ADOPTION OF SOIL AND WATER CONSERVATION PRACTICE AROUND LAKE HAWASSA, SIDAMA REGION, ETHIOPIA

MSc THESIS

BY:

ENDALE ESRAEL

COLLEGE OF AGRICULTURE

HAWASSA UNIVERSITY

HAWASSA, ETHIOPIA
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MAJOR ADVISOR: TERAMEGE TESFAYE (PHD)
CO-ADVISOR: ZERHUN DEMREW (PHD)

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APPROVAL SHEET-I

ADVISORS' APPROVAL SHEET

SCHOOL OF GRAGUATE STUDIES

HAWASSA UNIVERISITY ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled" **IMPACT OF SOIL AND WATER CONSERVATION PRACTICE AROUND LAKE HAWASSA ON THE COMMUNITY'S CLIMATE CHANGE ADAPTATION STRATEGIES, SIDAMA REGION, ETHIOPIA"** is submitted in partial fulfillment of the requirements for the degree of Master of Science with specialization in **CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE**, HAWASSA UNVERSITY COLLEGE OF AGRICULTURE and is a record of original research carried out by Endale Esrael, ID. No CCSAR/003/13, under our supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the courses of this investigation have been duly acknowledged. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

TERAMAGE TESFAYE(PHD)	________________	_________________
Name of Major Advisor	Signature	Date
ZERHUNI DEMREW(Ass. Prof)	_______________	_________________
Name of Co-advisor	Signature	Date

APPROVAL SHEET-II

We, the undersigned, members of the Board of examiners of the final open defense by ENDALE ASRAEL have read and evaluated his thesis entitled ‘‘IMPACT OF SOIL AND WATER CONSERVATION PRACTICE AROUND LAKE HAWASSA ON THE COMMUNITY’S CLIMATE CHANGE ADAPTATION STRATEGIES, SIDAMA REGION, ETHIOPIA and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the Degree of Master of CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

TERAMAGE TESFAYE(PHD)	________________	________________
Name of major advisor	Signature	Date
ZERHUN DEMREW(Ass.Prof)	________________	________________
Name of co-advisor	Signature	Date
ZERHIN GANEWO(Ass. Prof)	________________	________________
Name of the Chairperson	Signature	Date
FITSUM WAQWOYA(PHD)	________________	________________
Name of Internal Examiner	Signature	Date
DEMELASH KEFALE(PHD)	________________	________________
Name of External Examiner	Signature	Date
BIRUK BIRHANU(PHD)	________________	________________
SGS Approval	Signature	Date

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DEDICATION

I dedicate this thesis to my lovely family for tending me with love and for their dedicated parenting in the success of my life.

STATEMENT OF AUTHOR

I declare that this thesis is my work and that all sources or materials used in this thesis have been properly acknowledged. This thesis is submitted in partial fulfillment of the requirements for M.Sc. Degree at Hawassa University and to be made available at the University's Library under the rules of the Library. I confidently declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate.

___________________________ __________ ______________________

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Place: ______________________________________

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LIST OF ACRONOMYS

BOA	Bureau of Agriculture
BOANRD	Bureau of Agriculture and Natural Resource Development
CRGE	Climate-Resilient Green Economy
FAO	Food and Agricultural Organization
HZWOA	Hawassa Zuria Woreda of Agriculture
KgVDP	Kabo-girma Valley Development Program
LM	Land Management
MERET	Managing Environmental Resources to Enable Transitions
MOA	Ministry of Agriculture
NGO	Non-Governmental Organization
PSNP	Productive Safety Net Program
SWC	Soil and Water Conservation
SLM	Sustainable Land Management
SLMP	Sustainable Land Management Project
SWAT	Soil and Water Assessment Tool
TLU	Tropical Livestock Unit
UNFCCC	United Nations Framework Convention on Climate Change
VIF	Variance Inflation Factor
SZBOARD	Sidama Zone Bureau of Agriculture and Rural Development

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Author: Endale Esrael (email:endaleesrael66@gmail.com)

Major advisor: Teramaji Tesfaye (PHD)

Co-advisor: Zerhun Demrew (PHD)

ABSTRACT

Ethiopia is promoting SWC technologies for improving agricultural productivity, climate change adaptation, household food security and rural livelihoods. The effectiveness of these SWC practices that are alleged to enhance productivity is very important in order to evaluate their performance in reducing land degradation and rehabilitating the land. The major concern of this study is to analyze the adoption of soil and water conservation practice around Lake Hawassa. The data were collected from 150 farmers residing in 3 Kebeles that are randomly selected from 25 rural Kebeles where soil and water conservation have been introduced and widely implemented. Both qualitative and quantitative data were used to have reliable information. The basic data used for this study were collected from Sample households, focus group participants and key informants through structured questionnaire and semi-structured checklists. The collected data was analyzed using descriptive statistical tools such as mean, frequency, percentages, tables, Chi-square and t-test and inferential statistical tools such as binary logistic regression model and multiple linear regression models. The survey data identified that out of the total (150) households, 100 (66.7%) were being adopted SWC activities in their lands while the rest 50 (33.3) households didn't adopted SWC. The Chi-square result showed that sex, marital status, level of education, credit access and extension services were affects SWC positively and statistically at 5% significant level and the t-test result showed that age and land size affects SWC positively and statistically at 5% significant level. The logistic regression model showed that advisory services, training on SWC, number of family size and education level significantly influences adoption of SWC measure in the study area. The comparative analysis of maize production showed 17.5508 quintals average yield increment in case of SWC adopting households as compared to non-adopter during 2020/2021 production season. The results revealed positive relationships between total yield of maize and labor, seed, land, and oxen (draft access). Based on this result, labor and land are the most significant factors of maize production among SWC adopters. As more of these factors of production (land and labor) are used increasingly, there will exist more maize yield among the adopter households. This increased crop yield as a result introduction of SWC to farmer's farm also enhanced their income, achieving food security and livelihood in the study area. The researcher recommends, the stakeholders need to work jointly to improve the farmer's access to SWC training service, and provide different advisory services while promoting SWC technologies among small holders in the study area.

Key words: *Adoption, Food security, Hawassa zuria woreda, Soil and water conservation*

CHAPTER ONE

1. INRODUCTION

1.1. Background and justification

Land degradation remains one of the biggest environmental problems worldwide and it has been a major global agenda because of its adverse impact on environment and food security and the quality of life (Slegers, 2008). It is estimated that nine million hectares of the world lands are tremendously degraded and their original biotic functions are severely affected. Inappropriate agricultural practices account for 28% of the degraded soils (Addisu, 2011), and about 1.2 billion hectares of the land worldwide reported as moderately degraded.

At regional level especially in Sub-Sahara Africa (SSA) a sub-region where only 7% of land area of 24.6million sq.km total area is under cropland, 70% of the population depend on rain-fed agriculture as a principal source of their livelihood, 90% of food and feed come from rain-fed agriculture and 75% are smallholder farmers (FAO, 2011; Hellmuth et al., 2007; Rosegrant et al., 2002). In addition, rural livelihood of local population in Sahelian countries become unstable owing to the factors like inadequate access to food and health care; malnutrition; missing social safety nets, poor infrastructure; degradation of ecosystems; impacts of climate change; economic disparities and weak public institutions where risks such as drought and flood are the main driver of 80% loss of life and 70% loss of economy in SSA (FAO, 2011). Furthermore, the estimate indicated that 56% of cultivated area of all crops in SSA will be affected by climate change by 2050 (Hellmuth et al., 2007). Thus, land degradation in the form of soil erosion is dominant type of degradation in the continent partly because 80% of energy in SSA is derived from biomass which is the critical cause of vegetation clearing leaving the soil surface bare and rendering rainfall the possibility to change into overland flow (ECA, 2014).

In fact, evidences indicated that soil erosion is widespread across the continent with spatial and temporal variation. According to Kirui & Mirzabaev (2014) and den Biggelaar et al., (2004) estimates, in Maghreb of Northwestern Africa; east African highland, Madagascar and some portion of South Africa; northwest and south Africa; coastal parts of east Africa, Congo basin and some portion of south Africa; and most parts of west African Sahel, eastern and south Africa the erosion rate was 75Mg/ha/yr.; 50-75Mg/ha/yr.; 25-50Mg/ha/yr.; 10-25Mg/ha/yr; and less than 10Mg/ha/yr respectively. In order to tackle these problems, German Development Cooperation has developed and implemented SWC approaches in the Sahelian Countries. For instance, in Ethiopia, Niger, Burkina Faso, Chad and Mauritania rural population have been assisted through development programs in sustainable land management and SWC extension (Ackermann et al., 2015).

In Ethiopian context, since degradation of land has real economic, social, and human costs with substantial impacts on national economies, it also directly threatens the long-term growth of agricultural productivity, food security, and the quality of life, particularly in developing countries (Shiferaw et al., 2009). Land degradation, poverty and food insecurity are pervasive and interconnected problems in Ethiopia (Shiferaw et al., 2004). The problem is very serious particularly in steep lands where rain fed agriculture constitutes the main livelihood of the people (Shiferaw et al., 2001). Recent studies in Ethiopia also indicated that land degradation is a dominant process at the bottom land of the watersheds where there is a saturated soil, in this part of the watershed the soil will be easily removed by sheet and rill erosion and the formation of gullies (Tebebu et al., 2010; Tilahun et al., 2013; Ayele et al., 2015). Despite the severity of the problem, it is only in the past three decades, that land conservation has received policy attention in the country (Amsalu and de Graaff, 2007). SWC in Ethiopia is closely related to the improvement and conservation of biophysical environment, and ensuring sustainable development in agricultural sector and its economy at large (Abera, 2003). In Ethiopia, efforts towards this conservation goal were started since the mid-1970s and 80s (Bekele and Drake, 2003). Since then, different soil and water conserving practices with a variety of approaches have been underway (Adugnawet al., 2013). The focus was conserving soil, rainwater and vegetation effectively for productive uses, harvesting surplus water, rehabilitating and reclaim marginal lands through appropriate conservation measures and mix of trees, shrubs and grasses based on land potential (Lakew et al.,2005).

Effective SWC practices, including physical and biological methods, are substantial benefit for attaining and sustaining food security in smallholder farming scale, through the successful rehabilitation and management of natural resources (Kebede et al., 2013). Recognizing the threat of land degradation and benefits of SWC practices, the government of Ethiopia is promoting SWC technologies for improving agricultural productivity, household food security and rural livelihoods (Amsalu, 2006; Teshome et al., 2016). The positive effects of SWC occur through time and practicing of technologies depends on the ability to improve economic and environmental benefits. The assessment of the effectiveness of these SWC practices that are alleged to enhance productivity is very important in order to evaluate their performance in reducing land degradation and rehabilitating the land (Yitayal et al., 2014). The study area is characterized by overexploited soils, deforestation and overgrazed land resulted from high human and animal population it has supported for decades, low agricultural productivity, severe land degradation, and other environmental problems including climate change (HZWOA, 2014). It is therefore critical to examine the impact of SWC practice on community's climate change adaptation strategies. For this purpose, this study evaluate what adoption of SWC practiced in Hawassa Zuria woreda surrounding Lake Hawassa have brought to the community's capacity in climate change related to adaptation strategies as a show case.

1.2. Statement of the problem

Land degradation increases the vulnerability of people to the adverse effects of climate change by reducing soil organic carbon concentration and water holding capacity, which in turn reduces agricultural productivity and local resource assets (Mengistu et al., 2016). The Ethiopian government, non-governmental organizations and the community made efforts to combat land degradation by employing community centered watershed management practices to protect land degradation and reduce the risk of climate hazards.

Hawassa zuria woreda is known with many problems such as recurrent drought and flood, irregular rainfall and food insecurity (ZBoARD, 2007). Climate change and Food insecurity in the area is a major challenge and all these climate shocks have exacerbated the negative impacts on food security of poorer farm households as they have the lowest capacity to adapt to changes in climatic conditions (HZWOA, 2014).

Similarly, the above problem is also applies to particular study area where, farmers have cleared forest coverage to expand arable land due to ever increasing population. Indeed, lands' productive capacities have decreased due to climate change; yields per farm land had showed a dramatic decline. SWC plays an important role in supporting the livelihoods of the majority of people involved in agriculture, food security and poverty reduction but it cannot be achieved unless issues access to training, and land management. On the other hand with regard to SWC management research didn't yet been conduct in the study area and the attention given by the community and local government is unsatisfactory. To overcome the above-mentioned problems of the study area, several soil and water conservation measures have been initiated by the government, non-governmental organizations (WFP) and community. Hence, the main reason for conducting this research is to assess the adoption of SWC practices around Lake

Hawassa and to provide the possible recommendations on how to curb the problems for farmers and local government agents in the study areas.

1.3. Objective of the study

1.3.1. General objective

The purpose of this research is to assess the adoption of soil and water conservation practice around Lake Hawassa.

1.3.2. Specific objectives

- To identify the SWC measures that have been take in the study area.
- To determine factors that influence adoption of SWC practices.
- To assess the contribution of SWC as climate change adaptation strategies.
- To assess the contribution of SWC for house hold food security.

1.4. Research questions

- What type of SWC measures being taken among the community?
- What factors determine adoption of soil and water conservation practices?
- What are the contributions of SWC on households to adapt on climate change?
- What are the contributions of SWC for house hold food security?

1.5. Significance of the study

Policy makers, researchers, experts and NGOs need to understand factors affecting SWC practices and its impact on food security and climate change adaptation. It also helps to design effective policies and strategies and to develop appropriate SWC practices that promote the productivity of land as well as the efficient utilization of resources. Therefore, the finding of this study will help to give first-hand information for different governmental organization and policy makers to design and develop appropriate SWC strategies that taking in to consideration the issues of sustainability.

1.6. Scope of the study

This study focused on the identification of SWC practices around Lake Hawassa. The study was conducted in a small geographical area, particularly only in three kebeles namely Jara Hinessa, Dore Bafano and Galo Argissa. These kebeles are purposively selected due to SWC practice, widely implemented through the efforts of the community, government and NGO.

1.7. Limitation of the study

While conducting this study, some problems were also related to time, material constraints and some household farmers were not willing to respond and others did not want to give the required information and unavailability of recorded data with regard to soil and water conservation practices being practiced in the study area.

1.8. Organization of the thesis

This thesis is organized in to five chapters. Chapter one constituted the introduction, which focuses mainly on the background, statement of the problem, objectives, research questions, significance, scope of the study and limitation of the study. Chapter two deals with reviews of different literatures related to SWC to reduce land degradation and the conceptual frame work of the study. Chapter three contains short description of the study area and research methodology. Chapter four contains Discussion part. Chapter five contains Conclusion part.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Theoretical and Empirical review

2.1.1. Definition of Terms and Concepts

Soil and Water Conservation (SWC): The improvement or improved management of the two resources "soil" and "water" to maintain (support, increase) in a medium to long term perspective of the production capacity of the resources, often measured in terms of yield(WOCAT, 2004).

As Rogers (1983) **Adoption** is *"... the mental process through which an individual passes from first hearing about an innovation to final adoption."*

Franzel et al (1998) defines **adoption potential** as: *"The technical feasibility, economic viability and social acceptability of a technology when managed at field scale by a target population of farmers."*

Adoption of Soil and Water Conservation Measures: The process of accepting and implementing modern soil and water conservation technologies by the farmers of an area through experts and development agents for better land management practices (Yohannes and Herwege, 2000). Newly introduced SWC measures can be considered as adopted if the farmers continue to utilize them as part of their production system after the external assistance is withdrawn. The adoption of a technology can be assessed by analyzing farmers' attitudes, objectives and aspirations of whether they would like to use the introduced technologies as part of their fanning system (Woldeamlak, 2003). For this study farmers were classified into adopters and non-adopters of soil and water conservation measures depending on their behavior with regard to SWC practices.

Adopters of SWC measures: are those farmers who put into practices a given SWC structures such as terraces (stone bund, soil bund, fanyaa juu….e.t.c) introduced in their community and practiced in a sustained basis.

Non-adopters of SWC measures: are those farmers who choose not to practice SWC structures.

2.1.2. Soil and Water Conservation in Ethiopia

Currently rapid deforestation is taking place in the tropics and damaging the thin layer of soil that is fragile and quickly washed away when exposed to the heavy rain. Globally, agricultural activities that makes the land surface more susceptible to soil erosion account for 28% (2 billion hectares), overgrazing for 34% and deforestation for 29% of soil degradation (Tekalegni, 2011). Population pressure, mismanagement of agricultural lands, deforestation and overgrazing area among the major causes of soil erosion and environmental degradation. The average annual rate of soil loss in Ethiopia is estimated to be 12 tons/hectare/year, and can be even higher on steep slopes (greater than 300 tons/hectare/year or about 250 mm/year) where vegetation cover is scant (Alemu 2000). Moreover, it keeps proper soil compaction; maintain or improve soil fertility and conserve or drain water.

As a result, soil and water conservation practices exist as indigenous knowledge in some areas of Ethiopia (Nyssen et al. 2007; Watson and Currey 2009). The Konso terraces are estimated to be older than 400 years. Some rudimentary and poorly established terraces depicted on older aerial photographs and physical remnants can also be observed in different parts of the northern highlands. This is an indication of indigenous knowledge on SWC practices, and terracing is not only limited to the Konso area but it is also found in other parts of the country.

2.1.3. Sustainable soil and water Conservation and participation

Sustainable conservation is both directly and indirectly the focus of this study and it is also supposed to be the wish and expectation of both governments and donor organizations. Unfortunately, the process of ensuring sustained conservation has been a difficult task for a country that almost entirely depends on others for survival, and the maintenance of their environmental functions (Herweg et al., 2006). Ethiopia, being one of the poorest countries in the world, may continue to find it difficult to provide adequate funding that would ensure sustainable conservation and rehabilitation works (Indexmundi, 2009). Other reasons attributable to this are: the habitual payments for conservation and rehabilitation works in Ethiopia; the effect of the short term duration of government and/or donor funded conservation projects; and lack of capacity to maintain existing conservation structures while at the same time, ensure continuous survival and wellbeing of local people who are directly affected by land resource degradation. To be sustainable, community participation, community capacity building, unconditional roles of governments and donor agencies and effective joint management and coordination of conservation projects have to be ensured. The nation’s economy is mainly dependent on rain fed agriculture, which accounts for half the GDP, 60% of exports and 80% of employment Water Aid Ethiopia (WAE, 2008).

2.1.4. Assessment of soil and water conservation

Soil and water conservation has been considered a more or less technical issue, based on years of dominantly biophysical problem-oriented research on factors such as climate, soils, topography, vegetation, etc. Consequently, many SWC guidelines were published with dominantly technical character Much less information is available concerning solution-oriented research including that addresses, among other things, also negative side effects, about the compatibility of technical solutions with prevailing socio-cultural and economic settings of a specific area, and about the process of adapting

SWC to such settings (Liniger and Cahile, 2002). In the 1980s, SWC in Ethiopia focused on preventing further decline of the remaining soil resources and to rehabilitate already degraded soils. It was most unfortunate that the issue of resource management was split into different tasks addressed by different ministries and departments, e.g. controlling soil erosion (Community Forestry and Soil Conservation Department; SCRP) and agricultural production Agronomic Development Department, Institute of Agricultural Research – without appropriate coordination.

Ethiopian farmers began on a large scale, removing and modifying SWC schemes that were previously established by the government under the food for work program. These reactions can be seen as an eye-opener for many SWC experts who had to learn that SWC could only be made effective if it's economic viability and social acceptability is given the same attention as ecological soundness and technical feasibility. The poor conservation practices that cause land degradation in sub- Saharan Africa countries cut across sectors of agricultural practices, works and construction. Some of these include insufficient lengths of drainage network, over - grazing of rangelands, drainage constructed to earths' beds and the use of heavy machinery. Others are: absence of crop rotation and manure; planted trees and shrubs which do not survive because of lack of proper and adequate nurturing; poor human attitude, as when some politicians and individuals chop down trees planted by their political opponents; plugging of soil which leads to decline of soil organic matter of between 25 and 40 percent, thereby exposing land to wind and water erosion (UNEP, 1998).

Thus, the past and present human intervention in the utilization and manipulation of environmental resources have had unanticipated consequences (Oldeman, 1994). These interventions and manipulations are particularly crucial in the sub-Saharan Africa region, where unsustainable conservation practices have been identified as a threat to sustainable land uses. This study also notes that governments' disregard for traditional solutions to land degradation negatively affects conservation efforts. Further focuses attention on poor practices, so as to include the impact of a chain of international trade and economic practices which result in low prices for agricultural and livestock commodities. This forces most developing countries to promote adverse land use practices with the intention of earning foreign exchange assistance in small scale irrigation project indicate that same irrigation scheme are not operating the full potential land same is not function at all due to factor related to shortage of water damage the structure of poor water management (FAO, 2008).

2.1.5. Role of soil and water conservation for degraded land restoration

Studies have indicated that biological and mechanical SWC measures can help to reduce soil loss and regenerate vegetation (Carla et al., 2003; Fu et al., 2003; Mekuria et al., 2007; Kalinina et al., 2009). SWC measures reduced both the in-situ and offsite impacts of degradation. Mechanical structures such as terraces, check dams, tranches and micro-basins modify terrain through changing slope length and angel, which in turn reduces runoff velocity, enhances water infiltration and traps sediments washed down the terrain (Vancampenhout et al., 2006; Nyssen et al., 2007). Sediment accumulated behind the terrace provides suitable conditions for plants/crops through conserving nutrients and water (Dercon et al., 2003; Gebremichael et al., 2005; Vancampenhout et al., 2006).

Biological SWC measures such as enclosure, homestead tree plantation, reforestation and enrichment tree plantation within enclosures help to restore vegetation cover and diversity (Asefa et al., 2003; Carla et al., 2003; Fu et al., 2003). With vegetation cover restoration, beside soil fertility improvement through regular organic matter addition, the soil surface can also be protected from raindrop splash and scoring effects of runoff water. This reduces soil particle detachment and transportation. The vegetation intercepts the rainwater, which enhances infiltration and reduces runoff. The infiltrated water percolates into the ground (aquifer), which in turn improves the hydrology. People down-slope witnessed that spring discharges considerably increased after the enclosure, and even in some cases dried springs recovered. Flood risks and sedimentation on fertile farmlands by stones and gravely material has been reduced. These lands are mainly situated along streams.

Thus, the in-situ and offsite impacts of SWC interventions ultimately led to sustainable agricultural production and productivity in some areas, enclosures are divided among people who manage their land parcel and use grass through this system. The Kobo- Girana Valley Development Program (KgVDP) initiative can be cited as an example. They formed user groups and facilitated enclosures sharing among users, providing training on appropriate output use and management. As a result, the protected steep lands located above the farmlands showed reduced runoff, which had been damaging the cultivated lands. Following the closure practice, improved and traditional irrigation has also been expanded. Agriculture offices and NGOs have helped farmers to improve the traditional irrigation. Therefore, the SWC practices played a considerable role in improving the irrigation water supply through better recharge (Asefa et al., 2003).

2.1.6. Soil and water conservation strategies of degraded lands in Ethiopia

2.1.6.1. Biological soil and water conservation measures

Agronomic measures include mulching and crop management, which use the effect of surface covers to reduce erosion by water and wind (Morgan, 2005). Some possible agronomic measures are strip cropping, mixed cropping, intercropping, fallowing, mulching, contour plugging, grazing management and agro-forestry. Agronomic conservation measures help in reducing the impact of rain drops through interception and thus increasing infiltration rates and thereby reducing surface runoff (Amsalu, 2007). These agronomic conservation measures can be applied together with physical soil conservation measure in Watershed. In some systems they may be more effective than structural measures (Heathcoat and Isobel, 2008). Furthermore, it is the cheapest way of soil and water conservation (Wolka et al, 2013).

However, agronomic measures are often more difficult to implement compared with structural ones as they require a change in familiar practices (Heathcote and Isobel, 2008). Different types of material such as residues from the previous crop, brought-in mulch including grass, perennial shrubs, farmyard manure, compost, byproducts of agro-based industries, or inorganic materials and synthetic products can be used for mulching (Lal, 2005). It is effective against wind as well as water erosion. Some such plants as maize stalks, cotton stalks, tobacco stalks, potato tops etc. are used as mulch (a protective layer formed by the stubble, i.e., the basal parts of herbaceous plants, especially cereals attached to the soil after harvest). Crop residues also reduce the soil temperature by some degrees in the upper centimeters of the topsoil and provide better moisture conservation by reducing the intensity of radiation, wind velocity, and evaporation (Agele et al., 2000).

2.1.6.2. Physical soil and water conservation measures

Physical soil and water conservation structures are the permanent features made of earth, stones or masonry. They are designed to protect the soil from uncontrolled runoff or erosion, and to retain water where it is needed. In the watershed, steep land farming, physical structures such as rock barriers and contour bunds; waterways such as diversion ditches, terrace channels and grass waterways; and, stabilization structures or dams, windbreaks, and terraces such as diversion, retention and bench Are often necessary (Morgan,2008). The construction of physical structures is often labor intensive since steep slopes make construction difficult. Thus, both construction and maintenance require long-term collaborative effort by farmers, the local community and the government.

2.1.7. Climate change and soil and water conservation investment in Ethiopia

Adaptation through sustainable land management practices enable farmers and communities to adapt to climate change by increasing food production, conserving soil and water, enhancing food security and restoring productive natural resources. As a result of an increase in potential erosion rates due to climate change, agricultural productivity can be reduced by 10% to 20% (Delgado et al., 2011). Understanding the complementary factors to soil conservation in the face of climate change would therefore aid in the design and implementation of sound conservation practices. Accordingly, a growing body of literature identifies a strong link between climate change and soil and water conservation. For instance, Kassie et al. (2007) indicates that the effect of mean annual rainfall on the adoption of stone terracing varies based on agro ecology type. Their findings show the significant productivity benefit of the technology in conserving moisture in drier areas compared to higher rainfall areas. Similarly, based on a study of a sample of farmers in the Nile basin, Deressa et al (2009) indicate that the probability of adopting soil and water conservation practices in drier regions is higher than that of wetter regions.

In the same study, Deressa et al (2009) show a direct link between an increase in temperature and increasing the probability of using soil and water conservation by about 2.6%. They further argue that, with more warming, farmers will conserve soil to preserve the moisture content and use drought-tolerant varieties to cope with increased temperature. Apart from the climate related variables, a number of socioeconomic factors are indicated in most empirical literature as the main significant determinants of the adoption of different types of sustainable land management practices. For example, access to credit and extension, and farmers' awareness of climate change are some of the important 11 determinants of farm-level adaptation (Nemachena and Hassan, 2007). Tiwari et al.(2008) also indicate that several factors such as education of the household head, caste of the respondent, land holding size, cash crop vegetable farming, family member occupation in off farm sector, membership of the Conservation and Development Groups, and use of credit, influence the adoption of improved soil conservation technology.

Similarly, Gebremedhin and Swinton (2003) have indicated that secure land tenure, labour availability, proximity to the farmstead and learning opportunities via the existence of local food-for-work projects are important determinants of farmers' long term investments in stone terraces in the Tigray region of Ethiopia. By contrast, insecure land tenure and the absence of local food-for-work projects are associated with short-term investments in soil bunds. As could be seen from this brief review, different methods have been used to cope with the adverse effects of climate change on small holder agriculture in sub-Saharan Africa. Use of improved seed varieties (e.g. drought resistant varieties), changing planting dates, water management and irrigation, tree planting and soil and water conservation practices, are some of the adaptation options which have been suggested and used to counteract the negative consequences of climate change (Bradshaw et al. 2004). Though there are some empirical evidences on the socioeconomic determinants of adoption of sustainable land management technologies, there is still a need to have additional empirical evidences from Africa that will help policy makers understand the complex factors that affects the adoption behavior of small holder farmers.

2.1.8. Contribution of SWC to food security in Ethiopia

In Ethiopia, different study confirmed the positive impact of SWC measures. According to Gebremichael (2005), it contributed on farm income and food security by 50% and 56% respectively. Also, reduce the risk of crop failure due to moisture stress and climate shocks has reduced by up to 30% in Northern Tigray. According to Melaku et al., (2018), prediction of SWC structure impacts on runoff and erosion processes by using SWAT model in the northern Ethiopian highlands, it reduced soil loss by 25– 38% in the treated Gumara-Maksegnit watersheds. Study conducted in northern Ethiopian reported crop yields increased by 7% compared to the situation without stone bunds and also yield increased from 632 to 683 kg ha^{-1} for cereals, from 501 to 556 kg ha^{-1} (11%) for Eragrostistef and from 335 to 351 kg ha^{-1} for Cicerarietinum (Vancampenhout et al., 2006). SWC has a significant role in maintaining and/or restoring soil fertility, maintaining agricultural production, restoring vegetation cover, and mitigating anthropogenic land degradation (Shiene, 2012). The study conducted by

Haregeweyn et al., (2015) estimate a mean seasonal runoff reduction of 40%, with large spatial variability, ranging from 4%in AnditTid (Northwest Ethiopia) to 62% in Gununo (South Ethiopia). Similarly, soil loss was reduced by an average of 65% because SWC technologies.

The establishment of slow forming terraces therefore is of vital importance in fighting desertification and establishing sustainable agriculture in the Ethiopian highlands (Vancampenhout et al., 2006). Additionally, 80 % farmers benefited from natural resources by grazing their livestock and harvesting firewood and grasses (Eshete et al., 2015).

2.1.9. Factors influencing the implementation of Soil and water Conservation Practices

A number of factors are hypothesis to affect soil and water conservation effort. As indicated in Journal of Agricultural and resource economics of (2008) reported that the perception of farmer on adopted conservation impacts positively on soil and water conservation practices and effort. The level of net farm income was expected to affect soil and water conservation effort because farmers with higher net income are less likely to be financially constrained to adopt soil and water conservation measures. Previous studies also have thrown that farmers who own their land are more likely to adopt soil-water conservation and expand more conservation effort than those who do not own their land (Journal of agriculture, 2008). Additionally, many factors bear on farmers' decisions about adopting soil and water conservation measures. Each category of factors hypothesized to influence one or more of the decision-making process components. Each component can be visualized as a major step in the decision to control erosion.

Personal factors: personal factors such as education level, farming experience, conservation attitude and family size are factors which influences adoption of soil and water conservation and its practices. Higher education levels are hypothesized to be associated with improved knowledge about conservation measures, the productivity, and effects of erosion. Those personal characteristics involving acquisition cost can be associated with improved as human capital .The degree of physical land structure and erosion potential of farmers land may persuade him to choose particular practices (Addisu, 2011).

Institutional factors: An institutional factor portrays the role of educational and technical assistance programs in affecting perception of erosion problems, decision to use practices and erosion control effort. In addition to this, institutional factors like secure land tenure right, access to credit and extension training to farmers affects farmers‟ decision to conserve soil and water (Eleni, 2008; Gebremedhin and Swinton, 2003).

Physical factors: factors such as farm size, slope, farm terrain, type of erosion, soil amendments, location of farmland and land quality differentials are some physical factors which affect farmers ability to adopt methods of soil and water conservation measure (John, 2008).

Economic factor: Economic factors may either enhance or constrain farmer's dispositions toward erosion controls. For examples, high debt levels may inhibit investment in capital intensive terraces, while high net farm income will present tax advantages for the same practices. Educational programs, technical assistance, and cost sharing are institution instruments to persuade farmers to use soil-water conservation practices. Economic constraints such as wealth status of the farmers, off -farm income, annual income, cost of the fertilizers and debt status are factors, which tends to increase or reduce incentives for soil-water conservation (Eleni, 2008; John, 2008). All factors categories influence effort but in different ways than they influence the decision to use one or more practices.

2.1.10. Determinants of Household Food Security

A study conducted by (Epherm, 2008) household food security in the northeastern part of Ethiopia is strongly associated with various socio-economic and bio-physical factors that influence the food security status of households were the age of household head, dependency ratio, size of cultivated land, the total number of livestock owned, manure application, land quality and farmer's knowledge on the effect of land degradation on food security. According to studies conducted in Ethiopia, ownership of livestock, farmland size, family labor, off-farm income, market access, use of improved technology, education, health status, amount of rainfall and distribution, crop diseases, number of livestock, and family size are identified as major determinants of household food security (Regassa, 2011) and (Bedeke, 2012). The study conducted in Nigeria by (Olyuole et al., 2009) using the probit model found out that sex of household, educational level, age of household head, and income have a positive influence on food security; whereas, households size has a negative influence on household food security. However, a study, by (Sikwela, 2008) in South Africa using the binary logit model showed that per aggregate production, fertilizer application, cattle ownership and access to irrigation have a positive effect on household food security; whereas, farm size and family size have negative effects on household food security. On the other hand, (Fekadu, 2012) using multivariate logistic regression analysis indicated that dependency ratio, household family size, and market accessibility have shown significant and negative effects on food security; whereas cultivable land size, access to irrigation, number of livestock showed positive role for food security. Similarly, a study conducted by (Bogale and Shimelis, 2009)using a binary model reveals that the age of household head, cultivated land size, livestock ownership, the total income of the household, irrigation, and amount of credit received have negative and significant effects on household food security. Similarly, as studied by (Beyene and Muche, 2010) using binary logit model showed that age of the household head, size of land cultivated, livestock ownership, soil, and water conservation practice, and oxen ownership have a positive and significant relationship with household food security; whereas, education of household head, household size and off-farm/non-farm income have negative and significant influence on household food security.

2.2. Conceptual framework of adoption of SWC measures

The continued use of new soil and water conservation technologies in developing countries has attracted much attention from scientists and policy makers by knowing agriculture is an important sector in those countries (De Graaff et al., 2008). Integrating SWC practices with the system of agriculture is the issue of sustainability for many countries, particularly for developing countries whose economy largely depend on agriculture (Menale et al., 2008; Fikru, 2009). However, the adoptions of soil and water conservation measure are not satisfactory. To these effects, many studies have been conducted in different parts of world including Ethiopia to identify the determinant factors that affect the adoption of soil and water conservation practices. These include: demographic, socio economic, institutional and physical factors (Bekele & Drake, 2003). In this study, adoption of soil and water conservation is conceptualizing as decision to invest on SWC practices. Therefore to achieve the objective of the research and to address the stated research question a conceptual frame work was developed.

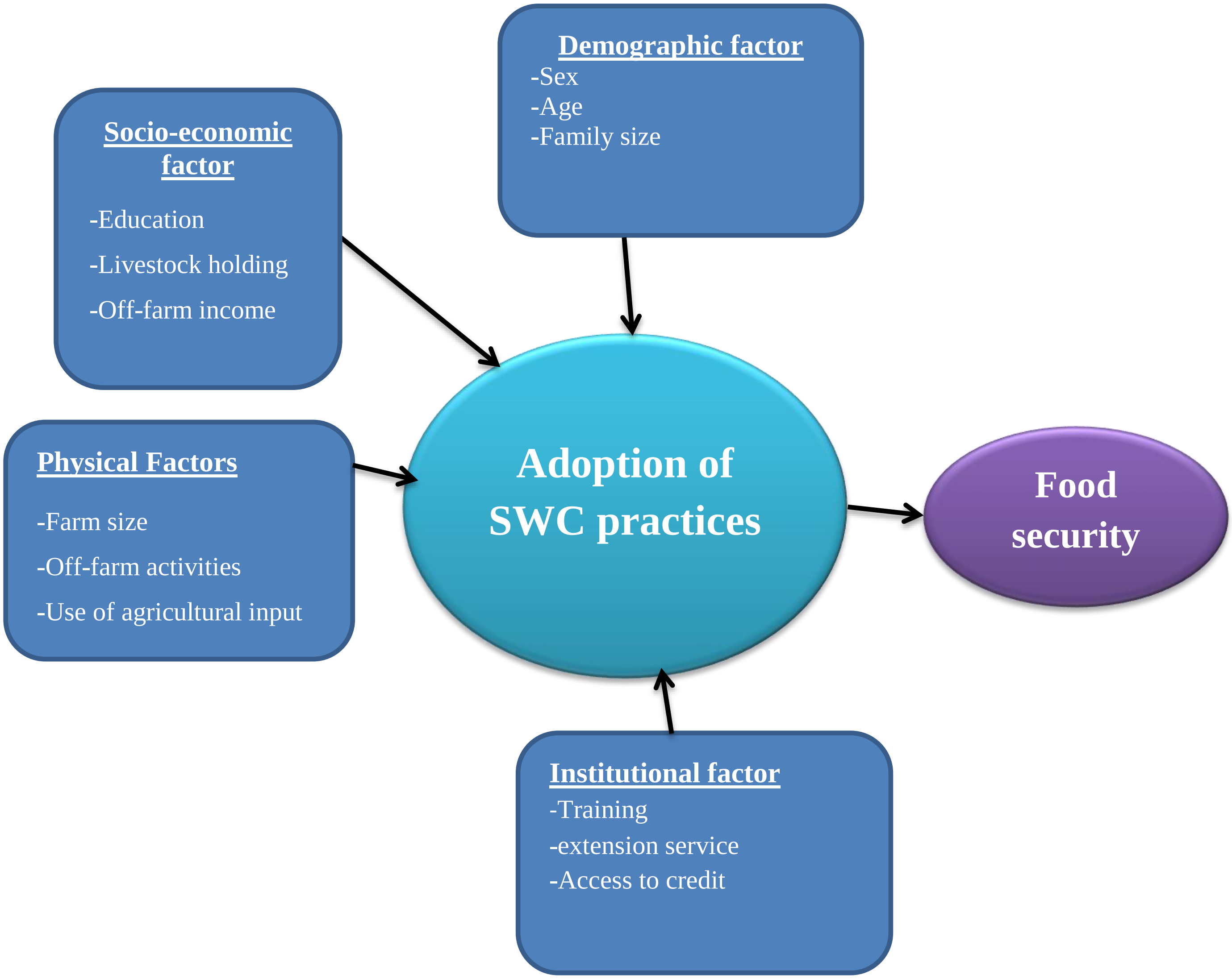

Figure 1: Conceptual frame work of the hypothesized factor that influence the adoption of SWC practice in the study area (Bekele and Drake, 2003).

CHAPTER THREE

3. RESEARCH METHOD

3.1 Description of the study area

3.1.1. Location and size

The study were carried out in Hawassa Zuria woreda that are found in Sidama Region. The woreda consists of twenty five kebeles, and it is located 297 kms to south of Addis Ababa and 23kms away south from Hawassa the capital town of Sidama Region. And its geographical location of the study area lies between coordinates 7° 2' 30'' and 7 ° 3' 30'' North latitude and 38° 17' 00'' to 38° 19' 00'' East longitude (BoANR, 2015). The district rests between 1501-2500 m above sea level with area size of 305 km^2. As a result of these altitudinal variations, the district consists both *W/Dega* (Midland), and *Dega* (Highland) agro ecological zones covering 6 and 19 kebeles, respectively (Seyoum, 2015).

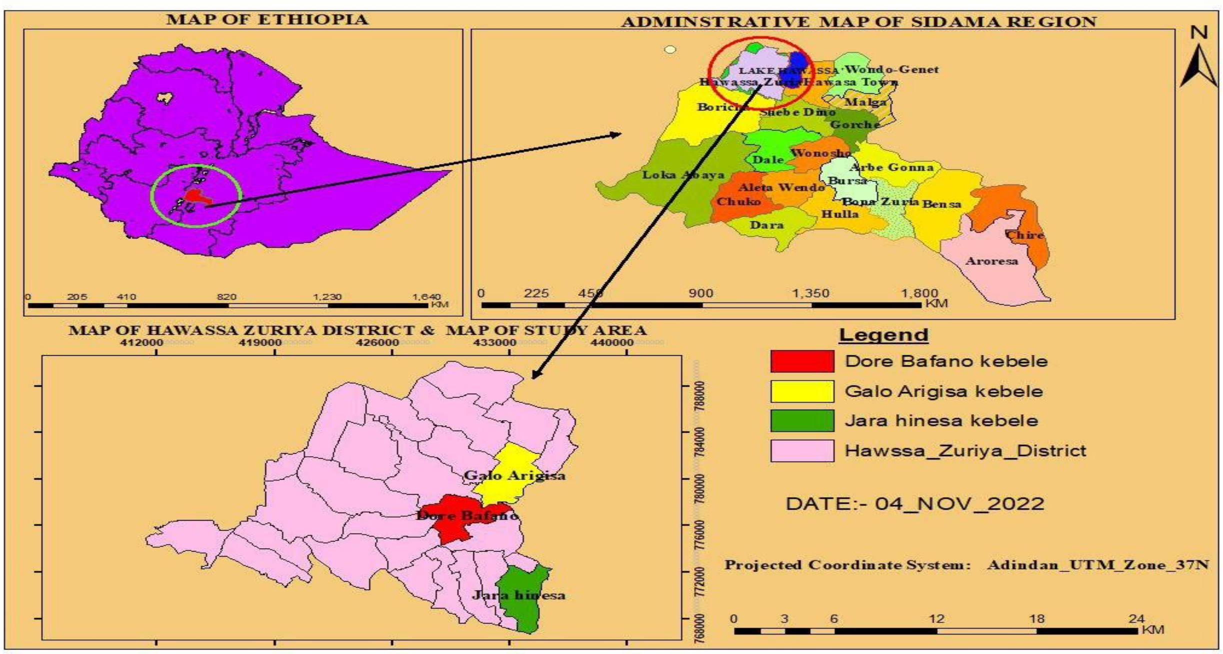

Figure2. Map of the study area and location of the sampling site.

The estimated population is 155,245 of which 78293 are males and 76951 are females (BOFED, 2015). Multiple cropping is the dominant form of farm practices and the watershed has the long boundary with Lake Hawassa, there are no water bodies and wetlands in the watershed. The livelihood of the majority of the households in the district depended on production of maize, sorghum, pulses (haricot beans), and teff, pulses, enset, fruits and vegetables. Maize, pulses (haricot beans) and enset are the three major crops occupying a total area of about 9530.34 hectares with productivity of 65, 20 and 12 quintals per ha respectively (MANR, 2016). On the other hand, about 5% of the households depend on none/off farm activities in addition to crop farming and livestock rearing (MANR, 2016).

3.2. Study design

Cross-sectional study design was employed to gather information on population at a single point in time. And also, mixed qualitative and quantitative approaches were used to answer the research questions outlined and address the four specific objectives set.

3.2.1. Sample design and sampling techniques

The sample size were determined by using statistical procedures. The estimation of population proportion, p = 0.11 were used, as this value gives sample size sufficiently large and guarantee an accurate prediction, at 95% confidence interval and 5% error of estimation. The following formula were used to decide the sample size (Naing et al., 2007 and Melese E., 2014)

$$n = \frac{[p(1-p)z^2]}{e^2}$$

Where:

n = sample size

z = level of confidence = 1.96 which means 95%

e = maximum allowable error = 0.05 which means 5%

P = estimate of population = 0.11(p is 0.11, proportion of the population to be included in the sample i.e.11%)

$$n = \frac{[0.11(1-0.11)1.96^2]}{0.05^2}$$

$$n = \frac{[0.11(0.89)3.8416}{0.0025}$$

$$n = \frac{0.38}{0.0025}$$

n = 150.4

Three kebeles were selected and the study were conducted in namely Jara Hinessa, Dore Bafano and Galo Argissa. These kebeles were randomly selected and the number of household heads were selected from each kebele based on the proportion of household heads (population) in the representative kebeles. A total of 150 sample households were selected through simple random sampling method using lottery draw technique.

Table1: Distribution of sample household heads in study area

Nº	Study area kebele	Total HH head		Sample HH head
		Frequency	Percentage (%)	Frequency
1	Jara hinessa	450	$\frac{450}{1364} * 100\%$=33	50
2	Dore bafano	456	$\frac{456}{1364} * 100\%$=33.4	50
3	Galo argissa	458	$\frac{458}{1364} * 100\%$ =33.6	50
	Total	1364	100%	150

3.2.2. Data type and source

Types of data collected were on demographic and socio-economic and farm characteristics of farming household head, institutional factors that affect adoption of SWC practices, Adoption of soil and water conservation practice by the community at the study area, Adaptation Strategies to Climate Change, Contribution of SWC for household's food security. Sources of the data were both primary and secondary data.

Primary data were obtained through questioner's survey, key informant interview, focus group discussion and personal observation.

Secondary data were gathered based on techniques like document analysis, report analysis, search on reliable internet sites.

3.2.3. Data collection instruments

Instruments that are used to collect the primary data include questionnaire survey, focus group discussion (FGD), key informant interview and personal field observation.

In this data collection instruments; the specific data collection instruments and how it is going to be exercised are presented as follows in detail.

3.2.3.1. Household survey

An investigation survey were held to have good insight into the study areas. Here informal discussion were held with extension workers about the study objectives and way of study. The questionnaire were pre-tested in the field using few farmers found in nearby areas. To generate quantitative and qualitative information at the household level, a household survey were undertaken by using a structured questionnaire. A structured questionnaire were developed making to include all necessary information to the objectives of the study. The household survey covered personal data, household resources, production and income issues related to SWC and climate change adaptation strategies. The questionnaire were prepared in English and later translate into the local language (Sidamu Affo) so that the respondents can easily understand the questions. Nine enumerators, three for each kebele, were employed based on their ability of local language, culture, and experiences in data collection. The training are provided to the enumerators on the procedure to follow while interviewing with respondents and deep discussion will also held to make the questionnaire clear. Supervision were made by the researcher in addition to some data collection during the detailed questionnaire survey administration process.

3.2.3.2. Interviews

In this study, the investigator uses semi-structured interview because of its flexibility and to make clear any time when there is ambiguity (Lankshear and Knobble, 2004). Interviews were held with key informants who were purposively selected from the community and also from different responsibility level so as to generate relevant information. Accordingly, eight key informants were selected for interview to collect qualitative data. The discussion were intends to dig out different views and perceptions of farmers' on SWC, benefit obtained from SWC practices and climate change adaptation strategies and their response on land degradation in the study area. It were conducted in face to face approach.

Table2: Sample respondents for key informant interview

№	Respondents	Number of interviews
1	Model farmers	2
2	Woreda natural resource expertise	1
3	Development agents	2
4	NGOs agent	1
5	Kebele administration	2
	Total	8

3.2.3.3. Focus group discussion (FGD)

Focus group discussion is essential to generate data on group dynamics and allows small group respondents to be guided by skilled moderator, to focus on the key issues of the research topic (Stewart and Shamadasani, 1990). The participants of the focus group discussion were farmers of each sample kebeles. In FGD the participants were discussed three times. Data that are collected through FGD include extent of land degradation, types of SWC practices, participation of government and community in SWC practice to enhance climate change adaptation, community participation on SWC practices and livelihood benefits on climate change adaptation through SWC practices.

Table3: Sample respondent for focus group discussion

$N^{\underline{O}}$	Name of kebele	Number of FGD	Number of farmers
1	Jara hinessa	1	8
2	Dore bafano	1	8
3	Galo argissa	1	8

3.2.3.4. Field observation

It is the method of data collection for the researcher, it is systematically planned and recorded to check and control its' validity and reliability. Under the observation method, the information is sought by way of investigator's own direct observation to understand study context and phenomenon without asking from the respondent. Accordingly, to understand what is currently happening with regard to the problem under investigation in the study area, researcher will observe the farmers' fields personal. While conducting observation in selected kebeles, I were record facts and general information like the surrounding topography, climate, farming system, physical and biological SWC practices and land management practices. Thus, in doing so, researchers' generally were try to investigate the real and accurate information concerning the integrated SWC practices, and its effect on community's climate change adaptation strategies in the study area.

3.3. Methods of data processing and analysis

Methods of data processing and analysis are one of the most important steps in the research process. It is the processes of summarizing and analyzing raw data to obtain the study outcomes. So, data has to be process and analyze in accordance with the outline laid down in the research plan. Data processing implies editing, coding, classification and tabulation of collected data so that they are amenable to analysis. Moreover, data analysis involves a number of closely related operations which are performed with the purpose of summarizing the collected data and organizing these in such a manner that they answer the research question(s).

As tried to discuss at the beginning of this chapter, the researchers' were employed both qualitative and quantitative research methods (triangulation) based on the nature of the study. Apart from these research methods, data processing and analysis methods are the major one. Accordingly, in order to summarize and organize the collected data, it is classified and tabulated and it is analyzed by using descriptive statistical tools such as mean, frequency, percentages, tables, Chi-square and t-test and inferential statistical tools are binary logistic regression model and multiple linear regression.

3.3.1. Specification of the model

Binary logistic model were used to identify the determinants of adoption of SWC measures and to assess their relative importance in determining the probability of being an adopter of soil and water conservation measures. Mathematically, the model can be specified following (Gujarati and Porter, 1999):

$$P_i = \frac{1}{1 + e^{-Zi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where P_i denotes the probability that the i^{th} household adopter and Z_i is a linear function of "n" explanatory variables (X), and is expressed as:

$$Z_i = \beta_0 + \beta_i \sum_{i=1}^{n} Xi + Ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where β_0 is the constant term, β_i is coefficients of explanatory variables, X_i explanatory variables, and U_i is the error term. The β_i tells us how the log-odds in favor of adopters change as the independent variables change. The odds to be used can be defined as the ratio of the probability that a household is an adopter (P_i) to the probability that he/she is not (1 -Pi) i.e.

$$\frac{Pi}{1 - Pi} = e^{zi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

$$\ln\left[\frac{p}{1-p}\right] = \ln(e^{Zi}) \Box \ln\left[\frac{p}{1-p}\right] = Z_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Finally, the model is specified as follows:

$$\ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_i \sum_{i=1}^{n} xi + Ui \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

There is no simple way to express the effect on the probability of increasing a predictor by one unit while holding the other variables constant. We can obtain an approximate answer by taking derivatives with respect to X_i, which of course makes sense for non-linear econometric models. This result tells us by how much the dependent variable changes with respect to a small change in the explanatory variables. As a result, the effect of each significant explanatory variable on the probability of adoption of SWC practices will be computed by keeping the continuous variables at their mean values and the dummy variables at their most frequent values (zero or one) i.e.

$$\frac{dp}{dxi} = \frac{d}{dxi}\left(\frac{e^{zi}}{1+e^{zi}}\right) = p_i (1-p_i) \beta_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

The existence of multicollinearity problem among explanatory variables will be detected by using Variance Inflation Factor (VIF). The problem of multicollinearity is serious when VIF is equal to 10; R^2 = 0.9 and Tolerance is close to zero.

VIF = $\frac{1}{1-R^2}$; tolerance = $\frac{1}{VIF}$, Where R^2 = Coefficient of determination

3.4. Definition of variables used for the study

I Dependent variables:

SWC practices can be conceived of having two components: whether to use SWC practices or not use. The dependent variable in this study is adoption of SWC practices, which is a dummy variable represented by (1 if participating in SWC Practices, 0, otherwise) that indicates respondent farmer's adoption and intensity of use of selected (improved) soil and water conservation practices.

Maize yield/ productivity: Maize production system widely practiced in the lowland of the country such as cultivation of maize and haricot bean. It is a continuous variable measured in quintals.

II Independent variables

This includes various socioeconomic characteristics expected to the Impact of SWC practices on the climate change adaptation strategies. Twelve explanatory variables, which are anticipated to have a significant Impact of SWC practices on community's climate change adaptation strategies, are selected and hypothesized. The explanatory variables that are hypothesized to have a positive or negative influence on climate change adaptation are described below.

Age of a Household Head (HHAGE): Age is a continuous variable measured in years. As the age of the household increases, they can acquire more knowledge and experience in farming and pre assume vulnerability and risk conditions of food insecurity. This variable has a positive relationship with biological and physical soil and water conservation practices or environmental restoration. Thus, younger farmers are more innovative and open to technological advances and are more willing to adopt new technology (Babatunde et al., 2008) and other related studies stated that young heads of households are stronger and are expected to cultivate larger-size farms than old heads. Hence, the expected effect of age climate change adaptation will be negative.

Education Level of a Household Head (HHEDUC): It is the number of years of schooling attained by the sampled households' heads up to the time of the survey. It is a continuous variable measured in formal schooling years completed by the household head. (Fikru., 2009) indicate that, better education level of the HH heads has strong and positive relationship with their adoption of SWC because of their ability to find new information and their understanding of new technologies. Hence, education has a positive contribution to environment and climate change adaptation.

Sex of household heads: is dummy variable which takes a value of 1 if the household head is male and 0 if it is female which influence adoption of technologies. (Tesfaye., 2006) found that male headed household has better access to information than female headed household because they have freedom of mobility and participation in different meetings. Hence male headed households are expected to adopt introduced improved technologies better than female headed households. Therefore male headed household was hypothesized to positively influence adoption of soil and water conservation structures.

Household size (HSIZE): Family labor plays an important role, particularly in rural families as a factor of production. A household that has a greater number of family members could share the workload with them and contribute a lot to the SWC practice. This was supported by (Geoffer., 2004), who found that household size was associated positively with adoption of conservation practice. He indicated that, large family size will be able to provide the labor requirement for maintaining SWC practices. Hence it is expected to influence the climate change adaptation positively or negatively.

Access to Credit (ACREDIT): are a dummy variable that takes the value 1 when the household takes a loan and 0 otherwise. Credit is very much useful to purchase inputs such as improved seeds, other important inputs including staple food. The research conducted by (Bekele and Drake., 2003) in Eastern high lands of Ethiopia indicated that credit services for inputs and consumption helps to increase the adoption of conservation measures by farmers. Hence, farmers who have access to credit would have a positive effect on crop production due to the use of agricultural inputs which enhance food production.

Participation in training service (TRASER): Extension service plays an important role for rural farmers in terms of providing advice and information. Among these, training is one of useful service to introduced and develop practices of modern technologies (proper types and rates of fertilizer, improved varieties of seeds, agro-chemicals, etc.) (Wagayehu., 2003) in his study indicated that if a farmer receives better information (training) from DAs, they will be willing to construct new SWC measures and to maintain the existing ones. Hence, those households who participated in a training organized at FTC or farm demonstration are supposed to apply their knowledge to increase farm production. Thus, this variable is hypothesized to influence adoption of conservation structures positively.

Extension Service: Farmers who have closer contact with agricultural extension agents are expected to be aware of the severity and impact of natural resources degradation. Therefore, as (Chomba., 2004) stated, extension services have positive effect on soil and water conservation practices.

Tropical Livestock Holdings /TLU/: This refers to the total number of livestock measured in the tropical livestock unit (TLU). Livestock is important the source of income, food, and draught power for crop cultivation in Ethiopian agriculture. Households with high numbers of livestock have a chance to obtain more direct food or income to purchase foods commodities, particularly during food and climate change crises. This is evident from many of the past adoption studies which have reported positive effect of livestock holding on adoption, Dereje (2008). Contrary to the above findings, Mesfin (2006) reported that livestock holding influenced negatively the farm level adoption of farmers' participation on soil conservation activity. His explanation for this reason is that livestock are generally considered a symbol of wealth and farmers with large livestock herd sizes tend to focus more on their livestock operations and pay less attention to their land conservation. Thus, this variable is expected to positively or negatively affect the adoption of SWC practices.

Land size (LTLAND): this refers to total cropping land cultivated by a household in the past one-year production period. It has a direct relation to crop production. A larger size of cultivated land implies more production and availability of food grains. According to (Haile, 2008)) and (Babatunde et al., 2008) food production can be increased extensively through the expansion of areas under cultivation. Hence, the size of cultivated land will be expected to have a positive effect on household food security status and climate change adaptation.

Participation in Off-farm activity (NONFARM): is a dummy variable representing whether the household was involved in nonfarm activities or not. Involve in non-farm activities compete out resource required to construct and maintain SWC practices. Hence, negative association is expected between involvements in non-farm activities and decision to adopt SWC practices (Habtamu, 2006). Thus, non-farm activity is hypothesized to influences the adoption of SWC technology negatively.

Off-farm income (NFRINC): This refers to annual income obtained from an employment of the household in off-farm activities like laborer and non-farm activities like petty trading, hand craft, selling of fire wood, gifts and remittance. It is a continuous variable and measured in Ethiopian Birr. Aemro et al., (2012) found that off/non-farm income positively affected farmers‟ use of SWC practices, adjusting planting date, and improved variety. In contrary to this, Belaineh et al., (2013) revealed that an increase in off-farm income decreases the likely of crop diversification and the use of SWC practices as adaptation strategy. Farmers are assumed to get additional income source and may or may not give time to take adaptation measures and pay less attention to agriculture. Therefore, it was expected to either positively or negatively affect farmers‟ adaptation decision.

Use of Agricultural inputs: This is the use of inorganic fertilize and seeds of improved crop varieties by the responds household. Application of improved fertilizer and improved seed of crop varieties perceived as improving yield per unit area (Eneyew and bekele, 2012). Application of inorganic fertilizer and improved crop varieties on farm land could increase agricultural productivity and production. Hence, it influences positively the climate change adaptation.

Table4: Summary of dependent and independent variables and hypothesized signs

Code	Variable definition	Variable type	Measurement	Expected sign
Dependent variable				
ADOPSTA	SWC Adoption status	Dummy	1and 2	+ve
Independent variable				
ACCIRR	Off-farm income participation	Continuous	1 and 2	+ve
FARMSIZ	Land size	Continuous	hectare	+ve
EDHH	Educational level	Continuous	year	+ve
HHAGE	Age of a household head	Continuous	year	-ve
TLU	Livestock holding	Continuous	TLU	+ve
NON-FARM	Participation in non-farm	Dummy	1 and 2	+ve
ACCRED	Use to credit	Dummy	1 and 2	+ve
HHSEX	Structure household head	Dummy	Number	+ve
EXTENCO	Extension contact	Dummy	1 and 2	+ve
HHSIZE	Household size	Continuous	Number	+ve
AGRINP	Agricultural input	Dummy	1 and 2	+ve
TRASER	Participation in training	Dummy	1 and 2	+ve

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1. Socio-demographic characteristics of Respondents

The demographic distribution of the sampled population is illustrated in Table below. The survey identified that out of the total (150) households, 100 (66.7%) were being adopted and practiced SWC activities in their lands while the rest 50 (33.3) households didn’t either adopted or practicing any forms of SWC on their owned lands.

4.1.1. Sex of respondents

Based on the survey results in (Table 5), about 86.7% of the respondents were male and 13.3% of them were female. Surprisingly, all female respondents (100%) were adopter of SWC while only 80% of male respondents practices different SWC practices, indicating somewhat the higher involvements of females in SWC activities in the areas. This result was in line with the findings of Belachew et al. (2020). They stated that, sex of household-head influenced the adoption of strip cropping negatively and significantly at 1%. Being male for household head, the adoption of strip cropping could decrease by 0.97 From these, 80% and 100 % (all) of the respondents were adopters and non-adopters of soil and water conservation practices in the study area. This indicated that majority of the interviewed households were male.

4.1.2. Marital status of the respondents

Regarding the marital status of the interviewed households, majority (79.4%) of the them were married and the rest 7.3%, 2% and 11.4% of the respondents were single, divorced and widowed, respectively (Table 5). From these, 77% and 84% of the respondents were married. These results showed that most of the respondents were married in the study area. This result also indicated us that marital status and adoption of soil and water conservation practices were positively and statistical at 5% significant level.

Although the sex category and the time line of practicing SWC were undefined, still all the respondents from both widow and divorced martial categories found to be adopter of SWC in the studied area, implying the diversity of demographic units involving the practice.

Table 5: Sex and marital status

Variables	**Response**	**Adopter SWC**		**Non-adopter SWC**		**Total**		**Chi-square test**	**P-value**
		N	%	N	%	N	%		
Sex	Male	80	80.0	50	100.0	130	86.7	11.538	0.001
	Female	20	20.0	0	0.0	20	13.3		
	Total	100	100.0	50	100.0	150	100		
Marital status	Single	3	3.0	8	16.0	11	7.3	19.890	0.000
	Married	77	77.0	42	84.0	119	79.4		
	Widowed	17	17.0	0	0.0	17	11.3		
	Divorced	3	3.0	0	0.0	3	2.0		
	Total	100	100.0	50	100.0	150	100.0		

4.1.3. Household structure

Respondents in the study area were headed by either male or female. In the (Table 6) below, 80% of the adopters of SWC practices were male headed. The remained 20% of the adopter respondents were female headed, whereas all (100%) of the non-adopters of SWC were only male headed. These results indicated us majority of the interviewed households were male headed.

4.1.4. Education level of the respondents

Regarding the education level, 71% of the adopters of SWC measures were attended secondary school level and 29% of them attended primary school level of education. On the other hand 28% of non-adopters of soil and water conservation measures attended the secondary level of education and the remained 40% and 32% of the non-adopters households were attended primary level of education and cannot read and write respectively. The Chi-square statistics results showed us that, there is statistical significant difference between adopters and non-adopters of soil and water conservation measures in the study area. Similar studies also showed that education has positive relation with the adoption of soil conservation tillage (Fikiru, 2009).

Table 6: Household headed and level of education

Variables Response		**Adopter**		**Non-adopter**		**Total**		**Chi-square test**	**P-value**
		N	%	N	%	N	%		
Household structure	Male headed	80	80.0	50	100.0	130	86.7	0.530	0.478
	Female headed	20	20.0	0	0.0	20	13.3		
	Total	100	100.0	50	100.0	150	100.0		
Level of education	Can't read and write	0	0.0	16	32.0	16	10.7	44.111	0.000
	Primary school	29	29.0	20	40.0	49	32.67		
	Secondary	71	71.0	14	28.0	85	56.6		
	Total	100	100.0	50	100.0	150	100.0		

4.1.5. Age of the households

The average age of the respondent was 38.31 years with standard deviation of 9.50729; the minimum age was 18 while the maximum age was 62 years. The average age of adopters and non-adopter households of soil and water conservation measures were 39.57 and 35.78 years with standard deviation of 8.093and 11.52, respectively. The minimum and maximum age of SWC measures adopters was 18 and 60 years respectively. The minimum and maximum age of non-adopters was 22 and 62 respectively.

The statistical analysis of mean age difference of adopters and non-adopters was non-significant ($p<0.05$) (Table 7). The results showed that when age of household increased, the level of adoption for new technology will be decreased and these results are similar with Workneh (2007), which showed that as the age of respondents increase, the adoption of improved bee box technologies decrease.

4.1.6. Family Size of the households

The average family size of the respondent household was 3.20 persons with standard deviation of 1.5982. Based on the survey results, the average family size of SWC adopters and non-adopters households were 3.3 and 3.02 persons with the standard deviation of 1.7892 and 1.11557 respectively. The average family size of the adopter households is not that much greater than the average family size of non-adopters and therefore it is non-significant at 5% probability level (Table7). The minimum family members of a household were one person while the maximum members of a household were 10 persons. The Chi-square test statistics result showed that there was insignificant association between family size and the adoption of SWC measures in the study area. This result was in line with the Yohannes (2001), and he stated that, large family size is not a decisive factor for adoption of SWC structures on a household farm whether single, large or small families. They do their adoption in a way that does not demand a great deal of labour at one time or the other, but rather extends the work over a number of months. Similarly, Bekele and Drake (2003) argued that households with larger family size are likely to face food scarcity. Consequently, they try to maximize short-term benefits and would be less interested in soil conservation measures whose benefits can be reaped in the long run also found similar results.

4.1.7. Land size

The average land size of the respondents was .4827 hectar with the standard deviation of .21375. From this the average land size of both adopters and non-adopters was 0.53ha and 0.24ha with the standard deviation of 0.23601 and 0.10874, respectively (Table 7). These results indicated us that the average land size of the adopter households was greater than the average land size of non-adopters and this was statistical significant at 5% probability level. This mean that household with large land size can adopt SWC measures easily because farmers with larger farm size can afford retaining structures compared to those with relatively lower farm size. This result was similar with the findings of Amsalu and De Graaff (2006) and they found that farmers who have a larger farm are more likely to invest in soil conservation measures because they have the funds to do so. This result is also inconsistent with the finding of who reported a negative relationship between size of holdings and the probability of continuous use of soil conserving structures. The studies explained this might be due to the labor-intensive nature of constructing soil conservation structures.

Table7: Age of HH, family size of HH and Land size of HH

Variables	**Group of respondent**	**Mean**	**St. deviation**	**Minimum**	**Maximum**	**t-test**	**p-Value**
Age of the households	Adopters	39.57	8.09321	18	60	2.33	0.002
	Non-adopters	35.78	11.52157	22	62		
Land size	Adopters	.5315	.23601	.15	1.25	4.163	0.000
	Non-adopters	.3852	.10874	0.23	0.60		
Family size	Adopters	3.30	1.78942	1.00	10.00	1.012	0.313
	Non-adopters	3.0200	1.11557	1.00	7		

4.1.8. Livestock Ownership

The average livestock holding size of the respondent households was 3.1 TLU with standard deviation of 2.98 TLU. The average TLU of adopter households was 1.65 with standard deviation of 1.47 whereas; the average TLU of non-adopter households was 1.58 with standard deviation of 1.51 (Table 8). The households in the study area were engaged in animal husbandry for different purposes. These include traction power, income generation, social dignity, family consumption, as well as use the animals' dung to fertilize the farming land (WOA, 2017). Having large number of livestock is considered as basic indicator of wealth situation of farming community at the study area. But, there was insignificant mean difference of livestock ownership of SWC adopters and non-adopters households at 5% level (Table 8). This result tells us that owning or not owning livestock had no contribution for the adoption of conservation agriculture.

Table 8: Livestock Ownership

Types of Livestock	Response	Number	TLU	Mean	SD
Cow	Adopters	249	249	2.4900	1.30651
	Non-adopters	160	160	3.2000	1.85164
Ox	Adopters	73	73	.7300	.69420
	Non-adopters	36	36	.7000	.90914
Bull	Adopters	18	18	.1800	.41145
	Non-adopters	17	17	.3600	.63116
Goat	Adopters	221	28.73	2.2100	2.04641
	Non-adopters	134	17.42	2.6800	2.80990
Sheep	Adopters	77	10	.7700	1.24604
	Non-adopters	70	9.1	1.4000	1.81827
Poultry	Adopters	751	9.76	7.5100	5.28863
	Non-adopters	446	5.8	8.9200	7.28947
Donkey	Adopters	44	30.8	.1400	.34874
	Non-adopters	20	14	.4000	.53452
Horse	Adopters	11	11	.1400	.37659
	Non-adopters	9	9	.1800	.38809

Where TLU value for Cow, Ox and Bull=1, donkey=0.7, sheep and goat=0.13, chicken=0.013, Horse= 1 (Source: Stork et al. (1991)

4.1.9. Household's off-farm activities

Farmers in Hawassa Zuria Woreda practiced different off-farm activities as their better alternative to adapt climate change impacts. According to the data obtained from the survey, 77% of adopters and 64% of non-adopters of soil and water conservation measures said that they and their family members engaged on off-farm activities. The remained 23% and 36% of the adopters and non-adopters did not engage in off-farm activities respectively (Table9). These results showed us that majority of the respondents were engaged in soil and water conservation practices and this was due to the fact that the off-farm activities could helped them to easily adapt climate change impact and enhance their income alternatives. 62.3% and 98.7% of adopters engaged in petty trade and poultry production respectively, whereas the 78% and 15% of non-adopters of soil and water conservation engaged in poultry production and petty trade respectively (Table9).

Table 9: Household's off-farm activities

Variables	**Response**	**Adopters**		**Non-adopters**		**Total sample**		**Chi-square**	**P-value**
		N	**%**	**N**	**%**	**N**	**%**		
Participation of family members work on off-farm activities	Yes	77	77.0	32	64.0	109	72.7	0.121	0.038
	No	23	23.0	18	36.0	41	27.3		
	Total	100	100.0	50	100.0	150	100.0		
If yes, what type of off-farm activity	Petty Trade	48	62.3	5	15.6	53	35.3		
	Transportation by motor	5	6.5	0.0	0.0	5	3.3		
	Fishing	8	10.4	2	6.0	10	6.7		
	Weaving	5	6.5	3	9.4	8	5.3		
	Poultry	76	98.7	25	78.0	101	67.3		

4.1.10. Income from off-farm activities

Regarding to the income obtained from off-farm activities, the average income obtained by adopter households from petty trade, fishing, transportation by motor cycle, poultry production, and weaving were 2625, 4467.50, 19400, 3619 and 12660 Birr with the standard deviation of 656, 2470, 3536, 281, and 2569 respectively. Whereas the average income obtained by non-adopter households from petty trade, fishing, transportation by motor cycle, poultry production, and weaving were 1900, 8850, 15000, 3160, and 9466 Birr respectively(Table10). The independent t-test statistics showed that, the average income from petty trade and fishing for both adopters and non-adopters, positive and significant association between adopters and non-adopter household households. This income from off-farm activities had helped farmers to easily adapt the impact of climate change.

Table 10: Income from off-farm activities

Sources of off-farm income	Group of respondents	**N**	Mean	St. deviation	T- test	Sig. (2-tailed)
Petty trade	adopter of SWC	48	2625.0000	656.3924	5.263	.000
	Non-adopters	5	1900.0000	223.6068		
Fishing	adopter of SWC	8	4467.5000	2470.25592	-2.398	.043
	Non-adopters	2	8850.0000	212.1320		
Transportation by motor cycle	adopter of SWC	5	19400.0000	3536	-	-
	Non-adopters	1	15000.0000	-		
Poultry	adopter of SWC	76	3619.3421	281.674	1.132	.261
	Non-adopters	25	3160.0000	292.01884		
Weaving	adopter of SWC	5	12660.0000	2569.6303	1.560	.170
	Non-adopters	3	9466.6667	3219.2131		

4.2. Institutional characteristics of the household

4.2.1. Credit access

Regarding the availability of credit access for households, 97% of adopters and 56% of non-adopters of SWC measure stated that they had credit access and the remained 3% and 44% of non-adopters were not credit access in the study area (Table11). This result showed that almost all of the adopter's households of SWC measure got credit service greater than non-adopters and as a result of that, adopter households adopt soil and water conservation measures greater than non-adopters in the study area. Access for credit service and adoption of SWC measures and this was in line with the findings of Zemenu and Minale (2014). They stated that access to credit affect the adoption of SWC practice positively.

4.2.2. Extension service for households

Farmers in the study area had been receiving the extension services from Kebele's DAs and different NGOs community facilitators. According to the data from the survey, 96% and 70% of the adopters and non-adopters of soil and water conservation measures stated that they were receiving different extension services respectively and the remained 4% of adopters and 30% of non-adopters did not get extension services about soil and water conservation measures in the study area (Table11). The result indicated us that most of the adopter's households of SWC measures got different extension services such as advisory service, and this showed that the existence of extension services and the adoption of soil and water conservation have positive and significant association at 5% significance level.

4.2.3. SWC Training access

Concerning the access for SWC trainings, 86% and 40% of the adopters and non-adopters of soil and water conservation measures stated that they received soil and water conservation training respectively and the remained 14% of adopters and 60% of non-adopters did not get training access about soil and water conservation measures in the study area (Table11). The result showed us that most of the adopter's households of soil and water conservation measures got different extension training on soil and water conservation practices, and this showed that the existence of SWC training and the adoption of soil and water conservation have significant association at 5% significance level.

Table11: Institutional characteristics of the household

Variables	**Response**	**Adopters SWC**		**Non-adopters SWC**		**Total sample(150)**		**Chi-square**	**P-value**
		N	**%**	**N**	**%**	**N**	**%**		
Credit access	Yes	97	97.0	28	56.0	125	83.3	40.344	0.000
	No	3	3.0	22	44.0	25	16.7		
	Total	100	100.0	50	100.0	150	100.0		
Extension service access	Yes	96	96.0	35	70.0	131	96.2	20.370	0.000
	No	4	4.0	15	30.0	19	3.8		
	Total	100	100.0	50	100.0	150	100.0		
SWC training access	Yes	86	86.0	20	40.0	106	70.6	34.027	0.000
	No	14	14.0	30	60.0	44	29.4		
	Total	100	100.0	50	100.0	150	100.0		

4.3. Types of SWC practice being taken among the community

In this section, researcher tried to identify the awareness of SWC practices, the commitment of farmers to practice SWC measures, types of soil and water conservation measures practiced in the study area, etc. Regarding the existences of SWC in the study area, almost all i.e. 148(98.7%) of the interviewed respondents stated that there was awareness about SWC measures in the study area. From this 100(100%) of adopters and 48(96%) of non-adopters stated that there were awareness about SWC measures (Table12). This result showed us that there was SWC practices in Hawassa Zuria Woreda.

However almost all respondents believed that there were participated SWC measures; only 66.7% of them adopted and practiced SWC measures, whereas the remained 33.3% of the respondents did not adopted and practiced SWC measures in the study area and these were categorized as non-adopters (Table12).

Based on the survey results in (Table12) below, the respondents who did not adopted and practiced mentioned different reasons that hampered them from practicing. Accordingly 66% of them said that the limited knowledge about SWC measures was the main factors that hampered their practices and the remained 34% of the respondents said that lack of interest in soil and water conservation measures was the main factors that prevented their practice in soil and water conservation measures (Table12), this showed that knowledge or awareness about the soil and water conservation technology is one of the most determining factor to utilize the technology. This results were in line with the reports of the FGD and KII. They stated that:

‘’ in our area lack of knowledge of designing different physical structures of soil and water conservation measures affected their participation in the activities. In addition to that we do not know its importance in controlling our soil from erosion. We also faced the challenge in identifying different trees to plant that can act as the most important means in conserving our soil and water in our community.’’

Concerning the family members that participated in SWC measures, 70% of the adopters said that the family members that participated in SWC measures were men and the remained 15% of them said that the family members who participated in SWC measures were women (Table12). This result showed that men had greater role in practicing SWC measures in the study area.

The FGD and KII interview witnessed that: ‘’in our community all of us including husband, wife and children in the activities of SWC measures. This is due to the fact that, in our area all our community are well aware about the importance of soil and water conservation measures.’’

Table12: Awareness of SWC practice among the community at the study area

Variables	Response	Adopter		Non-adopter		Total sample=150		Chi-square	p-Value
		N	%	N	%	N	%		
Awareness of SWC practices	Yes	100	100.0	48	96.0	148	98.7	4.054	0.044
	No	0	0.0	2	4.0	2	1.3		
	Total	100	100.0	50	100.0	150	100.0		
Participation in SWC measures either in community or on farm land	Yes	100	100.0	0	0.0	100	66.7	150.000	0.000
	No	0	0.0	50	100.0	50	33.33		
	Total	100	100.0	50	100.0	150	100.0		
If No, why?	Limited knowledge	0	0.0	33	66.0	33	22.0	141.667	0.000
	Lack of equipment	0	0.0	0	0	0	0.0		
	Lack of interest	0	0.0	17	34.0	17	28.0		
	Total	0	0.0	50	100.0	50	50.0		
Participation in soil and water conservation works	Man	70.0	70.0	0	0.0	70	70.0	-	-
	Woman	15.0	15.0	0	0.0	15	15.0		
	Children	0	0.0	0	0.0	0	0.0		
	All	15.0	15.0	0	0.0	15	15.0		
	Total	100	100.0	0	0.0	100	100.0		

The survey results in the table below stated that, farmers in the study area practiced different types of soil and water conservation measures. Based on the survey results 43% and 9% of the interviewed respondents stated that they used biological and physical types of soil and water conservation measures, whereas 48% of the respondents used both biological and physical types of soil and water conservation measures (Table13). This result showed that farmers in Hawassa Zuria Woreda used both biological and physical types of soil and water conservation measures.

Concerning the biological type of 22% of the adopters practiced crop rotation, intercropping, grass strip, alley cropping, agroforestry and tree planting as a biological types of soil and water conservation measures. The remained 16% and 5% of the adopters were practicing agroforestry and green manuring respectively (Table13). Biological SWC measures mainly involve tree planting in the form of afforestation or reforestation. Biological SWC measures such as vegetation has a curative and protective value (Chimdesa, 2016). It is much easier than physical types of SWC measure and it could be explained by the availability of improved seeds and fertilizers through governmental subsidies and the fact that they are easy and simple to apply (Ashafi, 2019).

On the other hand, the physical types of soil and water conservation measures were also mentioned in (Table13) below. Accordingly, 77.8% of the adopters stated that they practiced Contour ploughing and Fanya-juu and the remained 22.2% of them said that they used soil bund as physical types of SWC (Table13). These results showed that different types of soil and water conservation practices were used by different adopter households in Hawassa Zuria Woreda.

The report of FGD and KII witnessed that: ‘’there are different types of SWC measures undertaken in Hawassa Zuria. These included biological or agronomic and physical types. Biological/agronomic practices such as using of different grasses, agroforestry, crop rotation, mulching, intercropping of maize with haricot bean, etc. and mechanical or physical types such as terracing, contour ploughing, etc.’’

Table13: Biological and Physical types of SWC measures

Variables	**Response**	**Adopter**		**Total sample=150**	
		N	%	N	%
SWC measures	Biological	43	43.0	43	28.7
	Physical	9	9.0	9	6.0
	Both	48	48	48	32.0
	Total	100	100.0	100	66.7
Biological types of SWC measures	Green manuring	5	11.6	5	3.3
	Agroforestry	16	37.2	16	10.7
	Crop rotation, intercropping, grass strip, alley cropping	22	51.2	22	14.7
	Total	43	100	43	28.7
Physical types of SWC measures	Soil bund	2	22.2	2	1.3
	Contour ploughing and Fanya-juu	7	77.8	7	4.7
	Total	9	100.0	9	6.0

4.4 Factors that influence the adoption of SWC practices

This section mainly focused on the variables that significantly affected household's decision from adopting SWC technologies at the study area. Therefore these variables were selected and used to be estimated by binary logistic regression model. As shown in (Table 14) at 4^{th} step, the four variables namely advisory services households received from extension agents regarding SWC, training of household on SWC, number of family size of the households, education level of the households had been selected to have significant influence on the dependent variable i.e. adoption of SWC**.**

Table14: Likelihood estimate of the binary logistic regression model on determinants of a SWC adoption

	B	S.E.	Wald	df	Sig.	Exp(B)
Sex	-34.649	9157.244	.000	1	.997	.000
Age	-.026	.035	.549	1	.459	.975
Marital status	.019	1.290	.000	1	.988	1.019
Household structure	16.737	41223.003	.000	1	1.000	1.042
Advisory/Extension service	1.903	.493	14.886	1	.000**	.6709
SWC training	1.634	.553	18.716	1	.003**	.195
Credit access	19.087	5948.523	.000	1	.997	1.750
Land size	-5.730	2.430	5.558	1	.018	.003
Family Size	-.496	.149	11.133	1	.001*	.609
Education level	-.841	.236	12.689	1	.000*	.431
Livestock ownership	-3.262	25071.650	.000	1	1.000	.038
Agricultural input	35.534	6981.433	.000	1	.996	2.706
Constant	.752	44891.862	.000	1	1.000	2.121

*,** indicates significant at 1% and 5% probability level respectively

4.4.1. Interpretation of Output from Binary Logistic Regression model

Based on the analysis obtained from binary logistic regression model, the results were interpreted as follows. The odds for SWC adoption were 60.9 times higher in SWC adopters who got higher family size compared to non-adopter households of SWC. The odds for SWC adoption are 43.1 times higher in adopters whose education status was good compared to non-adopter household. The odds for SWC adoption are 67.09 times higher in SWC adopters who got SWC advisory services from development agents compared to non-adopters of SWC technologies. The odds for SWC adoption is 19.5 times higher in SWC adopters who got training on SWC technologies compared to non-adopters who did not have any training about SWC technologies.

4.4.1.1. Family size vs. the adoption of SWC practices

Having larger family size was negative and significantly affected the likelihood of SWC adoption decision of the farmers at the study area. This showed that households who got higher family size in their house are more likely adopted SWC technologies than who have lower family size number. The results obtained from binary logistic model showed that, the farmers who have higher number of family size in their household adopted SWC by a factor of 60.9 times higher than the farmers who did not have higher family size. Family size influenced the adoption of soil bund and strip cropping positively and negatively at 5% significant level. This result was similar with the finding of Belachew et al. (2020) and they stated that as the household size increased by one person, the adoption of soil bund increased by 0.82%. This means larger households adopted soil bund more than those with small household sizes. This indicates that larger households had better labor force to construct labor intensive physical SWC practices which are more labor demanding than biological measures.

4.4.1.2 Farmers Education vs. the adoption of Soil and Water conservation measures

Educational level of household-heads increases farmers' ability to get and use information and improves farmers' decision to adopt SWC practices. Based on the results from obtained from the model, increase in the improvement of the academic status of the farmers was negative and significantly affected the likelihood of the adoption of SWC measures by farmers at the study area. The results indicated that, households whose education level/status was improved by 1 grade adopted SWC measures by a factor of 43.1 times higher than the farmers who did not have a better education status. Based on this result we can understand that, increase in the education level provided favorable condition for the adoption of different SWC technologies. Farmer's education enhance the knowledge of the farmers to adopt and practice soil and water conservation measures easily. Unless and otherwise, farmers fail to adopt and practice soil and water conservation measures easily. And this was in line with (Molla& Sisheber, 2016) and he stated that, the main reason for the failure to achieve sustainable conservation structures is lack of knowledge and skill on soil and water conservation. Better exposure to education increases farmers' better understanding of the benefits and constraints of soil conservation (Mekonnen & Abiy, 2014; Asfaw & Neka, 2017; Mango et al., 2017; Meseret & Amsalu, 2017).On the other hand ,education did not had significant impact on SWC technologies (Mekuriaw.et.al 2018).

4.4.1.3. Advisor service from extension workers vs. the adoption of Soil and water conservation measures

Advisory service/extension contact influenced the adoption of soil bund and strip cropping positively at 5% significant level. Based on the results of the binary logistic model analysis, advisory services from Kebeles development agent was positive and significantly affected the likelihood of SWC adoption decision of the farmers at the study area. This showed that households who got advisory service from development agents (DAs) are more likely adopted SWC than who did not have advisory services. The results obtained from binary logistic model indicated that, the farmers who have got advisory service of extension agents adopted SWC by a factor of 67.09 times higher than the farmers who did not get advisory service. Depending on this result we can understand that advice of development agent workers and different technical support at individual farmer level has a great role by narrowing the knowledge gap of the farmers to adopt SWC farming practices at the study area. Agricultural extension service and training on SWC measures are the basic tools for smallholder farmers to get awareness about SWC ,the mechanism how to implement it and improve production methods because of this both of them were positively affecting SWC measures (Nkegbe, 2011; Asfaw & Neka, 2017; Mango et al., 2017; Mountain & Park, 2018)

4.4.1.4. SWC technology Training vs. the adoption of Soil and water conservation measures

Training affected the adoption of SWC practices positively. According to the result from binary logistic model analysis above, training on different SWC technologies components had positive and significant effect on the adoption of SWC technology. The households who received training on SWC technology components adopt SWC by a factor of 19.5 times higher than those who did not received any training on SWC technologies. This indicated that the farmers who received on full package of SWC technologies have more knowledge and confidence than those farmers who received partially and less understood its principles. According to Progress (2012), training in SWC significantly increased the likelihood of adoption of SWC. This is because SWC trainings were the most important source of information on SWC practices. This implies that farmers cannot adopt technologies if they do not have access to all the relevant information, but the information they obtained was often incomplete, mainly focused only on the technical aspects and overlooked some key criteria from a farmer's point of view. In order to adopt check dam successfully and efficiently practical training is essential. Thus, most trained farmers adopt strip cropping rather than check dam. This result is similar with Fikru (2009) who noted that access to training has adverse effects on the adoption of SWC technologies.

Classification table

Table 15: Classification table

Variables		Predicted		Percentage Correct
		HH practicing SWC		
		Adopter	Non adopter	
HH practicing SWC	Adopter	87	13	87.0[3]
	Non-Adopter	10	40	80.0
Overall Percentage				84.7[1]

1) 84.7 percent of overall sample households were predicted correctly. So, the model shows us the prediction success at a 50% probability classification
2) 87.3 percent of adopters sample households were predicted correctly at a 50% probability classification.
3) 80.0 percent of SWC non-adopter households were predicted correctly at a 50 % probability classification.

According to the results of the model in (Table15) above, 84.7 percent of overall sampled households were predicted correctly. This means that, 40 respondents out of 50 who did not adopt SWC technologies and 87 respondents out of 100 who adopted SWC technologies were predicted correctly. This showed that the model is a good fit of the data and predicts both groups of sample respondents properly. Therefore, the model adequately fits the data.

4.5. Contribution of soil and water conservation for climate change adaptation

In this section the researcher had assessed the contribution of soil and water conservation for climate change adaptation in Hawassa Zuria Woreda. To this end, he included different variables such as information about the existence of climate change, whether the respondents think or not the contribution of SWC to climate change adaptation, if yes, how SWC measures contribute climate change adaptation, why the farmers use soil and water conservations measures on their plots, the results that the adopters farmers could expect from the implemented soil and water conservation measures, etc.

Concerning the awareness of farmers about the existence of climate change in the study area, 92% of adopters and 78% of non-adopters noticed the climate change trends in the study area for the last 30 years, the remained 8% of adopters and 22% of non-adopters did not noticed the existence of climate change for the last 30 years. This result showed us that most of the farmers in Hawassa Zuria Woreda were aware about the trends of climate change for the last 30 years. Based on the survey results in (Table16) below, contribution of soil and water conservation practice to climate change adaptation was assessed. Accordingly, 92% of adopters and 16% of non-adopters thought that soil and water conservation contributed climate change adaptation in the study area, whereas the remained 84% of the non-adopter households did not know whether soil and water conservation measures could contribute climate change and adaptation strategies. This result showed us that soil and water conservation measure has greatest contribution in enhancing climate change adaptation to the systems (i.e. either the human or natural). It contributes to climate change adaptation by preventing run-off, flash flooding, increase soil fertility through nutrient cycling and which in turn enhance crop production and productivity.

Regarding the reason that households in the study area used SWC conservation measures, 65% of the adopter households said that they used soil and water conservation measures to conserve soil and water on their farm plots and the remained 25% and 10% of the respondents stated that they used soil and water conservation practices on their plots to conserve their soil and water from their farm plots respectively (Table16).

In addition to that farmers in Hawassa Zuria Woreda had been used soil and water conservation for different reasons for the last many years. According to the data in the (Table16) below, 68% of the households who adopted soil and water conservation measures said that they used SWC practices on their plots to reduce soil erosion, increase soil fertility, Increase crop production and control flood and the remained 25% and 7% of them said that, they used soil and water conservation measures on their farm plots to reduce soil erosion and increase crop production and productivity respectively (Table16). These results indicated us that farmers in the study area used soil and water conservation measures to reduce soil erosion, increase soil fertility, increase crop production and control flood.

These results showed that communities in the study area currently practicing the physical structures of soil and water conservation practices to keep their soil from loss through erosion which increase their soil fertility and this in turn enhance production and productivity for their crops. This result was similar with the finding of Mamush et al. (2021). They stated that SWC enhanced the reduction of soil erosion and increment of soil moisture, respectively. They also found that SWC measures resulted in stabilization of gullies and restoration of degraded lands. Field observation results also revealed observable indicators, which have important contributions towards livelihoods improvement, such as overflow of springs in the plots of adopter households, which are important for irrigation purposes, restoration of dried areas, and levelling of slopping places. This was in line with the study of (Hish et al. 2017), which indicated the intervention of soil and water conservation, as it was intended to prevent land degradation, maximize agricultural productivity, improve ground and surface water for domestic and irrigation uses, and promote food security of the rural community.

Concerning the frequency that the households maintain SWC structures in the study area, 68% of the adopters said that they maintain their soil and water conservation measures in every year on their farm plots and the remained 17% and 15% of them stated that they maintain soil and water conservation measures when damage is happened and every year and every two years respectively in the study area (Table16). These results showed us that farmers in Hawassa Zuria Woreda maintain their soil and water conservation structures in every year, every two years and when damages happened to the structures.

Table16: Contribution of soil and water conservation for climate change adaptation

Variables	Response	adopters		Non-adopter		Total sample(150)		Chi-square test	p-Value
		N	%	N	%	N	%		
Awareness of climate change	Yes	92	92.0	39	78.0	131	87.3	5.906	0.015
	No	8	8.0	11	22.0	19	12.7		
	Total	100	92.0	50	100.0	150	100.0		
Awareness of SWC practice to climate change adaptation	Yes	92	92.0	8	16.0	100	66.7	112.485	0.000
	No	7	7.0	0	0.0	7	4.6		
	I don't know	1	1.0	42	84.0	43	28.7		
	Total	100	100.0	50	100.0	150	100.0		
The uses of SWC measures	To conserve soil	25	25.0	0	0.0	25	16.6	-	-
	To conserve water	10	10.0	0	0.0	10	6.6		
	To conserve both soil and water	65	65.0	0	0.0	65	43.3		
	Total	100	100.0	0	0.0	100	100.0		
Results expected from SWC practices done on farm	Increase crop production	7	7.0	0	0.0	7	6.6	-	-
	Reduce soil erosion	25	25.0	0	0.0	23	15.3		
	Increase soil fertility and control flood	68	68.0	0	0.0	68	45.3		
	Total	100	100.0	0	0.0	100	100		
Frequency to maintain SWC structures	Every year	68	68.0	0	0.0	68		-	-
	When damage happens	17	17.0	0	0.0	17			
	Every two years	15	15.0	0	0.0	15			
	Total	100	100.0	0	0.0	100			

4.6. Assessing the contribution of SWC for house hold food security

4.6.1. Comparing the Indicators of Food Security between Adopters and Non-Adopters

In this section, the researcher assessed the contribution of SWC measures on household food security, and this was done by running the comparative analysis of adopters and non-adopters household's food security indicators and maize yield data obtained from adopters and non-adopter's households at the study area. This was done in two ways. Primarily household's food security indicators was obtained from both adopters and non-adopter households at the study area. These indicators included whether household has food shortage problem or not, causes of food shortage, crop production status before and after applying soil and water conservation measures on their farm plots, their food security status before and after applying SWC measures, rates of meals household and their family members consumed per a day before and after using SWC practices, amount of Maize crop yield between adopter and non-adopter famers, etc.

Based on the survey data obtained from the field, respondents were asked about the problem of food shortage before using SWC measures in the study area. Accordingly, 97% of the adopters of soil and water conservation practices stated that they had food shortage problems before implementing soil and water conservation measures on their farm plots. On the other hand, 93% of non-adopter households stated that they had food security problem before or after implementing soil and water conservation measures (Table17). This result showed us that both adopters and non-adopter households had food shortage problem before implementing soil and water conservation measures on their farm plots.

As most of the adopter households said that there was problem of agricultural production because of recurrent drought and flash flooding resulted from intensive rain fall were the main causes for shortage of food in the study area. 71% of the adopter and 28% of non-adopter household said that the main cause for food shortage were incidence of pest, diseases and weeds respectively and the remained 29% of adopters and 20% of non-adopters stated that the main causes for food shortage were Extreme variability in rainfall/drought. About 62% of non-adopter households said that the main causes for food shortage for the households in Hawassa Zuria Woreda were soil fertility decline (Table17). These results indicated us that climate change problem had greatest contribution for food shortage which was resulted from increased flash flooding and recurrent drought.

The study also assessed the status of crop production before and after implementing of soil and water conservation measures on their farm plots. Based on that, 74% and 20% of adopters stated that crop production before applying SWC measures on their farm land was decreasing and increasing respectively. This is due to loss of productive soil by erosion and this was similar with the findings of (Pimentel, 2000) and he stated that food security depends directly on soil productivity. Accelerated soil erosion is among principal causes of the decrease in soil productivity and increase in risks of global food insecurity. According to (Pimentel, 2000). The magnitude of erosional impacts on ecosystem productivity and food security is, however, complex, variable, and soil specific. All (100%) of non-adopter households said that their crop production before implementing soil and water conservation measures constant or no change at all. This showed that non-adopter households could not see any differences in their crop yield since they did not implemented soil and water conservation measures on their farm plots.

Regarding the status of crop production after implementing soil and water conservation measures, 93% of adopter households stated that their crop production was increasing after applying SWC measures on their farm land. On the other hand all (100%) of the non-adopter households stated that they did not know about increasing or decreasing of their crop production because of SWC measures since they did not used on their farm land. Implementation of SWC to household's farm had positive and significant contribution on household's food security status. These results were similar with the findings of Mamush et al., (2021) and they stated that SWC measures generated significant outcomes in surface and subsurface water resources, which could result in better agricultural production and thereby improve the livelihood of the rural households.

Table 17: Causes and status of crop production after and before implementing of SWC measure

Variables	Response	Adopter		Non-adopter		Total sample(150)		Chi-square test	p-Value
		N	%	N	%	N	%		
Food shortage problem before using SWC	Yes	97	97.0	47	93.0	144	96	122.453	0.000
	No	3	3.0	3	3.0	6	4		
	Total	100	100.0	50	100.0	150	100.0		
Causes of food shortage	Extreme variability in rainfall/Drought	29	29.0	10	20.0	39	26.0	97.376	0.000
	soil fertility decline	0	0.0	26	62.0	26	17.3		
	Incidence of pest, diseases and weeds	71	71.0	14	28.0	85	56.7		
	Total	100	100.0	50	100.0	150	100.0		
Status of Crop production before applying SWC measures on farm land	Increasing	20	20.0	0	0.0	20	13.0	98.077	0.000
	Decreasing	74	74.0	0	0.0	74	49.3		
	Constant/no change	6	6.0	50	100.0	56	37.3		
	Total	100	100.0	50	100.0	150	100.0		
Status of crop production after applying SWC measures on farm land	Increasing	93	93.0	0	0.0	93	62.0	122.368	0.000
	Decreasing	5	5.0	0	0.0	5	3.3		
	Constant/no change	2	2.0	0	0.0	2	1.3		
	I don't know	0	0.0	50	100.0	50	33.3		
	Total	100	100.0	50	100.0	150	100		

The study was also assessed the status of household's food security before implementing soil and water conservation measures on their farm size. Based on the survey data in (Table18) below 74% of the interviewed adopter's respondents stated that their food security status before applying soil and water conservation measures on their farm plots was decreasing and the remained 26% of adopters and all (100%) of non-adopters of soil and water conservation measures stated that their food security status before applying soil and water conservation measures on their farm plots was constant or not changed respectively.

However, after applying soil and water conservation measures on their farmland, the interviewed households answered that their food security status became improved. To this end, 93% of the adopter households of soil and water conservation measures stated that their food security status after implementing soil and water conservation measures to their farmland became increased (i.e. they became food secured). On the other hand, all (100%) of non-adopter households stated that they did not know any difference in their food security status as a result of soil and water conservation measures(Table18). The Chi-statistics results showed us that the adoption of soil and water conservation structures and improvement in food security status had positive and significant association at 5% significant level.

According to the survey result in (Table18) below, 48% of adopters and 34% of non-adopter households feed themselves three times per a day before using SWC measures. Whereas 52% of adopter and 66% of non-adopter households believed that they feed themselves two times per a day before using SWC measures. From these comparative analysis results of adopters and non-adopters, we can understand that majority of soil and water conservation adopter households feed themselves two times per a day and this was again significant at 5% level and this indicated that these households who feed themselves three or more than three times are food secured and this was in line with the findings of Getenesh (2019). Using

Pearson chi-square and Cross tabulation analysis, he found that there were significant association between SWC technologies adoption and household food security status in Ensaro Woreda. According to Getenesh (2019), greater proportion of food secured household were SWC technologies adopter. Based on the survey results in table below, the study also assessed the number of meals that households had per a day.

Table 18: Status of food security implementing after and before SWC

Variables	Response	Adopter		Non-adopter		Total sample		Chi-square test	p-Value
		N	%	N	%	N		N	%
Food security status before implementing SWC measures	Increasing	0	0.0	0	0.0	0	0.0	73.026	0.000
	Decreasing	74	74.0	0	0.0	74	49.33		
	Constant/no change	26	26.0	50	100.0	76	50.7		
	I don't know	0	0.0	0	0.0	0	0.0		
	Total	100	100.0	50	100.0	150	100.0		
Food security status after implementing SWC on your farmland	Increasing	93	93.0	0	0.0	93	62.0	122.368	0.000
	Decreasing	5	5.0	0	0.0	5	3.4		
	Constant/no change	2	2.0	0	0.0	2	1.3		
	I don't know	0	0.0	50	100.0	50	33.3		
	Total	100	100.0	50	100.0	150	100		
Frequency of eat per day before using SWC a day	More than 3 times	0	0.0	0	0.0	0	0.0	2.661	0.103
	3 times	48	48.0	17	34.0	65	43.3		
	2 times	52	52.0	33	66.0	85	56.7		
	1 time	0	0.0	0	0.0	0	0.0		
	Total	100	100.0	50	100.0	150	100.		

Frequency of eat per a day after using SWC a day	More than 3 times	87	87.0	0	0.0	87	58.0	137.684	0.000
	3 times	13	13.0	15	30.0	28	18.7		
	2 times	0	0.0	35	70.0	35	23.3		
	1 time	0	0.0	0	0.0	0	0.0		
	Total	100	100.0	50	100.0	150	100		

4.6.2. Econometrics model results

4.6.2.1. Estimated Results of Maize Production Functions for Adopters and Non-Adopter of SWC

In this section, the researcher contributions of SWC measures on household's food security at the study area, the researcher estimated the maize production for both adopter and non-adopter households of SWC by using Multiple linear regression model and comparison analysis between the amount of yield obtained either from SWC or Non-SWC plots during the time of climate change during 2020/2021growing season.

In table19, in a model summary, the “R” value is used to indicate the strength and direction of the relationship between the variables. The closer the value gets to 1, the stronger the relationship. In this case as shown below, R= 0.861. This means there was an overall strong and positive relationship between the variables. The R-Square in the study was found to be 0.741. This value indicates that the independent variables (Land size, improved seed, fertilizer, labor and Oxen draft power) can explain 74.1% of the variance in the Maize yield at Hawassa Zuria Woreda. The remaining 25.9% of the variance is explained by other variables not included in this study.

Crop production is the major food security activity for the majority of the sample households in the study area. The major crops grown in the districts in order of importance include maize, haricot bean, and others, and their mean values showed variation between adopter and non-adopter households. The estimated results in (Table19) below indicated that, the results for adopter households had positive relationship between total yield of maize and labor, seed, land, and draft access. This shows that as households at the study area employ more of these factors of production, there will be an increase in total output of maize yield. These results were in line with the findings of (Braun et al. 2003), and he stated that the implementation of SWC practices improves soil fertility and increases crop productivity, which enables farmers to grow more food, which translates into better diets and under market conditions that offer a level playing field, into higher farm incomes. This increased crop yield as a result introduction of SWC to farmer's farm also enhanced their income and livelihood in the study area and this was similar with loss (Wani et al., 2010). They stated that soil and water conservation measures conducted in India, China, Thailand and Vietnam watershed management is seen as an entry point for improving livelihoods achieving food security and has resulted in increasing agricultural productivity by 2 to 3 folds, doubling the family incomes, and reducing runoff up to 66% and soil loss by 2/3.

According to these results in (Table19) below, land, labor and seed had positive coefficients of elasticity among SWC adopters. Based on this result, labor and land are the most significant factors of maize production among SWC adopters. As more of these factors of production (land and labor) are used increasingly, there will exist more maize yield among the adopter households. The results of non-adopter households indicated that, there is positive relationship between maize output and land, labor, seed, fertilizer and draft access/oxen and again this implies that as the non-adopter households employ more of these factors of production, there will be increase in the output of maize yield.

The coefficients of seed and fertilizer for adopters and land size, labor and oxen for non-adopter households are not statistically significant in influencing maize production. This was due to that, majority of adopters and non-adopter households use local seeds and also in case of land preparation time, majority of adopter households use different soil and water conservation structure such as fanyaa-juu, trench, grass-strip, agroforestry, crop rotation, etc by using family labor instead of ploughing by draft animals. Due to this, the availability of draft animals and seed does not affect maize production at the study area.

The coefficient (β=0.786) of land for adopter household is statistical significant at 5% level. This indicated that, holding all other factors constant, an increase in land by one hectare will results in 78.6 percent increase in maize production.

The mean Variance Inflating Factor (VIF) was 1.215 for adopters and 1.39 for non-adopters indicating no Multicollinearity of these factors in the data collected since the VIF is less than 10 and this was in line with Hair et al., 1995; Marquardt,1970)

Table19: Econometrics model results

Model Summary	R	R Square				Adjusted R Square		Standard Error of estimate		Sig
	0.861	**0.741**				**0.727**		**4.551**		0.000*
	Variables	Adopters				Non-adopters				
		Standardized B	Std. Error	T-value	VIF	Standardized βs	Std. Error	T-value	VIF	
	Constants	4.410	2.348	1.878	**1.2152**	1.601	3.192	-.842	**1.395**	
Coefficients	Land Size	.786	1.941	12.3**		.172	3.516	1.286		
	Fertilizer	-.061	.017	-1.082		.408**	.151	3.331**		
	Labor	.166	.435	3.10**		.055	.019	3.737		
	Seed(Kg)	0.50	.235	.873		.416**	.239	.480**		
	Oxen(Draft access)	0.145	.893	2.48**		.114	.474	.958		

*, ** indicates Significant at 1% and 5% probability level respectivel

In (Table19) above, the coefficient of fertilizer for soil and water conservation measure adopters is negative and this negative and insignificant coefficient of fertilizer among SWC adopters implies that adding inorganic fertilizer to the soils where there is SWC is being practiced has no effect on maize production. These results enhance the chance for promoting SWC technologies in order to minimize the cost of production at the same time improving soil health. This opposes results against non-adopters where maize production responds to increase in application of inorganic fertilizers.

The paper reveals that, fertilizer is a significant factor in the production of maize among non-adopters households of SWC at 5% probability level and also keeping other things constant, if we increase fertilizer use by one kilogram for non-adopter households maize yield will increase by 40.8 percent.
For both adopters and non-adopters, land is an important factor of production in the study area. If farmer increases land size by one hectare, maize output will increase by 78.6 percent for adopters. Although increase in land responds high to maize output with 17.2 percent per hectare added for non-adopters, seed does not respond as much as compared to SWC adopters.

4.6.2.2. Comparing Maize Production for Adopters and Non-adopters of SWC

The study analysis computed the mean maize production for both adopter and non-adopters of SWC. The results suggest that the adopters have a higher mean maize production of 31.0168 quintals as compared to that of non-adopter, which was 13.4660 quintals (Table20). The mean difference between adopters and non-adopters was 17.5508 indicating that maize production is better for SWC adopters than non-adopters. The results are presented in the (Table20) below.

Table 20: Average Maize production

Condition	**Average production of maize yield**	**Std.error**	**t-value**	**Sig.**
Adopters	31.0168 quintals	.60504	19.154	0.000
Non-adopters	13.4660 quintals	.68815		
Differences	17.5508 quintals			

These results indicated that, SWC adopters had a greater role than non-SWC adopters in contributing maize production at the study area. Based on these findings, the basic message is that SWC measures can be a much better solution in ensuring household food security than the promotion of chemical fertilizer use through programs under the changing climatic condition**.**

The report of FGD and Key informants revealed that farmers in the study area are currently satisfied with the outcome of community based SWC activities. Most of the elders' interviewed from the FGD reported that: In the last 20 or more years, soil erosion which was caused by intensive rainfall resulted flooding and wind erosion was the serious problem in our environment. Even though we had a large area of cultivated land, we were not producing enough amount of food for our family. Having considered these problems, governmental and non-governmental organizations introduced different SWC practices. Since we were finding a solution for the problem, we engaged to the soil and water conservation measure works introduced by the above mentioned organization, and now we have constructed the SWC structures on different SWC measure and on our cultivated farm lands and we are currently able to keep the soil on our cultivated land and start to produce good yields.

CHAPTER FIVE

5. CONCLUSTIONS AND RECOMMENDATION

5.1. Conclusion

This study assessed the adoption of SWC around Lake Hawassa, in Sidama region, Ethiopia. The socio-demographic analysis from descriptive statistics showed that mostly male-headed households of adoption status in general adopt and practicing SWC technologies in the study area. The survey identified that out of the total (150) households, 100 (66.7%) were being adopted and practiced SWC activities in their lands while the rest 50 (33.3) households didn't either adopted or practicing any forms of SWC on their owned lands. About 86.7% of the respondents were male and 13.3% of them were female and all female respondents (100%) were adaptor of SWC while only 80% of male respondents practices different SWC practices, indicating somewhat the higher involvements of females in SWC activities in the areas. There is significant different in age, land size, sex, marital status, education level, HHs off-farm activities, income from off-farm activities, credit access extension services and SWC training accesses between adopters and non-adopters of the SWC measures. However, there are non-significant differences in the family size, household structure and livestock ownership between adopter and non-adopter of SWC measures. However, there are non-significant differences in the family size and household structure between adopter and non-adopter of SWC measures.

The factors influencing the probability of adoption of SWC measures in the study area are accesses for education of the household head, access to extension services and household SWC incentives. The Binary logistic regression analysis about the factors affecting the adoption of SWC measures in the study area showed that extension services, training of household on SWC, number of family size of the households, education level of the households had been selected to have significant influence on the dependent variable i.e. adoption of SWC**.** The odds for SWC adoption were 60.9 times higher in SWC adopters who got higher family size compared to non-adopter households of SWC. The odds for SWC adoption are 43.1 times higher in adopters whose education status was good compared to non-adopter household. The odds for SWC adoption are 67.09 times higher in SWC adopters who got SWC advisory services from development agents compared to non-adopters of SWC technologies. The odds for SWC adoption is 19.5 times higher in SWC adopters who got training on SWC technologies compared to non-adopters who did not have any training about SWC technologies.

The SWC measures had different roles in enhancing the household's climate change adaptation capacity for the communities in the study area. 92% of adopters and 16% of non-adopters thought that soil and water conservation contributed climate change adaptation in the study area, whereas the remained 84% of the non-adopter households did not know whether soil and water conservation measures could contribute climate change adaptation strategies.

A comparative analysis of food security between adopters and non-adopters of soil and water conservation measures showed that there exist a positive relationship between SWC adoption and achievement of food security condition in the study area. The results revealed that adoption of SWC technology improved household's maize productivity by 17.5508 quintals than those who did not adopted and practiced soil and water conservation measure. In addition, there were greater than proportionate unit increases in maize productivity with unit increase in land size, oxen/draft power and labor among SWC adopters. The contribution of SWC measures adoption on food security was also evident through farmers' report of increased number of meals per day and availability of food throughout the year among adopters.

5.2. Recommendation

- The farmers' access to SWC training services and access to different advisory services from extension workers, for farm households should be improved when promoting SWC technology among smallholders in the study area.
- The different non-governmental organizations (NGOs) and governmental organizations (GOs), planners and research institutes, who are working in promotion of different agricultural technologies such as SWC would be recommended to provide training and demonstration to farmers which would help their ability in knowledge acquisition and quick understanding of technology components of the farmers and reduce their fear on risk of SWC technology failure.
- Provide information about the importance of SWC measures to households, there should be provision of increased provision of the advisory services from DAs at Kebele levels just like another agricultural technology.
- There should be creation of awareness for farmers about the importance of SWC measures for climate change adaptation.

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APPENDIX

Appendix I

Model output

Logistic regression model output

Classification Table

Observed			Predicted: Adoption of SWC — Adopt	Predicted: Adoption of SWC — Do not adopt	Percentage Correct
Step 0	Adoption of SWC	Adopt	100	0	100.0
		Do not adopt	50	0	.0
	Overall Percentage				66.7

Variables in the Equation

		B	S.E.	Wald	df	Sig.
Step 1[a]	Advisor role	2.432	.421	33.428	1	.000
	Constant	-4.434	.719	37.985	1	.000
Step 2[b]	Education level	-.654	.203	10.358	1	.001
	advisor role	2.283	.439	27.086	1	.000
	Constant	-3.100	.794	15.248	1	.000
Step 3[c]	Family size	-.464	.142	10.660	1	.001
	Education level	-.856	.225	14.417	1	.000
	advisor role	2.369	.469	25.521	1	.000
	Constant	-.866	1.013	.730	1	.393
Step 4[d]	Family size	-.496	.149	11.133	1	.001
	Education level	-.841	.236	12.689	1	.000
	advisor role	1.903	.493	14.886	1	.000
	SWC Training	-1.634	.553	8.716	1	
	Constant	2.131	1.460	2.131	1	.144

Adopter's linear regression model output

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations
		B	Std. Error	Beta			Zero-order
1	(Constant)	4.410	2.348		1.878	.063	
	Land_Size	23.930	1.941	.786	12.329	.000	.833
	Seed	.205	.235	.050	.873	.385	.308
	Fertilizers	-.018	.017	-.061	-1.082	.282	.197
	Labor	1.352	.435	.166	3.109	.002	.087
	oxen	2.213	.893	.145	2.477	.015	.478

Non-adopter's linear regression model model output

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order
1	(Constant)	-2.687	3.192		-.842	.403	
	Land_Size	4.523	3.516	.172	1.286	.203	.224
	Seed	.503	.151	.416	3.331	.001	.375
	Fertilizers	.073	.019	.408	3.737	.000	.287
	Labor	.115	.239	.055	.480	.633	-.109
	Oxen	.454	.474	.114	.958	.342	-.002

Maize yield data for both two groups in 2021 production year							
Adopter of SWC					Non-adopter of SWC		
24.00	34.00	32.00	24.00	34.00	11.30	20.00	12.45
34.00	28.90	24.00	34.00	28.90	12.00	13.00	13.45
29.50	35.00	34.00	29.50	35.00	17.00	14.00	20.00
32.50	32.00	29.50	32.50	32.00	21.00	13.00	12.30
40.00	33.45	32.50	40.00	33.45	23.00	8.00	15.00
26.75	37.00	40.00	26.75	37.00	11.00	12.00	7.00
33.25	36.75	26.75	33.25	36.75	19.00	14.50	10.00
22.00	34.00	33.25	22.00	34.00	10.50	6.00	9.50
37.00	26.00	22.00	37.00	26.00	22.00	7.80	7.50
41.00	31.50	37.00	41.00	31.50	8.00	11.30	20.00
22.50	34.00	41.00	22.50	34.00	10.50	12.00	
36.00	30.50	22.50	36.00	30.50	12.45	17.00	
33.50	26.50	36.00	33.50	26.50	13.45	21.00	
23.40	24.35	33.50	23.40	24.35	20.00	23.00	
24.00	22.00	23.40	24.00	22.00	12.30	11.00	
42.00	32.00	24.00	42.00	32.00	15.00	19.00	
24.60	40.00	42.00	24.60	40.00	7.00	10.50	
18.56	29.30	24.60	18.56	29.30	10.00	22.00	
34.00	35.50	18.56	34.00	35.50	9.50	8.00	
36.00	28.25	34.00	36.00	28.25	7.50	10.50	

AppendixII

Household survey questionnaire

Hawassa University

College of Agriculture

Household level survey questionnaire

Dear Respondent, I am a graduate student in Climate change and Sustainable Agriculture, College of Agriculture, Hawassa University. By now, I am conducting my thesis on impact of soil and water conservation practices on community's climate change adaptation strategies dynamics around Lake Hawassa, Hawassa Zuria district. For this reason, your active participation and authentic responses are very important in meeting the proposed objectives of this study. Thus, I kindly request your active cooperation in responding to the questionnaires and give clear, appropriate and reliable information on the issues. Be sure that the information you provide is only for the purpose of this study.

Thank you so much!!

Direction: please give your answers based on the question.

Questioner Number: ______________________________

Date of interview: Day _______ Month _______ Year___________

Interviewed by: _________________________________

Data Entered: Day ______ Month ______ Year _____________

Region: _________________________________

District: ___________________________________

Part I: Socio-economic and Demographic characteristics

1. Name of the household head (HH): ____

2. Age of the household head: _______________

3. Marital status: i) Married_____ii) Not married______ iii) Divorced_____ iv) Widowed_____

4. Sex of the household head: 1. Male 2. Female

5. Size of the household. 1. Male__________ 2. Female_____________ 3. Total___________

6. What is the composition of the household with age and sex group?

Age group	Male	Female	Total
0-14			
15-64			
>65			
Total			

7. What is the educational status of the household head?

Edu. status	Cannot read and write(Illiterate)	0 grade	1-4	5-8	9-12	Diploma graduate	B.Sc degree	Above
Mark(√)								

8. Do you have domestic animals? 1. Yes 2. No

9. If your answer is yes for Q8, how many animals do you have?

Nº	Kind of animal	Amount in nº
1	Ox	
2	Cow	
3	Sheep	
4	Goat	
5	Donkey	
6	Horse	
7	Others specify…….	

10. How is the present number of your animal as compared to the previous years?

1) Increasing 2) decreasing 3) remain the same

11. What is/are the main source/s of feed for your animals?

1) Grazing 2) hay 3) crop residue 4) others, specify........

12. Is there feed shortage for your animals? 1) Yes 2) No

13. If yes for Q12, what is/are the causes of shortage/s?

1) Expansion of cropland   2) degradation of lands   3) expansion of settlements

4) Others Specify............

14. Do you or your family member work on off – farm activities? 1. Yes 2. No

15. If the answer to Q14 is yes, fill in the following table

Nº	Type of off-farm(Non –farm) activity	Yes	Total income obtained in one year (birr), approximate
1	Petty trade		
2	Transportation by motor cycle		
3	Fishing		
4	Transportation by “Gary”		
5	Weaving		
6	Poultry		
7	Hand craft		
8	Other		
9	None		

Part II: Adoption of soil and water conservation practice by the community at the study area.

16. Do you have your own farm land? 1. Yes 2. No

17. If your answer is yes, what is the size of your land in hectare?

1. <0.5ha 2. 0.5-1ha 3. 1-2ha 4. >2ha

18. Have you participated soil and water conservation measures on your own land? 1) Yes 2) No

19. If yes, since when? ___________________________

20. If you did not implement any soil and water conservation measures in all your plots, why?

1. Lack of extension service (advice) 5. Lack of inputs (resources)
2. No problem of land degradation 6. Inappropriateness of technology
3. Shortage of labour 7. I don’t have access to the technologies
4. Lack of interest 8. It reduces farmland 9. Others, specify

21. If no, for Q18, what is the reason?

1. Poverty 2. Limited knowledge 3. Lack of equipment 4. Land tenure insecurity

22. Which family members participate in soil and water conservation works?

1. Men 2.Women 3.Children 4. All of them participate

23. Have you noticed any climate change trend in your area? 1) Yes 2) No

24. If yes, for Q23 do you think that soil and water conservation practice will contribute to climate change adaptation? 1) Yes 2) No

25. If your answer is yes for Q24; mark the type of soil and water conservation measures that you have been applying on your land (in your watershed)? {Please tick (√) the box below}

1. Biological SWC	tick (√)	rank	**2. Physical SWC**	tick (√)	rank
Crop rotation			Soil bund		
Intercropping			Contour farming		
Grass strip			Terrace construction		
Green manuring			Bench terrace		
Alley cropping/ tree planting			Fanyaaju		
Agroforestry			Specify others		
Specify others					

26. Why do you construct SWC measure on your land? 1) Forced to participate
2) To get aid 3) voluntarily, because of its benefit for us 4) others, specify___________

27. Why do you use SWC conservation measures in your plots?
1) To conserve soil 2) To conserve water 3) Both 1 and 2 4) others, specify

28. What results do you expect from your effort on soil and water conservation practices done on your plots? (Possible to give more than one answer)
1) Reduce soil erosion, 2) Increase soil fertility 3) Increase crop production 4) Control flood
5) All

29. Did you maintain soil and water conservation practices in your farmland? 1. Yes 2. No

30. How frequent do you maintain SWC structures? 1) Every year
2) Within two years 3) when damage happens 4) others, specify_________

31. If you say **No** for Q29, what are the reasons?

____

____

____

____

Part III: Adaptation Strategies to Climate Change

32. Have you employed any of the following climate change adaptation strategies in your farm?

1. Yes 2. No

33. If say yes for Q32, mark that you have been applying on your land (in your watershed)? {Please tick (√) the box below}

Nº	Climate change adaptation	Response	
		Yes	No
1	Using different crop varieties		
2	Changing planting dates		
3	Agro-forestry/Planting trees		
4	Adoption of drought tolerant and early maturing crop varieties		
5	Crop diversification		
6	Water harvesting techniques		
7	Increased use of irrigation		
8	Mixed farming		
9	Temporary migration		
10	Specify others		

34. Do you use irrigation? 1. Yes 2. No

35. What are the sources of irrigation water in your area? 1. Rivers 2.Lakes 3.Water springs 4.Rain 5.Other (Specify) ____________

36. How do you irrigate your land? 1. Using pump 2. Direct furrow from rivers/lakes 3. Collect and pump from pit (water harvest) 4. Other (Specify) ________________

37. Which type of crop do you grow using irrigation?

1. Vegetable 2.Fruit 3. Annual crops 4. Khat 5. Others, specify_________

38. Do you use agricultural input on your farm? 1. Yes 2. No

39. Which kind of agricultural input you use on your farm plot to increase your crop production?

Nº	Agricultural practice (Input)	Mark(√)
1	Improved seeds	
2	Organic fertilizer	
3	Pesticides and insecticides	
4	Inorganic fertilizer	
5	Others	

Part IV: Contribution of SWC for household's food security.

40. Do you have a food shortage problem in your household after using SWC? 1) Yes 2) No

41. If yes, for how many months per year did your household face shortage of food and which month?

____

42. What is the cause of food insecurity? (Multiple responses are possible)

A. Extreme variability in rainfall/Drought

B. Incidence of pest, diseases, weeds

C. soil fertility decline

D. other (specify)

43. What proportion of your production of crops after using SWC on your farm?

Nº	Types of crops	Farm size in hectare	Amount of harvested in quintal/Kg	Amount consumed in quintal/Kg	Amount of sold out in quintal/Kg	Amount of annual sales income in Birr
1						
2						
3						
4						
5						

44. What is the status of your crop production after using SWC practice?

1) Increasing 2) decreasing 3) remain the same 4) I don't know

45. If decreasing for Q (44), what measures do you take to boost up your production?

1) Using SWC measures 2) using manure 3) using fertilizers 4) crop rotation

46. Did you produce enough food for your family after using SWC from your own land?

1) Yes 2) No

47. What proportion of your production was consumed by the family after using soil and water conservation practices?

1) All 2) half of the production 3) one third 4) One forth

48. What proportion of your production is consumed by the family now?

1) All 2) half of the production 3) One third 4) One forth 5. None

49. What was your food security status before implementing SWC measures?

1) Increasing 2) decreasing 3) constant/ no change 4) I don't know

50. What is your food security status after implementing SWC on your farmland?

1) Increasing 2) decreasing 3) constant/ no change 4) I don't know

51. How many times did you eat per day before using soil and water conservation a day?

1) 3 times 2) 2 times 3) Once

52. How many times do you eat per day after using soil and water conservation a day?

1) 3 times 2) 2 times 3) Once

Part V: Institutional Support.

53. Have you ever attended training related to SWC? 1. Yes 2. No

54. Do you get extension service? 1) Yes 2) No

55. If yes, who provides the extension service? 1) Development agents (DAs) 2) NGOs 3) All 4) Others, specify ___

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

57. If yes, what is the source of credit?

A. Government B. Local trader's C. Local credit institutions D. Micro Financial Institutions (MFIs). E. If other please specify__________

Guideline checklist for Focus group discussion (FGD)

1. What are the main activities (measures) implemented in the SWC practice?

2. Do these implemented soil and water conservation practices have advantage in terms of climate change adaptation?

3. What changes you observe on the soil and water conservation after SWC practice implemented? (Give answer by saying increasing or decreasing).

Eg. Flood____

Soil erosion____

Gully____

Crop production____

Livestock production_______________________________________

Water source____

Forest____

Annual income____

4. Is there difference in irrigation after soil and water conservation practice implemented?

5. Is there difference in use of inputs such as improved seed, natural fertilizer, and artificial fertilizer after the SWC practice implemented?

6. What are the contributions of SWC practice to adaptation to climate change?

7. What are the major crop types which are produced in the localities?

8. What benefits do you get from SWC measures implemented on your land?

Guideline check list for interview

1. Who initiated the SWC practice?

2. What changes you observe on the SWC practice after implemented? (Say Increases or Decreases)

Eg. In Soil erosion____

Flood____

Gully____

Crop production____

Livestock production____

Water source____

Forest____

Annual income____

3. What is the climate change adaptations developed in the SWC practice?

4. What are the most important adaptation options in the SWC practice?

5. What are the change do you observe on crop production after implementation of SWC practice?

6. What are the change do you observe on livestock production after implementation of SWC practice?

7. What non-farm income do you get from the SWC?

8. What are the change do you observe on income level of local community after implementation of soil and water conservation practices?

AppendixIII

Photo











AppendexIV

BIOGRAPHICAL SKETCH

The author was born in 1994 in Bilate zuria woreda, Sidama Region of Ethiopia. He attended his elementary education at Balela elementary Schools. He also attended his secondary and preparatory education at Hawassa Tabor preparatory and Senior Secondary School. After successful completion of his preparatory school education, he joined Gambella University in 2014 and graduated with BSc degree in Wildlife and Eco-tourism management on July 10/ 2016 with distinction. After his graduation, he joined earlier Sidama zone Boricha woreda Environment protection, Forest Development and Climate Change bureau as Forest biodiversity protection expert and served from Oct 2017 to Dec 2019 and Jan 2019 to 2020 served in Bilate zuria woreda in similar sector. After four year of service in both woreda, he joined Hawassa University in 2021 to pursue his MSc degree in Climate Change and Sustainable Agriculture