COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

CONTRIBUTION OF SOIL AND WATER CONSERVATION PRACTICES TO IMPROVE HOUSEHOLDS FOOD SECURITY IN SULULTA *WEREDA*, IN OROMIA REGION, ETHIOPIA

BY

ADDIS ASSEFA

OCTOBER, 2020

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OCTOBER, 2020

ADDIS ABABA

Adviser's Approval

Under my guidance and knowledge, the researcher has done the thesis entitled Contribution of Soil and Water Conservation Practices to Improve Households Food Security Sululta *Wereda*, in Oromia Region, Ethiopia. I evaluated the thesis and certify its submission for public defense.

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STATEMENT OF THE AUTHOR

First, I declare that this thesis is my original work, and that all sources of materials used in this thesis have been duly acknowledged. This thesis has been submitted in fulfillment of the requirements for the Msc degree at Addis Ababa University, College of development studies, and department of food security.

I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of the source is made.

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Abstract

The objective of this study was investigates the contribution of Soil and Water Conservation (SWC) and its impact on food security Sululta *wereda*, in Oromia region. The necessary data were generated principally from primary and to some extent secondary sources. The primary data was obtained through household surveys with 120 households from the three kebeles using a systematic sampling method, focus group discussions, key informant interviews and field observations. Descriptive statistics and econometric models were used. In this regard, multinomial regression model was put in place to explore determinants of participation on soil and water conservation practices. Eventually, ordered logistic regression was deployed to examine the impact of watershed management interventions through soil and water conservation on agricultural production and food security status of households. The result indicated that SWC showed positive impact on agricultural productivity and food security. SWC measures traditional water-ways, traditional ditches, contour ploughing, reduced tillage, intercropping, soil bunds, terraces, cut-off drains and waterways were significantly related to productivity. Moreover, the results of the study shows that households participating on all conservation practices are better to be food secure. According to the multinomial logit results, SWC measures are positively related with sex of the household head, education, family labor, farming experience, chemical fertilizer, and distance from home to nearby market, extension services. But age, family size, land size, land certificate and market access has negative and significant relation. Increased infrastructures, services and effort along with both the traditional and introduced SWC conservation activities are key recommendation in improving production efficiency and food security are stemmed out of the study.

Key words: watershed, Soil and Water conservation, Soil productivity, food security, Econometric model, Sululta, Ethiopia

Acknowledgement

I have received great support from different institutions and individuals during my Masters study. My sincere gratitude goes to my advisor Dr. Meskerem Abi for accepting me as her student and for her support through the entire study, valuable guidance and advice, her continued support and encouragement during the field research, write-up and her review of my thesis.

My thanks also go to Dr. Amare Bantider for his guidance during the study. My sincere thanks go to Sululta Wereda Urban and Rural Development Agriculture Office and DA experts for their data collection assistance in bringing out this thesis. I would also like to extend my sincere thanks to the Mr. Yared Kassahun for providing me with equipment, for his all-round support and motivation.

I would like to extend my deep thanks to my family. It was really difficult to accomplish my study in the absence of their support and motivation. I am also grateful to my father Assefa Ayalew, who laid the foundation for my schooling.

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Acronyms

CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organization NoU Number of Undernourished
GRFC	Global Report on Food Crises
HDRP	Humanitarian and Disaster Resilience Plan
IWMI	International Water Management Institute
MERET	Managing Environmental Resources to Enable Transitions
ODI	Overseas Development Institute
SFSN	State of Food Security and Nutrition
SWARDO	Sululta Weredas Agricultural and Rural Development Office
SWC	Soil and Water Conservation
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WFP	World Food Programme
WHO	World Health Organization

Chapter One: Introduction

1.1 Background of the Study

Rainfed agriculture has been the main economic activity and source of livelihood for a great majority of the population. Agriculture is concentrated in the highlands that represent 43% of the national territory. The highlands comprise of 95% of the cropped area, 85% of the total population and two-thirds of the total livestock. Most of the agricultural production is for meeting subsistence requirements (Aklilu, 2006; Gedefaw et al., 2018). However, land degradation remains a major challenge to the development of agriculture and food security. Particularly, the highlands suffer severe rates of land degradation due to soil erosion and nutrient depletion over the last decades (Aklilu, 2006; Gedefaw et al., 2018). Besides, land degradation in the form of soil erosion and excessive runoff is a major threatening and determinant factors for food insecurity (Global Report on Food Crises (GRFC), 2019). It results in loss of soil fertility, reduction of crop yields and thereby increase the risk of food insecurity (Tadele et al,, 2014; Nigatu, 2017; Agidew and Singh, 2018). In addition, land degradation is the main drivers of food insecurity and pressed another 29 million people into the situations of acute food insecurity in 2018; most of these individuals are in Africa (FAO and UNCCD, 2019).

Mitigation of land degradation is a pivotal factor for increased water productivity and for preserving both terrestrial and aquatic ecosystems and their accompanying services that are so central to livelihoods and food security (Bossio and Geheb, 2008). According to Overseas Development Institute (ODI) (2017), water-related interventions contribute to the economic growth and risk reduction through improved natural resource management in food-insecure communities. Hence, improving food security through watershed management, including soil and water conservation (SWC), needs higher attention (Bossio and Geheb, 2008; TerrAfrica, 2009). Watershed management has a positive impact on natural resource conservation, crop-livestock production and productivity, socioeconomic conditions and livelihoods (Gebregziabher et al., 2014).

Soil and water conservation (SWC) practices have been initiated in Ethiopia during the 1970s and 1980s. The main intent of the initiatives was to minimize erosion, restore soil fertility, rehabilitate degraded land, and increase agricultural productivity. Conservation programs were reviewed in different phases by considering their success. Since the 1990s, the implementation of SWC measures has been an integral part of agricultural extension packages. Community-based watershed management approaches and a nationwide 30-day public campaign (community mass-mobilization) for watershed management have been implemented since (Belayneh et al., 2019).

According to the International Water Management Institute (IWMI) (2018), the total investment in SWC in Ethiopia from 1995 to 2014 is more than USD 1 billion per year. This is still below the recent estimates of economic losses due to land degradation, projected to be USD 4.3 billion per year (Gebreselassie et al. 2016). In the different regions of Ethiopia, most SWC practices are implemented. For instance, farmland terrace, hillside terrace, waterways and cut-off drains, area enclosure, check dams and moisture conservation structures have been carried out in Oromia region over the last 10 years (2005-2014) (Adimassu et al.,2018).

Moreover, Gadisa (2016) and Tesfaye et al., (2018) reported that SWC achieved limited success in Ethiopia. For instance, working quality, strengthening awareness creation and capacity building, real community participation, benefit sharing between and among upstream and downstream community are limited. This is due to the fact that all attempts made to alleviate the problems are not fully based on the agro-ecological, socio economic and topographic variability considerations (Genene and Anteneh, 2015). Likewise, limited involvement of farmers in planning SWC practices, in appropriate application of SWC techniques, in adequate research support and poor technical understanding of field technicians limit successful implementation of SWC practices in Ethiopia (Worku and Tripathi, 2015). Morever, Tesfaye et al. (2018) show that limited sense of responsibility over assets created; inadequate policies lack of integration among stakeholders, unmanageable planning units and evaluation techniques limit the successful implementation of SWC in Ethiopia. Nevertheless, the success rate of watershed management interventions through SWC varies in both space and time due to diverse social and biophysical settings. This implies that watershed management needs careful analysis of the social and environmental dynamics to successfully address livelihood and conservation concerns (Gebregziabher et al., 2016; Alemmeta et al., 2018).

Moreover, Gebregziabher et al. (2016) show that watershed management has a positive impact on natural resource conservation, crop-livestock production and productivity, socioeconomic conditions and livelihoods. It enables the creation of small-scale irrigation projects for farmers working in watersheds or farmers who are also benefiting from improved water availability. A better water availability helps to create the conditions necessary for longer growing seasons and the cultivation of a variety of fruits and vegetables. Similarly, a study by Merkineh et al. (2017) revealed that watershed management increases soil fertility and land productivity. Also SWC practices allow households to diversify their crops which increase timing of crop harvest and consequently increase the spatial availability of crop products. This, would in turn, increases the products to be sold and boost income of households (Chot et al., 2019). A study of Derege et al. (2018) revealed that the living conditions and purchasing power of the farmers increased after the implementation of SWC practices. It helps to maintain seeds and reduce removal of top soil, seeds and fertilizer by erosion that in turn increased their crop harvest and able to buy the necessary materials by selling of the farm out puts. Also, in some watersheds, the risk of crop failure due to moisture stress and climate shocks has reduced.

Furthermore, Enyew et al. (2012) and G/Mariam et al. (2015) revealed that watershed management increases grain yields, milk yield of local dairy cow and improves the annual household income of beneficiaries. Some households are benefiting from increased grazing for their animals, generating a valuable and steady source of income (Farm Africa, 2015). The implementation of SWC practices improve fodder availability which provide high nutritious feed for livestock and thus sales of livestock and their products increase the amount of income earned by the household. Hence, it improves farm incomes and food security of the households who practiced it because watershed management through SWC have reduced soil erosion and consequently improve soil quality which creates a better medium for crops growth. However, there is still a gap in the evaluation of the extent to which SWC interventions contributes to improve household food security. This study therefore aimed to assess the contributions of watershed management to improve food security of smallholder’s.

1.2 Statement of the problem

Among many natural resources, the soil and water resources are degrading quickly in Ethiopia. However, improper land use management and extensive farming systems, with no or less preventive measures or poor watershed management are very common in the country (Nigatuet al., 2017; Melku et al., 2019; &Ermias et al., 2019). Land degradation is a severe problem in Ethiopia (Tamrat et al, 2018). Soil loss through water erosions is affecting the economy of communities in rural areas. The problem is due to mismanagement of land and poor agricultural practices (Semu, 2018). Likewise, low agricultural productivity is severe in the rural parts of the country that constitutes 95% of the cultivable area (Alemu et al, 2019). Productive land is exposed to degradation and threat both economic and survival of the people (Genene and Abby, 2014). The country has remained poor, depending totally on natural resources (land and vegetation) for its livelihood. Overexploitation, mismanagement, and natural disasters, natural resources (vegetation, soil, and water) were the causes of low and in many places declining agricultural productivity and continuing food insecurity and rural poverty in Ethiopia (Haregeweyn et al., 2005; Tsegaye et al., 2012). The ever-increasing land use change is aggravating the rates of soil erosion, soil fertility reduction, crop yield decline, and food insecurity (Million et al, 2019).

In Ethiopia, the agriculture sector in particularly has been identified as vulnerable to land degradation (Belay, 2016). According to Bezu &Tezera, (2019), the severity of land degradation process makes large areas unsuitable for agricultural production because the topsoil and even part of the sub-soil in some areas have been removed, and stones or bare rocks are exposed at the surfaces. The World Bank report (2019) also shows that about 27 million hectares (ha) of land are extensively eroded in the country. Similarly, Pereira et al (2020) suggested that a minor loss in top-soil can substantially reduce the productivity of the soil. In Ethiopian soil erosion is a serious problem, with estimating annual losses of topsoil to amount to 1.5 billion tons, costing Ethiopia an estimated 1–1.5 million tons of grain annually. Efforts are being made to avert the degradation, but with very little progress (Paulos, 2019).

However, in Ethiopia watershed management has a positive impact on natural resource conservation, crop-livestock production and productivity, socioeconomic conditions and livelihoods. It has improved farm incomes by an average of 50%, food security by 56%and in some watersheds reduced the risk of crop failure due to moisture stress and climate shocks by up to 30% (Gebregziabher et al., 2016).Lack of technical advice and information to support the selection of interventions suitable for the local context; uncoordinated interventions, institutions and actors within a watershed; and, importantly, the uneven distribution of the water management costs and benefits several challenges were threaten the success of watershed management **(**Gebregziabher et al., 2016). Evidences indicate that the SWC measures did not bring a net increase in crop yield and biomass production. By contrast, another case study by Adgo et al. (2013) reported that SWC measures have long-term benefits to smallholder farmers. An assessment of the effects of stone bunds on crop yields and farm profitability based on on-farm showed that investment in stone bunds yielded a 50% rate of return (Nigussie et al., 2015).

Various empirical evidences show that implementation of SWC structures are difficult, due to lack of integration, biophysical measures ,absence of integrating indigenous practices, negative impacts of incentives ,lack of considering socio economic profile ,low participation of farmers ,poor conservation design, improper land use ,less maintenance, weak monitoring and evaluation of soil and water conservation are the major constraints that determine the implementation of SWC in Ethiopia (Genene and Wagayehu, 2010; Nigatu et al., 2017; Tamiru et al., 2016; Genene et al., 2014 and Kassaye et al., 2018).

A study conducted in Sululta *wereda* indicates that farmers are aware of the impact of soil erosion on their farms and practiced soil conservation interventions (Alemu, 2014). The study shows that farmers in the *wereda* have been using biological and agronomic soil conservation measures either separately or in combination with structural soil conservation measures. However, there is a limited research particularly in Sululta *wereda* conducted on the contribution of watershed management interventions particularly through soil and water conservation intervention. Thus, this study was intended to fill the gap through assessing the contribution of watershed management interventions in improving rural household's food security.

1.3. Objectives of the Study

1.3.1. General objective

The overall objective of the study was to investigate the contribution of soil and water conservation to improve food security of rural households in Sululta *Wereda*, Oromia Region.

1.3.2. Specific objectives

The study was pursues the following specific objectives:

- To identify impact of watershed management interventions through soil and water conservation on agricultural production and food security status of households in the study area.
- To explore determinants of participation on soil and water conservation practices, its impact and food security in the study area.

1.4. Research Questions

The following pertinent research question was addressed in this study.

- Does watershed management intervention in the soil and water conservation have a positive impact on agricultural productivity and food security condition improvement?
- What are the major demographic and socioeconomic factors determining watershed management interventions in the soil and water conservation practices?

1.5. Significance of the Study

Land degradation and soil erosion is responsible for the recurring food insecurity in the *wereda*. However, soil erosion within the study area would have an implication of its impact on food security. Therefore, this study would provide baseline information on the issues of soil and water conservation practice to DAs, agricultural offices, NGOs and policy makers. It will also provide baseline information on the extent of soil erosion risk of the study area to DAs, agricultural offices, NGOs and policy makers. Basically, such information are vital for establishing the past, present condition and predicting the future trends of soil erosion, soil and water resource conservation and the physical resources of in the *wereda*. Furthermore, the research contributes in identifying soil conservation practices in the area and their effectiveness in controlling soil erosion. Therefore, the findings of this study was primarily benefited the local farmers, *wereda* land manager and NGOs, policy makers and NGOs can be benefited from the outcome of the research to improve the SWC practices of the area to equitable to the natural resources.

1.6. Scope and Limitations of the research

This study was conducted in Sululta *Wereda*, Oromia Regional State, Ethiopia. The study focused on the contributions of watershed management (SWC) to households' food security in the selected study area. The study is limited in terms of sample size and area, covered owing to financial and time resources available and Corona disruption when the data was collected.

1.7. Ethical consideration

Letter was received from the graduate school of AAU and approval to carry out the research was granted. Ethical clearance was accepted from Sululta. The questionnaires was administered to the respondents upon obtaining an informed written. Before approval was obtained, the researcher and the research assistants were explained the purpose of the study and respondents were assured of confidentiality of the information they give. To ensure privacy, names and other means of identity was not been used during the data collection.

1.8. Thesis Outline

This research consists of five chapters. The first chapter introduces the background, the statement of the problem, objectives, justification, significance and limitations of the study. Chapter two reviews related literature to the research topic. Methodological issues including the study area description are presented in chapter three. The fourth chapter presents the results of the study and discusses it in comparison with the results of similar studies. The final chapter presents the main findings, conclusions and recommendations made based on the study.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Definitions and concepts of soil and water conservation

Soil conservation can be defined as the combination of the appropriate land use and management practices that promotes the productive and sustainable use of soils and, in the process, minimizes soil erosion and other forms of land degradation (Sanders, 2004). It is about solving the problems of land degradation, particularly accelerated soil erosion. Soil conservation is fundamentally a matter of determining a correct form of land use and management. Likewise, water conservation is defined as any beneficial deduction in water loss, use, or waste; it is a reduction in water use accomplished by implementation of water conservation or water efficiency measures. Improved water management practices that reduce or enhance the beneficial use of water a water conservation measure is an action, behavioral change, device, technology, or improved design or process implemented to reduce water loss, waste, or use. Water efficiency is a tool of water conservation that results in more efficient water use and thus reduces water demand. The value and cost-effectiveness of a water efficiency measure must be evaluated in relation to its effects on the use and cost of other natural resources (E.g. energy or chemicals) **(**Singh, 2016).

SWC refers to activities that maintain or enhance the productive capacity of land in areas affected by or prone to soil erosion. Soil erosion, on the other hand, is the movement of soil from one part of the land to another through the action of wind or water. Thus, soil erosion by water is caused by raindrop impact surface sealing, and crust formation leading to high runoff rate and amount, high runoff velocity on long and undulating slopes, and low soil strength of structurally weak soils with high moisture content due to frequent rains. Soil erosion by wind is caused by lack of vegetation cover, dry pulverized soils, strong wind speeds, and poor land management practices such as continuous tillage and over-grazing (Mati, 2012).

2.2 Land degradation in Ethiopia

Land degradation in the form of soil erosion is not a problem long years ago when the people are fewer in number and living without depleting natural resources as well as erosion was checked naturally. This history is changed at the time of emperor Menillik (Eshetu, 2015). But, Temesgen (2015) mentioned that land degradation in Ethiopia has been going on for centuries. Since then, land degradation is common but little has been done to minimize their impact on productivity. There are several reasons such as shortage of rainfall, pest, soil erosion and week institutional support for low level of agricultural productivity (Eshetu, 2015).

The Ethiopian highland, which covers about 44% of the country's total geographical area and sustains the livelihood of about 87% of the population, is the most eroded physiographical regions in the country (Nigussie, 2012; Temesgen, 2015). A report from the Soil Conservation Research Program (SCRP) indicates that almost 50% of the Ethiopian highlands were seriously eroded, while 4% of the highland areas have reached a level of irreversibility that they will no longer give economic productivity in the foreseen future (Gezahegn et al., 2020).Land degradation in the forms of soil erosion and soil nutrient depletion have been considered as among the major factors responsible for the recurrent malnutrition and famine problems in Ethiopia (Gadisa, 2016). This implies that land degradation has reached a severe stage and has become a major root cause of poverty with significant negative impacts on the national economy. It is caused by the interacting effects of different factors such as biophysical characteristics and socio-economic aspects. The immediate consequence of land degradation includes reduction in crop yield which, in turn, resulting economic decline and social stress. Tesfa (2015) indicates that soil nutrient depletion is arising from continuous cropping together with removal of crop residues, low external inputs and absence of adequate soil nutrient saving and recycling technologies

Moreover, the rapidly increasing population in Ethiopia and growing demand posed a greater pressure on land resources, leading to severe soil erosion and land degradation in various parts of the country. On the other hand, historic land use and land cover change in Ethiopia had induced great impact on biodiversity, water resources, forest and local livelihoods of the country. Due to deforestation and permanent removal of other vegetation in Ethiopian highlands before some few years, about 27.5 million ha of the areas show significant signs of accelerated soil erosion, while about 14.5 million ha of land were considered the 'worst affected areas' and were recommended to be abandoned(Tsegaye,2019).

It was also predicted that, erosion could reduce per capita income of highland population by about 30%by 2010. Also, 88% of human population, 60% of livestock and 90% of agriculturally suitable area is found in highland of Ethiopia. However, annual soil loss is 42 tons per hectare per year from cropland, which will remove total of top soil within 100 to 150 years with loss of production is between 1 % to 2%. This indicates thatabout 75% of highlands areas in Ethiopia are estimated to need soil conservation measures if they are to support sustained cultivation. Intense rainfall, low vegetation cover, rugged topography, and anthropogenic factors are thought to be the most important factors contributing to a higher rate of soil erosion in Ethiopia. Deforestation, agriculture land and urban expansion, cultivation in upslope areas, uncontrolled and overgrazing were the major anthropogenic drivers of soil erosion in the highland areas of the country (Gadisa, 2016; Mengie et al., 2017). In addition anthropogenic activities such as slash- and burn agriculture, intensive and uncontrolled grazing, deforestation and burning of biomass and intensive plowing are the main factors which trigger accelerated soil erosion (Gadisa, 2016).

Studies suggested that high rates of soil erosion in Ethiopia is mainly caused by extensive deforestation due to the prevalence of high demand for fuel wood collection and grazing into steep land areas. Ethiopia is a country of great geographical diversity with high and rugged mountains, 20 flat-topped plateau, deep gorges, incised river valleys, rolling plains, a wide range of temperature and rainfall regimes, a variety of agricultural crops and land uses. About 43 % of the country is classified as highland, where most of the populations (about 88 %) carry out mixed crop-livestock agriculture. Deforestation, population growth, 25 overgrazing and use of marginal lands intensify erosion, and the intensification of the agriculture production also results in high erosion rates (Adugna et al., 2015). Also poor farming practice, over cultivation and improper utilization of land are major causes of soil erosion are major causes of soil erosion (Dejene, 2018). The study of Desalew et al., 2017 revealed that soil erosion, caused by remove of crop residue from the field, highly undermines the role of agriculture to alleviate poverty and food insecurity in whole parts of Ethiopia.

Soil erosion still remains a significant problem in large parts of Ethiopia, and it could get worse in the future because of the forecasted increase in population and the occurrence of extreme precipitation events throughout the 21st century (Nigussie et al., 2015). Semu (2018) indicates that Ethiopia face annual yield reduction of 1-2% is estimated due to soil erosion. In decreasing productivity of farmlands and 2 million hectares of land in Ethiopia has been severely degraded. Similar to farmers in the other parts of the country, farmers in Sululta wereda are affected to severe soil erosion problem and very low fertility of the farmland. According to Getachew (2014), in Sululta *wereda* continuous cultivation or absence of fallowing is one of the reasons for the causes of soil erosion and repeated preparation of the land for cropping facilitates the soil easy for soil erosion.

2.3 Food Security in Ethiopia

The most commonly used definition of food security is that of the FAO (2003: 28), which defines food security as "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Ensuring food security in Ethiopia is one of the country's greatest challenges. That nearly one in five Ethiopians required food support during the 2015/16 drought demonstrates a high level of food insecurity as well as a large segment of the population who vulnerable to becoming food-insecure (Cochrane, 2017). It is commonly argued that Ethiopia has made little progress in advancing food security, or that its policies and initiatives are unlikely to achieve this goal. Improvements in responding to extreme food insecurity events have occurred aggregate yields have increased substantially some policies have been effective, such as land certification and water harvesting schemes some extension activities have been relatively successful, such as the introduction of improved crop varieties and there is increasing adoption of some agricultural inputs, such as fertilizer(Cochrane ,2016).

Food insecurity is defined as a situation where people, individuals at times, lack physical and economic access to sufficient, safe and nutritious food needed to maintain a healthy and active life. Household food insecurity results when food is not available, cannot be accessed with certainty in socially acceptable ways, or is not physiologically utilized completely. Food insecurity occurs whenever enough and safe foods are not available or the ability to acquire such foods is limited (Tizita, 2017). In Ethiopia, availability of fresh water as well as food from the harvest of major crops is subject to rainfall variability. Currently Ethiopian government is putting much more effort with a key goal to enable food insecure household to acquire sufficient assets and income (Abebayehu, 2014).

As in other sub-Sahara African countries, Ethiopia is one of the most famine-prone countries with a long history of famines and food shortages that can be traced back to 250 BC (Webb and von Braun 1994). In Ethiopia, food insecurity among the population is widespread. Serious food shortages and high levels of malnutrition continue to affect a large number of people in several parts of Ethiopia. The recent 2002–2003 food crisis has been evaluated to be the result of a suite of political, social, and economic factors rather than only the result of environmental stressors leading to production shortfalls. Frequent droughts are not the only factors contributing to Ethiopia's food security problems (Veen and Tagel, 2011). In 2003, the number of households chronically affected by food insecurity and covered by the food security package program was 49,427. Study revealed that food availability and food self-sufficiency at the regional and district level improved over the period 2000-2008. survey also confirm that the food security package program influencing the household's food security status, indicating the role of government policy instruments as important tools to ensure food security at the household level (Veen and Tagel, 2011).The 2008-09 food price crises demonstrated vividly that access to food can be an even more important factor. This is the case in Ethiopia as well. The impressive growth of the country's main staple grains (5.6% per annum) over the past decade – largely the result of small-scale farmers' expansion onto new land, improved yields and cropping patterns – has been eaten away by population growth (Ayele, 2014).

Food security is still the major concern for Ethiopians. According to humanitarian requirements document, around 3.76 million people in Ethiopia required relief food assistance between August and December 2012. Household food security in Ethiopia is largely determined by factors like rainfall patterns, land degradation, limited alternative livelihood opportunities, and climate change and low levels of rural investment (MoFED, 2006; Ayele, 2014). Low agricultural productivity, poverty, food insecurity, and land degradation are pervasive and interconnected problems in the Ethiopian highlands. Social factors such as population pressure, traditional farming systems and practices, and economic limitations like poor infrastructural services, shortage of farm land and other productive assets, are also factors responsible for households' food insecurity. About 44.2% of the Ethiopian people are under absolute poverty that is unable them to get the minimum required calorie intake due to insufficient food production of rural population from their farm (Fekede, 2015). Also the policy frameworks of the past governments and decades in the country have played a role in exacerbating food insecurity. To summarize, food security is a deep rooted problem in Ethiopia in general. It is a multifaceted issue and its attainment demands integrated policies and technologies that can contribute to increased production and improved food security(Veen and Tagel, 2011).

The severity of food insecurity problem in Ethiopia varies from region to region depending up on natural resources availability. Drought is the only significant cause of chronic food insecurity in Ethiopia. The most affected regions by drought and food insecurity are mainly Tigray, Amhara, Afar, Somalia and some parts of Oromia regions (Tsegamariam and Wakjira, 2019).Food security situation remain stable in most Oromia region due to good harvest and stable grain food price. However food security situation becoming volatile in pastoral and agro-pastoral areas of Oromia region due to water and pasture shortage, rising in prices of cereals and drastic fall in livestock price, especially cattle price in drought affected parts resulted in increased request for relief food assistance by the region (Fekede,2015).

There is continued uncertainty regarding its future development and actual impacts, in particular on the local level. Nevertheless, there is little doubt that Ethiopia will face serious water shortages, soil degradation, more frequent and more severe floods and droughts, deforestation and desertification, with yields reduced by as much as 50% by 2020(Schmidt et al., 2014).

2.4. Soil and water conservation practices in Ethiopia

Soil and Water Conservation has a long history in Ethiopia. It has been applied for centuries and first implemented during the Aksumite Kingdom 400 BC to 800 AD (Haregeweyn et al., 2015). The traditional terrace in Konso was one of the impressive cultural traditions stretching back to more than 400 years. Terracing was developed under traditional agriculture in Tigray and Chercher Highlands (Abebe & Ketema 2019). Soil and water conservation practices exist as indigenous knowledge in some areas of Ethiopia (Woldeamlak, 2006; Schaften, 2012).

However, institutionalized SWC activities in Ethiopia were very localized and insignificant before the mid-1970s. The most widely applied interventions include the use of soil or stone bunds and also include trenches and/or agro forestry in croplands and on slopes and area enclosures on steep slopes in which natural vegetation is protected from humans and livestock, which are enhanced with planting of tree seedlings, stone bunds and check dams in gullies. SWC interventions in the highlands focused both on mechanical and biological measures. The mechanical measures included construction of bunds, terraces, diversion ditches, check dams, micro-basins and hillside terraces. SWC intervention has been widely implemented in the northern highlands, which cover large areas. A different SWC intervention has been widely implemented on farmlands (Schaften, 2012). Most farmers are taking various measures to control soil-water erosion in the study villages. In Sululta wereda, the SWC technologies under implementation were physical structures: soil bunds, stone bunds, cutoff drains, check dam, waterway and biological measures. Stone bunds are generally quite common in the dry zones of the tropics, since they are relatively easy to construct during the dry season. The Stone bunds retain or slow down run off and hence control erosion. In the study area farmers prefer this type of structural soil conservation measures soil bunds and cutoff drains is practiced as effective methods of erosion control. A cutoff drains prevent loss of seeds, fertilizers, manure and soil due to water flowing onto the plot from uphill. Check dams for the gully control may be made of stones, soils or brush-woods. In the study area stone is hardly enough to make check dams. Diverting runoff from cultivation field to the main and community road is very common in the study area. Other method of controlling soil erosion in the study area is waterways. This method can receive diverted runoff from cutoff drains in upper slope. The waterway carries the excess runoff to rivers, reservoirs, or gullies safely without causing more erosion damages (Getachew, 2014).

However, the rate of adoption of the interventions is considerably low due to space occupied by SWC structures, impediment to traditional farming activity, water logging problems, weed, and rodent problems and huge maintenance requirements are some of the reasons that cause farmers refrain from implementing SWC measures (Abebe & Ketema 2019). They are less effective to control resource degradation (Temesgen, 2015). It was achieved only limited success due to its failure in addressing to the problems of local people. The prominent reasons assigned were lack of community participation, ignoring indigenous knowledge, adopting top down approach and poor institutional collaboration (Tesfa and Tripathi, 2015). According to the research finding large household sizes, adequate labor, old age, and their income source, farmers' experience, educational, gender, lack of training, government policies and strategies and physical factorshave been the major influencing factors for participating in SWC activities(Nigatu et al., 2017; Dejene, 2018).

In 1970, soil and water conservation division was established under the Ministry of Agriculture. After the drought it was gave a greater emphasis on soil and water conservation endeavors' in the country. Soil and water conservation division grew into a Community Forest and Soil Conservation Department. With international institutions and NGO's help, extensive soil and water conservation activities such as: stone and soil bunds, hillside terraces, area enclosure, establishment of tree nurseries and tree planting through food for work were extended into many parts of the country. However, at the end it remained fail, because food for work was discontinued, most of the participating farmers became unwilling to maintain those already established and even some of them removed the structures from their lands (Gadisa, 2016). The success rate of SWC has been minimal. It may be recognized to lack of involvement of local people in planning and implementation of the scheme, poor implementation and maintenance of the soil and water conservation structures, limited in span and scope, and lacked the long-term commitments needed to address underlying causes and long-term management issues in a satisfactory way, too much emphasis on natural resources conservation and little attention to human activities and the priorities and needs of people (Tesfa and Tripathi, 2015).

From a policy point of view, even though there was lack of conducive policy that promotes sound environmental management practices and technology adoptions, the 1974 Land Reform Proclamation and the subsequent formation of Peasant Associations demarcated the area of responsibilities and provided the means of mobilizing resources for large-scale conservation activities. Since the beginning of the 1990s, Ethiopian SWC tactic was watershed management approaches that integrate SWC, intensified natural resource use, and livelihood objectives have been implemented in several micro-watersheds. The newly introduced SWC measures, stone and soil bunds, were widely acknowledged as being effective measures in arresting soil erosion and as having the potential to improve land productivity. But, these new soil and water conservation practices by the farmers appear less likely (Fikru, 2009). In Ethiopia, indigenous SWC practices are generally poorly recorded and not considered by SWC experts and policymakers(Abebe & Ketema 2019).

2.5. Traditional and Introduced SWC Measures in Ethiopia

Ashoori, (2015) found that Ethiopian farmers used both traditional and improved practices for soil and water conservation. These measures included: physical measures such the use of stone bunds, contour farming and drainage, biological measures such as planting trees; and agronomic measures such as spreading manure, leaving crop residues in the field and allowing land to remain fallow.Also a study of (Abiy et al., 2015) measures were categorized into indigenous and introduced types. Indigenous methods used were contour farming, furrow making, making trash line across slope on contour, *gulgualo*, *gilalo* and leaving crop residue on farmland. Similarly, introduced measures practiced in the area include soil bund, fanya- juu terrace, bund and fanya-juu stabilized with biological measure. According to Ali and Surur, (2012); Hurni et al., (2016) and Mengie et al., (2017)the most important conservation structures widely used in Ethiopia are include:

Manureis used by many farmers in order to improve the fertility of the soil. Manure consisting of animal dung and urine, is the best form of organic fertilizer. Farmers used manure mainly near the homestead. Farmers (especially, those who were poor) have increased the use of manure applied because of the high current price of inorganic fertilizers.

Check dams for the gully control may be made of stones, soils or brush-woods. In the study area stone is hardly enough to make check dams. Dominantly, the brush-woods and soil are used to construct check dams (Getachew, 2014). It prevents the effect of runoff by changing the direction of runoff (Habtamu, 2014). Check dams are implemented privately and in groups with high effort, valuable agricultural products were obtained through them and enabled the owners of the interventions to sustain food at their household levels (Birhanu, 2011).

Conservation tillage is a tillage practice aimed at creating a favorable soil environment for germination, establishment and plant growth with minimal soil disturbance. It reduces or avoids full ploughing operations, which are used to remove weeds and prepare moisture uptake, but destroy the soil structure and disturb soil organisms. It reduces runoff and conserves water in the soil after the soil organisms soften the soil. It greatly reduces erosion, improves the soil structure and conserves organic matter in the soil. It prevents the building up of fertile and less fertile strips as caused by the soil movement between bunds (Hurni et al., 2016).

Contour ploughingis a practice of tilling the land along the contours of the slope in order to reduce the runoff on a steep sloping land. It is used separately or in combination with other conservation structures such as plantation trees and cut- off drains. In Ethiopia it is part of the normal farming activity; it needs no extra labor and time for construction (Ali & Surur, 2012). It is intensively applied by many farmers. Contour plowing is practiced to minimize the energetic downward flow of floods and facilitates rain water percolation. Contour ploughing widely used in Ethiopia. Farmers used contour ploughing irrespective of slope steepness. The practice inherited from ancestors. It no more labor than ploughing and, hence, are an efficient technique for reducing runoff mainly in moderately and gently sloping areas. On steep slopes contour ploughing is needed to be used together with terraces and bunds to effectively control erosion (Aklilu, 2006; Mengie et al., 2017).

Crop rotation is planting of a series of different crops in the same field over a period of time alternatively, so that the soil fertility is maintained. Cereal crops are grown at a given farm plot after two or more years of production leaving the preceding and succeeding production seasons for other crops so as to enable the soil to replenish and restore fertilizing nutrients taken up by the produced crops during the preceding production season(s) (Mengie et al., 2017). Crop rotation and rotational fallows also constitute the most important soil fertility management practices in the area. The main rotation system is the cultivation of cereals alternated with pulses. With declining per capita farm size, it is difficult to practice the traditional system of prolonged fallowing. However, there is a significant difference between upstream and downstream farmers in the use of crop rotation most downstream farmers use crop rotation than upstream farmers due mainly to the relatively large farm size per capita and the possibility of growing several crop types (Aklilu, 2006; Melkie, 2016).

Cut off drains are one of the physical structure constructed by digging the soil deep in order to divert the runoff before reaching the farmland. The farmer constructed such structures to prevent loss of seeds, fertilizer and soil due to excessive run– off coming from uplands and dispose the excess water for the field. It usually protects cultivated land from upslope forestland or grassland. It also protect down slope land from upslope runoff and erosion (Hurni et al, 2016; Ali & Surur (2012). It is the most important and widely practiced structural indigenous soil conservation measure. The structure is production-oriented as well as conservation-oriented. Farmers used to avoid seed loss mainly cereal crops like „teff" and to increase yield per unit area (production-oriented) and to conserve soil from the erosive power of runoff (protection-oriented) (Habtamu, 2014).

Drainage ditches are one of the widely used SWC practices in Ethiopia and also known as traditional ditches. These are micro-channels constructed on cultivated farms to drain off excess water and control soil erosion. These are low cost measures in which construction is part of the normal ploughing activity. However, unlike the plough furrows, the ditches are made wider and deeper in dimension and usually run diagonally across the field. Locally farmers call the drainage ditches "Boye". Their construction is executed in every cropping season. Farmers connect the ditches to waterways constructed alongside the farm plots for the safe disposal of excess water (Aklilu, 2006; Ali & Surur, 2012).

Fanya juu an improved SWC structures, are made by digging a trench and throwing the soil uphill to form an embankment and over time creates sloping bench-like terraces(Ali & Surur, 2012). It is an embankment constructed by throwing the soil dug from basin to uphill and the term was coined from Swahili language; meaning "throwing up-hill" .This conservation structure is also constructed during dry season. The aim is to reduce and stop erosion and increase water holding capacity of the soil so as to enhance crop yield. The main benefit of fanya juu is its capacity to become bench terrace within few years than soil bunds, yet it has overtopping and breakages (Getachew, 2014). They provide an opportunity to grow fodder or grass on the riser, but they can also experience water-logging(Akalu et al., 2014). It is a soil bund type where in a ditch is dug along the contour and the soil is thrown up to form a ridge above; a natural bench terrace will subsequently form over the next few years. They are usually constructed in the fields sloping (Mengie et al., 2017).

Grass strip is a ribbon-like band of grass laid out on cultivated land along the contour. They are mainly used to replace physical structures on soil with good infiltration (sandy, silty) on gentle slopes. They are especially suitable on soil with good infiltration and where the climate is not too dry for dense grass development (Hurni et al., 2016). Grass strips are a popular and easy way to terrace land, especially in areas with relatively good rainfall where grass is used also as fodder. It helps to reduce run off and filter out sediments carried by runoff and stabilize fanya juu and soil bund in farm plot. Also it provides cattle fodder (Mengie et al., 2017).

Soil bund is an embankment or ridge built across a slope along the contour. Soil bunds are made of soil or mud. On moderately sloping areas the farmers construct the soil bunds for erosion control. On steep eroded bare lands stone terraces are most used structures in study area. It was considered effective in erosion control in steeply areas (Ali &Surur2012). Soil bunds can be easily eroded during heavy rainfall in steeply sloping areas(Akalu et al 2014). It is used to control runoff and erosion from cultivation fields by reducing the slope length of the field which ultimately reduces and stops velocity of runoff (Mengie et al; 2017).

The effect of soil bunds on the total yield of crops is not different from previous results in Ethiopia. For example, a study in the Galessa watershed of Ethiopia showed that 3-year-old soil bunds reduced total grain yield of barley by 7% as compared to control plots. Nevertheless, it is difficult to make this generalization, as there are cases where soil or stone bunds increase crop yield in drier parts of Ethiopia. For example, soil and stone bunds increased crop yield per hectare. This shows that the effect of soil bunds on crop yield is site specific (Kebede, 2014; Zenebe et al., 2017). Development team in the watershed mainly advises the farmer to constructs this conservation structure but the farmers do not apply this method. Soil bund is effective in controlling soil loss, retaining moisture, and ultimately enhancing productivity of land (Habtamu, 2014).

Stone bunds are barriers of stones placed at regular intervals along the contour. They have been used for generations in Ethiopia where they are locally known as "daagaa". The size of the stone bunds varies between 0.5-2m and may be 5 to 10m apart, depending on the availability of stones and the topography. Stone bunds retain or slow down run off and hence control erosion. Stone bunds are usually constructed where stones are readily available on or near the field (Getachew, 2014). Stone bunds are stable and durable measures. They can reduce runoff and soil erosion in steeply sloping areas and excess water can pass more easily through stone terraces. However, construction does require a large amount of labor. Furthermore, they are not convenient for ox-plowing and can harbor rodents (Akalu et al, 2014).However, stone bunds contribute to agricultural productivity due to its moisture conserving role (Kebede, 2014).In the semi-arid areas of northern Ethiopia, it increases in cereal crop yields and 11% in teff yields after implementation of stone bunds. Also increase of more than 25% and 30% of grain and biomass yields, respectively, after implementation of SWC measures in (Daniel et al., 2015).

Traditional water ways is constructed mainly by oxen drawn plough, but depending on the runoff expected, which depends on the slope length and gradient, intensity of rainfall and the type of crop planted upstream of the field, reinforcement by hoeing may be necessary. This conservation measure is constructed alongside the farm plots for the safe disposal of runoff (Mengie et al., 2017). This structure is a widely practiced form currently throughout the country to reduce soil loss by runoff on higher altitude. It is a common practice to protect crop fields from being damaged by run-off that comes from certain direction. It looks like cutoff drains but it relatively covers wider area at the top of a hillside to drain runoff coming from any direction to the nearest riverbank.

There are two-type of waterway structures: stone waterway and grass/soil waterways. The stone paved waterways are used for a long period than the grass waterway and normally it require maintenance and the dredging of sediments, chores taken care of by farmers of adjacent plots. Many farmers inherited most of these techniques from their fathers and forefathers, though preferences largely depend on perceived effectiveness and workability (Aklilu, 2006 and Habtamu, 2014). It can be natural or manmade drainage channel to receive diverted runoff from cutoff drains in upper slope. The waterway carries the excess runoff to rivers, reservoirs, or gullies safely without causing more erosion damages. A vegetative waterway construction has better attention where the stone is absent. This is applicable in all agro-ecological conditions, especially in moist area and area prone to water logging(Getachew, 2014). Maintenance is needed to cut the grass along and in waterways, to repair the stone paving or to improve drop structures. If gullying is observed, additional measures have to be put into waterways (Ali & Surur, 2012). These structures divert runoff safely from hill slopes to valley bottoms where it joins a stream or river. It may be natural or artificially made and well stabilized with grass, stone, masonry, or concrete (Karanja et al., 2019).

Tree planting is an activity to improve the vegetative ground cover, thereby reducing runoff and soil erosion and producing wood. Tree planting supports many other conservation activities when combined with them. Trees provide close canopy, improve infiltration of moisture in the soil, provide mulch and organic matter, recycle nutrients, and provide high protein manure or animal feed. They also produce wood and other products for various uses (Hurni et al., 2016).

Terraces are constructed in areas where construction material like stone is available. It is the conservation measure of soil and water practiced highly over farmland. The construction of stone terracing is labor demanding. Therefore, farmers construct the structure in groups mainly during the dry season. During those season farmers have relatively more free time to work in groups along with their families (Habtamu, 2014). Terracing is effective in erosion control, although it is labour-intensive, hosts rodents, and returns investment only gradually. The structures serve as boundaries between the adjoining farm plots of different owners. In addition, it helps to enhance soil fertility and improve the infiltration capacity of the soil. A new stone terrace is then constructed slightly downhill from the previous (i.e., the destroyed) terrace. Such practices illustrate the dynamics of adoption and adaptation of SWC technologies to fit local conditions (Aklilu, 2006).

The implementation of terraces improved water productivity of the crops against un-terraced plots, which clearly shows that the advantage of terracing in terms of efficient use of rainwater. Most of the measures implemented in the catchment reduced the runoff by trapping overland flow, for instance in trenches behind stone bunds or in small basins behind check dams (Abebe and Ketema, 2019). Terracing structures are inadequate to curb soil erosion by water effectively. Erosion control practices (especially terracing and traditional ditches) often cause rill formation unless they properly constructed, maintained and stabilized (Ermias et al., 2019). Daniel et al (2015) found that increase in crop yields following implementation of stone terraces. Terraced farms are obviously more productive than un-terraced ones showing an average yield increment for teff, barley and maize, as compared to those without terraces. Similarly it shows positive effect of soil conservation on crop yield in the highlands of Ethiopia. A study of Schmidt et al., (2014)Crop yields such as maize and teff are also significantly higher for households in mid-slope areas that implemented terrace. Crops yields are increased after construction of soil conservation structures, although the yield increment differed from farmers to farmers which is probably due to the differences in soil management activities of the farmers. After construction of soil and water conservation measures however, the yields of *teff*, wheat, maize and potato increased (Derege et al., 2018). This is associated with the positive effects of terracing in improving moisture availability, nutrient supply and conservation of soils. On the other hand, that fanya juu, soil/stone bund; grass strips did not increase crop yield and biomass production in the highlands of Ethiopia (Enyew et al., 2012).

2.6 Empirical evidences on impacts of SWC Practices and determinant factors

SWC practices have positive impacts on soil and crop productivity of cultivated lands; however, their effect is more pronounced when physical SWC practices are integrated with biological SWC practices and at a longer establishment (Tesfaye et al, 2019). According to Kebede, (2014) SWC measures have promising effects on reducing soil loss, trapping a significant quantity of sediment at early stages and improving soil moisture.

Meshesha et al., (2018) revealed that farmers who perceived SWC more effective in controlling soil erosion and ensuring sustainability of crop yields adopted modern conservation methods. Bindraban et al., (2012) show that specific solutions will remain essential for actual interventions to mitigate and rehabilitate degradation and increase soil productivity and improve livelihood, because of the complex socio-economic and bio-physical interactions. SWC implemented has positively impacted on the livelihoods of the community and recommend that its sustainability should be given due attention at all levels (Solomon et al., 2019).

According to Sisay (2017), soil and water conservation has high contribution to improve biophysical feature (forest coverage, bushes and shrubs increased; and rock out crops were totally eliminated) as compared to DMW (treated) and Sholit (untreated) watersheds, and in terms of income. Also Meshesha et al. (2018) mentioned that soil and water conservation covered the land by vegetation and increases crop yields. The studies of (Enyew and Akalu, 2014) indicate that soil and water conservation had improved crop productivity. Household incomes and food security had improved and soil erosion drastically reduced. Soil and water conservation found to be effective in changing slope gradient, improving soil fertility, and increasing crop yield (Mulat et al; 2020).

In the central highlands of Ethiopia, the soil bund increased yield of barley by 1.7%, (Kidane, 2018)**.**The result of Dejene (2018) confirms that soil and water conservation can improve moisture retention during low rainfall- periods and thereby reduce moisture stress and enhance plant growth. Accordingly, reports have shown that some soil and water conservation practices have resulted in positive effects on soil fertility, moisture and agricultural productivity (Tesfa and Tripathi, 2015).

Investments in SWC contribute to the intensification of agricultural system which enhance food production and alleviates poverty. Terrace technologies control soil erosion by reducing the slope of the cultivated land and this facilitates the conservation of moisture for crop use, which leads to increased crop yields. Also found that farms with greater investment in soil conservation had much greater land productivity than did farms without such investment (Abebe and Ketema, 2019). As an approach, soil and water conservation measures are important to improve soil fertility, crop yield increment particularly in highly degraded areas. In most soil and water conservation structures are improve crop yield by enhancing soil moisture and controlling erosion occurred in the area. Even though, soil and water conservation structures are improve crop production, it also reduces the area available for cultivation and crop production by occupying a larger proportion of cropland (Nigatu et al., 2017).SWC measures improved land suitability that further improves the yield of major crops. They identified that the watershed was moderately and marginally suitable for the major crops such as teff, barley, wheat, and maize before SWC implemented. However, after massive SWC significant improvement on land suitability was achieved. Hence, after implementing SWC measures about half of the area has been changed to highly suitable for wheat and teff, and the remaining has been changed to moderately suitable for barley and maize (Abebe and Ketema, 2019).

Various studies have been conducted to investigate the effect of SWC interventions in Ethiopia. For instance Nigatu et al, (2017) indicate that soil and water conservation practices significantly reduce the damaging effects in associated with erosion and water loss. The food security status is influenced positively by farmers' participation in SWC activities, age of households' head, education level, ox ownership, cultivated farm land, off-farm income and farm income. Farm households faced with high farm-to-market access costs or poor market access makes less investment in SWC practices (Kidane, 2018). On the other hand it is influenced negatively by family size, soil infertility problem and dependence ratio. It can be conclude that farmers' participation in soil and water conservation activities has key role to enhance food security status of the household. Soil infertility can be the key factor which leads to food insecurity (Delelegn et al., 2018). The empirical result shows that plot size is positively and significantly affected the likelihood of adopting SWC. An extension agent is expected to serve as change agents; therefore, increases in contact with farm households will lead to a change in farm households' attitude and increase adoption of SWC practices(Kidane 2018).

Farmers who are highly engaged in off-farm economic activities and their land source by rent showed less participation in SWC activities mainly because of the preoccupation to earn additional income for their livelihoods (Abera et al., 2016).Another study revealed that SWC intervention did not result in a significant difference between program participant and non-participant households in terms of total crop and household income, and crop yield (Yitayal et al., 2014). The result of this study indicates that participation in non-farm activities has positive and significant influence on the adoption decision of SWC practice. Non-farm income may also provide incentive to invest in SWC practices by allowing them to hire labor and to buy farm implements; especially in underdeveloped credit market setting. Farm households' involvement in non-farm income promotes investment in long-term land management practices (e.g. SWC)**(**Kidane, 2018).The study reveals that farm households who are far away from market center are less likely to practice SWC (Kidane, 2018).

According to Kidane (2018)several SWC practices have a statistically significant impact on the value of crop production. For instance, they found that crop productivity is 18%, and 64% higher in plots with and stone terraces, and reduced tillage, respectively. In the same vein, in eastern Ethiopia adopting SWC practice results in more high yield and net return. Abebe and Ketema (2019) found that positive and significant impact was found on crop yield using contour hedgerows. The study found significant and positive association between wheat yield and soil conservation measures. Also that implementing SWC measures had positive impact on grain and biomass yield and the increment of more than 25% for grain and 30% for biomass yields. The study revealed that the construction of terraces improved grain yield dramatically; the yield is the highest in maize production where it was more than double when the crop is grown on terraced farms as compared to non-terraced farms. He further mentioned that the highest increment in crop yield was realized in the upper slopes where maize yields were increased and beans yields increased. However, this study found that fanya juu, soil/stone bund, and grass strips did not increase crop yield and biomass production in the highlands of Ethiopia.

Even though terracing contributes to reducing soil erosion, it also has negative impacts on crops sensitive to certain effects, such as water-logging. This negative impact of terracing has been observed with respect to wheat. The lowest wheat yield on gently sloping terrain could partly be attributed to the negative effects of terracing, in this case water-logging. Structures (e.g., level bund, level terraces and level *FanyaJuu*) could result in water-logging problems at lower terrain positions. Other studies also show that water-logging critically limits wheat yield.This clearly shows that terracing positively impacted crop production. Also indicates that terracing played important role and that otherwise yields could have significantly decreased. It can be concluded that terracing has helped to achieve sustainable production; however terracing alone may not improve agricultural productivity. Generally, SWC in general has positive impacts on agricultural production; nevertheless implementation of alternative livelihood options is most important in order to lessen the potential pressure on the land (Schaften, 2012, Chilot et al., 2019).

Soil and water conservation practices on soil properties were found more effective in cultivated land uses as compared to that of grazing land uses. This is because conservation treatments had significant effects on organic carbon, total nitrogen, exchangeable Na+ and Mg2+ in cultivated land uses but only on exchangeable Na+ in grazing land uses (Mengie et al; 2019).The study of (Tesfaye and Laekemariam 2019) revealed that integrated SWC for 5 years reduced the soil bulk density; and increased soil pH, organic carbon and available phosphorous compared tonon-conserved land, respectively. It enhanced plant height, tiller formation, spike length, thousand seed weight, biomass, and grain yield of wheat. Integrated SWC increased grain yield.
Studies showed that crop yield on conserved dry land was increased significantly and the economic evaluation also showed positive increment with conservation. In addition, SWC resulted in positive relationship with soil quality improvement and enhancement of water resources. Moreover, SWC measures enhanced carbon sequestration of the soil due to improvement of soil fertility status (Abebe and Ketema, 2019).

A study of Getachew (2014), in the area female farmers has an interest to construct soil-water conservation measures that need large number of labor, but they need the support from others. As a result, the majority of female farmers who depend on farming excluded the construction of soil bunds, fanya juu, check dam and trench digging. They have been practicing cutoff drains, waterways and biological and agronomic soil conservation techniques in combination and/or separately.

Age is believed to influence adoption decision because of its influence on planning horizon. Conservation measures such as terrace are long term investments .But, the aged farmers have troubles with practicing soil conservation on their fields and usually have short planning horizon. Older farmers couldn't make soil conservation practices that require work hard which would not be accomplished by aged persons. On the other hand, aged persons practice less labor demanding technologies such as simple cutoff drains, contour ploughing, planting grasses and use of other agronomic conservation measures. This practice also reflects that aged farmers are practicing short staying structures in their cultivation field which also allow free movement and take smaller pieces of land (Getachew, 2014).

Heads of household who attended formal education are more likely to adopt stone and soil bunds than their uneducated counterpart heads of household. This might be because better education is associated with greater access to information and awareness about the severity of soil degradation and its consequences, which, in turn, motivate them to adopt SWC measures. Moreover, educated farmers are also more likely to use appropriate SWC measures than uneducated farmers. Elsewhere in Ethiopia, scholars also found education to be an important factor of accelerating the adoption of SWC measures (Million et al., 2019).

Family size is negatively and significantly related to the practices of SWC(Kidane, 2018). Also, studies of Getachew (2014) in the study area, farmers who have small household size, require additional labor to construct and maintain soil conservation structures. When the majority of family members are capable of working soil-water conservation measures tend to positively correlate with large family sizes. Also land availability often influences farming practice and affects the land degradation process. Most of the agricultural land in the study area has so far been subdivided to the smallest land holdings that are no longer economically viable for smallholders' subsistence. The study also revealed the existing land shortage. In the area farmers, present landholdings are too small (less than 1.5 hectare) compared to the land needs of the household and they are not in a position to inherit land to their children. The negative relationship between family size and the adoption of stone bund is not surprising; particularly for households with a high dependency ratio. Thus, households with a large family size are less likely to choose the stone bund conservation structure than are smaller sized families. This relationship is also reported by Million et al., (2019) who found the adoption of SWC measures decreasing with family size.

Access to credits from formal lending institutions increase the practices of terracing. Most subsistence farmers lacked the capital, which is needed in reinvesting in farming, including the financial resources, which are needed for the construction of SWC structures. Hence, access to credit was vital for farmers to make timely purchase of agricultural inputs and invest in SWC structures (Million et al., 2019). Households' access to credit services had also shown a significant positive correlation with soil bund and grass strip with mostly soil bund (Fekadu and Engdawork, 2019).

Land size significantly influences the practice and continued use of stone terraces. Its effect on adoption is positive; the effect on continued use is negative. The continued use of the stone terraces is likely to be lower with increase in farm size. In the highland Ethiopia where there is increasing population pressure and limited area for agricultural expansion, declining per capita farm area often results in production intensification (Abebe and Ketema ,2019).

Farmers land holding size, cropland slope, access to soil and water conservation trainings, and contact with extension workers are positively influence their participation in conservation activities (Amanuel et al., 2018). This implies participations of farmers with relatively larger land holding size are better than the smaller size. Previous studies indicate, farmers having larger farm sizes are interest to implement conservation technologies in their cropland than the others (Amanuel et al., 2018). The farm land size significant and positive effects on the practice of SWC (Fekadu and Engdawork, 2019).

2.7. Conceptual Framework

Land degradation in the form of soil erosion has been considered as among the major factors responsible for the recurrent food insecurity in Ethiopia. It reduces the production potential of land, and thus makes it difficult to produce enough to feed the growing population. It also increases farmers' vulnerability to food shortages and becomes a threat to the mere survival of the people (Aklilu, 2006 and Gadisa, 2017). Soil erosion results in depletion of soil fertility, decreased moisture storage capacity and consequently in decreased crop productivity (Bashir et al., 2017).In addition inappropriate SWC practices, poor soil fertility and low community participation are among the main factors that contribute to low production and productivity (Gebregziabher et al., 2016). The immediate outcomes of watershed management interventions include rehabilitation of natural resources, including recharge of the groundwater table; reforestation of upper catchments; reduction in soil erosion and associated downstream siltation; and regeneration of plant resources. These outcomes in turn contribute to increased agricultural output, diversification of food and income sources, reduced migration and improved biodiversity. The resultant development impacts include increased food and nutrition security, improved status for women, reductions in poverty and an improved natural environment. A recent impact assessment by Temesgen, (2015)also showed increased water availability and quality; increased ground water recharge and improved downstream base flow of streams; lessened damage from seasonal floods; enhanced down-stream crop production through soil and water conservation interventions; increased biodiversity, and increased social cohesion by improving livelihoods. Accordingly to the reports of (Tesfa and Tripathi2015) have shown that some soil and water conservation practices have resulted in positive effects on soil fertility, moisture conservation and agricultural productivity, while there was soil and water conservation systems have not. However, the integrated application of traditional and introduced SWC practices have been vital for the rehabilitation of degraded lands since they reduce flood risks, nutrient losses, and increase grain yields.

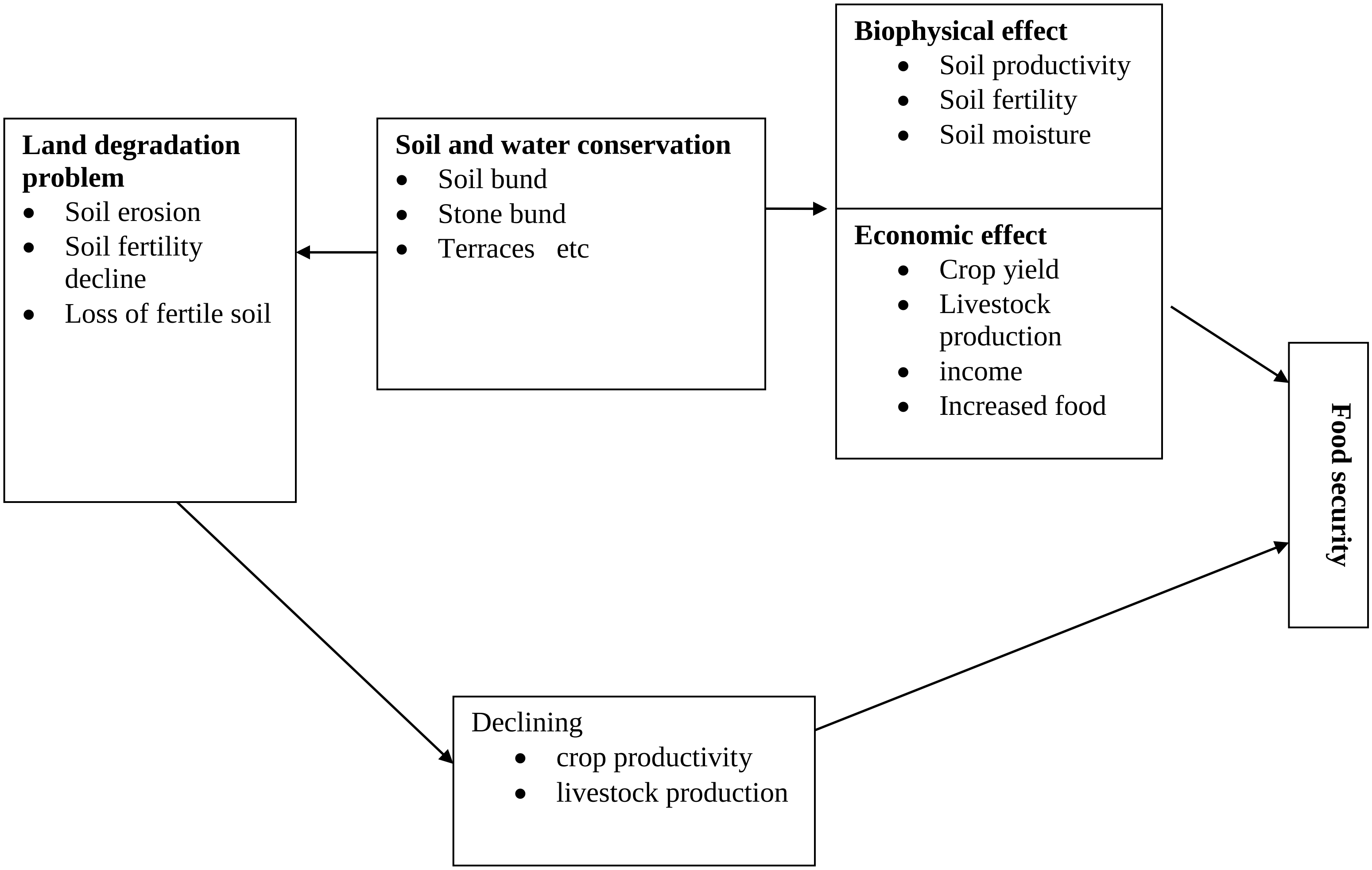

Figure 1: Conceptual frameworks (source: Developed based on literature reviewed)

CHAPTER THREE: MATERIALS AND METHODS

3.1. Description of the study area

Sululta town is one of the eight cities administrations of Oromia Special Zone surrounding Finfinne. Sululta town was established nearly 82 years ago. As written history shows and some known elder people said that Sululta town was inaugurated in 1929 by Italic fishiest and from1934-1955 the capital city of Sululta Wereda; from1956-1998 small town of Sululta Wereda; in1999 became under reform, and by 21/11/1999 Sululta developed to 2nd level "A" city Administration (Gizachew ,2019). As the City reform of Oromia regional state proclamation No.65/1995 E.C, indicates the municipality was begin in 1999 E.C (Hailu, 2019).

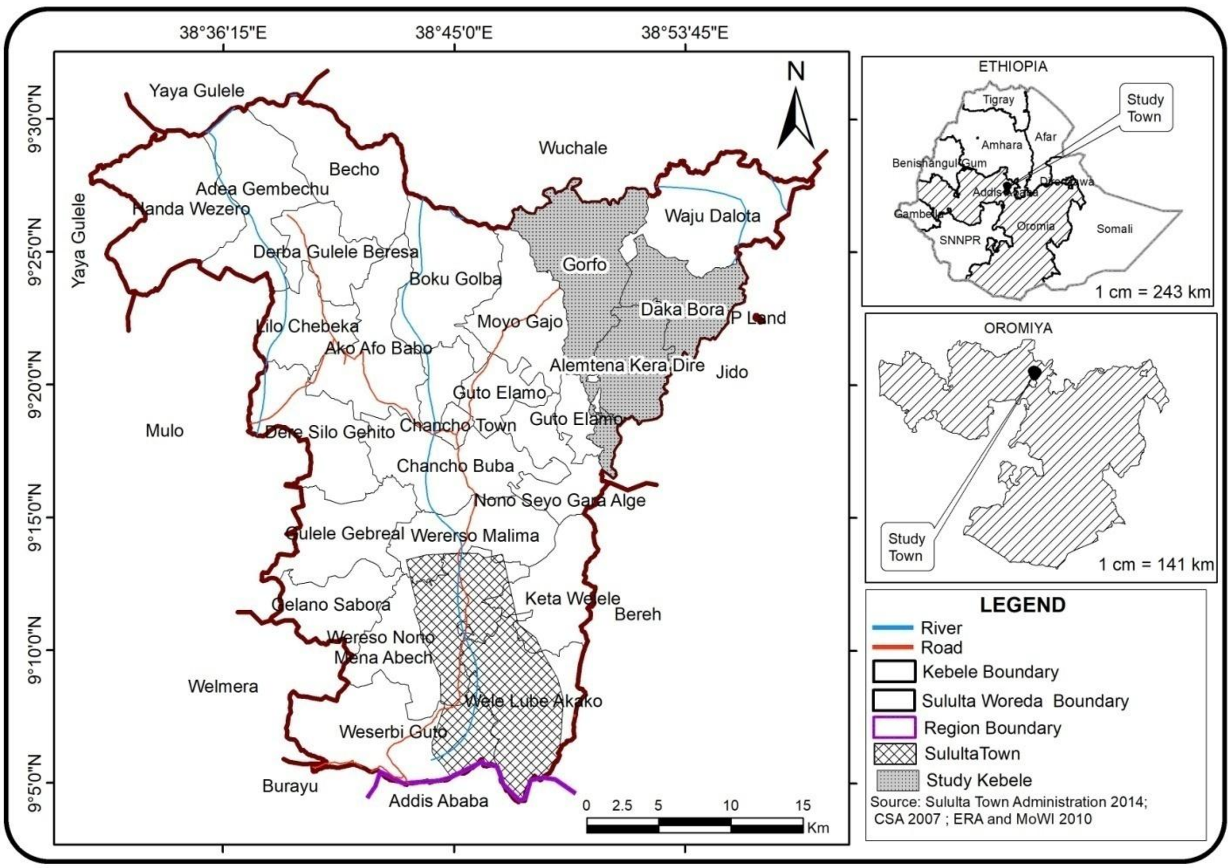

Figure 2: Map of the study area (Source CSA, 2020)

3.1.1. Location

Sululta is one of the *Districts* in Oromia regional state of Ethiopia, which is located about 40 Km North West of Addis Ababa. It was formerly named as Sululta and Mulo. After it was separately recognized as an independent *District*, Sululta is administered under Special Zone Surrounding Finfinne (SWARDO and Getachew,2014) .it is located between 9°50'0''N to 9°30'0''N and 38°36'16''E to 38°53'45''E (CSA,2020). Sululta town is found in Surrounding Finfinne, Special Zone of Oromia and it separated from finfine by "Entoto" plateau. This town is called by its brand name "Town of milk Hub"" and located 23 kilometer away north of Addis Ababa with the total area of 10,424.4 hectares (Gizachew, 2019).

3.1.2. Topography

According to Getachew (2014) the nature of topography of particular entities has multi-dimensional implication up on the development of physical infrastructure, human way of life and the existing type of flora and fauna. The landforms of the area are made up of river cut-gorges, valleys, plateaus, mountains and plains. Thus, plains account (46%), rugged topography (22%), plateaus (26%) and mountain (6%) are commonly observed in the study area (SWAARDO, 2014), and the altitude ranges from1500m to 3075m above sea level (Topo-sheet, Ethiopian Mapping Authority 1:250,000 (NC 37-10).

3.1.3. Climate

Sululta *District* exhibits three major agro ecological conditions. These are Kola (Low altitude), Dega (high altitude) and Woina Dega (mid altitude) which accounts 3.6 %, 71% and 25.4% of the study area respectively. The altitude of the study area ranges between 1500 to 3571m.The mean annual temperature is 15.36℃ with the mean minimum of 6.2℃ in December and maximum 22.9℃ in February and May. Due to its location within the tropics, the region receives high solar radiation in fact modified by its high altitude. As a result, highland areas of the region experience low temperature and high rainfall, while lowland areas (below 1500m) experience high temperature and low rainfall. Temperature and rainfall distributions of the study area have been discussed hereunder (Getachew, (2014) and Dereje (2018).

Also the study area experiences bi-modal type of rainfall. The long rains fall between Mid-Aprils to September followed by a cold season and the short rains from Mid-October to March. The town is also characterized by receiving an average annual rainfall of 1000 mm with an average daily temperature of 20 0C (Gizachew,2019). The average monthly rainfall ranges from 3.4mm in the month of December up to 332.7mm in the month of July. From 2004 to 2015, the town has got average annual rainfall of 1232.3mm which enables the town to be categorized under big rainfall places of the country. Heavy rain is received in summer (June to August) and light rain is in spring season, December to February (ibid). But according to Sululta town planning commission office document studied with collaboration of different sectors in 2011E.C, the average temperature of the town at the moment is 180C and the average annual rain fall ranges from 800mm-1200 mm and the altitude ranges from 2600 a.s.l.-3200a.s.l (Hailu,2019).

3.1.4. Soil

Cambisols, Nitosols and Vertisols are typical of the soil composition in the *district*, which accounts for 49%, 24.5% and 0.5% respectively. The remaining soil typologies make up 26 percent of the land (Getachew, 2014). The major study area is covered by highland soils, which are from being fertile. Their fertility is conducive for livestock keeping and grass land and growth of some food crops such as wheat, barley (Gizachew, 2019).

3.1.5. Population

As per to CSA (2013) population projection from 2014-2017, the study area has 160,837 total population; 138,552 (86.1%) are rural and 50.2 percent are females. Population density of the area is 147 people perkm2. (DMC, 2008and Dereje, 2018). The study area inhabited by 156,679 total population (CSA, 2014), of whom 135,459 (86.46%) its population are rural dwellers and 21,220 (13.54%) are urban dwellers with population density of 136.1 people perkm2. The proportion of male and female in Sululta wereda are 67,748 and 67,711 in rural area and 10,315 and 10,905 in urban center respectively. The wereda had 23 kebeles and 3 towns such as Chancho, Duber and Derba (Getachew, 2014).

Sululta town is one of the fastest growing towns in Oromia in terms of population. According to the report the urban population size of Sululta town was counted to be 37,988 in 2014. Based on this figure attempt has been made to estimate the population size of Sululta, and hence, the current (2016) population size of the town is reckoned to be close to 52,126 and out of this, 25,476 are male and 26,650 female which constitute 48.4% and 51.6% male and female respectively. From this population the number of male household head are 8,364 and female households are 8,917 totally 17,281 (Gizachew, 2019).

Sululta Town is one of the fastest growing towns in Oromia in terms of population. According to the second and third censuses carried out at national level in 1994 and 2007 the population size of Sululta town was 1,271and 6,407, respectively. But this number was grown to 129,843(62,896 male and 66,947 female) of which 60% or 77,905 are youths according to Sululta town planning commission office document studied in 2019. The importance of knowing the total number of population in the town helps the researcher to investigate the need and coverage of urban infrastructure for dwellers in the town (Hailu, 2019).

3.1.6. Drainage System and Wetland

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

A drainage system describes the way of streams that feed other larger streams and rivers branch off in different directions. Thus, major drainage pattern in the study area can be described as streams and rivers, in which the Streams tend to from about 2 major rivers in the area. These are Dima, and Billo rivers, as most areas of the town is flat and the rivers transient through it are narrow in width and shallow in depth, they are over flooded. In addition, they also filled with wastes discharged in to it by different units. These in turn aggravated the river pollution and unpleasant odor that prohibited the dwellers to get the benefits that the resource gives. There are also seasonal wetlands that situated mostly in the East and northwest of the town. The wetland contributes a lot of environmental benefits like run off reduction, ground water recharge, waste water purification, and home for a variety of birds‟ life. However, these benefits are not considered by the town administration and local community thus the current condition of the resource is not seems under consideration (Gizachew, 2019).

3.1.7. Vegetation cover

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

3.1.8. Land use

The total area of Sululta *wereda* is 115,123 hectare. According to the data from GIS based poverty analysis and mapping in rural Oromia regional state (2012) about 71,242 hectare (61.88%) of the total land is cultivated. The rest of the area is occupied by several land uses pattern such as grassland, tree cover, and shrub (Getachew, 2014). According to Sululta Socio Economic Profile, 2016, the study area is characterized by livestock grass land with 33.1% of household engaged in agriculture which is dominantly dairy farm endowed in livestock grass. Besides the open grass land and cultivated lands, the main land-cover types are flower farm, plantation forest and wood land forests surrounding “Entoto” mountain. The area under settlements is expanding very rapidly on peri-urban agricultural land due to residences, industry, social services, green area, urban Agriculture and transport and terminal. Looking all the existing non-agricultural use, residence is a visible major urban land use. The existing green area is unique, all the different types of greens like urban agriculture, grazing land and protective forest available in within the boundary of the town (Gizachew, 2019).

3.1.9. Socio-Economic activities

According to Getachew (2014) the dominant economic activities in the study area are crop productions integrated with livestock raisings. The crop pattern and production depends on agronomic factors such as altitude, climate, soil and rainfall. A wide variety of crops are grown in the study area. However, crop production is at subsistence level. The major factors responsible for the low productivity are increase in population growth, land scarcity, loss of soil fertility and erosion problem, shortage of farm oxen, lack of agricultural inputs, occurrence of drought, erratic nature of rainfall and pest occurrence. Livestock husbandry is also an important sector of the area’s economy. Mixed farming was found to be the mainstay of the household economy, small-scale irrigation and extracting forest products were also used as supplementary economic activities (Dereje & Berhanu, 2018).

Dairy farming is the main occupation of households among those engaged in agriculture. This is because the town is endowed with grass which is the main source of animal feed in the area. It is the leading sub sector in terms of employment, food security, income earnings, and overall contribution to the socio-economic well-being of the people (Sema et al., 2019).

Majority of the people in the area depend on the Agricultural sector for their livelihood, with14, 249directly or indirectly employed in the sector and contributes 37.5 per cent of the area's population income. According to data from Sululta Town education Office, (2018), non-governmental organizations, communities, private institutions and confidence based organizations are the operators of pre-primary education programs. Regarding health institutions at present there is only 1 health center with two beds and 4 health posts in the town. With regard to health professionals there are 2 health officers, 22 nurses in governmental health institutions. The overall picture is of a poor towards improved infrastructure both at the higher and the lower level of health system. This town is located on the main road which takes from Addis Ababa to Fiche. Its proximity to Addis-Ababa city gives her best advantage. Sululta town is also found on the road which takes to Darban cement factory and also this gave the best advantage for Sululta town to enhance their income for different households in the town. Not only has its proximity to capital city of the zone but also its location found near Entoto Mountain and its vegetation coverage is best economic advantage for the town (Gizachew, 2019).

3.2. Research Design

The research has a cross-sectional survey design. These are used to collect information from different groups in the study area. Also, qualitative and quantitative data's were analyzed to answer the research questions outlined in order to achieve objectives to get the expected results.

According to Creswell (2009) there are three basic views that are considered to be bases for quantitative, qualitative and mixed research methods. In order to achieve the objective of the research, considering the nature of the problem and the type of the assessment, this study employed descriptive design in which both qualitative and quantitative research approaches (that is mixed method). Mixed methods helps for triangulation pertaining to a situation where researchers seek junction, justification, correspondence of results from quantitative and qualitative methods to increase validity of constructs and inquiry results. A mixed method helps researchers seek elaboration, enhancement, figure, clarification of the results from one method with the results from the other method. Also, it helps researchers to use the results from one method to help develop or inform the other method. Mixed methods support the discovery of new interpretations, the recasting of questions or results from one method with questions or results from the other method. Finally, it helps to increase the scope of inquiry to extend the breadth and range of inquiry by using different methods for different inquiry components.

3.3 Research methods

3.3.1. Sources of Data

For the purpose of this study, both primary and secondary sources of data were employed. The major sources of primary information for the study were from household, DA‟s, wereda experts and elders. Moreover, regarding the main sources of secondary data policies, strategy documents, government guidelines, books, journals, and other official documents such as, reports of SWC practices, CSA documents, and the like were consulted to understand the current situation of the issue and to triangulate data obtained from different sources so as to maintain the validity of the data obtained, which in turn enrich the findings of the study.

3.3.2. Sample population and Sampling Techniques

The target population for the study was household head populations within Sululta Wereda. The wereda has 23 Kebeles where three kebeles (namely; Gorfo, Daka Bora and Alemtena Kera Dire). For this study, multistage sampling techniques were used. At the first stage, Sululta wereda was purposely selected. The purpose was its proximity to the capital city, convenience to reach farmers, accessibility to transportation, familiarity with the study area. At the second stage, watershed was selected based on specific criteria, such as success rate of the activities, interventions practiced and based on time when the work started or where the program first started and observable evidence related to the performance of the watershed management activities. Finally, at the fourth stage, 120 sample farmers were selected from the three kebeles using a systematic sampling method using the formula Yamane (1988)

This formula is:

$$n = \frac{N}{1 + (N(e)^2} =$$

Where:

n = statistically acceptable sample size
N = total household size of the sample kebeles i.e. 2507
E = level of precision (error level)

Table 1. Distribution of sampled household heads by Kebele

Sample Kebele	Total Household	Sample Household
Gorfo	1049	42
Daka Bora	810	42
Alemtena Kera Dire	648	36
Total	2507	120

Source: Own survey, 2020.

3.3.3. Methods of Data collection

Household surveys

Household surveys were organized to obtain information around specific topics allowing understand soil and water conservation practices, households' participation and their perception. It was carried out to assess the impact of watershed management interventions on farmers' investments in SWC. All the necessary data was collected through a sample farm household survey conducted. At the first stage of the survey, informal discussions were undertaken with a sampled *kebeles*' representatives, in order to know the general social, cultural, and economic situations of the population of the study area.

Regarding the house hold surveys, structured questionnaires with both open and closed ended questions were designed. This solicited information on background socio-economic characteristics of the respondents, SWC practices employed by farmers, determinants of SWC practices and other related issues. The questionnaires were per-tested to check their validity and adjustments were necessary.

Key Informant Interviews

The purpose of interview is obtaining more information to strengthen the responses gained from the questionnaire. Semi-structured interview was conducted due to its flexibility to raise new question based on the response of the interviewee in the study area. As a result it was conducted with six (6) key informants involving one respondent from each Kebele Administrators, Development Agents and Agricultural Experts related to SWC practices and food security issues. To avoid language barriers the interview was conducted in Amharic and finally translated to English for analyzing and interpretation. Interview involves a series of open ended questions on the SWC practices, determinant of SWC activities and other related issues. The open-ended natures of the questions define the topics under investigation and provide opportunities to both interviewer and interviewee to discuss some topics in more detail. If the interviewee has difficulty in answering a question or provides only a brief response, the interviewer used clue or could prompt them to encourage the interviewee to consider the question further. In a semi-structured interview the interviewer also had the freedom to probe the interviewee to elaborate on the original response or to follow a line of inquiry introduced by the interviewees.

Focus group discussions

For the focus group discussion (FGD), the researcher selected seven (7) respondents from model farmers and elders based on socially respected within the society and who are known to have better knowledge on the present and past environmental, social and economic status of the study area. The purpose of FGD was to get insights on and understand the determinant of SWC practices in the study area.

Observations

Observation techniques were methods by which an individual or individuals gather first hand data on programs, processes, or behaviors being studied with photographs. It has been used to gather primary information with regard to the current conditions of SWC practices, the observable of Soil and water Conservation, determinants of SWC practices and the surrounding environmental conditions relating to the integration between indigenous and modern SWC practices and treated and untreated through careful observation around the lands of the study area.

3.4. Method of Data Analysis

The data gathered via the above aforementioned tools were analyzed quantitatively and qualitatively. The qualitative data obtained through interviews, FGD, observation, and others were analyzed and incorporated in the analysis to supplement and substantiate the data secured through questionnaires. Then, based on the nature of basic research questions and the data collected, various techniques of analysis were employed. Regarding the data that were collected through questionnaires were analyzed by using descriptive statistics like percentages, frequencies and graphs.

As deemed necessary both descriptive and econometrics methods are applied in analyzing and interpreting the data collected. The main techniques included discussion of key descriptive statistics (frequency, mean, standard deviation, maximum and minimum) of the selected variable which are used as dependent and explanatory variables in the models used in the study. The models used in the study include:

Household food insecurity experience (HFIES)

The FIES measures the severity of food insecurity modeled as a latent trait, broadly conceptualized as the condition of not being able to freely access the food one needs to conduct a healthy, active and dignified life. The measure is based on conditions and behaviors reported by responding to an 8-item questionnaire, resulting from the inability to access food due to lack of money or other resources. These conditions have been selected, among the many possible ones that could be meant to be a direct consequence of the latent condition, as those holding the greater promise to be empirically valid in many different contexts.

The module contains questions, concerning the household's coping strategies during the 7 days prior to the survey.7 The questions capture the severity of food insecurity from the most mild form of food insecurity (worrying about having enough food) to the most severe form (going an entire day without food) (Nzinga et al., 2016). The dichotomous ("yes"/"no") responses to the FIES-SM questions, provide information sufficient to construct a one-dimensional measure, using the Rasch model. Based on the measured severity of food insecurity, each respondent in a representative sample is assigned a probability of being beyond a specified threshold of severity to compile an estimate of the prevalence rate of food insecurity in the reference population. Thresholds used for classification and, thus, prevalence rates of food insecurity, are made comparable across countries by calibrating the measures obtained from estimating the Rasch model parameter separately on each dataset, against a common, global reference scale (Nord et al., 2014)

By asking the series of related questions that compose the FIES, it is possible to classify respondents at different levels of severity: “food secure” (those who answer “no” to all the questions about food insecurity-related experiences) or “food insecure” along a continuum of food insecurity severity (Cafiero et al., 2013), as shown the figure in the appendices.

3.4.1 Econometric model

Econometric model were used to assess the impact of watershed management interventions through soil and water conservation on agricultural production and food security status of households and determinants of participation on soil and water conservation practices.

There is evidence that the practices of a specific SWC measure by smallholder farmers is not mutually exclusive or independent of other measures that are implemented on the same farm plot. Most economic models that have been used to analyze the practices of these measures failed to capture the interdependence and relationship between them as well as the potential correlation between unobserved disturbances (error term). For instance, binary logit/probit models are only able to estimate the adoption of a single measure, with only two binary outcomes. Thus, this explores impacts of participation on soil and water conservation practices on security in the study area. On the other hand, multinomial models are useful when the bivariate response models involve more than two possible outcomes. In other words, the multinomial models are useful when the outcome variables are unordered and mutually exclusive, and the farmer can choose only a single outcome from among a set of independent (Million et al., 2019).

There is also a lack of data and adoptable methodologies to assess the impacts at the watershed level. Hence, there is a need for research that shows a more integrated evaluation of the impacts of watershed. There appears to be a lack of general consensus among researchers on the methodological approach to be employed when analyzing the impacts of SWC interventions. Traditionally, most of the analyses conducted on the economic benefits of SWC measures only consider the impact on crop yield, but studies should also address externalities such as changes in ecosystem services, water availability, soil fertility, moisture, erosion and food security (Nigussie et al., 2015). Hence, this study employs a multinomial logistic regression model. A multinomial logistic regression model used to examine determinants of participation on soil and water conservation practices. The model used in the study includes:

Multinomial logistic regression model

Multinomial logistic regression model is one of the important methods for categorical data analysis. This model deals with one nominal/ordinal response variable that has more than two categories, whether nominal or ordinal variable. This model has been applied in data analysis in many areas (EL-HABIL, 2016). A multinomial logistic regression model is a form of regression where the outcome variable (risk factor-dependent variable) is binary or dichotomous and the independents are continuous variables, categorical variables, or both. Most of multivariate analysis techniques require the basic assumptions of normality and continuous data, involving independent and/or dependent variables as aforementioned. This necessity manifests itself also in the application of MLR data collection and measurement steps in risk analysis, but to varying degree. Thus, whereas much stronger interval and ratio scales provide a good basis for a more comprehensive multivariate analysis, commonly used risk measurement scales such as five-point likert, ordinal, and nominal scales are usually considered unsuitable for multivariate analysis techniques, due to various assumption as listed above. For this reason, multinomial logistic regression was used Bayaga and Lani (2010).

Multinomial logistic regression is used to predict categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables. The independent variables can be either dichotomous (i.e., binary) or continuous (i.e., interval or ratio in scale) (Starkweather and Moske 2011; Llinás and Carreño ,2012).The multinomial logistic regression model is the most widely used multivariate approach to study the dynamics (Baulch, 2011). The content of this section draws extensively in Greene (2003).

The multinomial logistic regression model is defined as follows:

$$pji=\frac{e^{x_{i} j\beta_j}}{\sum_{j=1}^{m} e^{x_{i} j\beta j}} \qquad j=1,\ldots,m \qquad (1)$$

Results 1, 2, 3… m are supposed for y and the explanatory variables are defined as X. it is also assumed that there are m=3 results, which are unordered. This property of the categorical variable y is typical of multinomial regressions.

In the multinomial logistic regression model, a set of coefficients β_1, β_2, and β_3 are estimated, corresponding to each result the following probabilities for each case of the value of the dependent variable (food security):

$$\text{pr (y=1)} = \frac{e^{\beta(1)}}{e^{\beta(1)} + e^{\beta(2)} + e^{\beta(3)}} \quad (2)$$

$$\text{pr (y=1)} = \frac{e^{\beta(2)}}{e^{\beta(1)} + e^{\beta(2)} + e^{\beta(3)}} \quad (3)$$

$$\text{pr (y=1)} = \frac{e^{\beta(3)}}{e^{\beta(1)} + e^{\beta(2)} + e^{\beta(3)}} \quad (4)$$

This model is indeterminate in the sense that there exists more than one solution for β_1, β_2, and β_3 which lead to the same probability for y=1, y=2, y=3. If a value of 0 is assigned to β_1, the remaining coefficients β^2, and β^3 will measure the relative change for y=2. The coefficients may differ because they have different interpretations, but the odds of y= 1, 2 and 3 are the same.

Ordered logit regression model

Ordered logit regression model was used to explore impacts of SWC on food insecurity. The model is applied to perform analysis of ordinal and categorical variables (Grilli & Rampichini, 2014). This model was selected because, the two dependent variables are categorical and ordinal in nature as a result they fit to the model.

Suppose that Y is an ordinal dependent variable with © categories and pr (y≤j) denotes the probability that the response on (Y) falls in category (j) or below (i.e., in category 1, 2… or j). This is called a cumulative probability. It equals the sum of the probabilities in category j and below:

$$\text{Pr } (y \leq j) - \text{pr}(y=1) + (\text{pr}(y=2) + \ldots. \text{ Pr}(y=j) \quad (1)$$

A category (c) and dependent (Y) variable has cumulative probabilities (c): pr (y≤1), pr(y≤ 2),… pr (y≤c). The final cumulative probability uses the entire scale; as a consequence, therefore, pr (y≤c)=1. The order of forming the final cumulative probabilities reflects the ordering of the dependent variable scale, and those probabilities themselves satisfy:

$$\text{Pr}(y \leq 1) \leq \text{pr}(y=2) \leq \ldots \leq \text{pr}(y \leq c)=1 \quad (2)$$

In an ordered logit model, an underlying probability score for an observation of being in the i^{th} response category is estimated as a linear function of the independent variables and a set of cut points. The probability of observing response category I corresponds to the probability that the estimated linear function, plus random error, is within the range of the cut points estimated for that response.

Pr(Response category for the j^{th} outcome=i) = $pr(k_{i-1}) > b_1x_{1j}+b_2x_{2j} + b_kx_{kj} + u_j \leq k_j$ (3)

It is necessary to estimate the coefficients $b_1, b_2, \ldots b_k$, along with cut points $k_1, k_2, \ldots, k_{i-1}$, where (i) is the number of possible response categories of the dependent variable. The coefficients and cut points are estimated using maximum likelihood.

3.5 Definition of Variables and Hypothesis

Among the studied explanatory variables age of household head, family size, sex of household head, marital status, education of household head, family labor availability, farming experiences, land size, access to extension service, market access, distance from home to nearby market, cultivated land, chemical fertilizer and a different SWC measures were independent variables having a significant relation with food security included in the analysis. Also in the survey analysis food security were the dependent variables. Variables considered this study are presented in Table 3.1.

Table 3.1 A summary of explanatory variables, their measurement and expected sign.

Description of Variables	Measurement	Expected Sign on practice
Socio-cultural characteristics		
Age of Household Head	Years	-
Family size	Number of families in the HH	+
Sex of Household head	Dummy,1=male,2 = female	-
Marital status	Dummy,1=Single,2=Married,3=Divorced, 4=Widow	+
Education of Household Head	1=Illiterate,2=Readandwrite,3=Elementary school (1-4),4=Secondary school (5-8),5= Other, specify	+
Family labor availability	Level in number	+
Farming experiences	Years	+
Land Size	In Hectare(timad)	+
Off farm Income	Birr /years	+
Economic characteristics		
Income from crops	Birr /years	+
Income from livestock	Birr /years	+
Crop yield	Quintal/ year	+
Livestock size	TLU*	+
Institutional characteristics		
Access to Extension Service	Dummy,1=yes,2= no	+
Market access	Dummy,1=yes,2= no	+
Distance from home to nearby market	In kilometer	+
Perception characteristics		
Chemical fertilizer	Dummy,1=yes,2= no	+

Source: Self-formulated based on extensive review and key informant interview

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter describes both the descriptive and econometric result of the study. The descriptive statistic result includes household socio-cultural related information, household economic and farm related information, household institutional related information, household perception on soil erosion, decline in soil fertility and SWC related information, food security status and. The econometric analysis section result shows the determinants of participation on SWC impact of SWC on household food security.

4.1 Descriptive Statistics

4.1.1 Household socio-cultural related information of respondents

A total of 120 respondents were included for the analysis of contribution of watershed management to household food security from 3 kebele of Sululta *Wereda*. Among the study participants, 89.2% and 10.8%were male headed and female headed households' respectively. Also, the results show that about 35.0% of households were illiterate,28.3 able to read and write ,15% was attending elementary school and secondary school and 6.7 % of farming household was attending in other informal education. Out of the total respondents, 3.3 % of the households were single and 88.3% of households were married. Among the participants 95.8% were capable to work and only 3.3% of households were unable to work because of sick (0.8%), disabilities (0.8%) and other cases (0.8%). Concerning the wealth status of study households, about 11.7%, 78.3% and 8.3% were better- off middle and poor, respectively.

Table 4.1: List of dummy and categorical variables and their descriptive statistics of household socio-cultural related information of respondents

Category	**Characteristics**	**Number**	**Percent**
Sex of the household	Male Female	107 13	89.2 10.8
Education status of household	uneducated read and write elementary school secondary school other	42 34 18 18 8	35.0 28.3 15.0 15.0 6.7
Marital status	Single Married Divorced widow	4 106 2 6	3.3 88.3 1.7 5.0
Capable to work	Yes No	115 4	95.8 3.3
Unable to work why	Sick Disable Other	1 1 1	.8 .8 .8
Wealth status category	Better- off Middle poor	14 94 10	11.7 78.3 8.3

4.1.2 Age, family size, labor available and farming experiences of household head

The mean age of households included in the study was 41.69 years. On average household size of the study area was about 5.46. The surveys also revealed that the average available family labor reported was 4.63. The other continuous variable used in the model is farming experience. The results show that the average farming experiences of the study households was 19.03 years.

Table 4.2 List of continuous variables and their descriptive statistics of household socio-cultural related information

Category	Observation	Minimum	Maximum	Mean	Std. Deviation
Age	120	23	71	41.69	8.667
Family size	120	2	11	5.46	2.153
Family labor available	104	1	14	4.63	2.989
Farming experience in years	113	3	60	19.03	9.584

4.1.3 Farmland related information of the study household

Almost all households in the study area owned cultivated lands. Results show that households in the study area had access to cultivated farmlands through land distribution (35.8%), inherited from parents (50.0%), shared with relatives (1.7%), Sharecropped-in (1.7%) and rented-in (1.7%). The mean size of cultivated land was 7.57 timad. And the mean cultivated land number of plots was 4.22.

Table 4.3 Farm related information of the study households

Category	Characteristics		Number	Percent
Cultivated land use types	Yes		120	100.0
Means of access cultivated land	land distribution inherited from parents shared with relatives Sharecropped-in rented-in		43 60 2 2 2	35.8 50.0 1.7 1.7 1.7
	Minimum	**Maximum**	**Mean**	**Std. Dev**
Cultivated land size	.5	25	7.571429	5.840858
Cultivated land number of plots	1	12	4.226891	2.245285

The characteristics of cultivated farm plots results (Table 4.4) indicate that the mean 22.42 of the cultivated farm plot slope was flat, 6.17 gentle and 25.84 of cultivated farm plots was steep slope. However, in terms of soil color, the mean of 11.84 was black, 31.76 red, 11.49 brown, and the mean of 1.55 was sandy. In the study area the mean of 38.66 soil fertility status owned by households was poor, 7.6 medium and mean of 9.25 was a good fertile soil fertile. Also, the mean of 7.95 in the study area experience low soil erosion, mean of 44.41 was medium and 5.025 experienced severe soil erosion. This represents that vast majority of the cultivated farm plots soil fertility status was poor. It is also evident from Getachew (2014), farmers in the study area confirmed that low and very low fertility of the farmland. According to the discussion with the focus group and KII, in the area farmer's experienced medium degree of soil erosion. Most of the cultivated farm plots experience medium and severe soil erosion. In the study area there is moderate degree of soil erosion problem was and also there is minor erosion problem on their farms plots (Getachew, 2014). The mean distance from home to farm lands was 17.96 minutes and a minimum of 2.6 and a maximum of 42.5 minutes.

Table 4.4 Characteristics of cultivated farm plots

Character	**Variables**	**Mean**
Cultivated farm plot slope	flat	22.42
	gentle	6.17
	steep	25.84
Soil color	black	11.84
	red	31.76
	brown	11.97
	sandy	1.55
Soil fertility status	poor	38.66
	Medium	7.6
	good	9.25
Soil erosion experience	low	7.95
	medium	44.41
	Severe	5.025
Distance from home (Minutes)	Minimum	2.6
	Maximum	42.5
	Mean	17.96
	Std. Deviation	12.603

4.1.4 Types of crop cultivated and income obtained

According to results data from sample survey that is presented on Table 4.6,the type of crop most cultivated in the study area are wheat (98.3%), barley (92.5 %), teff (83.3 %), bean 83.3 %, lentil 42.5 % ,Chickpea 16.7% and peas 26.7 %.However, the mean crop produced was 5.055; quantity of crop retained for consumption was 4.1475, the mean quantity of crop sold to market was 27.2725 and mean of income obtained from sale of crop products was 218.18.

Table 4.5 Economic and farm related information on crop production

Type of crop cultivated	Category	Frequency	Percent
Teff	yes	100	83.3
	no	2	1.7
Maize	yes	1	.8
	no	18	15.0
Sorghum	yes	1	.8
	no	19	15.8
Wheat	yes	118	98.3
Barley	yes	111	92.5
	no	4	3.3
Chickpea	no	20	16.7
Lentil	yes	51	42.5
	no	17	14.2
Beans	yes	100	83.3
Peas	yes	32	26.7
	no	16	13.3
Total crop produced	Mean	5.055	
	Std. Deviation	8.867333	
Total quantity retained for consumption	Mean	4.1475	
	Std. Deviation	6.425333	
Total quantity sold to market	Mean	27.2725	
	Std. Deviation	139.7964	
Total income obtained from sale of crop products	Mean	218.18	
	Std. Deviation	978.575	

4.1.5 Types of farm inputs applied

Among the total samples, the proportions of households with DAP used are 93.2 %, UREA used 90.8 %, compost 87.5 % and manure 56.7 %. According to interviews with DAs, and experts from Wereda agriculture office, DAP and UREA was supplied to support farmers to increase production, however, there were limitation in used.

Table 4.6 Dummy variables of inputs applied

Variable	Frequency		Percentage	
	Yes	**No**	**Yes**	**No**
DAP fertilizer used	112	5	93.2	4.2
UREA fertilizer used	109	5	90.8	4.2
compost applied	105	6	87.5	5.0
manure applied	68	12	56.7	10.0

4.1.6 Types of farm implements/equipment's

The study revealed that, 98.3% of households' had access to farm implements to carry-out their farming activities. From the study households, about 84.2 % farmers had farm oxen, 5.8% had plough and yolk, 3.3 % had flat hoes, 5.0 % had shovel and 0.8 % of households had hammer.

Table 4.7 Dummy variables of implement farming activities

Variable	Category	Frequency	Percent
Have access to farming implements	Yes no	118 1	98.3 .8
Type of farm implement	farm oxen plough and yolk flat hoes shovel hammer	101 7 4 6 1	84.2 5.8 3.3 5.0 .8

4.1.7. Types of livestock production and income obtained

From sample survey of household heads about 98.3 % have oxen, 97.5 % cows, 72.5 % bulls, 80.0 % heifers, 90.8 % calves, 92.5 % sheep, horse 49.2%, 84.2 % donkey, and 96.7 % of households have poultry. However, the mean of number of livestock owned was 3.699, livestock sold 568.626 and the mean of income obtained from livestock was 9603.976(Table 4.8).

Table 4.8 Dummy variables of Livestock production

Livestock types	Response	Frequency	Percent	Mean in TLU[1]
Oxen	yes	118	99.16	3.08
	no		0.84	
Cows	yes	117	99.15	2.85
			0.85	
Bulls	yes	87	94.57	1.80
	no		5.43	
Heifers	yes	96	98.97	1.83
	no		1.03	
Calves	yes	109	99.09	2.69
	no		0.91	
Sheep	yes	111	99.11	9.29
			0.89	
Goats	yes	23	53.49	5.22
	no		46.51	

Horses	yes	59	80.82	1.68
	no		19.18	
Donkeys	yes	101	97.12	1.76
	no		2.88	
Poultry	yes	117	99.15	6.79
	no		0.85	
Average livestock size owned in TLU			3.699	
Income obtained from livestock			9603.976	
			6965.345	

Note: TLU = Stands for Tropical Livestock Unit

Source: own survey, 2020

The sample households from this 97.5 % of sample households produced milk, 42.5 % cheese, 48.3% butter and 93.3 % produced egg. Although, the mean estimated amount of livestock produced was 1428.615, estimated amount sold to market was 4977.888 and, the mean estimated income obtained from livestock was 19101.51 (Table 4.9).

Table 4.9 Describes livestock products produced

Livestock products produced	Category	Frequency	Percentage
Milk	yes	117	97.5
	no	2	1.7
Cheese	yes	51	42.5
	no	22	18.3
Butter	yes	58	48.3
	no	23	19.2
Egg	yes	112	93.3
	no	6	5.0
Estimated amount produced	Mean	1428.615	
	Std. Deviation	2393.449	
Estimated amount sold to market	Mean	4977.888	
	Std. Deviation	9929.624	
Estimated income obtained (Birr)	Mean	19101.51	
	Std. Deviation	30457.19	

Regarding farming household’s off-farm activities, the results show that 85.0 % of them have access to off farm activities, and only 14.2 have off farm sources of income. Among farmers who engaged in off-farm income generating activities, about 10.0 % of the households have petty trades' activities, 2.5% of pottery activity, and 4.2 % weaving activity, 2.5 % leather making activities, 1.7 % have selling of fire wood, and the remaining 1.7% were a driver (*Gary* or Bajaj). A few of them are participating in off-farm. However, the mean income obtained from off-farm activities by was 1.961.

Table 4.10 Income generating activities

Variable	Category	Frequency	Percent
having off-farm income sources	yes	17	14.2
	No	102	85.0
petty trades activities	yes	12	10.0
	no	105	87.5
pottery activity	yes	3	2.5
	no	114	95.0
weaving activity	yes	5	4.2
	no	112	93.3
leather making activities	yes	3	2.5
	no	112	93.3
selling of fire wood	yes	2	1.7
	no	113	94.2
driver (gary or bajaj)	yes	2	1.7
	no	113	94.2
Income from off-farm activities	Mean	1.961	
	Std. Deviation	0.181542	

About 99.2% of the study area accessed extension services. From this 81.7 % were development agents (DAs) who provided extension services, and 18.3% were both Das and NGO's. Similarly, 97.5% households contacted DAs and/or other agricultural experts on soil and water conservation for the last five years. From this, 15.8% of households contacted for once a month, 42.5% contacted two times per month, 35.0 % contacted for three times per month and 5.8% of households contacted for twice a year development agents and/or other agricultural experts on soil and water conservation for the last five years.

Out of respondents 90.0% of households' have access to information about SWC technology. Development Agents (DAs) were main sources of information regarding soil and water conservation practices for majority of households (95.8%). Having good relation with DAs helps farmers in reducing hazard associated with soil erosion and conservation structures by providing information. In terms of relationship with soil conservation expert many studies pointed out that, the farther a village is from the place of residence of the extension agents, the less likely it is to be visited by the extension agents (Kidane, 2018).

Out of the respondents, 88.3% of the HHH were participating training on soil and water conservation for the last five years. According to DAs discussions and community representatives there were limited and always similar training in the SWC practices and had limited access to information. Moreover, they gave attention for fertilizer and other credit services rather increase awareness on soil and water conservation. At *wereda* level, land administration and environmental protection office were distributing land certification for farming household as a result, all farmers had land certificate and majority of the farmers received map of farming area. About 93.3% of the household head were had feeling land ownership because of land certification with land map. And also 83.3 % of households did not access credit. Only 14.2% of households had credit access. 5.0% received credit to purchase improved seed and 3.3% received for other purposes.

Table 4.11 Dummy and categorical variables of household institutional related information of study participants

Characteristics	**Response**	**Number**	**Percent**
access to extension services	yes	119	99.2
providers the extension services	development agents (DAs)	98	81.7
	both	22	18.3
contacted development agents and/or other agricultural experts	yes	117	97.5
	no	2	1.7
how often do contacted development agents and/or other agricultural experts	once a month	19	15.8
	two times per month	51	42.5
	three times per month	42	35.0
	twice a year	7	5.8
having access to information about any SWC technology	yes	108	90.0
sources of information regarding soil and water conservation practices	development agent	115	95.8
	NGOs	2	1.7
	mass media	1	.8
	neighbor farmers	1	.8
participated in training on soil and water conservation	yes	106	88.3
	no	13	10.8
having a land certificate	yes	112	93.3

	no	6	5.0
having access to credit services	yes	17	14.2
	no	100	83.3
purpose to receive credit	to purchase improved seed	6	5.0
	to purchase fertilizer	1	.8
	other	4	3.3
having access to market	yes	109	90.8
	no	11	9.2

In the study area result revealed that 90.8% households had market access farm location were in maximum of 40 minute with mean of 19.14 minute. The farming households were travelled with maximum of 40 minutes for purchasing agricultural inputs and selling their product.

Table 4.12 Categorical variable of study participants

Characteristics	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
the distance from home to nearby market (in hours)	0	40	19.14	15.671

4.1.8 Descriptive analysis of household Perception on Soil erosion, Decline in soil fertility and SWC related information

I. Descriptive analysis of household Perception on Soil erosion

Regarding farming households' perception about soil erosion as a problem, all households confirmed that there were soil erosion problems in the area. They reported that over cultivation, over grazing, removal of natural vegetation for fuel and construction, cultivating steep slope, and continued cultivation/no fallowing were the dominant cause of soil erosion. According to the interviews with DAs and expert in Wereda office there were soil erosion problem and that's due to deforestation and overgrazing. About 96.7% of the households perceived that cultivating marginal land were the major causes of soil erosion, 98.3% erosive rainfall, 95.8 poor farming practices, 95.8 % lack of using SWC technologies such as bunds, and 95.8 %damaged bunds. Almost all of the household farmers believed that the land was highly exposed to soil erosion. People were already aware of the negative consequences of soil erosion on agricultural production and the environment centuries ago. As a result, soil and water conservation practices exist as indigenous knowledge in some areas of Ethiopia (Woldeamlak, 2006; Schaften, 2012).The human population, poor farming practice, over cultivation and improper utilization of land are major causes of soil erosion are major causes of soil erosion (Dejene, 2018).According to Getachew (2014), in the study area continuous cultivation or absence of fallowing is one of the reasons for the causes of soil erosion and repeated preparation of the land for cropping facilitates the soil easy for soil erosion.

Table 4.13: Perception of respondents for soil erosion as a problem and technologies profitability

Characteristics	Category	Frequency	Percent
Is there is soil erosion problem?	yes	120	100.0
Causes of soil erosion			
over cultivation	yes	120	100.0
over grazing	yes	120	100.0
removal of natural vegetation for fuel and construction	yes	120	100.0
cultivating steep slope	yes	120	100.0
continued cultivation/no fallowing	yes	120	100.0
cultivating marginal land	yes	116	96.7
	no	4	3.3
erosive rainfall	yes	118	98.3
	no	2	1.7
poor farming practices	yes	115	95.8
	no	4	3.3
lack of using SWC technologies such as bunds	yes	115	95.8
	no	5	4.2
damaged bunds	yes	115	95.8
	no	5	4.2

Figure 4.5 Focus group discussions with community representatives

II. Descriptive analysis of perceived loss of soil fertility on farmlands in the study area

About 97.5 % of the households perceived loss of soil fertility on farmland. According to interviews with DAs expert of wereda office, from time to time in the area soil fertility were reduced because of cutting of trees, slope of the farmland and lack of fertilizer. In the area soil fertility management and conservation measures were less effective and need special attention and support to the society even for experts.

Table 4.14 Result of Soil Fertility Status

Characteristics	Category	Frequency	Percent
Do households perceive loss of soil fertility on farmland?	yes	117	97.5
	no	1	.8

Concerning the causes of land degradation, about 98.3 % perceived that repeated cultivation causes land degradation. Similarly, lack of applying manure (81.7%), and chemical fertilizer (72.5%) were perceived as the causes of land degradation. Among experience in maintaining and replenishing soil fertility of farmlands, 90.0 % of households responded that they had experience. Among this household, about 80.8 % of households practiced chemical fertilizer to maintain soil fertility, 95.0% applied compost, 91.7% applied manure, and 95.0% practiced crop-rotation.

Table 4.15 Causes of decline in soil fertility

Characteristics	Category	Frequency	Percent
Causes of decline in soil fertility			
repeated cultivation	yes	118	98.3
	no	1	.8
lack of applying manure	yes	98	81.7
	no	21	17.5
lack of using chemical fertilizer	yes	87	72.5
	no	32	26.7
experience in maintaining and replenishing soil fertility of your farmland	yes	108	90.0
	no	8	6.7
Chemical fertilizer	yes	97	80.8
	no	21	17.5
Compost	yes	114	95.0
	no	4	3.3
Manure	yes	110	91.7
	no	8	6.7
Crop-rotation	yes	114	95.0
	no	4	3.3

III. Descriptive analysis of soil conservation Practices on farmland in the Study area

As can be seen from the Table 4.16 of the sample households from this 92.5% of sample households were experienced in protecting/managing their farmland from erosion problems.

Table 4.16 Dummy variables of soil conservation Practices on farmland in the study area

Variable	Category	Frequency	Percent
Do households have experience in protecting/ managing farmland from erosion problems?	yes	111	92.5
	no	2	1.7

The results of descriptive analysis summarized in table 4.17 for different SWC measures practiced in the study area. The most and widely applied SWC measures are the traditional water-ways (100.0 %), followed by the cut-off drains (98.3%), waterways (97.5%), Contour ploughing (97.5%), crop rotation (95.8%), stone bunds (95.0%), planting trees (95.0 %), traditional ditches (94.2%), reduced tillage (94.2%), terraces (82.5%), soil bunds and (78.3%). Others such as intercropping (43.3%) and grass strip (30.8 %) are practiced. According to the interview with Das expert in wereda office and community representative's farmers were practice some of the soil and water conservation measures once or two in a year applied to protect erosion in the area. They were highly involved in soil bund, terrace, traditional ditches, and stone bund activities.

According to the interview with community representatives stone bund SWC technologies are effective to reduce erosion on farmland. SWC interventions in the highlands focused both on mechanical and biological measures. SWC intervention has been widely implemented in the northern highlands, which cover large areas. A different SWC intervention has been widely implemented on farmlands (Schaften, 2012). Most farmers are taking various measures to control soil-water erosion in the study villages. In the study area, the SWC technologies under implementation were physical structures: soil bunds, stone bunds, cutoff drains, check dam, waterway and biological measures. Stone bunds are generally quite common in the dry zones, since they are relatively easy to construct during the dry season (Figure 4.6). The Stone bunds retain or slow down run off and hence control erosion. In the study area farmers prefer this type of structural soil conservation measures.

Figure 4.6 Stone bund implemented on farmlands in Terea kebele, Source own survey

Soil bunds and cutoff drains is practiced as effective methods of erosion control. In the study area stone is hardly enough to make check dams. Diverting runoff from cultivation field to the main and community road is very common in the study area. Other method of controlling soil erosion in the study area is waterways. This method can receive diverted runoff from cutoff drains in upper slope. The waterway carries the excess runoff to rivers, reservoirs, or gullies safely without causing more erosion damages (Getachew, 2014).

Table 4.17 Soil and water conservation practices applied in the study area

Variable	**Category**	**Frequency**	**Percent**
Traditional water-ways	Yes	120	100.0
Traditional ditches	Yes	113	94.2
	No	7	5.8
Grass strip	Yes	37	30.8
	No	83	69.2
Planting trees	Yes	114	95.0
	No	6	5.0
Contour ploughing	Yes	117	97.5
	No	3	2.5
Reduced tillage	Yes	113	94.2
	No	7	5.8
Crop rotation	Yes	115	95.8
	No	5	4.2
Intercropping	Yes	52	43.3
	No	68	56.7
Stone bunds	Yes	114	95.0

	No	6	5.0
Soil bunds	Yes	94	78.3
	No	26	21.7
Terraces	Yes	99	82.5
	No	21	17.5
Cut-off drains	Yes	118	98.3
	No	2	1.7
Waterways	Yes	117	97.5
	No	2	1.7

Table 4.18showsSWC practice of the sample households from this 73.3% of sample households practiced soil and water conservation in farm plot before government intervention. As the 83.3 %of households evaluated soil erosion problem on farmland after soil and water conservation practices was reduced. And also 95.0 % of households reported that the rate of productivity of farm land after started using soil and water conservation practices was increased. In the study area 95.0 % of households reported that water availability/soil moisture on the field were increased since started implementing soil and water conservation practices. And also 95.0 % of households confirmed that the productivity of crop yields since started implementing soil and water conservation practices. In the central highlands of Ethiopia, the soil bund increased yield of barley (Kidane, 2018)**.**The result of study by Dejene (2018) confirms that soil and water conservation can improve moisture retention during low rainfall- periods and thereby reduce moisture stress and enhance plant growth. Accordingly, reports have shown that some soil and water conservation practices have resulted in positive effects on soil fertility, moisture and agricultural productivity (Tesfa and Tripathi, 2015).

Investments in SWC contribute to the intensification of agricultural system which enhance food production and alleviates poverty. Terrace technologies control soil erosion by reducing the slope of the cultivated land and this facilitates the conservation of moisture for crop use, which leads to increased crop yields. Also found that farms with greater investment in soil conservation had much greater land productivity than did farms without such investment (Abebe and Ketema, 2019). As an approach, soil and water conservation measures are important to improve soil fertility, crop yield increment particularly in highly degraded areas. In most soil and water conservation structures are improve crop yield by enhancing soil moisture and controlling erosion occurred in the area. Even though, soil and water conservation structures are improve crop production, it also reduces the area available for cultivation and crop production by occupying a larger proportion of cropland (Nigatu et al., 2017).

Table 4.18 Soil and water conservation practices

Character	Category	Frequency	Percent
practice soil and water conservation in farm plot before government intervention	Yes	88	73.3
	No	29	24.2
the trend in soil erosion problems on farmland after soil and water conservation practices	reduced	100	83.3
	increased	16	13.3
	no change	1	.8
the rate productivity of farm land after started using soil and water conservation practices	decreasing	3	2.5
	increasing	114	95.0
water availability/soil moisture on the field increased since started implementing soil and water conservation practices	Yes	114	95.0
	No	1	.8
the productivity of crop yields since started implementing soil and water conservation practices	increased	3	95.0
	no change	114	2.5

In the study area respondents reported that the mean of teff grown yield obtained before implementing soil and water conservation practices was 78.04 quintal and after implementing soil and water conservation practices the mean was 8.25 quintal. The mean of maize grown yield obtained before implementing soil and water conservation practices was 7.00 quintal and after implementing soil and water conservation practices the mean was 4.25 quintal and. The mean of sorghum grown yield obtained before implementing soil and water conservation practices was 2.25 quintal and after implementing soil and water conservation practices the mean was 13.33 quintal. The mean of wheat grown yield obtained before implementing soil and water conservation practices was 4.25 quintal and after implementing soil and water conservation practices the mean was 7.13 quintal. The mean of barley grown yield obtained before implementing soil and water conservation practices was 3.91 quintal and after implementing soil and water conservation practices the mean was 6.83 quintal. The mean of lentil grown yield obtained before implementing soil and water conservation practices was 2.75 quintal and after implementing soil and water conservation practices the mean was 4.83 quintal. The mean of beans grown yield obtained before implementing soil and water conservation practices was 3.65

quintal and after implementing soil and water conservation practices the mean was 6.43 quintal. The mean of peas grown yield obtained before implementing soil and water conservation practices was 3.06 quintal and after implementing soil and water conservation practices the mean was 5.63 quintal.

Overall, the survey indicates that yield obtained was higher after implementing SWC compared to before the intervention in the study area. SWC measures improved land suitability that further improves the yield of major crops. They identified that the watershed was moderately and marginally suitable for the major crops such as teff, barley, wheat, and maize before SWC implemented. However, after massive SWC significant improvement on land suitability was achieved. Hence, after implementing SWC measures about half of the area has been changed to highly suitable for wheat and teff, and the remaining has been changed to moderately suitable for barley and maize (Abebe and Ketema, 2019). From the data presented in Table 4.19 no general conclusion can be drawn whether or not SWC measures increase crop yields. As has been presented in the study of Rolker (2012), farmers apply different amounts of fertilizers. The amounts of organic and inorganic fertilizers applied and the SWC measures influence crop yields.

Table 4.19 Yields obtained before and after implementing soil and water conservation practices

Yields (quintal/timad) obtained before implementing SWC			Yields (quintal/timad) obtained after implementing SWC		
Crops	**Mean**	**Std. Deviation**	**Crops**	**Mean**	**Std. Deviation**
Teff	8.25	273.601	Teff	78.04	7.221
Maize	4.25	7.000	Maize	7.00	4.596
Sorghum	2.25	1.500	Sorghum	13.33	17.898
Wheat	4.25	2.665	Wheat	7.13	4.351
Barley	3.91	2.469	Barley	6.83	3.453
Chickpea	2.00	.000	Chickpea	3.00	.000
Lentil	2.75	1.274	Lentil	4.83	1.800
Beans	3.65	2.383	Beans	6.43	3.997
Peas	3.06	1.771	Peas	5.63	2.733

4.2 Econometric model result

4.2.1 Determinant factors that affecting SWC participation

The estimated results of the model of the maximum likelihood, multicollinearity test result and the marginal effects (dy/dx) are used. A total of 15 explanatory variables were used to compute the econometric model in order to identify factors that affect SWC participation. Out the total variables, six of them were able to significantly market engagement. Based on the result presented below, households SWC participation status were negatively affected by age status of household head, education, family size, land size in timad, land certificate and market access at 10%, 10%, 10%, 10%, 10%, 10% and 1% significant level, respectively. It was positively influenced by sex, family labor, farming experience, chemical fertilizer, and distance from home to nearby market at 1%, 10%, 1%, 1% and 1% significant level, respectively. According to the research finding large household sizes, adequate labor, old age, and their income source, farmers' experience, educational, gender, lack of training, government policies and strategies and physical factors have been the major influencing factors for participating in SWC activities(Nigatu et al., 2017; Dejene, 2018).

Table 4.20 Determinants of SWC participation

Variable	**dy/dx**	**Std. Err.**	**z**
Sex	.0548235	.0171063	3.20***
age	-.0027631	.002507	-1.10*
education	.0552888	.4404601	0.13 *
Family size	-.0023412	.0188041	-0.12 *
Family labor	.0381325	.0196471	1.94 *
Farming experience	.0028983	.0013653	2.12 ***
Land size in timad	.0013254	.0037683	0.35*
Plots number	.0130787	.0067148	1.95
Extension access	.412995	.2203328	1.87 *
Off farm	.034162	.0314483	1.09
Chemical fertilizer	.4744236	.2328752	2.04 ***
credit services	.030344	.0419751	0.72 *
distance from home to nearby market	.0494624	.0221889	2.23***
Market access	-.1539876	.0562338	-2.74***

*Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level

Source: Authors" estimates based on 2020 survey

As a result sex of the households positively affected SWC participation by .054. Similar study by Getachew (2014) shows that female farmers have an interest to construct soil-water conservation measures that need large number of labor, but they need the support from others. As a result, the majority of female farmers who depend on farming excluded the construction of soil bunds, fanya juu, check dam and trench digging. Female farmers have an interest to construct soil-water conservation measures that need large number of labor, but they need the support from others. As a result, the majority of female farmers who depend on farming excluded the construction of soil bunds, *fanya juu,* check dam and trench digging. They are practicing cutoff drains, waterways and biological and agronomic soil conservation techniques in combination and/or separately (Getachew, 2014).

They have been practicing cutoff drains, waterways and biological and agronomic soil conservation techniques in combination and/or separately. Age of the households negatively affected SWC participation by -.0027. Age is believed to influence adoption decision because of its influence on planning horizon. Conservation measures such as terrace are long term investments .But, the aged farmers have troubles with practicing soil conservation on their fields and usually have short planning horizon. Older farmers couldn't make soil conservation practices that require work hard which would not be accomplished by aged persons. On the other hand, aged persons practice less labor demanding technologies such as simple cutoff drains, contour ploughing, planting grasses and use of other agronomic conservation measures. This practice also reflects that aged farmers are practicing short staying structures in their cultivation field which also allow free movement and take smaller pieces of land (Getachew, 2014).

Soil and Water Conservation measures increased with the level of education of the household head and the relationship was significant at the 10% level. Heads of household who attended formal education were more likely to adopt stone and soil bunds than their uneducated counterpart heads of household. This might be because better education is associated with greater access to information and awareness about the severity of soil degradation and its consequences, which, in turn, motivate them to adopt SWC measures. Moreover, educated farmers are also more likely to use appropriate SWC measures than uneducated farmers. Elsewhere in Ethiopia, scholars also found education to be an important factor of accelerating the adoption of SWC measures (Million et al., 2019).The practice of SWC was decreasing with family size and this relationship was significant at 1 percent level. The negative relationship between family size and the adoption of stone bund is not surprising; particularly for households with a high dependency ratio. Thus, households with a large family size are less likely to choose the stone bund conservation structure than are smaller sized families. This relationship is also reported by Million et al., (2019) who found the adoption of SWC measures decreasing with family size. Family size is negatively and significantly related to the practices of SWC (Kidane, 2018). Also, studies of Getachew (2014) in the study area, farmers who have small household size, require additional labor to construct and maintain soil conservation structures.

Family labor positively affected SWC participation by .038. According to Getachew (2014) when the majority of family members are capable of working soil-water conservation measures tend to positively correlate with large family sizes. Farming experiences positively affected SWC participation by .00289. Land size in timad increases the probability of SWC participation by-.0013. Farmers with relatively larger land holding size are better than the smaller size. Previous studies indicate, farmers having larger farm sizes are interest to implement conservation technologies in their cropland than the others (Amanuel et al., 2018). The farm land size significant and positive effects on the practice of SWC (Fekadu and Engdawork, 2019).

Plots number positively affected SWC participation and bring about.013 increments. The empirical result shows that plot size is positively and significantly affected the likelihood of adopting SWC (Kidane, 2018).Extension services access positively affected SWC participation by .4129. An extension agent is expected to serve as change agents; therefore, increases in contact with farm households will lead to a change in farm households' attitude and increase adoption of SWC practices (Kidane 2018).

Having any off-farm income generating sources positively affected SWC participation and increased by.034. The result of this study indicates that participation in off farm activities has positive and significant influence on SWC practice. Farm households' involvement in non-farm income promotes investment in long-term land management practices (e.g. SWC)**(**Kidane, 2018).Chemical fertilizer increases SWC participation by .47.

Having access to credit services positively affected SWC participation by.030. Households' access to credit services had also shown a significant positive correlation with soil bund and grass strip with mostly soil bund (Fekadu and Engdawork, 2019). Distance from home to nearby market positively affected and increased SWC participation by .049. Market access negatively influenced SWC participation that market transaction decreased the tendency of presenting agricultural products to market by -.153. The study reveals that farm households who are far away from market center are less likely to practice SWC (Kidane, 2018).

4.2.2 Impact of SWC on agricultural productivity and food security

Among the studied SWC measures traditional water-ways, traditional ditches, contour ploughing, reduced tillage, intercropping, soil bunds, terraces, cut-off drains and waterways significantly related to productivity. The result of the analysis is presented in Table 4.27.

Table 4.21: Impact of SWC on crop productivity

Treatment-effects estimation	Number of Obs = 117
Estimator: propensity-score matching	Matches: requested = 1
Outcome model: matching	min = 1
Treatment model: logit	max = 101

SWC Measures	Coef.	Std. Err.	P>z
Tradiwatr	.0281797	.0160448**	0.079
Tradditches	.0294872	.0167932**	0.079
Plantingtree	-.1718433	.1902934	0.367
Contploughing	-.0338744	.0310431**	0.275
Redtillage	-.0077407	.0285848**	0.787
Croprotation	-.4569513	.472477	0.333
Intercropping	-.0094619	.028852**	0.743
Stonebund	-.0186235	.3339766	0.956
Soilbunds	.0357297	.0206898**	0.084
Terraces	.0097166	.018674**	0.603
Waterways	.0259259	.0147733**	0.079
Cutoff	.0262172	.0149374**	0.079

Note: - ** statistically significant at .05 level * statistically significant at .01 level.

The results suggested that SWC has positive effect on productivity at 1% significant level.(Kidane, 2018)noted that several SWC practices have a statistically significant impact on the value of crop production. For instance, they found that crop productivity is 18%, and 64% higher in plots with and stone terraces, and reduced tillage, respectively. In the same vein, in eastern Ethiopia adopting SWC practice results in more high yield and net return.

Figure 4.7 Effects of stone bund in Sululta wereda, source own survey

4.2.3 Impacts of SWC on households severely food security

As indicated in Table 4.22 the results found that SWC between Traditional water-ways, grass strip, contour ploughing, reduced tillage, intercropping and soil bunds measures have a significant relation with household food insecurity. It improves farm incomes and food security of the households who practiced it because watershed management through SWC (Chot et al., 2019).

The implementation of traditional and indigenous SWC practices improve fodder availability, which provide high nutritious feed for livestock and thus sales of livestock and their products increase the amount of income earned by the household. Also SWC practiced households diversify their crops which increase timing of crop harvest and consequently increase the spatial availability of crop products. This increases the products to be sold and boost income of households (Chot et al., 2019). A study of Melkie (2016) revealed traditional SWC practice, plays an important role in maintaining ecological stability and improving agricultural productivity. The newly introduced SWC measures soil bunds, were widely acknowledged as being effective measures in arresting soil erosion and as having the potential to improve land productivity. But, these new soil and water conservation practices by the farmers appear less likely (Fikru, 2009).

Table 4.22 Impact of SWC on household severely food insecure

Number of obs = 120
Wald chi2(7) = 20.26
Prob > chi2 = 0.0050
Log pseudo likelihood = -62.684447 Pseudo R2 = 0.1449

SWC measures	Coef.	Std. Err.	z	P>|z|
Tradiwatr	17.23178	.4444043	38.78	0.000***
Tradditches	.2711956	.9353201	0.29	0.772
Grastrip	.9356571	.4574195	2.05	0.041**
Plantingtree	.1967673	1.191355	0.17	0.869
Contploughing	15.66572	1.394043	11.24	0.000***
Redtillage	16.83196	.7348889	22.90	0.000***
Croprotation	.4457131	1.139951	0.39	0.696
Intercropping	1.308978	.4706073	2.78	0.005***
Stonebund	-1.283059	1.839411	-0.70	0.485
Soilbunds	2.098612	.9680274	2.17	0.030**
Terraces	.4735229	.8624139	0.55	0.583
Cutoff	-2.590502	1.652367	-1.57	0.117
Waterways	-.6057285	1.257128	-0.48	0.630

Note: -*, **, *** Significant at 10, 5, and 1 % level of significance, respectively

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

This research investigated the contribution of watershed management through SWC practices to household food security in Sululta Wereda, Oromia region of Ethiopia. The multinomial logit selection model result revealed that the SWC practice is influenced by sex, age, education, family size, land size, extension access, market access and distance from home. More specifically, the SWC is positively related with sex. The survey results indicate that household's perceived SWCPs impacts (social, environmental and economic) have a positive and significant effect on the participation and the extent of participation in SWCPs activities.

SWC is positively related with family labor. Indicating there is limited focus on protection and maintenances of watersheds. Therefore, availability of labor need to target construction of conservation structures in watersheds.SWC is positively related with farming experience. The survey result indicating a better farming experience has effect on SWCPs. SWC is positively related with extension access. Indicating there is limited focus on participation of SWC. Therefore, extension services need to create awareness of SWC measures. The results reveal that SWC is positively related with chemical fertilizer. This indicating that different inputs used have a significant role in improving soil fertility. Whereas SWC has negative relation with age. This implies that younger households are more willing to participate in SWCs.SWC has negative relation with family size. The survey result indicates that households having small family size were less likely to participate on SWC. The study suggests that improvement in credit access and inputs applied are needed.

SWC has negative relation with land size. Indicating there is limited in practicing SWC measures. This is due to the fact that farmers with large farm size are likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size. And SWC has negative relation with market access. The study reveals that farm households who are far away from market center are less likely to practice SWC. On the contrary, increasing walking minutes to the nearest car road encourages investment in labor demanding practices such as SWC and manure.

It was based on the results of the descriptive analysis, the cultivated farm plot slope was steep and flat and soil fertility status was poor in the study area. Results identified that households perceived loss of soil fertility on farmland. Result of this study indicated that soil erosion experience was medium. In the study area households had experience in maintaining and replenishing soil fertility of their farmland and the types of inputs used were DAP,UREA, compost and manure. Similarly, lack of applying manure and chemical fertilizer were perceived as the causes of land degradation. Also results indicated that households in the study area did not access credit. This research suggests that households who accessed credit for the purpose of inputs used on farm plots are better to improve soil fertility.

This result identified that households contacted DAs and/or other agricultural experts on soil and water conservation for the last five years. And they have access to information about SWC technology and participating training on SWC. This suggests the role of DAs and/or other agricultural experts to provide information and creates awareness on SWC.

Based on results of descriptive analysis, households confirmed that there were soil erosion problems in the area. As the results identified over cultivation, over grazing, removal of natural vegetation for fuel and construction, cultivating steep slope, and continued cultivation/no fallowing were the dominant cause of soil erosion. The most and widely applied SWC measures are the traditional water-ways, followed by the cut-off drains, waterways, contour ploughing, crop rotation, stone bunds, planting trees, traditional ditches, reduced tillage, terraces, soil bunds and. Others such as intercropping and grass strip are practiced in farm plot before government intervention. As households evaluated soil erosion problem on farmland after soil and water conservation practices was reduced. And also the rate of productivity on farm land after started using soil and water conservation practices was increased. The SWC measure enhanced water availability/soil moisture on the field since started implementing soil and water conservation practices. These results indicate the contribution of SWC to productivity, especially regarding to SWC practices.

The study revealed that SWC measures, land size, market access and family size were factors that significantly determine household food security in Sululta Wereda. There was significant positive association between SWC productivity and household food security. The SWC participation such as on traditional ditches and crop rotation has a significant impact on food security. The result of this study indicated that all SWC measures have a positive association with food insecure households and benefit of having better food security status.

5.2. Recommendations

The following recommendations have been forwarded based on the results of the research.

- The practices of SWC was positively influenced by the level of education of the household head, sex, family labor, farming experience, land size, extension access, chemical fertilizer and the credit services.
- The participation of women in soil and water conservation was also positively related. Policy and programs that are improving women's role in the SWC will assist in overall improvement of rural life and farm productivity. This could be achieved through improvement of their access to productive farm resources. In addition, awareness creating and incentive programs designed to reach all household members will have a significant positive contribution to conservation of soil and water. Thus, a strong effort requires from the government and other stakeholders to promote SWC practices through improving factors significantly affecting (extension services, experience/age, and education) the use of soil and water conservation. While influenced negatively by age, family size, and market access. Based on these findings, the study recommends that efforts of addressing land degradation using SWC structures should focus on strengthening the human and institutional capacity. This should be done through enhancing farmers' education and continuous training and creation of awareness on the effects of land degradation, as well as, the importance of adopting appropriate SWC to control soil degradation and enhance farm productivity. The study suggests that any further research in the study area on soil and water conservation practices should acknowledge the mixture of personal and demographic, institutional, and socioeconomic factors.
- Distance from home and market increase the household's participation on SWC practices. Thus, the government should increase the access of road infrastructure.
- SWC measures showed positive impact on food security status of farming households. This is due to the fact that SWC enhance productivity, but households did not have access and awareness on the different SWC measures mostly on introduced SWC measures. Therefore, households should be accompanied by awareness creation and participation.

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Appendices

Appendix1 Household Survey Questionnaire

ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

My name is Addis Assefa, a postgraduate student at Addis Ababa University. Currently, I am conducting study for my MSc thesis entitled 'contribution of watershed management interventions through soil and water conservation to improve household's food security in Sululta micro-watershed, in Oromia region'. Your response to this Questionnaire will serve as sources of information. Any response you provide here is strictly secreted and will be used exclusively for the research purpose. No individual's responses will be identified as such and the identity of persons responding will not be published or released to anyone. Your honesty in responding the right answer is vital for the research outcome to be reliable. Thank you in advance for your kind cooperation and dedicating your time.

Sincerely,

Addis Assefa

Part I. General information

1.	Questionnaire code		
2.	Wereda		
3.	Kebele		
4.	Date of Interview		
5.	Time of interview:	Starting time	
		Finishing time	
6.	Name of interviewer		

Part II. Household socio-cultural related information

No	Questions		Code
1.	**Sex of household head:** 1. Male 2. Female		
2.	**Age of household head:** In years		
3.	**Education status of household head**: 1. Illiterate 2. Read and write 3. Elementary school (1-4) 4. Secondary school (5-8) 5. Other, specify		
4.	**Family size**		
4.1.	Number of family members in the household	1. Male	
		2. Female	
		3. Total	
5.	**Marital status**: 1. Single 2. Married 3. Divorced 4. Widow 5		
6.	**Health Status**		
6.1.	Is the household head active/capable to work? 1. Yes 2. No		
6.2.	If 'no' to question # 5.1., why? 1. Sick 2. Aged 3. Disable 4. Other, specify		
7.	**Labor available**		
7.1.	Number of permanent family labor for farming activities at time of survey	1. Male	
		2. Female	
		3. Total	
8.	**Wealth status**		
8.1.	Household category in terms of wealth status: 1. Better-off 2. Middle 3. Poor		
9.	**Farming experience in years**		

Part III. Household economic and farm related information

1. Farmland

1.1. Please indicate the type of land use you owned, means of access to it, size in Timad and the number of plot(s) for each type of land uses you owned.

Land use types	1.1.1. 1. Yes 2. No	1.1.2 **Means of access (Multiple response is possible)** 1. Land distribution 4. Sharecropped-in 2. Inherited from parents 5. Rented-in 3. Shared with relatives 6. Other, specify	1.1.3 **Size in *Timad***	1.1.4 **Number of plot/plots**
Cultivated land				
Grazing land				
Homestead area				
Other, specify				
		Total		

1.2. Would you tell us the characteristics of each cultivated farm plots you have?

Plots	**1.2.1.** **Slope** 1. Flat 2. Gentle 3. Steep	**1.2.2.** **Soil colour** 1. Black 2. Red 3. Brown 4. Sandy	**1.2.3.** **Distance** from home (Minutes)	**1.2.4.** **Soil fertility status** 1. Poor 2. Medium 3. Good	**1.2.5.** **Soil erosion experience** 1. Low 2. Medium 3. Severe
Plot 1					
Plot 2					
Plot 3					
Plot 4					
Plot 5					
Plot 6					
Plot 7					
Plot 8					
Plot 9					
Plot 10					

2. **Crop production**

2.1. Would you tell us the type of crops have you grown, amount of crop products you produced and income obtained in the year 2010/11 E.C.

Type of crop cultivated	**1. Yes 2. No**	**Cultivated area (Timad)**	**Quantity produced (Qt)**	**Quantity retained for consumption (Qt)**	**Quantity sold to market (Qt)**
Teff					
Maize					
Sorghum					
Wheat					
Barley					
Chickpea					
Lentil					
Beans					
Peas					
Other, specify					

3. **Inputs applied**

3.1. Would you tell us farm inputs you applied to help you increase production in 2010/2011 E.C?

No	**Input applied**	**1. Yes 2. No**	**If 'Yes', tell us amount applied (Kg/ha)**
1.	**Chemical fertilizer**		
1.1.	Have you used DAP?		
1.2.	Have you used UREA?		
2.	**Natural fertilizer**		
2.1.	Have you applied compost?		
2.2.	Have you used manure?		

4. **Farm-implements**

4.1.	Do you have farm implements for farming activities? 1. Yes 2. No	
4.2.	If 'yes' to question # 4.1., which type/s of farm implements do you have? (multiple response is possible) 1. Farm oxen 2. Plough and yolk 3. Flat hoes 4. Shovel 5. Hammer 6. Other, specify	

5. **Livestock production**

5.1. Would you tell us the types of livestock you have, their number and income obtained from sale of livestock's in the year 2008/09 (2015/16)?

No	Livestock types	5.1.1.	5.1.2.	5.1.3.	5.1.4.
		1. Yes 2. No	**Number owned**	**Livestock sold**	**Income obtained**
1.	Oxen				
2.	Cows				
3.	Bulls				
4.	Heifers				
5.	Calves				
6.	Sheep				
7.	Goats				
8.	Horses				
9.	Donkeys				
10.	Mule				
11.	Chicken/poultry				
12.	Other, specify				

5.2. Would you tell us livestock products you produced, products sold to market and estimated income obtained from sale of livestock products in the year 2010/11 E.C?

No	Livestock products produced	5.2.1.	5.2.2.	5.2.3.	5.2.4.
		1. Yes 2. No	**Estimated amount produced**	**Estimated amount sold to market**	**Estimated income obtained (Birr)**
1.	Milk				
2.	Cheese				
3.	Butter				
4.	Eggs				
5.	Other, specify				

6. **Income generating activities**

6.1.	Do you have any off-farm income generating sources? 1. Yes 2. No	
6.2.	If 'yes' to question # 5.1., would you tell us about the type of activities and estimated income obtained in the year 2010/11 E.C?	

No	Type of off-farm activities	6.2.1.	6.2.2.
		1. Yes 2. No	**Estimated income obtained**
1.	Petty trades		
2.	Pottery		
3.	Weaving		
4.	Leather making		
5.	Selling of fire wood		
6.	Driver (Gary or Bajaj)		
7.	Other, specify		

Part IV. Household institutional related information

1.	**Extension**	
1.1.	Do you have access to extension services? 1. Yes 2. No	
1.2.	If 'Yes' to Q#1.1., who provides the extension services? 1. Development Agents (DAs) 2. NGOs 3. Both 3. Other, specify	
1.3.	Have you contacted development agents and/or other agricultural experts on soil and water conservation for the last five years? 1. Yes 2. No	
1.4.	If your response is 'yes' to Q#1.5., how often do you contacted them? 1. Once a month 2. two times per month 3. Three times per month 4. Twice a year 5. Other, specify	
2.	**Access to information**	
2.1.	Do you have access to information about any SWC technology? 1. Yes 2. No	
2.2.	If 'Ye' to Q# 2.1., what are your sources of information regarding soil and water conservation practices? 1. Development Agents 2. NGOs 3. Mass media 4. Neighbor farmers 5. Parents 6. Other, specify	
3.	**Training**	
3.1.	Have you participated in training on soil and water conservation for the last five years? 1. Yes 2. No	
4.	**Land certificate**	
4.1.	Do you have a land certificate? 1. Yes 2. No	
5.	**Credit services**	
5.1.	Do you have access to credit services? 1. Yes 2. No	
5.2.	If 'yes' to question # 11.1, for what purpose do you receive credit? (multiple response is possible) 1. To purchase improved seed 2. To purchase fertilizer 3. To purchase farm equipment/ tools 4. To start income generating activities 5. Other, specify	

6.	**Access to market**	
6.1.	Do you have access to market? 1. Yes 2. No	
6.2.	Please tell us the distance from home to nearby market (in hours)	

Part V. Household Perception on Soil erosion, Decline in soil fertility and SWC related information

1.	**Soil erosion**	
1.1.	Do you think that there is soil erosion problem in your area? 1. Yes 2. No	
1.2.	If your response is 'yes' to Q #4, what do you think are the causes of soil erosion on your farmland? (Multiple response is possible)	

No	Causes of soil erosion	1. Yes 2. No
1.	Over cultivation	
2.	Over grazing	
3.	Removal of natural vegetation for fuel and construction	
4.	Cultivating steep slope	
5.	Continued cultivation/no fallowing	
6.	Cultivating marginal land	
7.	Erosive rainfall	
8.	Poor farming practices	
9.	Lack of using SWC technologies such as bunds	
10.	Damaged bunds	
11.	Other, specify	

1.3.	Do you have experience in protecting/managing your farmland from erosion problems? 1. Yes 2. No	
1.4.	Which of the following soil and water conservation practices do you practiced to protect/manage your farmland from erosion?	

No	Measures	1. Yes 2. No
1.	Traditional water-ways	
2.	Traditional ditches	
3.	Grass strip	
4.	Planting trees	
5.	Contour ploughing	
6.	Reduced tillage	
7.	Crop rotation	
8.	Intercropping	
9.	Stone bunds	
10.	Soil bunds	

11.	Terraces	
12.	Cut-off drains	
13.	Waterways	
14.	Other, specify	

2.	**Soil fertility**	
2.1.	Do you perceive that there is loss of soil fertility on your farmland? 1. Yes 2. No	
2.2.	If your response is 'yes' to Q #2.1, what do you think are the reasons for decline in soil fertility on your farmland? (Multiple response is possible)	

No	Causes of decline in soil fertility	1. Yes 2. No
1.	Soil erosion	
2.	Repeated cultivation	
3.	Lack of applying manure	
4.	Lack of using chemical fertilizer	
5.	Other, specify	

2.3.	Do you have experience in maintaining and replenishing soil fertility of your farmland? 1. Yes 2. No	
2.4.	If your response is 'yes' to Q #2.3, which of the following measures do you practice	

No	Measures	1. Yes 2. No
1.	Chemical fertilizer	
2.	Compost	
3.	Manure	
4.	Crop-rotation	
5.	Others, specify	

3.	**Soil and water conservation practices**	
3.1.	Did you practice soil and water conservation in your farm plot before government intervention? 1. Yes 2. No	
3.2.	How do you evaluate the trend in soil erosion problems on your farmland after soil and water conservation practices have been implemented? 1. Increased 2. Decreased 3. No change	
3.3.	How do you rate the productivity of your farm land after you have started using soil and water conservation practices? 1. Increasing 2. Decreasing 3. No change	
3.4.	Has water availability/soil moisture on the field have increased since you have started implementing soil and water conservation practices? 1. Yes 2. No	

3.5.	How do you evaluate the productivity of crop yields since you have started implementing soil and water conservation practices? 1. Increased 2. Decreasing 3. No change	
3.6.	If your response is 'increased' to Q#3.6., would you tell us the type of crop grown and yield obtained before and after implementing soil and water conservation practices?	

No	**Types of crop grown**	**1. Yes 2. No**	**Yield obtained**	
			Before	**After**
1.	Teff			
2.	Maize			
3.	Sorghum			
4.	Wheat			
5.	Barley			
6.	Chickpea			
7.	Lentil			
8.	Beans			
9.	Peas			
10.	Other, specify			

Part VI: Food access information (Household Food Insecurity Experience Scale)

1. The following questions are provided to gather information within the time frame of the last 6 months; from September 2019 to February 2020 (Meskerem to Yekatit2012 in E.C)

No	Questions	Responses	Code
1.1.	Is there a time when you were worried you would not have enough food to eat because of a lack of money or other resources?	1. Yes 2. No	
1.2.	Is there a time when you were unable to eat healthy and nutritious food because of a lack of money or other resources?	1. Yes 2. No	
1.3.	Is there a time when you ate only a few kinds of foods because of a lack of money or other resources?	1. Yes 2. No	
1.4.	Is there a time when you had to skip a meal because there was not enough money or other resources to get food?	1. Yes 2. No	
1.5.	Is there a time when you ate less than you thought you should because of a lack of money or other resources?	1. Yes 2. No	
1.6.	Is there a time when your household ran out of food because of a lack of money or other resources?	1. Yes 2. No	
1.7.	Is there a time when you were hungry but did not eat because there was not enough money or other resources for food?	1. Yes 2. No	
1.8.	Is there a time when you went without eating for a whole day because of a lack of money or other resources?	1. Yes 2. No	

Thank you for your time!!!

Appendix 2

Key informant interview for DAs experts in wereda office

1. Perception on soil erosion problem in the area. What are the causes of soil erosion?

2. Perception on loss of soil fertility on farmlands in this area. What are the causes?

3. Soil and water conservation practices applied to protect erosion in the area.

4. Training provided to farmers in the past five years.

5. Do farmers participate in soil and water conservation activities in planning, implementation and maintenance?

6. Type of farmers implementing soil and water conservation measures on their farm lands.

7. Farm inputs supplied to support farmers increases production?

8. Perception on the roles of soil and water conservation measures for farmer's food security.

Appendix 3

Key informant interview for community representative in the wereda

1. Perception on the causes of land degradation in the wereda.

2. Perception on soil erosion problem in the wereda. What are the causes of soil erosion?

3. What is the effect of SWC on the farm land after practicing?

4. What type of SWC measures are used by farmers?

5. Any training provided by the wereda experts and development agents to increase awareness on soil and water conservation?

6. What experiences does the community have in the past in terms of collectively managing natural resources in general and soil and water conservation in particular?

7. What are the factors affecting soil and water conservation practices?

8. What do you think about the role of soil and water conservation practices to improve land productivity?

Appendix 4

Checklists for focus group discussion

1. What are the main constraints related to improving agricultural productivity in this area?
2. Perception on soil erosion and loss of soil fertility. Explain the causes.
3. Do you think that soil and water conservation practices under taken in wereda are effective in the reduction in soil erosion and loss of soil fertility?
4. Which SWC technologies are effective to reduce erosion on farmland?
5. What are the main constraints related to implementing soil and water conservation practices in the wereda?
6. Have you evaluate awareness raising training soil and water conservation provided to farmers in this area?
7. Who is responsible to maintain soil and water conservation practices implemented on farmlands?
8. What do you think about the role of soil and water conservation practices to improve soil productivity?
9. Explain how soil and water conservation practices help to improve food security.