception on the soil erosion and physical SWC practice

Most of the respondents indicated that they perceived soil erosion problem in their farm land (Table 8). Regarding signs with which it can be identified, they rightly mentioned visible erosion features such as sheet, rills, gullies and landslides. This is in agreement with Meshesha and Tripathi (2016) who reported the same results for Beressa watershed Ethiopia Bewket (2003), also reported 98.4 % of the surveyed farmers recognized that soil erosion was a problem in their own farm. During focus group discussions, farmers also mentioned that even if the degree of erosion differs from plot to plot due to management practices and slope category they agreed on occurrence of soil erosion in the watershed. With regard to causes of soil erosion, in their day-to-day activities, men have caused soil erosion problems. Their interaction with the natural environment resulted in the loss of precious topsoil that contains important minerals for plant growth, water holding capacity of the soil and ultimately leads to reduced crop yields (Kediro, 2015). Some farmers have a clear idea of why they have been facing erosion problems; whereas others only have general ideas rather than detailed causes of erosion. They asked to indicate about the prominent causes for the problems and they mentioned free grazing (36.7 %), over cultivation (32.5 %), cultivation of steep slopes (17.5 %), and deforestation (13.3%) of the respondents. This result support the findings of (Mengstie, 2009) who reports Thirty six percent of the sample farmers believed that free grazing was the most important cause of soil erosion. Free grazing got the larger value because in the study area, livestock were feed 100 % free on individual and communal land which might exacerbate the degree of soil erosion which was in contrast with the result reported by (Merkineh *et al.*, 2018) who reported poor agricultural practices as the leading causes of soil erosion at Kindo Didaye district, southern Ethiopia. However, most of the respondents considered that combination of two or more factors were being used as the causes of soil erosion.

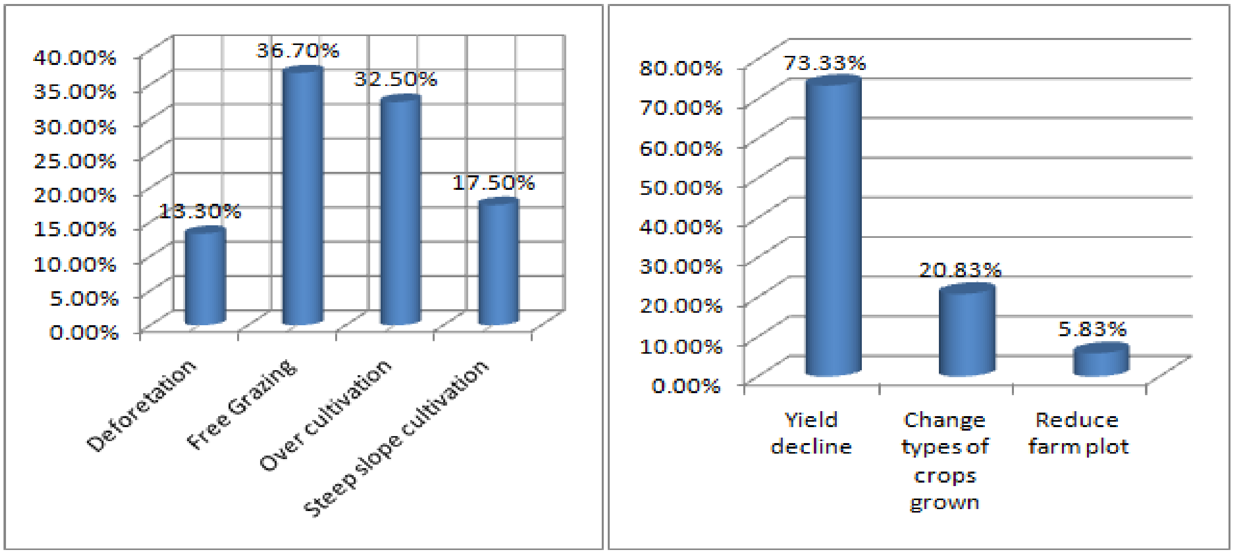

Figure 5: Farmers' response to causes and effects of soil erosion in the study area

Farmers also asked for the severity of soil erosion in their farm plots and 76.7 % of the respondents were answered as severe, 22.5 % as medium and only 0.8 % of the house hold were perceived as low (Table 8). The results support the findings of (Zerssa *et al.*, 2017) reported as almost half of the farmers rated the extent of the problem as sever and some respondents mentioned that the rate of soil erosion has been increasing over the time while small number of respondents believed that the extents of erosion were minor.

Table 8: Farmers perception on soil erosion as a problem

Farmer's response to	option	Frequency	Percentage (N= 120)
Is there soil erosion on your farm plot	Yes	120	100
	No	0	
Severity of soil erosion	medium	27	22.5
	Severe	92	76.7
	Low	1	0.8
Severity over the past five yrs	More severe	9	7.5
	Medium	74	61.7
	No change	37	30.8
Can soil erosion be controlled	Yes	115	95.8
	No	5	4.2
Do you know existence of SWC structures	Yes	113	94.2
	No	7	5.8

Erosion reduces infiltration rate and water holding capacity of the soil, as well as a loss of plant nutrients which ultimately results reduction in productivity. Concerning the consequence s of soil erosion the opinion of the farmers on the impact of soil erosion on farm production was almost evenly divided between yield declines (73.33 %), Change types of crops grown (20.83 %) and reduces farm plots (5.83 %) (Figure, 5)

4.4.3 Farmers participation on physical soil and water conservation practices

The participation of different actors at different phases of SWC practices enhances the possibi lity of achieving sustainable SWC outcomes. In the study area, almost all farmers agreed that, SWC practice were very helpful for erosion control and better to improve soil productivity. The physical SWC practice, mainly soil bund and Fanya juu, have been practiced by integrati ng them with multipurpose biological measures such as vetiver grass. Soil bunds were constructed through community mass mobilization by technical support from development agents and woreda experts. Menschen fiir Menschen NGO were mainly focused on fanya juu. More than 95.8 % of the respondents were agreed that they were participated on physical soil and water conservation practices during the last seven years. However, around 68.3 % of the respondents were not actively participated in to SWC practice this year as community mass mobilization because of security problem around the wolega area. But 31.7% were constructe d soil bund on their farm plots by the supports of Das (Table 9). Regular maintenance and management of the implemented SWC practice should be done for its sustainability in the area. However, field observation during the transect walk indicated that, there wasn't regular maintenance and management of once implemented structures. Majority of respondents (90.8 %) agreed that there was no maintenance and management activity once the structures were constructed. The results agree with (Mekuriaw *et al.*, 2018) that many farmers of the high-potential areas have not maintained physical SWC structures. But this finding is in contrast with (Meshesha *et al.*, 2018), who reported majority of the respondents (56.57 %) maintained soil and water conservation structures.

Table 9: Farmers' participation on SWC measures

Item description	option	Frequency	Percent
Did you participate in SWC practice during the last seven Years?	Yes	115	95.8
	No	5	4.2
Did you participate in SWC practice this year?	Yes	38	31.7
	No	82	68.3
Did the structure maintained?	Yes	11	9.2
	No	109	90.8

4.4.4 Soil and water conservation practice in the study area

Farmers of the study area use different types of SWC structures including soil bund, fanya juu, cutoff drain, stone and wooden check dams, planting different types of tree. 48.3 % of the interviewed farmers tried to implement conservation structures in their plots, while 51.7 were not tried any of the conservation practice on their farm plots. From those constructed SWC structures, 34.5 % was soil bund, 24.1 % was fanya juu, 19.2% was stone bund and the rest is 22.2 %. The development agents and some farmers stated during the survey that Fanya juu was introduced on a few farmers' land, but most of it failed or was broken shortly after construction, owing to the nature of the structure, and its liability to damage on steep land and high rain fall area. Moreover, farmers were also asked to compare the problem of soil erosion in their farm plots after conservation structures were built; accordingly, the majority of them (69.2 %) confirmed that soil erosion rate had decreased after the implementation of different types of conservation structures. However, 0.8 % and 30 % of the respondents were perceived as aggravated and no change respectively. More than half of the interviewed farmers (67.5 %) were agreed that implemented soil and water conservation structures had the potential to improve land productivity and increase yield. This result are generally supported by the finding of (Meshesha *et al.*,2018), who reported that soil and water conservation practices improved soil fertility of their farmland, increased water holding capacity of the soils, reduced runoff and erosion and increased land productivity at Akusti micro watershed, northwest Ethiopia. However, 31.7 % of the respondents were never seen any of change on their farm plot and crop yield and 0.8 % perceived as reduced yield.

Table 10:Soil and water conservation practice in the study area.

Farmers response to	Option	Frequency	Percentage
Whether SWC structures exist on farmers farm plot	Yes	58	48.3
	No	62	51.7
If yes for the above what are their types?	Soil bund	41	34.5
	Stone bund	23	19.2
	Fanya juu	29	24.1
	Others	27	22.2
Problem of soil erosion after SWC measures	Aggravated	1	0.8
	Reduced	83	69.2
	No change	36	30
Productivity after SWC measures	Increased	81	67.5
	Reduced	1	0.8
	No change	38	31.7

4.4.5 Problems of SWC practices in the study area

Although there had been great efforts on SWC practice in Africa including Ethiopia, land degradation especially soil erosion is still escalating from time to time. This can be attributed to the inappropriateness of conservation practices, inefficiency of experts, lack of awareness of farmers, land tenure relationships and the like(Kediro, 2015). Focus group discussion result revealed that, more than 85% of physical soil and water conservation was implemented starting from December 15. In other way December is the intensive harvesting season in the study area, Hence, the SWC measures implementation program was overlapped with the intensive harvesting seasons in the area. In this regard, all respondents complained about the timing of SWC measure implementation. During key informant interview, development agents (DAs) confirmed that during planning soil and water conservation intervention, top-down approach was pursued where woreda office of agriculture and natural resources tell them what they are going to do and the opportunity for the farmers and DAs in participating all level of the intervention was rare.

Table 11:HHs response on problems of SWC structures

Problems	Farmers response to the problem	
	Frequency	Percentage
Reduce the size of farm land	23	19.2
Difficult to turn oxen	31	25.8
Labor intensive	43	35.8
Difficult to implement technically	23	19.2

Farmers in the study area asked to rank from the listed problems of physical SWC structures including soil bund, fanya juu and stone bund and they revealed as 35.8% labor intensive, 25.8 % difficult to turn oxen, 19.2 % difficult to implement technically and 19.2 % told the structure reduces the size of their farm plot (Table 11). This result is supported by (Simeneh and Getachew, 2015), who reported as from the interviewed farmers, majority reported that some conservation measures like bunds, cut of drain and water ways were difficult to tillage, need much labor, need incentives to implement, difficult to implement and reduce farm size.

4.4.6 Factors affecting the adoption of SWC practices in the study area

To identify the major factors that determine household heads to adopt SWC practice/ whether soil and water conservation structures were exist on their farm plot, dependent variables were analyzed with 10 explanatory variables by using binary logistic regression model.

Here logistic regression was used because the dependent variables (adoption of SWC practice) are categorical, i.e. a value of 1 is given if the farmer was an adopter of SWCP and or 0 for a non adopter of SWCP. Among the hypothesized explanatory variables, seven variables were found to significantly affecting the adoption of SWC structures and the remaini ng was not significant.

Table 12:Adoption of SWC practice as affected by categorical variables

	Level of Adoption of SWC practices					
	Adopter		Non-adopter		Total	
Sex of HH	N	%	N	%	N	%
Male	55	94.83	53	85.48	108	90
Female	3	5.17	9	14.52	12	10
Total	58	100	62	100	120	100
Marital status						
Single	2	3.45	5	8.1	7	5.8
Married	56	96.55	57	91.9	113	94.2
Total	58	100	62	100	120	100
Labor shortage						
No	34	58.62	13	20.97	47	39.17
Yes	24	41.38	49	79.03	73	60.83
Total	58	100	62	100	120	100
DA contact						
Yes	54	93.1	26	42	80	66.67
No	4	6.9	36	58	40	33.33
Total	58	100	62	100	120	100

Table 13: Adoption of SWC practice as affected by continuous variables

	Level of Adoption of SWC practices					
	Adopters		Non adopters		Total	
	Mean	S.D	Mean	S.D	Mean	S.D
Age	43.36	7.94	38.13	10.89	40.66	9.89
Education level	6.22	3.26	5.46	3.12	5.83	3.2
Family size	5.71	2.27	3.84	2.77	4.74	2.69
Land size	1.88	1.1	2.44	1.17	2.17	1.168
Farm Exp.	25.32	10.49	17.87	10.45	21.47	11.07
Livestock holding	5.3	5.83	3	3.14	4	4.76

Table 14: Result of binary logistic regression model for factors influencing adoption of SWC practices.

	Estimated coefficient(B)	S.E.	Wald	df	Sig.	Odd ratio Exp(B)
Sex	.919 ^{ns}	.906	1.029	1	.310	2.508
Age	.058***	.020	7.913	1	.005	1.059
Marital status	1.857^{ns}	1.082	2.949	1	.086	6.406
Education level	.259**	.112	5.349	1	.021	1.295
Family size	.272**	.138	3.871	1	.049	1.312
Land holding	-.502**	.223	5.054	1	.025	.605
Farm experience	.067***	.019	12.543	1	.000	1.069
Existence of labor shortage	1.380***	.530	6.785	1	.009	3.976
Extension service/DA contact	1.607**	.684	5.521	1	.019	4.988
Livestock holding	-.122 ^{ns}	.086	1.990	1	.158	.886
Constant	-7.375	2.560	8.298	1	.004	.001

Source: SPSS version 20 result output: ns= not significant

*** Statistically significant at 5 % *** statistically significant at 1 %*

4.4.6.1 Demographic factors and adoption of SWC practices

Sex: The binary logistic regression result depicts that household heads sex had no impact in their adoption behavior of SWC technologies. This finding is similar to (Fikru, 2009) who stat es that women have no significant difference with male headed households in the adoption of SWC practices. Demissie (2009) reported no significant relation between household head sex and adoption of SWC measures.

However, significant relationships were reported by (Birhanu, 2016) that there was limited pa rticipation of women in the adoption of SWC practices and had limited access to information. They were highly involved in regular household activities than men.

Age: The age of the household head was highly significantly related to the adoption of SWCP in the study area. This may be due to the fact that older farmers were more aware of the problems of erosion and the importance of soil and water conservation practices. This result is similar with the finding of (Mengstie, 2009) who reported a unit increase in age of HH head increases the adoption behavior of improved SWC structures by a factor of 0.35 %. However,(Wolka and Negash, 2014; Asfaw and Neka, 2017) reported as the age of a farmer increases, the acceptance level about the introduced soil and water conservation practices decreases.

Marital status: From those interviewed households**,** about 94.2 % were married and the rema ining 5.8 % were single. The binary logistic regression result showed that there was no signifi cant relationship between married and single household heads regarding the adoption of soil and water conservation technologies (Table 14). This result was in line with (Mulie, 2012). Who reported that even if it has a positive values sex, and marital status of households did not show significant relation with adoption of SWC practices in Karita wuha watershed.

4.4.6.2 Socioeconomic factors and adoption of SWC practices

Education level: education influences farmers' decision to adopt technologies by enhancing farmers' ability to obtain, understand and utilize the practice, and by improving overall manag erial ability of farmers (Mulie, 2012). In this study, education was found to affect adoption and continued use of soil and water conservation technologies positively at 5 % significance level and increase the probability of use by a factor of 5.3 per additional year of education (Table 15). This implies that education may enable farmers to easily understand and recognize the problem of soil erosion, able to change and put in to practice the knowledge and skill they obtained from extension services and other sources. This result is in line with the finding of (Long, 2003). Tedla (2003) reported that, education enables farmers to tackle land degradatio n using various ways of soil conservation practices and it is significant at 95% of confidence level. However, (Wolka and Negash, 2014) reported negatively and insignificant relationship between farmers education level and adoption of soil and water conservation practice that as the educational level increases, the tendency to seek off-farm employment increases, while attention to the rural lifestyle decreases. Bagdi (2005) confirmed that educated young farmers are more interested in jobs and business, rather than in taking up cultivation as an occupation.

Family Size: This is the number of household members living together. Physical conservatio n practices are labor intensive technologies. Studies conducted in Ethiopia indicated that, for installation of recommended physical conservation measures, about 70 and 50 person days per ha for soil and stone bunds, respectively, were estimated to be required (Bekele and Drake, 2003). As it can be seen from table 15 house hold family size was positively affected the adoption of SWC practices at 5% significant level. Different research findings were also support this result, for instance Bewket (2003) identified lack of interest in SWC practices to be shortage of labor. Bagdi (2005) reported that large family size can provide more help in maintaining and repairing damaged SWC structures. But others mentioned that population growth has brought about land scarcity and land degradation (Mengstie, 2009), according to him large families do not spend their money on conservation practices; rather they spend it for food and other basic necessities.

Land holding size: Land size is negatively and significantly affects the adoption of SWC measures in the study area. As land size increase the adoption probability of conservation structure were decreased. This is because Farmers with large farms have alternative land to plough, and can allow for a fallow period; hence, they may neglect the adoption and maintena nce of SWC structures. This result is supported by the findings of (Wolka and Negash, 2014) at Bokole watersheds southern Ethiopia. However many researchers reported what was in contrast with this in different watersheds of Ethiopia. For instance, according to (Reddy and Melese, 2016)land holding (Farm size) has positively influenced the adoption of SWC practic es. Thus, farmers with small size of land have no initiation and motivation to invest in SWC practices, so that their adoption level is less. Also (Seenga, 2014) reported Adoption of SWC practice increased as farm size increased from less than an acre to more than 4 acres. The intension behind the proponents of this result was that, a large farm size gives the farmer more flexibility in using various technologies than it is for farmers having small land size.

Existence of labor shortage: Labor, in addition to land and capital, is one of the ingredient s for agricultural production. In the study area, farmers mainly depend on family labor for their farm activities and social purposes. Amount of labor available in a household is an important factor in a decision of adoption of soil and water conservation practices (Erkie, 2016). In the study area, the average family size for adopters was 5 which were greater than that of non adopters 3. This indicated that, families having small labor were less adopter than those of large family. During focus group discussion farmers also revealed that labor was one of the major constraints to implement SWC as well as agricultural practices and hence daily labors were required at the peak agricultural period and implementing of physical SWC practices. The statistical analysis showed significant mean difference between the two groups in their total labor size which was supported by the thesis of Beyene and Temesgen (2014) who reported significant relationship between farmers' perception to adopt ISWC technologies and labor availability in Lemo district southern Ethiopia.

Furthermore, according to Haregeweyn *e al.*(2015) the high labor demand required for the implementation of SWC measures was found to be an important bottleneck in several case studies. This result is opposite with the findings of Demissie (2009) who reported no significant relationships between HH labor availability and adoption of SWC practices at Meket Woreda north eastern Ethiopia.

Extension service/DA contact: one of the widely used means of addressing information to the rural part of Ethiopia is public extension service. Development agents(DA) are responsible to disseminating the information for each kebeles to provide extension services(Birhanu, 2016). Having good relation with DAs help farmers to be aware about improved SWC practic es in reducing hazard associated with soil erosion (Beyene and Temesgen, 2014). In the study area, Extension support to SWC technologies had a significant relation at $p \leq 5\%$ as shown in table 15. Having good relation with DA helps farmers in reducing hazard associated with soil erosion and conservation by providing information. Farmers those had access to extension support to SWC technologies like provision of seeds and seedlings and organizing farmers by teams adopted the improved SWC practices than those did not had the access to the above supports. Focus group discussion with selected farmers also revealed that farmers those had opportunity to see good exercise in and outside the district adopted improved SWC practices than those who did not participate in the experience sharing tour. The study indicated that if a farmer receives better information/advice from extension agents, the farmer will be willing to construct new conservation practices and to maintain the existing ones (Bekele and Drake, 2003). Generally extension service is expected to influence farmers' adoption of improved soil and water conservation practices positively in the study area.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

According to this study, implementation of soil bunds and fanya juu can reduce soil erosion problem in farm lands and cause some desirable change on some physicochemical properties of the soil which in turn improves the productive capacity of the land. The laboratory output showed that, except for sand content that showed significant Variation with SWC structures, the rest soil textural fractions, soil bulk density and soil moisture contents were not showed significant difference with respect to SWC practice even if the maximum mean values were observed for soil bund. Regarding the slope effects, soil textural fractions were significantly affected by slope gradients but bulk density and moisture content did not showed any variation with slopes. The laboratory result also showed that, except for available phosphorous, which was not significant with slope and SWC practice, the rest soil chemical properties were statistically significant in relation to conservation structures. However, exclusive of CEC which was significantly affected by slope gradients the other soil chemical properties were not showed variation with slope. Soil properties are relatively better on the conserved farm plots than on the non conserved one. Also, soil organic carbon stock under conserved plots was highly significantly difference from that of not conserved. Conservation measures such as soil bunds and fanya juu were found to be important not only to reduce soil erosion but also to maintain the soil fertility such as soil OM, TN and CEC. This implies that SWC measures positively affected the productivity of agricultural lands.

The third objective for this study was to identify factors affecting the adoption of SWC practic e. To realize the objective, 120 House Hold were randomly selected and interviewed, out of which 48.3% were adopter and 51.7% were non-adopters of SWC structures. The binary logistic regression model was used to estimate the effects of the independent variables on the probability of the household heads to adopt introduced soil and water conservation practices. Adopters and non-adopters of SWC structures differed in some demographic, socio-economic and institutional variables; such as family size, farm experience, availability of labor shortage, farm size, extension visit and total livestock holding between the two groups, which implies the differences in their soil and water conservation practices adoption behaviors. A total of 10 variables were fitted in the logistic regression model. Out of this, Education level, family size, land holding, availability of labor shortage, age, farm experience and extension service were significantly related to adoption of soil and water conservation practices by the farmers. However, variables such as: sex, marital status and livestock holding were not significantly related at conventional level of probability.

5.2 Recommendations

Even though the intervention with soil bund and fanya juu causes significance variation in soil properties within treatments (conserved and non conserved form plot) by minimizing soil loss through runoff, the soil fertility status in the watershed is still very low. Thus should incorporate biological soil conservation measures and other soil management activities to improve the soil.

All soil properties were better at the soil bund therefore, it should be recommended for the study area.

Contact with extension agent influenced the probability of farmers' adoption of physical SWC significantly and positively. Therefore, increasing the quantity and quality of DAs can facilitate adoption of such technologies. Conservation works were done more by farmers who took training and experience sharing tour on improved SWC practices. Therefore Woreda office of agriculture should provide training and experience sharing tour at different levels.

Education level of the household significantly affects the adoption of physical SWC practice in the study area therefore, Provision of education through farmers training centre should facil itate the adoption of improved SWC practices and reduce farm lands degradation.

In the study area SWC initiation was through campaign work with a top down approach, due to this DA's and the communities were not contented with the plan which comes from the woreda office of agriculture and natural resource. Hence, SWC program planning must be the concern of every farmer and the initiation must come from the community. The office of agriculture at local level can only present the technical consideration.

Even though farmers in the study area were well aware of the problems of soil erosion and started using SWC structures in their farm plots, most SWC structures were not regularly maintained. Thus there should be a continuous awareness creation mechanism and DAs follow up process on the proper maintenance of the structures.

Farmers those had large farm size did not invest much on SWC practice. Therefore, the government should promote need based land tenure system. The positive effects of soil and water conservation (SWC) occur through time and practicing of SWC technologies depends on the ability of the technologies to improve economic and environmental benefits. Therefore, further investigation should be done on the environmental and economic effectiveness of SWC practices.

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7. APPENDICES

Annex 1 Analysis of variances (ANOVA) tables.

Annex 1.1.Analysis of Variance for PH

SOV	df	SS	MS	F. Value	P. Value
Replication	2	0.045	0.022	0.47^{ns}	0.633
Slope	2	0.197	0.098	2.07^{ns}	0.158
SWC Structure	2	1.090	0.545	11.48**	0.0008
Interaction	4	0.172	0.043	0.91^{ns}	0.483
Error	16	0.760	0.047		
Total	26	2.265			

*** = Significant at 1% level   ns = not significant*

Annex 1.2.Analysis of Variance for Soil organic carbon (SOC).

SOV	df	SS	MS	F. Value	P. Value
Replication	2	0.139	0.069	0.82^{ns}	0.458
Slope	2	0.332	0.166	1.95^{ns}	0.174
SWC Structure	2	1.694	0.847	9.94^{**}	0.0016
Interaction	4	0.190	0.047	0.56^{ns}	0.6954
Error	16	1.363	0.085		
Total	26	3.718			

*** = Significant at 1% level   ns = not significant*

Annex 1.3. Analysis of Variance for Sand

SOV	df	SS	MS	F. Value	P. Value
Replication	2	58.074	29.037	1.35^{ns}	0.287
Slope	2	400.296	200.148	9.29^{**}	0.0021
SWC Structure	2	178.962	89.481	4.15^{*}	0.0352
Interaction	4	450.370	112.592	5.23^{**}	0.0069
Error	16	344.592	21.537		
Total	26	1432.296			

*Note: ns= not significant ** = significant at 1% * = significant at 5%*

Annex 1.4. Analysis of Variance for Clay

SOV	df	SS	MS	F. Value	P. Value
Replication	2	90.074	45.037	1.60^{ns}	0.233
Slope	2	480.296	240.148	8.51^{**}	0.0030
SWC Structure	2	151.407	75.703	2.68^{ns}	0.098
Interaction	4	693.925	173.481	6.15^{**}	0.0034
Error	16	451.259	28.203		
Total	26	1866.962			

*ns= not significant ** = significant at 1%*

Annex 1.5. Analysis of Variance for Silt

SOV	df	SS	MS	F. Value	P. Value
Replication	2	8.296	4.148	0.71^{ns}	0.504
Slope	2	33.185	16.592	2.85^{ns}	0.087
SWC Structure	2	10.963	5.481	0.94^{ns}	0.410
Interaction	4	80.593	20.148	3.46^{*}	0.032
Error	16	93.037	5.814		
Total	26	226.074			

*= 5% significant level.

Annex 1.6Analysisof Variance for (TN)

SOV	df	SS	MS	F. Value	P. Value
Replication	2	0.0002	0.0005	0.79^{ns}	0.469
Slope	2	0.002	0.0012	1.94^{ns}	0.176
SWC Structure	2	0.012	0.0063	10.01^{**}	0.0015
Interaction	4	0.001	0.0003	0.56^{ns}	0.697
Error	16	0.010	0.0006		
Total	26	0.0252			

**= significant at 1% ns = not significant

Annex 1.7.Analysis of Variance for (AV.P)

SOV	df	SS	MS	F. Value	P. Value
Replication	2	0.427	0.213	0.57^{ns}	0.575
Slope	2	2.065	1.032	2.76^{ns}	0.093
SWC Structure	2	0.327	0.163	0.44^{ns}	0.652
Interaction	4	7.960	1.990	5.33^{**}	0.0064
Error	16	5.978	0.373		
Total	26	16.759			

**= 1% significant level   ns= not significant

Annex 1.8.Analysis of Variance for (CEC)

SOV	df	SS	MS	F. Value	P. Value
Replication	2	36.272	18.136	2.55^{ns}	0.109
Slope	2	91.389	45.694	6.42^{**}	0.0090
SWC Structure	2	58.523	29.261	4.11^{*}	0.0363
Interaction	4	199.946	49.986	7.02^{**}	0.0018
Error	16	113.928	7.1205		
Total	26	500.059			

**= 1% significant level *= 5% significant levels ns= not significant

Annex 1.9. Analysis of Variance for (BD)

SOV	df	SS	MS	F. Value	P. Value
Replication	2	0.001	0.0005	0.04 ns	0.9633
Slope	2	0.041	0.0208	1.53 ns	0.2467
SWC Structure	2	0.043	0.0216	1.59 ns	0.2354
Interaction	4	0.009	0.0023	0.17 ns	0.9483
Error	16	0.218	0.0136		
Total	26	0.313			

ns= not significant

Annex 1.10.Analysis of variance for (MC).

SOV	df	SS	MS	F. Value	P. Value
Replication	2	0.265	0.132	0.04 ns	0.9653
Slope	2	11.023	5.511	1.47 ns	0.2584
SWC Structure	2	7.569	3.784	1.01 ns	0.3855
Interaction	4	4.275	1.068	0.29 ns	0.8828
Error	16	59.816	3.738		
Total	26	82.950			

ns= not significant

Annex 1.11.Analysis of Variance for soil carbon stock (CS)

SOV	df	SS	MS	F. Value	P. Value
Replication	2	164.016	82.008	0.62 ns	0.5483
Slope	2	820.857	410.428	3.12 ns	0.0716
SWC Structure	2	1843.869	921.934	7.60**	0.0031
Interaction	4	400.741	100.185	0.76 ns	0.5649
Error	16	2102.764	131.422		
Total	26	5332.248			

**= 1% significant level   ns= not significant

Annex 2. Survey Questionnaires on farmers' adoption of physical SWC practices

Master's thesis Survey

Sirna Gadisa Denu

Jimma University

1. General information

1.1) Respondent name: --------------------

1.2) Sex: 1) Male 2) Female

1.3) Age ________ years

1.4) marital status: 1) Single 2) Married 3) Divorced (separated) 4) Widow

1.5) Social position in the kebele 1) Member of kebele council 2) Religious leader

3) Others specify __________________4) none

1.6) Education level ________________grade

2. Household Characteristics

2.1) Household family size: Male--------- Female------------ Total-------------

Age, 0-15yr_________ 16-64yr__________ Greater than 64 ________

Education, 0 grade____ 1-4___ 5-8____9-12___ B.Sc degree___ Above_____

3) Landholding size in hectare

1) Less than 0.25 2) 0.25-0.5 3) 0.5-1 4) 1-1.5 5) 1.5-5 and above

4. Description of farm plots

1. Major types of crops grown:----------------,-----------------,--------------,------------------

2. Average fertilizer use in Kg --------------

3. Seed types used: 1) local seed 2) improved seed

4. Plot fertility: 1) High 2) Medium 3) Low

5Yield in kg -----------------

6 Degree of erosion problem on the plot: 1) High 2) medium 3) Low

7 No of years since plot is used-------------------

8 Presence of at least one types of improved conservation structures: 1) Yes 2) No

9 If question No 8 is yes what types of SWC structures are there? -----------------,----------------,-----------------------,--------------------------------,------------------------ and How was these structures are constructed? 1) By community mass mobilization 2) By family/Hired labor 3) by NGOs

10. Do improved SWC structures maintained: 1) Yes 2) No

11 Who did the maintenance work? 1) Community participation 2) family 3) others

12 How do you compare the problem of soil erosion in your farm plot after SWC structures were built? 1) Aggravated 2) reduced 3) no change

5) Labor Availability

5.1) Do you have labor shortage for your farm activities? 1) Yes 2) No

5.2) if the answer to question 5.1 is yes, how do you solve labor shortage?

1) Hiring labor 2) By cooperating with other farmers

3) Others, specify_______________

5.3) if labor is hired what type of labor do you hire? 1) Casual 2) permanent 3) both

5.4) Can you easily get labor whenever you need? 1) Yes 2) No

5.5) which family members participate in soil and water conservation works?

1) Men 2) women 3) Children 4) all of them participate

6) Perception of soil erosion problems

6.1) Do you think that soil erosion is a problem for your farm plots? 1) Yes 2) no

6.2) rank to the following major causes of soil erosion in your area?

1) Deforestation ____________ 2) Over grazing ____________

3) Over cultivation _________ 4) Poor agricultural practices ________

5) Cultivation of steep slopes _______ 6) Excess rainfall _________

7) Poor government polices _________ 8) others (specify) ___________

6.3) what do you think is the consequences of soil erosion?

1) Land productivity (yield) decline 2) Change in type of crops grown

3) Reduces farm plot size 4) all 5) 1&3 6) others (specify) ________

6.4 Farmers' perceptions of soil erosion hazards

1. Perception on erosion

Whether soil erosion was perceived as a problem in own farm: Yes No

2. Severity of the problem, if yes to the above question: Severe Medium Moderate
3. Observed change in soil erosion severity over the past 5 years: 1,more severe 2,less severe 3,No change
4. Extent of impact of soil erosion on farm production: Severe Moderate has no effect
5. Believing that soil erosion can be controlled: Yes No

7) Soil and water Conservation technologies and farmers' attitude

7.1) Do you know the existence of improved soil and water conservation structures?

1) Yes 2) No

7.2) If yes, which type do you know?

1) Stone bunds 2) Soil bund 3) Cutoff drain 4) Water way 5) Fanya juu 6) Planting of d/t tree

7.3) what is your source of information?

1) Neighboring farmers 2) Extension agents (DAs) 3) NGOs 4) From field days and Trainings

5) Others, specify____________

7.4) which of the following types of soil and water conservation measures are efficient to reduce the problem of soil erosion?

1) Stone bund 2) Soil bund 3) cut off drain 4) Water way 5) Fanya juu 6) Planting of d/t trees

7.5) Have you participated in community conservation activities this year?1) Yes, 2) No

7.6) did you undertake the maintenance work by your own? 1) Yes 2) No

7.7) if no, what were the reasons for not doing?

1) I have shortage of labor 2) Lack of skill and knowledge

3) Conservation structures were built without my knowledge and willingness

4) I expect the land will be transferred to other farmers

5) There was no need for maintenance

7.8 Do you believe that investment in soil and water conservation practices is profitable in the long run? 1) Yes, 2) No

7.9) if the farmer did not use any improved conservation structures in all his plots, why you did not use it?

1) No problem of soil erosion 2) Shortage of labor

3) Expecting that the structures will be done by financial incentives

4) I feel that the land belongs to the government and it is the duty of the government to maintain the land 5) it reduces farmland 6) Due to problems of rodents and others pests

7) I did not get extension service 8) others, specify

7.10) what are the problems related to each soil and water conservation structures? Hint, choose from 1-5

Problems	Soil bund	Fanya juu bund	Stone/wooden check dams	Plantation
2.Reduce farm land				
3. Difficult to turn oxen				
4. Labor intensive				
5.Difficult to implement technically				

8. Tenure arrangement

8.1) whom do you think land belongs to?

1) My own 2) the government 3) Other____________

8.2) Do you think that you have the right to inherit the land to your children? 1) Yes 2) No

8.3) Do you expect that you will use the land throughout your life time? 1) Yes 2) No

8.4) Do you agree if the government allows the farmers to sell their land?

1) Agree 2) Disagree 3) Difficult to decide

8.5) have you rented in land before? 1) Yes 2) No

8.6) If yes, who is responsible for keeping the rented land quality?

1) The owner 2) Myself 3) both of us 4) NA

8.7 Are your plots all registered? 1) Yes 2) No

8.8 If yes, did you get certificate for all plots? 1) Yes 2) No

9) Institutional Support

9.1) Do you get extension service? 1) Yes 2) No

9.2) If yes, who provides the extension service?

1) Development agents (DAs) 2) NGOs 3) All 4) Others, specify ___

9.3) how often you have been visited by DAs last year?

1) Once per month, 2) Twice per month, 3) Three times per month 4) others, specify --------

9.4) how often you have obtained extension advice on soil and water conservation practices

1) Once per month 2) twice per month 3) Three times per month 4) Once per three months 5) Twice per three months 6) others, specify____________________

9.5) Have you participated in training of soil and water conservation for the last five years?

1) Yes 2) No

9.6) If yes for how many days? __________

9.7 Was the training useful? 1) Yes 2) No

9.8 Do you participate from access of Credit? 1. Yes 2. No

10) Wealth status of the respondents

10.1) Livestock

S. No	Types of live stocks	In number
1	Cattles	
2	Small Ruminants	
3	Equines.	
4	Chicken	

10.2) how was these livestock feed 1) Open grazing 2) cut and carry

10.3) how pasturelands are owned in your area? 1) Individually 2) Communally 3) Both 4) Others_______

Annex 3. Related figures