CONTRIBUTION OF SOIL AND WATER CONSERVATION MEASURES TO CLIMATE CHANGE ADAPTATION: THE CASE OF ‘ENABERED' CATCHMENT, ADWA WOREDA, TIGRAY, ETHIOPIA

MSc. THESIS

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JUNE, 2019

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A THESIS SUBMITTED TO HAWASSA UNNIVERSITY THE DEPARTMENT OF AGRO FORESTRY, CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESSMENT PROGRAM, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES, HAWASSA UNIVERSITY,

WONDO GENET, ETHIOPIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CLIMATE SMART AGRICULTURAL LANDSCAPE ASSESSMENT

JUNE, 2019

APPROVAL SHEET I

This is to certify that the thesis entitled "Contribution of Soil and Water Conservation Measures to Climate Change Adaptation: The Case of 'Enabered' Catchment, Adwa Woreda, Tigray, Ethiopia" is submitted in partial fulfillment of the requirements for the Degree of Master of Science with specialization in Climate Smart Agricultural Landscape Assessment program of the Department of Agro Forestry, Wondo Genet College of Forestry and Natural Resources, is a record of original research carried out by Gebremariam Hagos Gebreselassie I.D.N0. MSc/CSAL/R007/09, under my 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 I recommended that it be accepted as fulfilling the thesis requirement.

______________________	______________________	______________________
Name of major advisor	Signature	Date

APPROVAL SHEET II

We, the undersigned members of the Board examiners of the final open defense by Gebremariam Hagos have read and evaluated his thesis entitled "Contribution of Soil and Water Conservation Measures to Climate Change Adaptation: The Case of 'Enabered' Catchment, Adwa Woreda, Tigray, 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 Science in Climate Smart Agricultural Landscape Assessment Program.

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Name of the Chairperson	Signature	Date
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ACKNOWLEDGMENTS

First I would like to thank God for helping to completing this thesis work. I would like to express my deepest thanks to my main advisor, Dr. Menfese Tadesse, for his regular keen support, gentleness and follow up while I am conducting this research from the beginning of the development of the thesis proposal to the accomplishment of the research. I am also very grateful to Mr. Ashebir Asayehegn Adwa woreda office of agriculture and rural development soil and water conservation expert for his support during data collection by providing information. And again I would like to thank Kebele DAs, Manager and Administrators of Endabagerima for their help during data collection and organizing group discussion and interviewees. I would like to extend my heartfelt gratitude also to MRV project of Hawassa University Wondo Genet College of Forestry and Natural Resources for its financial support to the completion of this thesis. I have no words to express my unique appreciation to my beloved wife Teacher Letebrhan G/mariam for her endurance and to take all responsibilities of the family during the study period. I give her a special place in my heart and owe her more than a more expression of thanks.

DECLARATION

I, G/mariam Hagos, hereby declare that this thesis entitled "Contribution of Soil and Water Conservation Measures to Climate Change Adaptation the case of 'Enabered' Catchment, Adwa Woreda, Tigray, Ethiopia" submitted for the partial fulfillment of the requirements for the Masters of Science in climate-smart agricultural landscape assessment, is the original work done by me under the supervision of Menfese Tadesse (Ph.D) and this thesis has not been published or submitted elsewhere for the requirement of a degree program to the best of my knowledge and belief. Materials or ideas of other authors used in this thesis have been duly acknowledged and references are listed at the end of the main text.

Name	Signature	Date
G/mariam Hagos	______________	________________

DEDICATION

This thesis is dedicated to my beloved father Ato Hagos Gebreselassie for his inspiration, love, and support throughout his lifetime.

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ACRONYMS AND ABBREVIATIONS

ADCS	Adigrat Diocesan Catholic Secretariat
CRGE	Climate Resilient Green Economy
DA	Development Agent
FAO	Food and Agricultural Organization of the United Nations
FGD	Focus Group Discussion
GFDRR	Global Facility for Disaster Reduction Recovery
GHG	Greenhouse Gases
GIZ	Gesellschaft International Zusammenarbeit
IFRC	International Federation of Red Cross
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
NAPA	National Adaptation Program of Action
OARD	Office of Agriculture and Rural Development
OECD	Organization for Economic Co-operation and Development
OFED	Office of Finance and Economic Development
ReST	Relief Society of Tigray
SPSS	Statistical Package for Social Science
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Program
WFP	World Food Program

ABSTRACT

Ethiopia is one of the countries affected by the adverse effect of climate change, other biophysical environmental factors and dependency on rain-fed agriculture. Tigray region has a problem of land degradation in general and particularly the study area 'Enabered'. The study area is known with many problems such as recurrent drought, flood, food insecurity, and chronic famine. To overcome the problems in the study area, several watershed management measures have been implemented by the government, non-governmental organizations and the community. This study needed in order to focus on watershed managements such as physical and biological activities for rehabilitation. The contribution of integrated physical and biological soil and water conservation measures to climate change adaptation have not been scientifically studied and documented in the study area. The objective of the study was to examine the role of soil and water conservation measures for resource and environmental rehabilitation and socio-economic improvement as a means of leveraging adaptation to climate change in Adwa Enabered catchment. Stratified random sampling technique was implemented to select sample households. Data was collected using semi-structured questionnaire from 120 randomly selected HHs. KII, and FGD were conducted to complement the data from the survey. Data analysis was carried by using spreadsheets, statistical packages such as SPSS version 20 and descriptive analysis such as tables, graphs and summary statistics such as mean, percentages, and frequency. The result showed that a decreasing trend in the amount and duration of rainfall over the past 30 years. From the survey, group discussants and interviewees it was indicated that temperature has been showing increasing trend. This finding was consistent with the meteorological data analysis. Various types of physical and biological soil and water conservation measures have been implemented in the study area. The implemented different structures enabled households to improve crop production, increase water availability and increase irrigation utilization, improve households' income, reduced land degradation and improved households' adaptation to climate change in the study area. The total output of the sampled households increased from 61650Kg before intervention to 70075Kg per year after intervention. The study also showed that structure destruction, lack of integration among sectors, and lack of follow up are the main challenges in the watershed. The study recommends that expansion of integrated physical and biological watershed management practices is important. Follow up is necessary in order to get households' continuous benefit to climate change adaptation from the watershed.

Keywords: climate change adaptation, rainfall, temperature, climatic hazards, household income

1. INTRODUCTION

1.1. Background of the study

Climate change is any significant change in measures of climate (such as temperature or precipitation) lasting for an extended period of time, three or more decades. It is a change of climate which is attributed directly or indirectly to human activities that alters the composition of the global and/or regional atmosphere (Zerga and Mengesha, 2016). Global climate change is caused by a complex chain of both micro and macro social and environmental processes. Addressing it forces us to distinguish global transformations in atmospheric and human systems, from other pervasive environmental problems and hazards. The climate has changed over the last 100 years, with a global increase in temperature of 0.74^0C, changes to precipitation patterns and an increase in extreme weather events; projected global future climate change of between 1.1 - 6.4^0C, as well significant changes to precipitation and weather events over the next 100 years (Solomon et al., 2007).

Climate change is a fact of life. We need to act urgently if we are to avoid an irreversible build-up of greenhouse gases (GHGs) and global warming at a potentially huge cost to the economy and society worldwide. The build-up of GHGs in the atmosphere, much of it driven by human activities, is already affecting the global climate. Under current projections, concentrations of GHGs will continue to increase into the indefinite future, entailing a process of continued global warming (OECD, 2008). Climate change is likely to affect health, many aspects of ecological and social systems, and will be slow and difficult (perhaps impossible) to reverse. Many therefore would judge that there is already sufficient motivation to act, both to mitigate the causes of climate change, and to adapt to its effects. However, such actions would require economic and behavioral changes bringing costs or co-benefits to different sectors of society (WHO, 2003). The emissions of GHGs to the atmosphere are predominantly from developed (industrial) countries while the negative effects of climate change are predominantly in low-income countries. Developing countries are less capable of mitigating or adapting to the changes because of their poverty and high dependence on the environment for subsistence. Ethiopia's contribution to GHG emissions is very low on a global scale (Zerga and Mengesha, 2016). Climate change could be damaging particularly to African countries. Ethiopia is one of the affected countries by the adverse effect of climate change due to its topography and dependent on rain-fed agriculture, because of the mountainous and rugged terrain, flood and soil erosion takes place easily, drought also one damaging to the country.

Integrated physical and biological soil and water conservation measures are now considered innovative actions for sustaining ecosystems while improving human welfare. It encompasses the holistic approach to managing watershed resources that integrates forestry, agriculture, pasture and water management which can be broadened rural development with a strong link to the livelihoods of the local people. Currently, the Ethiopian government has been implementing watershed management intervention through different soil and water conservation measures in different catchment areas. In line with this, 'Enabered' Watershed is one of the catchments, were integrated physical and biological soil and water conservation measures has been implemented and is located in Adwa Woreda Tigray Region, Ethiopia.

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. Tigray region has a problem of land degradation in general and the study area 'Enabered' in particular. The study area is known with many problems such as irregular rainfall, recurrent drought, flood, food insecurity, and chronic famine. Moreover, the topographic features of the area are characterized by mountain chains, plateau, hills and a small proportion of flat terrain threaten food security. 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 (World Food Program (WFP), Relief Society of Tigray (ReST), Gesellschaft International Zusammenarbeit (GIZ) and Adigrat Diocesan Catholic Secretariat (ADCS)) and the community. The efforts aimed at reducing the degradation of natural resources and at the same time enhance adaptation to climate change. The activities include the conservation of soil, water, and forest through the construction of hillside terraces, hillside terrace with the trench, stone bund, stone bund with the trench, trench, stone check dam, gabion check dam, ponds and planting of trees and grasses (Gebreegziabher et al., 2009). As a result, a number of positive changes have been observed. However, the contribution of these integrated physical and biological watershed management practices to climate change adaptation have not been scientifically studied and documented in the study area. A study on community-based watershed development for climate change adaptation in Choke mountain, Muga watershed in east Gojjam of Ethiopia, (Berhanu, 2011), indicated improvement in livelihood resources such as income, soil fertility, land productivity, forest, water, and food supply. The same author also suggested that impacts of watershed management in different agro-ecological zones may differ and require other studies. Therefore, this study examined the role of soil and water conservation measures for resource and environmental rehabilitation and socio-economic improvement as a means of leveraging adaptation to climate change in Adwa Enabered catchment located in Adwa woreda.

1.3. Objectives of the research

1.3.1. General objective

The general objective of the study is to assess the role of soil and water conservation measures to climate change adaptation in the case of 'Enabered' catchment Adwa woreda.

1.3.2. Specific objectives

The specific objectives of the study are:

- To characterize the socio-economic of the households in the study area and assess how these characteristics affect decision to climate change adaptation.

- To assess farmers' perception about the link between soil and water conservation and adaptation to climate change.

- To identify challenges in the implementation of soil and water conservation measures from the perspective of adaptation to climate change.

- To assess the contribution of soil and water conservation as a way to increase production and income buffering household against the adverse effects of climate and related shocks.

1.4. Research questions

In order to address the stated objectives, the study attempted to answer the following questions.

- How the socio-economic of the households characterize and affect to climate change adaptation in the study area?

- How do farmers' perceive the link between soil and water conservation and adaptation to climate change?

- What are the challenges in the implementation of integrated physical and biological soil and water conservation measures?

- What is the role of soil and water conservation measures on household income and adaptation to climate change?

1.5. The significance of the research

The aim of this research was to investigate the impacts of soil and water conservation measures to climate change adaptation. The outcome of the study is believed to be an important source of information for policy makers and planners at the regional and national level in the design and implementation of watershed management or land resource management. More importantly, region and woreda experts, as well as kebele DAs, can use these findings for local people awareness creation.

2. LITERATURE REVIEW

2.1. Climate change

UNFCCC defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere (UNFCCC, 2006). The historical climate record for Africa indicates warming of nearly 0.7°C over most of the continent during the 20th century, a decrease in rainfall over large portions of the Sahel and an increase in precipitation in east-central Africa (Woodfine, 2009). Most climate modeling scenarios show that the dry lands of the west and central Asia and North Africa, for example, will be severely affected by droughts and high temperatures in the years to come (JO et al., 2009). In East Africa, temperature projections range from approximately no change to 4^0C warmer conditions in both DGF (December, January, February) and JJA (June, July, August) seasons by 2050 (Daron, 2018). Climate change brings critical new perspectives to important global challenges similar to food security and rural livelihoods. Mainstreaming climate change issues into development is a necessary step of overall development policy, but it is not sufficient. To be sufficient, sustainable development policies must also be reformulated in order to include important new temporal and spatial scales that have become relevant only because of climate change (Tubiello, 2012). Over the last decades, the temperature in Ethiopia increased at about 0.2^0C per decade (Marius, 2009). Ethiopia is extremely vulnerable to the impacts of climate change due to social, economic, and environmental factors. In particular, high levels of poverty, rapid population growth, high dependence on rain-fed agriculture, severe environmental degradation, chronic food insecurity, and frequent natural drought cycles complicate the vulnerability of this country to climatic changes (Mulinge and Getu, 2013). Over the past three decades, Ethiopia has experienced countless localized drought events and seven major droughts, five of which resulted in famines (GFDRR, 2011)

2.2. Impacts of climate change

Climate change leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, which result in extraordinary extreme weather and climate events, and has a crisis on economic, social health and safety, food production, security and other dimensions (Solomon et al., 2007). Any increases in the frequency and intensity of extreme weather events such as storms, heat, cold and cyclones the frequency of floods and droughts would adversely impact human health through a variety of pathways; these natural hazards can cause direct loss of life and injury and can damage health indirectly through loss of shelter, population displacement, contamination of water resources, loss of food production (leading to hunger and malnutrition), increased risk of infectious disease epidemics (including diarrheal and respiratory disease), and damage to infrastructure for provision of health services (very high confidence) (Change, 2001). Climate change adversely affects health and is likely to impose new stresses, resulting in a number of direct and indirect impacts, increased malnutrition diarrhea and malaria have been identified as the impacts of greatest significance. Impacts of such climate-related extremes include alteration of ecosystems, disturbance of food production and water supply, damage to infrastructure and settlements, morbidity and mortality and consequences for mental health and human well-being; for countries at all levels of development, these impacts are consistent with a significant lack of preparedness for current climate change and variability in some sectors (Field et al., 2014). The effects of climate change such as rising temperature and changes in precipitation are undeniably clear with impacts already affecting ecosystems, biodiversity, and people (Case, 2006).

In Ethiopia, drought and flood are the most frequent climate-related natural hazards impacting the country significantly which happening every three to five years. Ethiopia is the most impacted country by drought which has experienced at least five major national droughts since the 1980s. Persistent drought events in the past have resulted in huge loss of life and property as well as the migration of people (Ababa, 2007). As Aragie (2013) implies, Precipitation in Ethiopia has shown a general decreasing trend since the 1990s. The decrease in precipitation has multiple effects on agricultural production and water availability for irrigation and other farming uses, especially in the north, northeast, and eastern lowlands of the country (Aragie, 2013). Future climate change of Ethiopia is expected to worsen these conditions, potentially accelerating already high levels of land degradation, soil erosion, deforestation, loss of biodiversity desertification, recurrent floods, as well as water and air pollution (GFDRR, 2011).

2.3. Climate change adaptation

National and sub-national policies and strategies are crucial for the implementation of multifunctional interventions which provide mitigation, adaptation, development, and conservation benefits simultaneously (Duguma et al., 2014). Adaptation to climate change refers to adjustments in natural and human systems in response to actual or expected climate change impacts, which moderate harm or exploit beneficial opportunities (Doswald and Osti, 2011). Adaptive capacity to climate change is the ability to adjust or to cope with the consequences (Bryan et al., 2010). There are various interpretations of an ecosystem-based approach, but all share the rationale of working with nature, and most converge on the principle of sustainable management, conservation, and restoration of ecosystems as part of an overall adaptation strategy (Lo, 2016). As UNFCCC, 2006, briefs in many cases, people will adapt to climate change simply by changing their behavior by moving a different location say, or by changing their occupation. But often they will employ different forms of technologies, whether hard forms or soft forms. Hard forms of technologies such as new irrigation systems, and drought-resistant seeds, soft forms of technologies such as insurance schemes and crop rotation patterns, or they could use with a combination of hard and soft technologies as with early warning systems that combine hard measuring devices with soft knowledge and skills that can raise awareness and stimulate appropriate action (UNFCCC, 2006). There are a number of factors that determine farmers' adaptation to climate change. These factors include education, household size, household income, access to information, credit and markets, and membership of farmer-based organizations. The unpredictability of weather, high farm input cost, lack of access to timely weather information and limited access to water resources also are the most critical barriers to adaptation to climate change (Ndamani and Watanabe, 2016).

The government of Ethiopia is currently in the process of developing the climate resilient component of its CRGE Strategy. The Climate Resilient component is expected to aggregate the sectoral and regional adaptation programs that have already been prepared by Ethiopia's sectoral ministries and regional governments; to assess (i) the current and future risks faced by Ethiopia; (ii) the most important hazards; (iii) the associated likely magnitude of loss; and (iv) how and what adaptation response measures should be prioritized for a CRGE Strategy, particularly based on economic cost-benefit analysis and also taking into account all relevant response measures identified by the government of Ethiopia in its disaster risk management strategic program and investment framework (Ethiopia U.N.D.P., 2011). The Ethiopian

Government has already put in place a number of policies, strategies and programs such as accelerated and sustainable development to end poverty, the environmental policy, and the agriculture and rural development policy and strategy; Ethiopia's Climate Resilient Green Economy and strategic investment framework for sustainable land management, aimed at enhancing the adaptive capacity and reducing the vulnerability of the country to climate change (Zerga and Mengesha, 2016). Ethiopia's much championed and large-scale Productive Safety Net Program has been built on the success of the smaller (but still substantial) Managing Environmental Resources to Enable Transitions to more sustainable livelihoods (MERET) program, as well as experiences from other programs on social protection, disaster risk management and food security (Tongul and Hobson, 2013).

2.4. Watershed

A watershed is an area of land that drains water or dissolved materials to a lake, river, wet-land, or other waterway or outlet. When precipitation occurs, water travels over the forest, agricultural, or urban/suburban land areas before entering a waterway or a common receiving body. Water can also travel into underground aquifers on its way to larger bodies of water. Together, land and water make up a watershed system (Gilland et al., 2009). Watershed is not simply the hydrological unit, but also the socio-political entity which plays a crucial role in determining food, social, and economic security and provides life support services to rural people (Wani and Garg, 2009). The efforts made so far resulted in enhancement of agricultural production and productivity of lands, increase in employment generation, improving the environment of the areas and socio-economic up-gradation of the people. Integrated watershed management approach has been adopted as a key national strategy for sustainable development of rural areas (Bhan, 2013). The purpose of the watershed analysis should be to develop and interpret memory data in a form that will permit the selection of appropriate alternative methods of managing the watersheds (Marilyn, 2001).

2.5. Watershed management

Watershed management is increasingly being recognized as the ideal approach for integrated natural resources management in rain fed areas (Wani et al., 2003). An integrated and comprehensive approach to watershed management is necessary to meet watershed goals (Combe and Najjar, 2009). As Canadian council of ministers of the environment, 2016 briefs, Integrated watershed management is a continuous adaptive process of managing human activities in an ecosystem, within a defined watershed. Various interventions implemented as part of a development program in the watershed were simulated using the arc SWAT model, including structures such as check dams, ponds, and changes in land use/cover (Lodha and Gosain, 2008).

Watershed management has contributed to more sustainable development through concerted efforts of water harvesting and improved agricultural productivity. It has also contributed towards groundwater and surface water recharge, which, in turn, has realized opportunities for smallholder irrigation and helped communities become more resilient to climate change (Gebregziabher et al., 2016). Integrated management by watershed is an example of adaptation based on the ecosystem, which implies in addition to conserving ecosystems that supply water, economic, political, and cultural dynamics (Allan, 2014). Moreover, soil and water conservation practices should not only be aimed at minimizing soil erosion but should also cover other household objectives like securing economic and livelihoods, and follow up process on the proper maintenance and management of the soil and water conservation structures along with integrating agronomic measures using appropriate plant species (Gidey, 2015). Healthy watersheds are a vital component of a healthy environment, watersheds act as a filter for runoff that occurs from precipitation and snowmelt, providing clean water for drinking, irrigation, and industry (Gilland et al., 2009).

2.6. The linkage between watershed management and adaptation to climate change

The vulnerability of climatic changes is mainly due to water stress, degradation of natural vegetation, degradation in health and hygiene conditions, and poor information communication technology (KHAN and Omprakash, 2016). Sustainable land management represents a holistic approach to changing long-term productive ecosystems by integrating biophysical, socio-cultural and economic needs and values. It is one of the main mechanisms to achieve land degradation neutrality (United Nations convention to combat desertification, 2017). Watershed is a living organism, with a "human face", it is the lungs and heart of the river basin. People do live in the watershed and development activities do change the conditions, ecosystem, and people already and always adapting to changes (Kien and Vithet, 2011). The impacts and resultant changes that are anticipated from climate change on all the natural features and processes presently managed on a watershed basis will occur over a time frame stretching into many years. Given the nature of the changes which are likely as a result of climate change, we can expect impacts in virtually all aspects of the strategies and procedures currently in place for managing watersheds (Haley and Auld, 2000).

2.7. Challenges in the implementation of watershed management

The watershed is considered to be the integrating focus, the major appropriate spatial arrangement and functional unit for managing complex environmental problems. For example, managing issues of biocomplexity in the environment on a watershed basis offers the potential benefit of balancing the competing demands placed on natural and human systems (Tim and Mallavaram, 2003). A major challenge in the traditional watershed management approach was the assumption of technology transfer instead of the development of technology on peoples land and their surroundings. Another important challenge was regarding the training and research where the major responsibility for training has been given to agricultural research institutions and agricultural universities, which are sound in technical aspect of watershed but are weak in social science aspects of the institution building as well as forging links with non-farm sector to generate value-added products from watersheds (Yoganand and Gebremedhin, 2006). Equitable sharing of the benefits among all the intended population of the watershed remains a major challenge. By their nature, area development programs offer benefits primarily to landowners, with landless people benefiting indirectly, either through peripheral program activities or trickle-down effects. In fact, watershed projects can actually make women and landless people worse off restricting their access to resources that contribute to their livelihoods. In general government projects focus on largely on technical improvements, the non-governmental organizations focus more on social organization and the collaborative projects try to draw on the strength of both the approaches (Sharma et al., 2005).

In Ethiopia, the main environmental problems of watershed include land degradation, soil erosion, and deforestation of natural resource, desertification and los of biodiversity, and recurrent drought resulting in declining productivity and continuing in food shortage. The soil erosion and deforestation reduces the production potential of land and the overall utility of land resource, and thus making it unsustainable to produce sufficient to feed for the growing population (Worku and Tripathi, 2015).

2.8. Role of watershed management on household income and adaptation to climate change

The participatory watershed management is a critical area of rural development that could support rural people in many ways (Yoganand and Gebremedhin, 2006). Community-based watershed management organizations have very strong adaptive capacity in collaborating with critical institutions, building human and social capital, increasing the public's perceived understanding of the issue, and assessing in the risk spreading process. However, they are very limited in their access to technical resources for adaptation, their ability to manage information specific to climate change and the availability of resources to support their factors (Elwell, 2009). In the process of ensuring food security and poverty alleviation, the government of Ethiopia and donor agencies have been adopting different strategies to implement a food security program. The watershed approach has been used as one of the main strategies to implement food security program in Tigray (Sebhatu, 2010). An integration of all the village development indices at the watershed level would represent the general well-being of the community inhabiting the entire watershed in a holistic manner and such an integrated index is described as watershed development index (Lodha and Gosain, 2008).

3. MATERIALS AND METHODS

3.1. Study area description

3.1.1. Location

The Enabered watershed is located in Adwa woreda, the central zone of Tigray region. It is located 1003 Km from Addis Ababa via Desse - Mekelle road in northern Ethiopia, and 220 Km far from the regional capital city (Mekelle), via Adigrat - Adwa road. Geographical location of the study area (Enabered watershed) is 38^0 53' E to 38^0 57' E longitude and 14^0 08' N to 14^0 11' N latitude. The study area lies on three rural kebeles namely Endabagerima, Soleda, and Maitum. The total kebele of the woreda is 18 kebeles. The size of the study area is 2160 hectare.

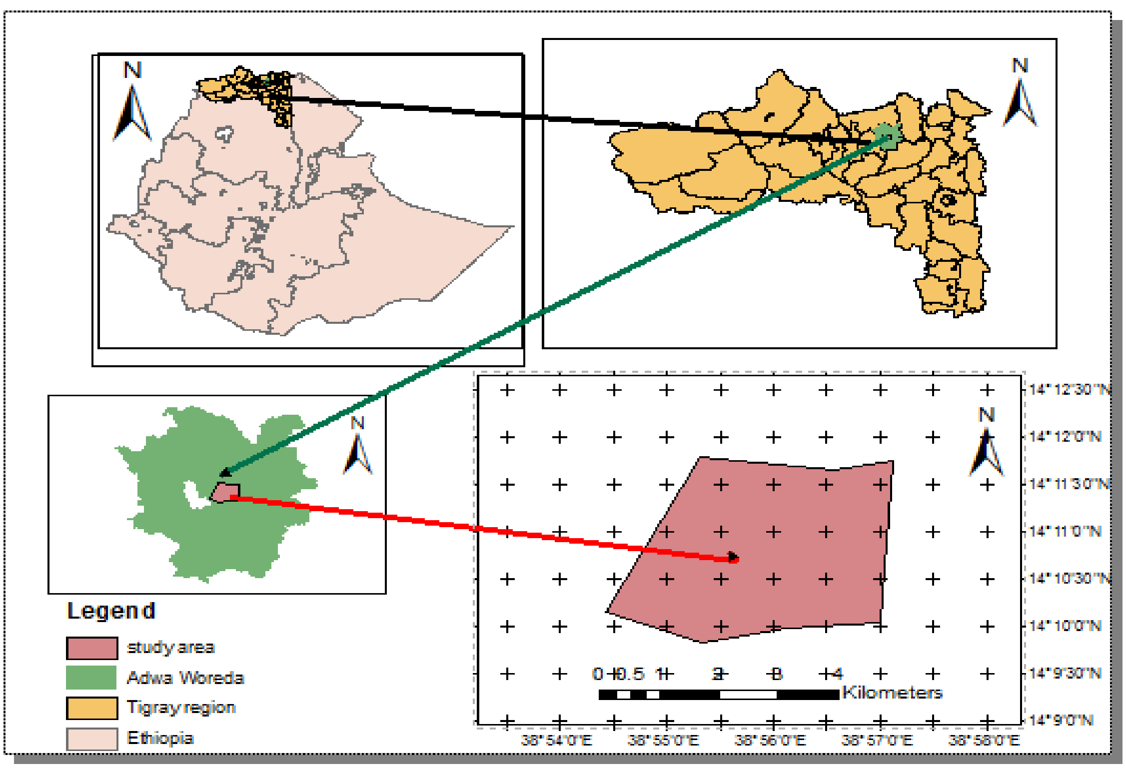

Figure 1: Map of the study area

3.1.2. Population

The total population of the woreda is 110452 from this 54398 male, and 56054 are female. Total households of the woreda are 24012 of which 16807 male and 7205 are females (Adwa woreda OFED, 2017). The total population of the watershed is 2839 from this 1410 male, and 1429 are female. Total households of the watershed are 660 from this 586 male and 74 are female (Adwa woreda OARD, 2017).

3.1.3. Climate

Based on national meteorological agency Mekelle branch collected from Adwa station (2018) and Adwa woreda office of agriculture and rural development, most of the study area is lies in Midland with average temperature 28^0C. The average annual rainfall of the watershed is also ranges from 600 - 850 mm.

3.1.4. Topography and soil

The Enabered watershed has undulating topography. Its altitude ranges from 1850 - 2540 m.a.s.l. It is dominated by rugged terrain, but most part of the cultivated land has a gentle slope and is concentrated in the middle and bottom part of the watershed. The area closures are situated on the hills, but after the soil and water conservation measures could be done the cultivated land also closed. Whereas homesteads are situated in the middle watershed and relatively gentle slopes. There are many rills and gullies in all land use types of the watershed. The biggest gully is found on the cultivated land having a gentle slope. The gullies have been formed due to the undulating topography, erodible soil, less vegetation cover, misuse of natural resources and continuous farming practices. Dominant soil type of the watershed are vertisols, fluvisols, and cambisols (Adwa woreda OARD, 2017).

3.1.5. Existing land use

The watershed has different land use types with the total area of 2160 hectare. It includes 835 ha cultivated land, 302.5 ha forest land, 255 ha area closure, 150 ha bushland, 30 ha grazing land, 20 ha plantation, 282.5 ha homestead and 285 ha miscellaneous land (Adwa woreda OARD, 2017). Major vegetation types include in the study area are eucleaschimperi, dodonia angustifolia, croton macrostachyus, cordia africana, acacia nilotica, acacia etbaica schweinf, acacia albida, olea africana, carissa edulis, Gravillea, eucalyptus camaldulensis, Elephant grass, and 'Tehag' grass (Rhodes grass).

3.1.6. Socio-economic condition and farming system

Crop production is the main source of income for farmers living in the study area. Farmers residing in the watershed plow their farmlands with indigenous farming system, that is with oxen plow and it is subsistence farming. The agro-ecological zone is suitable for crop cultivation such as Teff, Wheat, Barley, Pulses, Maize, Millet, and Sorghum, as well as different vegetables and fruits. The major crops cultivated in the watershed are Teff, Wheat, Barley, Maize, and Millet. Farmers saw their most crops from June to July and they harvest their crops from October to November. Livestock production is also another source of income to the farmers living in the watershed area. Cattle, Goat, Sheep and Poultry are the major animals reproduce in the study area. Farmers feed their animals grass from area closure by cut and curry system and crop residue such as straw. The community use woods and cow dung as their source of fuelwood, and they get water from hand pumps and spring.

3.2. Methods

3.2.1. Study site selection

The study site was selected purposely. The Enabered watershed was degraded due to mountainous, hilly and rugged topography, unpredicted rainfall, overgrazing and low degree of vegetation cover. Due to this the soil was eroded and the land is fragmented, different big and small gullies damage fertile land; resulting in decreased land productivities and contributed to the lowering of the groundwater table in the area. To overcome the problem government, non-governmental organizations and community launched soil and water conservation practices with integrated watershed management approach and constructed many physical and biological conservation measures. The Enabered watershed has shown a big change after the management practices were done. Therefore, the watershed was selected purposively to assess the contribution of the integrated physical and biological soil and water conservation measures to climate change adaptation.

3.2.2. Sampling techniques and sample size

3.2.2.1. Sampling techniques

The study used a multistage sampling technique in order to select respondents for the survey. In the first stage, the households were categorized based on the topography i.e. (middle and lower catchment). The upper catchment was not included in the study because it is not occupied by human beings since it is too steep for farming, above 50% slope. In the second stage the households were registered stratified based on age, i.e. elderly (above 60 years of age), medium (36 - 60 years of age) and youth (18 - 35 years of age). After accomplishing the strata simple random sampling was implemented in each stratum using the sampling frame.

3.2.2.2. Sample size

The sample size of the household survey was determined using a two formula of (Rose et al., 2015). The first formula determined required sample size, while the second one was the actual sample size based on the household size of the selected watershed. So to calculate the sample size with an approximate 95% level of confidence:

$n_r = \frac{4s^2}{d^2}$ where n_r = required sample size, s = the population standard deviation, a measure of the variation in the population d = the degree of precision required.

standard deviation (s) = 1.5 (from the Rose et al., 2015) studied, margin of error (d) = 0.25

$$n_r = \frac{4*1.5^2}{0.25^2} = \frac{9}{0.0625} = 144$$

But when the sample represents over 5% significant, a finite population correction factor applied.

$n_a = \frac{nr}{1+(\frac{nr-1}{N})}$ where n_a = the adjusted sample size nr = the original required sample size (calculated above), N = Population size

The number of households living in the study area are 660 of which 585 males and 74 females.

$$n_a = \frac{144}{1+(\frac{144-1}{660})} = \frac{144}{1.22} = 119.008 \sim 120$$

Therefore the sample size of the study is 120 in total.

From the total 660 households 120 sample households were selected from different groups. These are from 269 total elders 49 households, from 314 total medium households 57, and from 77 youths 14 households were selected based on the ratio of each group by simple random sampling. In each group includes households from middle catchment and lower catchment and also males and females were inclusion in each group.

Table 1: Total number of households and sampled households in the study area

Catchment	Sex	Elder hh		Medium hh		Youth hh		Total hh	
		Total	Sample	Total	Sample	Total	Sample	Total	Sample
Middle	Male	180	32	205	36	49	9	434	77
Catchment	Female	18	4	21	5	6	1	45	10
	Total	198	36	226	41	55	10	479	87
Lower	Male	59	12	74	14	19	3	152	29
Catchment	Female	12	1	14	2	3	1	29	4
	Total	71	13	88	16	22	4	181	33
	Male	239	45	279	51	68	10	586	106
Total	Female	30	4	35	6	9	4	74	14
	Total	269	49	314	57	77	14	660	120

Source: Office of Administration Endabagerima Kebele, 2018 and randomly sampled

3.2.3. Data collection

For the purpose of this study, both primary and secondary data were collected. The primary data were collected using the household survey. Besides, qualitative data were gathered using focus group discussion and key informant interview, field observation and photographs also used to understand all conditions. With regard to secondary data, information was collected from published sources and other documents. Climatic data was collected from National Metrological Agency Mekelle branch that collected from Adwa station.

3.2.3.1. Household survey

General information of the household and watershed activities which have been implemented by the community, government and non-governmental organizations and benefit gain from the watershed management to development of climate change adaptation options and income development, assessed using semi-structured questionnaire. The purpose of the household survey is to collect data from households with minimizing biasedness. Questionnaire was prepared to address the specific research questions of the study. The questions that were included by the survey include socio-economic and demographic status of respondents, linkage between watershed management and adaptation to climate change, main activities (measures) implemented in the watershed, challenges in implementation of integrated physical and biological watershed management, and role of watershed management on household income and adaptation to climate change. Five data collectors were participated in the collection of data. Before the actual survey, a preliminary test was undertaken to include unforeseen variables and to test the compatibility of the questions. In addition, training on the nature of each question and collecting strategies were offered to the enumerators.

3.2.3.2. Focus group discussion

FGD was employed to capture additional information particularly qualitative data which are difficult to gather using a household survey. To this effect, Six focus group discussions were carried out with the stratified categories in the watershed, which was two from elder group (one male group and one female group), two from medium age group (one male group and one female group) two from youth group (one male group and one female group). The members were selected randomly each individuals. Each group had 6 individuals; they have various experiences and knowledge about the watershed.

3.2.3.3. Key informant interview

The purpose of this method is to collect technical and additional data that supports information collected from household survey. Key informant interview was conducted with ten different individuals. Those were nine at kebele level and one at woreda level. At the kebele level 3 DAs (one natural resource, one agronomy, and one livestock) who have information about the watershed how the community benefits from the managed watershed and what challenges they face. Moreover, 3 kebele administrators who have information about the watershed, and 3 technicians (farmers) who have expert knowledge to generate specific information about the area were involved in the interview. At the woreda level, one natural resource expert who has enough information and knowledge about the watershed management practices of the study area was also used as a key informant. These were selected purposively.

3.2.3.4. Field observation and photographs

To understand the overall condition of the topography of the study area field observation through transact walk across the study site was under taken. All the environmental statuses of the watershed were observed. The condition of the area closure site, the managed gullies, the croplands and forest status patterns at the current time was observed. All the physical and biological watershed management measures that have been implemented could be addressed by this method. Photographs of before and after the gully treatment, irrigation utilization of the site was used to critically analyze the changes occurred because of the intervention of watershed management.

3.2.4. Data analysis

Data analysis was conducted by using descriptive and inferential statistics and the results are presented using tables, graphs and summary statistics such as mean, percentages, and frequency was employed to analyze the quantitative data. Statistical tests such as Chi-square (X^2) was carried out to compare and analyze the involvement of the different age group households of the community and middle and lower catchment in the watershed management practices and the link with climate change adaptation. Qualitative data analysis were done using appropriate words (narratives) from focus group discussion, key informant interview and evidences from field observations.

4. RESULTS AND DISCUSSION

4.1. Socio-economic characteristics of households

4.1.1. Demographic characteristics

The primary data that collected using household survey was indicated the following results. In this study, the respondents were farming households living in the study area. Total sampled households in the study area were 120, among which 106 (88.3%) were males and 14 (11.7) were females. Female households were either widow, divorce, and migration of husbands. From the total sampled households, 40.8% were elders, 47.5% were medium age households, and 11.7% were youth households. Based on the organization of Tigray region kebeles, youths are 18 - 35 years old, medium 36 - 60 years old and elders are above 60 years old. Age of household is an important factor to adapt climate change (Mulatu and Negash, 2011). As group discussants and interviewees indicated, youths were less implementer of climate change adaptation mechanisms. Elder and medium age households were found to be high implementers of climate change adaptation practices. Most of the time, male youths migrate to other places such as the western zone of Tigray in search of a job. The survey results showed that, the largest family size of households from the sampled respondents was 10 and the smallest family size was 1. The majority of households had 4-6 family member account 54 (45%) (Table 2).

Table 2: Demographic characteristics of households

Variable		Frequency	Percent
Sex	Male	106	11.7
	Female	14	88.33
Age	18 - 35	14	11.7
	36 - 60	57	47.5
	> 60	49	40.8
Family size	1 - 3	48	40
	4 - 6	54	45
	7 - 8	14	11.7
	> 8	4	3.3

4.1.2. Educational status of households

Educational level is one criterion assumed to enhance climate change adaptation mechanisms. An increase in educational level of households increases the probability of their capacity to find new technologies to adapt to climate change problems (Mulatu and Negash, 2011). From the survey (Table 3), majority of the sampled households in the study area were illiterates which is 50 (41.7%). This affect negatively to introduce new technologies in the watershed and to adapt to climate change.

Table 3 : Educational status of respondents

Education level	Frequency	Percent
illiterate	50	41.7
can read and write	14	11.7
grade 1-8	46	38.3
Grade 9-12	10	8.3
Total	120	100.0

4.1.3. Farmers landholding

The land is exceptionally so important resource that the policy on land ownership affects all aspects of peasants' lives: economic wellbeing, land use decisions, efficiency in land use and social relations (Zerga, 2016). The land is the basic resource of income of human society in the rural area of Ethiopia as well as in the study area. As indicated in Table 4, 119 (99.2%) of the sampled households have farmland and 1 (0.8%) of the sampled households do not have farmland. Majority of landholding size of the respondents in the watershed is 0.25 - 1.5 hectare, which is small in size. Households' land size in the watershed is found to be very small. The last re-distribution of land took place in 1991 in the study area. Most youth households got farmland from their parents. Some youths got farmland by kebele land administration committee farm plots with no owner. Many studies suggest that as the size of farm land increases the production and average income from increased land increases but with introduction of irrigation and other technologies to the land it can be compensated (Bhan, 2013). The size of the farm land has implications on vulnerability and adaptation to climate change, with smaller land holding, farmers will have lesser chance to carry out alternative activities on land.

Table 4 : Farmers' landholding

Size of land in ha	Frequency	Percent
0	1	0.8
0.25-0.75	66	55
1-1.5	47	39.2
1.75-2.25	5	4.2
2.5-3	1	0.8
Total	120	100

There is significant difference among different age groups in landholding. The statistical analysis of the one way ANOVA test for different age categories shows that (P = 0.000, F = 18.865, df = 2). Youths have more small landholding than medium aged and elder households. All the youths that have farm land had between 0.25 - 0.75 hectare, the medium aged and elders had 0.25 - 1.5 ha and 0.25 - 3 hectare respectively (Table 5). So youths had less implementers of climate change adaptation mechanisms because of small farm landholding.

Table 5: Farmers landholding with age

Age	Size of land in hectare and frequency					
	0 ha	0.25-0.75 ha	1-1.5 ha	1.75-2.25 ha	2.5-3 ha	Total
18-35	1	13	0	0	0	14
36-60	0	38	19	0	0	57
> 60	0	15	28	5	1	49
Total	1	66	47	5	1	120

From the land owned by the sampled households, only 10 (8.3%) households have an irrigated land before the intervention of watershed management practices in the study area. After implementation, 47 (39.16%) households from the sampled households have an access to irrigation (Table 6). This is a significant change in irrigation coverage which in turn results in households' income improvement.

Table 6 : Farmers' irrigated land before and after intervention

Size of land in ha	Before the watershed management implementation		After the watershed management Implementation	
	frequency	percent	frequency	Percent
0	110	91.7	73	60.81
0.03125	0	0	1	0.83
0.0625	7	5.8	10	8.33
0.125	3	2.5	35	29.2
0.25	0	0	1	0.83
Total	120	100	120	100

There is a difference between middle and lower catchment in irrigation access before and after the watershed management intervention occurred. Before the soil and water conservation measures implemented in the study area, the irrigation access is only in the lower catchment. After the intervention of the soil and water conservation measures, the irrigation access extend in to the middle catchment (Table 7). The chi-square analysis also showed that there is statistically significant difference between the two sections of the catchments (lower and the middle) on irrigation use (X^2 = 38.242, df = 4, P = 000).

Table 7: Irrigated land in middle and lower catchment before and after intervention

	Size of land in hectare	Middle catchment frequency	Lower catchment frequency	Total
Irrigated land before intervention	0	87	23	110
	0.0625	0	7	7
	0.125	0	3	3
	Total	87	33	120
Irrigated land after intervention	0	67	6	73
	0.03125	0	2	2
	0.0625	5	4	9
	0.125	15	20	35
	0.25	0	1	1
	Total	87	33	120

4.2. Farmers view about trends in climate change and variability

As this survey indicated, (97.5%) respondents said that there is climate change, (2.5%) respondents said that no climate change and don't know whether climate change is happening or not. But there is a difference in explanation of trend of climate change among different age group farmers. The Chi-square test for different age categories shows significant difference (X^2 = 23.297, df = 2, P = 0.000) on their perception to climate change. Elderly and medium group respondents assured that there is climate change in the past 30 years than the youth group. The fourth assessment report of the IPCC observes that climate change is already happening (IFRC, 2009). In the study area, two main indicators of climate change were conducted. These are rainfall and temperature trends. Because these are main indicators to climate change.

4.2.1. Farmers view about trends in rainfall

Rainfall amount and duration were examined in the survey to see the trends. The survey indicates that 97.5% of the respondents said that rainfall amount and rainfall duration are in decreasing trend in the last 30 years and 2.5% of the respondents said that there is no change in rainfall amount and duration in the study area (Table 8). The group discussants also support the data obtained from the survey. The elder male group said that the amount and duration of rainfall has decreased. They also add some ideas, some seed species were used previously back 30 years such as Maize ('Angy'), Barley ('Gunaza') and Wheat ('Tselimoy'); but these species can't longer be used because the shortage of rainfall. The farmers are now using improved seeds that can mature within a short period of time and with little rain. Rivers have dried, stream flows have decreased. The elder female group also said that previously we used vegetables such as pepper in our farmyard with rain fed, now we can't use because there is not enough rainfall and duration of rainfall is very short. The other medium and youth group also support the idea and the interviewee also had similar ideas.

Table 8: Farmers' view about rainfall amount and duration

Status	RF amount		RF duration	
	Frequency	Percent	Frequency	Percent
Increasing	0	0	0	0
No change	3	2.5	3	2.5
Decreasing	117	97.5	117	97.5
Total	120	100	120	100

Meteorological data of the study area also indicates decreased annual rainfall. Most of the idea presented by the respondents focus group discussants and interviewees were consistent with the meteorological data of decreasing trend in rainfall amount and duration. The maximum rainfall record for the area was obtained in 1998 with rainfall amount of 1054.1 mm and the minimum rainfall record was in 2002 that recorded 538.2 mm (Table 9). The annual average rainfall for the study area was 792.70 mm with the standard deviation of 137.55. According to Hare (2003) CV was used to classify the degree of variability of rainfall events as less (CV<20%), moderately (CV, 20-30%) and highly (CV > 30%) variable. Thus, areas with CV > 30% is an indicator of larger variability and are said to be vulnerable to drought, and vice versa. Hence, the CV of annual rainfall indicated the existence of less variability of inter-annual rainfall (CV < 20%).

Table 9: Descriptive statistics of annual rainfall

Variable	Observed year	Minimum	Maximum	Mean	Standard deviation	CV (%)
Annual rainfall (mm)	26	538.20	1054.1	792.7	137.55	17.4

Source: NMA (2018).

The Mann-Kendall (MK) trend test and Sen's slope estimator result showed no significant trend for the long term inter-annual rainfall (Table 10). In general, this result indicated that rainfall remained more or less constant when averaged over the whole period for the study area and this is in agreement with the national rainfall trend (NMA, 2007). However, even if statistically not significant, there is a slight declining trend of inter-annual rainfall amount at a rate of 71.6mm per decade, and this partly agree with farmers perception. This non significant declining trend also agrees with the national long term rainfall trend (MEF, 2015).

Table 10: Trends of annual rainfall

Study area	Mann-Kendall tau	Sen's slope	P value
Adwa/Enabered	-0.218	-7.16	0.124^{ns}

Source: NMA (2018).

Slope (Sen's slope) is the change (mm)/annual; ns = non-significant trend at 0.05 significant level.

4.2.2. Farmers view about trends in temperature

Trends in temperature were examined in three ways a hot day, hot night, and hot season. As presented in Table 11, 97.5% of the respondents said that there is an increasing trend in hot day and hot night temperature in the last 30 years. While 96.7% of the respondents replied that there is an increasing trend in hot season in the study area. The hot season is in the months of March April and May. This indicates that more than 96% of the sampled households said that daily and seasonal temperature is in an increasing trend.

Table 11: Farmers view about temperature

Status	Hot day temperature		Hot night temperature		Hot season temperature	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Increased	117	97.5	117	97.5	116	96.7
No change	3	2.5	3	2.5	4	3.3
Decreased	0	0	0	0	0	0
Total	120	100	120	100	120	100

The data obtained from group discussants and interviewees were also consistent with each other and with the survey data. The elder female group discussed that because of the increase in temperature, we couldn't store 'Ingera' for more than 3 days at this time, because it disturbs (rotten) with fungi attack due to increased temperature. Before 30 years, we could store 'Ingera' for one week. Previously 'Tela' (local beer) stay for more than 10 days without changing its taste, now it can stay only for 5 - 6 days. Milk products without butter such as Yoghurt and cheese stayed for more than one week (10 days) previously; now these can't stay for one week; disturb with temperature hotness and change their taste. The elder male group discussants explained that trends of hotness has increased. Style of dressing have also been changed. Before 30 years, people dress thick cloths; now a days people dress thin cloths. The other groups and interviewees also support the ideas. Meteorological data of the study area indicates that the average annual temperature of the study area increased. All of the idea presented by the sampled households, group discussants and interviewees were consistent with the meteorological data analysis of the increased trend in temperature hotness. Berhanu, (2011) and ABABA (2007) or NAPA (2007) also have similar findings (increasing trend of temperature hotness).

The result of Mann-Kendall trend test for mean temperature showed that temperature trend was very clear, unlike rainfall trends. The result for mean temperature revealed that there was a significant increasing trend of inter-annual temperature, which indicates the existence of significant warming trend over the study area (Table 12). The annual mean temperature showed a positive trend at a rate of 0.38°C per decade, which is contributed to the national annual mean temperature rate of change that in fact differ according to different sources. The national rate of change for annual mean temperature 0.28°C per decade based on 1960 to 2006 data (McSweeney et al., 2010). All indicated the existence of a warming trend in the country.

Table 12: Annual temperature trend

Study area	Mann-Kendall tau	Sen's slope	P value
Adwa /Enabered	0.298	0.038	0.034**

** = significant at 5% significant level.

4.3. Soil and water conservation measures implemented in the study area

Soil and water conservation activities have been carried out by the Ministry of Agriculture in the past forty years on a large scale on cultivated land with contour (level) bunds, on hillsides with afforestation, terraces, and on degraded hills with hillside closures (MoA, 2016). Previously traditional soil and water conservation measures such as soil bund and stone bund were familiar with farmers in Tigray. But not supported technically and the government started different approaches to succeed the soil and water conservation program effectively and to increase production as well as to adapt climate change hazards. Integrated physical and biological soil and water conservation measures in watershed approach is one technical method in Tigray region.

Table 13: Soil and water conservation measures implemented in "Enabered' Watershed

No	Activities	Measurement	Year					Total
			2003	2004	2005	2006	2007	
1	Hillside terrace	Km	83	78.2	57	-	-	218.2
2	Hillside terrace with trench	Km	72	112	153.2	-	-	337.2
3	Stone bund	Km	-	-	41	97	44	182
4	Stone bund with trench	Km	-	5.6	44	58	86	193.6
5	Trench	Km	-	-	5	6.7	-	11.7
6	Gabion check dam	Km	-	-	-	2	2	4
7	Stone check dam	Km	-	-	1.7	1.3	0.2	3.2
8	Percolation pond	No.	28	48	12	-	-	88
9	Half moon bund	No.	4350	3710	4138	-	-	12198
10	Compost preparation	M^3	333	236	110	169	115	963
11	Tree seedling plantation	Ha	41.4	59	72.67	66.8	80.5	320.4
12	Grass planting and sawing	Ha	-	-	-	20	26	46
13	Area closure	Ha	95	50	-	110	-	255

Source: Adwa woreda OARD report 2008.

As shown in Table 13, different structures have been implemented in the watershed. According to Adwa Woreda Office of Agriculture and Rural Development report, 1978.75 ha of the area was treated with different soil and water conservation structures and 7.2 Km treated by loose rock and gabion check dams. All the physical structures are supported by biological soil and water conservation measures. The key informants (Woreda expert and DAs) explained that hillside terraces, hillside terrace with trench, stone bund, stone bund with trench, trench, gabion check dam, stone check dam, gully rehabilitation, compost preparation, tree seedling plantation, grass planting, grass sawing, area closure, protect deforestation, percolation ponds, and half moon bunds have been the main structures implemented in the 'Enabered' watershed area. These include terraces at the hillside, bunds in the farmlands, soil moisture harvesting structures such as half moon at the forest land and check dams in the gullies have been implemented. After these physical soil and water conservation measures implemented biological soil and water conservation measures such as tree seedling plantation, grass sawing and grass planting also implemented. Because of the implemented different soil and water conservation structures, such improvements would be increased. Two rivers that was dried 'Maicolom' and 'Maiawear' recharge/flow in the watershed and use for irrigation access. River 'Maiaini' that was not completely dried but increase flow charge after intervention. In line with this field observation also carried out and checked the structures implemented in the study area.

Table 14: Advantages in terms of climate change adaptation/implemented practices

		Middle catchment	Lower catchment	Total
Advantages in climate change adaptation	Yes	83	33	116
	No	4	0	4
	Total	87	33	120

From the survey, 96.7% of the respondents said that these implemented soil and water conservation measures have advantages in terms of climate change adaptation, because after the implementation, increase feed access to livestock, increase water availability as well as increase irrigation access, the unproductive area be productive and increase income of households. While 3.3% of the respondents said that these implemented soil and water conservation measures have not advantaged in terms of climate change adaptation. All respondents from lower catchment said that these soil and water conservation measures have an advantages in terms of climate change adaptation. From the middle catchment 4 (3.3%) of respondents said that these soil and water conservation measures have not advantaged in terms of climate change adaptation. In general the implementation of physical and biological soil and water conservation measures have their role to improve adaptations to climate change hazards in increasing productions in the study area.

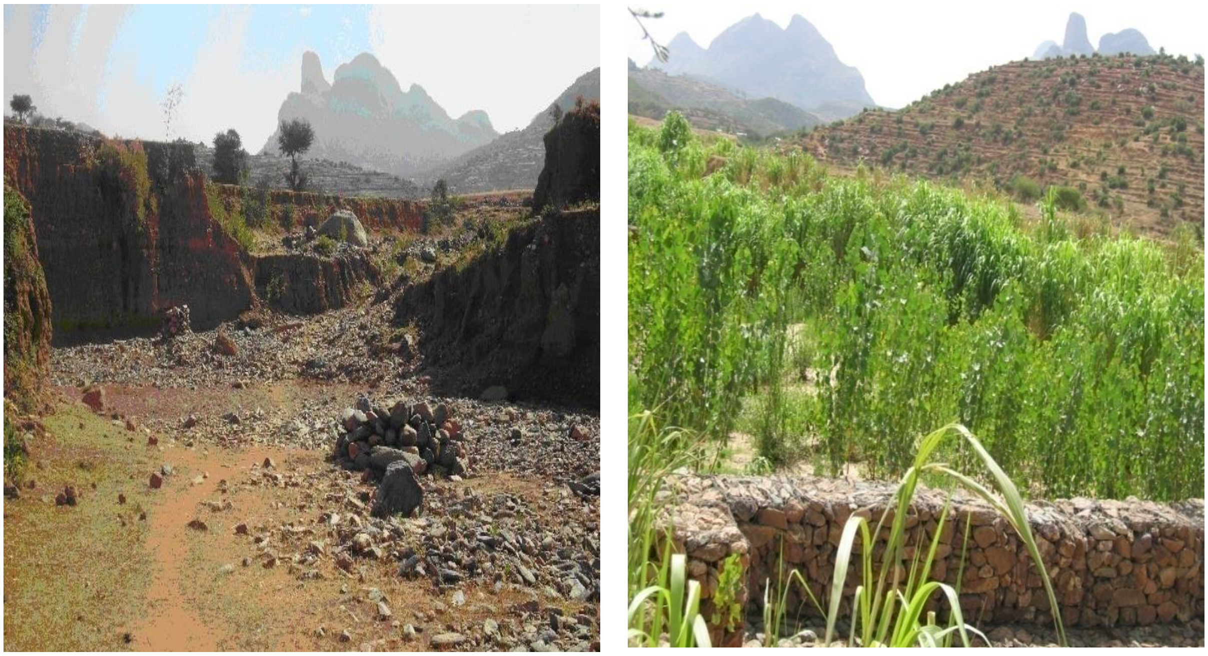

Figure 2: Before and after gully rehabilitation in 'Enabered' watershed

Source: Adwa woreda OARD 2018

4.4. Farmers' views on the changes after the watershed management practices implementation

After the implementation of watershed management practices, there are indicators that many changes have occurred. As indicated in Table 12, 98.3% of the respondents replied that after the management practices implemented soil and water have been conserved in the watershed, While 1.7% of the respondents stated no change is observed. On the other hand, majority of respondents (95.8%) revealed that after the watershed management intervention, there has been an increase in fertility of land and 4.2% of respondents said that there is no change in fertility of land after the management practices implemented. While 100% of respondents said that there is an increase in irrigation in the watershed after the management practices were implemented. With regard to water resource, 95.8% of the respondents said that there is an increase in water availability while 4.2% of the respondents said that there is no change in water availability even after the management practices implemented. But there is a difference in explanation of water resource in the middle catchment and lower catchment respondents. All the respondents from lower catchment said that there is an increasing trend of water availability after the implementation of soil and water conservation measures; and 5 (4.2%) of respondents from middle catchment said that there is no change in water resource after the watershed management intervention.

Table 15: Changes observed after intervention in the study area

No.			Frequency	Percent
1	Soil and water	conserved	118	98.3
		no change	2	1.7
2	Fertility of land	increased	115	95.8
		No change	5	4.2
3	Irrigation	increased	120	100
4	Water resource	Increased	115	95.8
		No change	5	4.2
5	Flood	decreased	120	100
6	Recurrent drought	Increased	3	2.5
		No change	6	5
		decreased	111	92.5

As the survey indicated all respondents (100%) said that there is a decreased in flood after the watershed management practices implemented. In other words 92.5% of the respondents said that there is decreased in recurrent drought after the management practices implemented, 5% of the respondents said that there is no change in recurrent drought after the management practices implemented and 2.5% of the respondents said that there is an increase in recurrent drought after intervention. The group discussants and key informants also supported the finding of the household survey. The group discussants affirm that after the watershed management practices implemented, land fertility has increased which this in turn results in rise in crop production. Besides, it has been stated by the discussants that rise in livestock production has been observed as a result of watershed management practice. Irrigation practices have been increased because, water availability was increased; and production from irrigation also increased. Interview with woreda natural resource (soil and water conservation expert) and kebele DAs indicated that after implementation flood was significantly decreased because the velocity of runoff decreased by the constructed different structures and use of irrigation has also increased. Before implementation, there were few irrigation users, but after implementation, there are many irrigation users in the study area. There are such positive changes in the watershed. All of these changes have their own role to adapt to climate change

4.5. Challenges in the implementation of soil and water conservation measures

The implementations of soil and water conservation measures in the watershed were faced with different challenges. The respondents put some challenges and add some other challenges and ideas the group discussants and interviewees. As indicated in Table 16, there are different challenges in the watershed. About 88.3% of the respondents said that the main challenge in the watershed management is structure destruction, 6.5% of the respondents said that gully reshape is the main challenge in the watershed management and 5% of the respondents said that less mobilization is the main challenge in the watershed management implementation. As solutions sets to the challenges, 88.3%, 6.5% and 5% of the respondents said that structure maintenance, more mobilization, and technical carefulness are solutions to the challenges respectively.

Table 16: Challenges in the watershed management

No.	Challenges	Frequency	percent
1	Structure destruction	106	88.3
2	Less mobilization	6	5
3	Gully re-shape	8	6.7
	Total	120	100

It is observed that previously constructed structures are now partly being destroyed which would probably the result of poor maintenance and follow up works by stake holders. This problem pose a critical question regarding the sustainability of the watershed management interventions. To ensure the sustainability of the conservation measures, therefore, farmers need be incentivized via various projects such as food for work to maintain the watershed, but the government pays only for the new construction of structures. In some parts of the gully rehabilitation practices gully re-shape was compute to the cultivated land. In large gullies, large re-shape was done and the cultivated land remains small plots.

There is a difference in explanation of challenges in 'Enabered' watershed between farmers living in the middle and lower catchment showed significant difference (X^2 = 22.699; df = 2; P = 000). Most of the farmers living in the middle catchment assured structure destruction is the main challenge in the watershed; but most farmers living in the lower catchment said that structure destruction and gully reshape are major challenges in the watershed. Group discussants and key informants have also supported the results of the household survey but they add some additional ideas; lack of awareness, lack of integration among sectors, and lack of follow up are the main challenges in the watershed. Sometimes work programs of sectors overlap each other, for example, Agriculture, water resource and Education sectors.

4.6. Role of soil and water conservation measures on household income and adaptation to climate change

4.6.1. Impact on crop production

Different types of crops are cultivated in the study area. The most cultivated crops are Teff, Wheat, Millet, Maize, and Barley. Households living in the study area depend on crop production as the source of their income. Utilization of improved seed before the soil and water conservation measures implemented in the study area and after implementation have showed a small differences. The survey indicates that, the total sampled households use 2962 Kg per year of improved seed in total before implementation of the watershed management practices in the study area. After the watershed management practices implemented in the study area the sampled households use 3075 Kg per year of improved seed in total. Before intervention only 2 households used 30 Kg per year of improved seeds from the sampled households, but after intervention 19 households used 30 Kg per year of improved seeds

(Table 17). This shows an increasing trend in utilization of improved seed after the watershed management practices are implemented in the study area.

Table 17: Utilization of improved seed before and after intervention

Utilization of improved seed in Kg	Before intervention		After intervention	
	HH Frequency	Percent	HH Frequency	Percent
0	11	9.2	7	5.8
7.5	30	25.0	22	18.3
15	23	19.2	26	21.7
30	2	1.7	19	15.8
37.5	18	15.0	18	15.0
45	31	25.8	26	21.7
52.5	5	4.2	2	1.7
Total	120	100.0	120	100.0

The survey indicates that, the total sampled households used 420,800 Kg per year of natural fertilizer in total before the interventions. After intervention, the sampled households were used 440,400 Kg of natural fertilizer per year. This is due to the increase in the number of livestock, there is an increasing trend in utilization of natural fertilizer after the watershed management practices implemented in the study area. These natural fertilizers are useful for sustainable soil development. According to Rajeev (2012); the addition of organic fertilizers improves soil physico-chemical, biochemical and microbiological properties and thus positively influences soil quality and plant productivity parameters. Organic amendments can also promote plant health, and it is also possible to obtain equivalent or even increased yields through organic production (Rajeev, 2012).

Table 18: Utilization of natural fertilizer before and after intervention

Utilization of natural fertilizer in Kg	Before intervention		After intervention	
	HH frequency	Percent	HH frequency	Percent
0	9	7.5	7	5.8
1500-2500	30	25.0	30	25.0
2600-3500	16	13.3	15	12.5
3600-4500	25	20.8	22	18.3
4600-5500	34	28.3	40	33.3
5600-6500	6	5.0	6	5.0
Total	120	100.0	120	100.0

Utilization of artificial fertilizers (Urea and Dap) also showed increasing trend after intervention; but, with little difference. The survey indicates that, the total sampled households use 10900 Kg per year of artificial fertilizer in total before the watershed management practices implemented in the study area. After the watershed management practices implemented in the study area the sampled households use 11100 Kg of artificial fertilizer in total per year.

Table 19: Utilization of artificial fertilizer before and after intervention

Utilization of artificial fertilizer in Kg	Before watershed management implementation		After watershed management implementation	
	HH frequency	Percent	HH frequency	Percent
0	3	2.5	1	.8
25	3	2.5	3	2.5
50	25	20.8	36	30.0
75	9	7.5	3	2.5
100	58	48.3	51	42.5
150	22	18.3	26	21.7
Total	120	100.0	120	100.0

When see output from non irrigated land, due to the watershed management practices implemented in the study area productivity of crops has increased. The core challenge of climate change adaptation in agriculture is to produce more food, more efficiently and under more volatile condition (Travis and Daniel, 2010). The total output of the sampled households before the watershed management practices implemented in the study area was 61650 Kg per year. After the watershed management practices implemented, the output increases to 70075 Kg per year. Type of crops of the output were Teff, Wheat, Millet, Maize and Barley. Crop production has shown increasing trend after the watershed management interventions in the study area; because fertility of land was increase and the land save from erosion by flood. The above finding in line with Habtamu, (2011) and Gebreegziabher et al., (2016). Since the implementation of watershed management, a 200-300% increase in crop productivity has been observed in Abraha-Atsbaha, Kereba and Bechyti watersheds (Gebreegziabher et al., 2016).

Table 20: Output from non irrigated land before and after intervention

Output in quintal	Before intervention		After intervention	
	Frequency	Percent	Frequency	Percent
0	4	3.3	1	.8
1-2	7	5.8	4	3.3
2.25-3.75	18	15.0	17	14.2
4-5.5	37	30.8	34	28.3
6-7.5	43	35.8	36	30.0
8-10	10	8.3	25	20.8
> 10	1	.8	3	2.5
Total	120	100.0	120	100.0

Output from irrigated land is in increasing trend. From 120 respondents only 10 (8.33%) households have been using irrigation before intervention; after intervention irrigation users increased to 47 (39.16%). From the sampled households the total production increased from 1450 Kg to 14075 Kg per season. These outputs were Cabbages, onions, Maize, Tomatoes and Potatoes. This indicates that integrated physical and biological watershed management practices have a great role to increase surface and sub-surface water resources and enhance household crop production and income. In line with this finding Berhanu (2011) indicated that, both biological and physical land management practices are the same coin of a different face, and one supports the other, and one without the other is not as much effective in improving cropland productivity. Output from irrigation has a significant difference between farmers living in the middle catchment and lower catchment. The statistical analysis of one way ANOVA test for the middle and lower catchments shows that (P = 0.000, F = 28.820, df = 1). Most farmers living in the lower catchment produce more output from irrigation than farmers living in the middle catchment, because there is more irrigation access in the lower catchment. Altitude of the irrigated land is 1856 - 1948m a.s.l.

Table 21: Output from irrigated land before and after watershed management implementation

Output in quintal	Before intervention		After intervention	
	Frequency	Percent	Frequency	Percent
0	110	91.7	73	61.7
1-2	9	7.5	16	13.3
2.25-3.75	0	0	16	13.3
4-5.5	1	0.8	13	10.0
6-7.5	0	0	2	1.7
Total	120	100.0	120	100.0

According to the group discussant and interview, the implementation of physical and biological watershed management practices have a significant contribution in increasing irrigation practices. After implementation; increase number of springs, increase irrigation access, increase farmers income and increase adaptations to climate change in the 'Enabered' watershed has been reported by all respondents. Most technologies used for irrigation purpose in the study area are motor pump from a shallow well and gravity irrigation. Ato Tsegay Kinfe is a farmer in Enabered produce crops (Maize) and vegetables using irrigation practices (Figure 3). He said the irrigation saved from migration to Western Tigray in search of job. Because irrigation access increase in the watershed and practices in the irrigation field. He used motor pump for irrigation water.

Figure 3: Irrigation Practices in 'Enabered' Watershed April, 2018

The sampled households could be able to feed their family members for 12 months from their cultivated land. Food availability at household level has increased from 31.7% to 54.2% after the intervention. Crop production has a great impact on the watershed to the farmers' income. Due to the different physical and biological soil and water conservation measures implementation, irrigation and non-irrigation crop and vegetable production are increased in the study area. The integrated management practices have the advantage to increase surface and subsurface water availability, to protect early drying of crops, to increase water harvesting and soil moisture, to protect soil nutrients from depletion and to increase production and productivity. Before the watershed management practices implemented in the study area, the households' agricultural production was poor due to drought, flood, lack of enough soil moisture, and depletion of soil nutrients. However, after implementation, the production is increased due to increase surface and subsurface sources of water availability, increase irrigation, and due to overcoming the above challenge in general by the integrated physical and biological measures.

Table 22: Availability of food from their cultivated land to households

Number of months	Before watershed management implementation		After watershed management implementation	
	Frequency	Percent	Frequency	Percent
0	2	1.7	1	0.8
1-3	3	2.5	-	-
3.5-6	31	25.8	14	11.7
6.5-9	46	38.3	40	33.3
9.5-12	38	31.7	65	54.2
Total	120	100.0	120	100.0

4.6.2. Impact on livestock production

Livestock is important for farmers to increase their income. For example, oxen are necessary to plough cultivated land in Tigray including the study area. So production of oxen for land cultivation is the priority reason in Enabered watershed.

Table 23: Livestock production before and after watershed management implementation

Type of livestock	Number	Before watershed management implementation		After watershed management implementation	
		Frequency	Percent	Frequency	Percent
Ox	0	14	11.7	6	5.0
	1	33	27.5	28	23.3
	2	73	60.8	86	71.7
	> 2	0	0	0	0
Cow	0	50	41.7	46	38.3
	1	59	49.2	55	45.8
	2	10	8.3	19	15.8
	> 2	1	0.8	0	0
Goat	0	74	61.7	74	61.7
	1-5	6	5.0	2	1.7
	6-10	20	16.7	9	7.5
	11-15	15	12.5	22	18.3
	16-20	3	2.5	13	10.8
	> 20	2	17	0	0
Sheep	0	86	71.7	81	67.5
	1-5	6	5.0	3	2.5
	6-10	20	16.7	15	12.5
	11-15	5	4.2	12	10
	16-20	3	2.5	8	6.7
	> 20	0	0	1	0.8

Majority of households in the study area have different types of domestic animals such as cattle (ox, cow), goat, sheep, poultry, and beehive. As presented in Table 23, the number of livestock in the watershed management project area has shown increasing trend from time to time.

Table 24: Poultry and Bee hive before and after watershed management implementation

Kind	Number	Before watershed management implementation		After watershed management implementation	
		Frequency	Percent	Frequency	Percent
Poultry	0	54	45	46	38.3
	1-5	21	17.5	6	5.0
	6-10	40	33.3	34	28.3
	11-15	4	3.3	20	16.7
	16-20	1	0.8	12	10.0
	> 20	0	0	2	1.7
Bee hive	0	95	79.2	88	73.3
	1-2	21	17.5	19	15.8
	3-4	2	1.7	13	10.8
	7-8	1	0.8	0	0
	>8	1	0.8	0	0

The respondents have a total 179 oxen, 86 cows, 544 goats, 341 sheep, 511 poultry, and 60 beehives before the watershed management practices intervention in the study area. After implementation, the sampled households have a total 200 oxen, 93 cows, 646 goats, 476 sheep, 893 poultry and 71 beehives. Focus group discussant and interviewees also confirm the idea, because of increased availability of animal feed such as elephant grass and other grasses has contributed to increasing number of livestock. This result was similar with the findings of Madalcho and Gashaw, (2018) at Kindo Didaye District, Southern Ethiopia and

Gebreegziabher et al., (2016) at Abraha-Atsbaha, Kereba and Bechyti watersheds. The overall performance of individual animals in household has been increased since the availability of feed resources increased by using cut-and-curry feeding as a response to watershed management (Madalcho and Gashaw, 2018). The main source of feed for livestock before the watershed management implementation were straw and hay. After the watershed management practices implemented in the watershed, the main source of livestock feed is straw, hay, elephant grass and other types of grasses. About 95% of the sampled households said that straw and hay were the main sources of livestock feed before implementation. After implementation, 24.2%, and 70.8% of respondents said that main source of livestock feed is straw + hay and straw + hay + elephant grass + other grasses respectively, but 5% of the respondents have no livestock. Utilization of cut and carry feeding system also one system to rehabilitate the watershed and to improve production and productivity. The survey indicates before implementation not introduces cut and carry system to the study area but after implementation, 100% use cut and carry feeding system in 'Enabered' watershed.

There is a difference among different age groups in owning of livestock. The chi-square shows (X^2 = 21.548; df = 4; P = 000). Most Elderly and medium age groups have more ox than youths. Source of animal feed also different between middle and lower catchments (X^2 = 14.533; df = 2; P = 001). Most farmers living in the lower catchment have more additional source of animal feed than farmers living in the middle catchment.

4.6.3. Impact on water resources and qualities

Integrated physical and biological watershed management practices were seen in improving the surface and sub-surface water availability.

Table 25: Source of drinking water

No.			Frequency	Percent
1	Source of drinking water before watershed management implementation	spring	90	75
		spring pump	7	5.8
		hand pump	23	19.2
2	Source of drinking water after watershed management implementation	spring pump	7	5.8
		hand pump	113	94.2

As the survey indicates before the integrated physical and biological watershed management practices were implemented in the study area, 75% of the sampled households used drinking water from springs, 5.8% from spring pump and 19.2% from the hand pump. Before implementation majority of households used drinking water from unprotected springs. After implementation 5.8% of the sampled households used from spring pump and 94.2% used from hand pump water. Almost 100% of the sampled households drink pure quality water after implementation. Based on the group discussants and interviewees the integrated physical and biological watershed management practices have a great contribution to surface and subsurface water availability (to increase water resources). The implementations of different physical and biological soil and water conservation measures helped in sustaining sub-surface water levels even in the dry season.

4.6.4. Impact on saving

Table 26: Annual saving from all outputs

Birr	Before intervention		After intervention	
	Frequency	Percent	Frequency	Percent
0	105	87.5	98	81.7
500 - 1000	3	2.5	0	0
1001 - 2000	5	4.2	6	5
2001 - 3000	5	4.2	8	6.7
3001 - 5000	2	1.7	7	5.8
> 5000	0	0	1	0.8
Total	120	100	120	100

According to the survey, 15 households of the respondents save 38,000 birr per year before intervention in the study area from all sources of income. After implementation 22 households save 74,100 birr annually from the sampled households. This indicates the integrated physical and biological watershed management practices have its role to increase households production and income. This is also in line with finding of Madalcho and Gashaw, (2018). Due to the various water storage structures including biological and physical soil and water conservation, surface and ground water availability increased resulted in increased cropping intensity, and helped households to find new ways to raise incomes while reducing environmental risks (Madalcho and Gashaw, 2018).

There is a significant difference in savings between farmers living in the middle and lower catchments. The statistical analysis of the one way ANOVA shows that ($p = 0.000$, $F = 39.396$, $df = 1$) for saving of middle and lower catchment households. Farmers living in the lower catchment saved more money than farmers living in the middle catchment annually after the watershed management intervention implemented in Enabered watershed.

4.7. Impacts of climatic hazards

Table 27: Impacts of climatic hazards before and after implementation

No.	Kind of climatic hazards	Severity before watershed management (percent)					Severity after watershed management (percent)				
		very severe	Sever	medium	less severe	very less sever	very severe	sever	medium	less severe	very less sever
1	Flood	70.8	28.3	0.8	0	0	0	0	9.2	65.5	23.3
2	Drought	4.2	83.3	12.5	0	0	0	4.2	60	35	0.8
3	Soil erosion	71.7	27.5	0	0.8	0	0	0	5.8	83.3	10.8
4	Disease to humans	27.5	70.8	1.7	0	0	0	0	5	95	0
5	Rainfall variability	2.5	87.5	10	0	0	0	28.3	70	1.7	0
6	Temperature rise	1.7	95.8	2.5	0	0	0	26.7	71.7	1.7	0
7	Crop damage due to temp.	0	87.5	4.2	8.3	0	0	2.5	82.5	15	0
8	Pest and disease to crop	0	52.5	47.5	0	0	0	0	63.3	36.7	0
9	Disease to livestock	16.7	70.8	12.5	0	0	0	0	85.8	14.2	0
10	New weed species in the area	0	56.7	43.3	0	0	0	0	63.3	36.7	0

The survey indicates that 70.8% and 28.3 % of the sampled households consider flood as very sever and sever respectively in the study area before intervention. Whereas, 65.5%, 23.3% and 9.2% of households consider as less severe, very less severe and medium severity respectively after intervention. 83.3% of respondents perceive that drought was sever before implementation and 60%, 35% and 4.2% said that drought become moderate, less sever, and sever respectively after intervention. The soil erosion showed a decreasing trend after intervention. 71.7% and 27.5% of the respondents said that soil erosion was very severe and severe respectively before implemented the physical and biological soil and water conservation measures in the study area. After intervention 83.3%, 10.8% and 5.8% of respondents said that soil erosion becomes to less severe, very less severe and medium severity respectively. Group discussants and interviewee also assured that, the area was exposed to soil nutrient depletion with soil erosion, deforestation, gully formation, and moisture stress. Poor soil was found in the cultivated land. New gullies were created every year and increase in size and number of gullies from year to year. After implementation, the different integrated physical and biological watershed management measures, a decreasing trend has been observed in climatic hazards such as flood, drought and soil erosion in the 'Enabered' watershed. 95% and 5% of respondents consider diseases to humans as less sever and medium severity respectively after intervention. 85.8% and 14.2% of the sampled households said that disease to livestock becomes medium and less sever respectively after intervention.

Group discussants and interviewee also consistent with each other and add some ideas such as many people were with health problem before implementation, because most people drink water from flat spring which is unprotected and poor in quality. Water born disease such as diarrhea was the most disease to the community. After implementation, there is no disease like that. Due to the different physical and biological watershed management practices implemented in the study area, there had been less and medium severity of impacts of climatic hazards after implementation. From this, it could be understood that the integrated physical and biological watershed management practices are a great contribution to reduce the impacts of climatic hazards.

5. SUMMARY AND CONCLUSION

5.1. Summary

The government of Ethiopia, NGOs and communities implemented many physical and biological soil and water conservation measures such as terraces, bunds, trenches, check dams, ponds, afforestation, tree seedling plantation, grass sawing and plantation, as well as area closure in the study area to conserve soil and water and to support the communities to adapt to impacts of climate change. The majority of households in the study area had 4-6 family members and landholding 0.25-1.5 hectare. The implemented different structures enabled households to improve crop production, increase water availability and increase irrigation utilization, improve households' income, reduce land degradation and improved households' adaptation to climate change in the study area. Increasing household income is best mechanism to increasing adaptation to climate change. Livestock number and productivity in the study area has improved, because of the availability of animal feed such as elephant grass and other grasses. Households' utilization of livestock and livestock products has also improved.

However, the current study findings show that there are some challenges in the watershed such as structure destruction, less mobilization, lack of integration among sectors and lack of follow up are the main challenges in the study area. Before the watershed management intervention in the study area, impacts of climatic hazards were much severe and sever. After intervention, these climatic hazards were medium and less severe and also in decreasing trend. So integrated physical and biological soil and water conservation measure have a great role in climate change adaptation in the study area.

5.2. Conclusion

Based on the findings of the study the following conclusions are important to develop farmers' adaptive capacity to climate change and to increase the benefits of the watershed for households' income.

1. In order to enhance the water availability for irrigation and other uses, integrated physical and biological watershed management practices must be sustainable.
2. Since many physical and biological soil and water conservation measures have been implemented in the study area, follow up is necessary in order to get households' continuously benefit from the watershed interventions and adapt to impacts current climate change and variability.
3. In the study area, there was a lack of integration among sectors, as a result, there was overlap among sector programs, so it is necessary to collaborate sectors for sustainable development of watershed management.
4. Since structure destruction is occurring in the study area, continuous maintenance should be necessary for better household to adapt to climate change.
5. Since the integrated physical and biological watershed management practices have brought many improvements in the study area, these practices should be promoted to other watersheds.

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APPENDICES

ANNEX 1: QUESTIONNAIRE

Hawassa University

Wondo Genet College of Forestry and Natural Resources

School of Forestry

Msc. Program of Climate Smart Agricultural Landscape Assessment

Questionnaire on contribution of integrated physical and biological watershed management to climate change adaptation

Tigray region, Central zone, Adwa woreda, Enabered Catchment.

Code of respondent ________

1. General information

1.1. Sex (HH) Male ☐ Female ☐

1.2. Age __________ years.

1.3. Education level Illiterate ☐ Can read and write ☐ Grade 1 - 8 ☐

Grade 9 - 12 ☐ College certificate and above ☐

1.4. Family size Male ___________ Female _________ Total _____________.

2. Linkage between watershed management and adaptation to climate change.

2.1. Is there climate change within your respective perception? Yes ☐ No ☐

How do you perceive about the following climate elements compare with past 30 years

No.	Climate elements		Increased much	Increased	No change	Less decreased	Decreased	Decreased much
1	Rainfall	Amount						
2		Duration						
3		Intensity						
4		Erratic						
5	Temperature	Hot day						
6		Hot night						
7		Hot season						

2.2. What are the main activities (measures) implemented in the watershed?

No.	Activities	Response		No.	Activities	Response	
		Yes	No			Yes	No
1	Hillside terrace			11	Tree seedling plantation		
2	Hillside terrace with trench			12	Grass planting		
3	Stone bund			13	Grass sawing		
4	Stone bund with trench			14	Area closure		
5	Soil bund			15	Protect deforestation		
6	Trench			16	Using improved seed		
7	Gabion check dam			17	Using natural fertilizer		
8	Stone check dam			18	Using artificial fertilizer		
9	Gully rehabilitation			19	Using fuel saving stove		
10	Compost preparation			20			

2.3. Do these implemented watershed management practices have an advantage in terms of climate change adaptation? Yes ☐ No ☐

2.4. What changes do you observe after the watershed management practices implemented?

For example, in soil and water conservation ______________________________________

Fertility of land (soil fertility) ____

Irrigation ____

Water resource ____

Flooding ____

Recurrent drought ____

Others indicate ------

3. Challenges in implementation of integrated physical and biological watershed management

3.1. What are the challenges in the watershed management implementation? ___________

3.2. What are the solutions to the problems within your perception? __________________

4. Role of watershed management on household income and adaptation to climate change

4.1. Do you have farm land?   yes ☐   NO ☐

If your answer is yes, how much is the size of land in hectare? __________.

From the land you have how much is irrigated land in hectare?

Before watershed management _____________   After watershed management __________

4.2. Do you use improved seed? Before watershed management Yes ☐ No ☐

After watershed management Yes ☐ No ☐

If your answer is yes how much Kg.? Before watershed management ___________

After watershed management ___________________

4.3. Do you use natural fertilizer? Before watershed management Yes ☐ No ☐

After watershed management Yes ☐ No ☐

If your answer is yes how much in quintal? Before watershed management ___________

After watershed management ___________________

4.4. Do you use artificial fertilizer? Before watershed management Yes ☐ No ☐

After watershed management Yes ☐ No ☐

If your answer is yes how much in Kg.? Before watershed management ______________

After watershed management ___________________

4.5. What types of crop you cultivate?

No.	Before watershed management			After watershed management		
	Type of crop	Area coverage in ha	Total annual production in quintal	Type of crop	Area coverage in ha	Total annual production in quintal
1						
2						
3						
4						
5						

4.6. How much output can get from the cultivated land annually?

Source	Before watershed management		After watershed management	
	In quintal	In birr	In quintal	In birr
From non irrigated land				
From irrigated land				

4.7. For how many months you feed from your cultivated land ? Before watershed management _______________ After watershed management ______________

4.8. Do you have domestic animals ? Yes ☐ No ☐

If your answer is yes how many animals do you have?

No	Kind of animals	Before watershed management in number	After watershed management in number	No	Kind of animals	Before watershed management in number	After watershed management in number
1	Ox			7	Mule		
2	Cow			8	Horse		
3	Other cattle			9	Camel		
4	Goat			10	Poultry		
5	Sheep			11	Bee hive		
6	Donkey						

4.9. What are the main source of animal feed? Before watershed management _________

After watershed management ____

4.10. Do you use cut and carry system? Before watershed management Yes ☐ No

After watershed management Yes ☐ No ☐

4.11. How much output can get from animal resource annually?

Before watershed management in birr ___________

After watershed management in birr ____________

4.12. Do you involve in productive safetynet program?

If your answer is yes how many family members are involved? _________. How many Kg of wheat or how much of birr can you get annually from the safetynet?

Before watershed management ____________________________________

After watershed management ______________________________________

4.13. What other source of income do you have? And how much output can get annually?

Before watershed management ____

After watershed management ____

4.14. How much birr per year can you save from all your own output? Before watershed management ______________ After watershed management __________________

4.15. What are the sources of your drinking water? Before watershed management _____ ____________________ After watershed management ______________________________

4.16. How are the impact of climatic hazards? Compare before and after watershed management.

No.	Climatic hazards	Severity before watershed management					Severity after watershed management					Trend after watershed management		
		very sever	sever	medium	less sever	very less sever	very sever	sever	Medium	less sever	very less sever	increase	Decrease	No change
1	Flood more rainfall													
2	Drought less rainfall													
3	Soil erosion													
4	Disease to humans													
5	Rainfall variability													
6	Temperature rise													
7	Crop damage due to temp.													
8	Pest and disease to crop													
9	Disease to livestock													
10	New weed species in the area													

Guideline checklist for Focus group discussion

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

2. Do these implemented watershed management practices have advantage in terms of climate change adaptation?

3. What changes you observe on the watershed before and after management implemented? Eg. Flood, soil erosion, gully, crop production, livestock production, water source, forest, annual income -------.

4. Is there a change in climate elements between the past and present conditions? Eg. Rainfall, Temperature.

5. Is there difference in irrigation before and after watershed management implemented ?

6. What change in water charge have you see? or how many rivers re-charge ?

7. Is there difference in use of inputs such as improved seed, natural fertilizer, and artificial fertilizer before and after the watershed management implemented?

8. How much output can get from the cultivated land annually?

Source	Before watershed management		After watershed management	
	In quintal	In birr	In quintal	In birr
From non irrigated land				
From irrigated land				

9. For how many months you feed from your cultivated land?

- Before watershed management ___________________________

- After watershed management ____________________________

10. Do you use cut and carry system for animal feeding?

  - Before watershed management _________________________

  - After watershed management ___________________________

11. Is there difference in annual output from animal resource before and after watershed management?

12. What other source of income do you have? and how much output can get annually?

  - Before watershed management _______________________________

  - After watershed management _________________________________

13. How much birr per year can you save from all your own output?

  - Before watershed management __________________________

  - After watershed management ____________________________

14. Who are more implementers of climate change adaptation mechanisms between male and female? why?

15. What are the challenges in the watershed implementation? what are the solutions to the challenges?

16. What are the contribution of watershed management to household income and adaptation to climate change?

17. How are the impact of climatic hazards? compare before and after watershed management.

No.	Climatic hazards	Severity before watershed management					Severity after watershed management					Trend after watershed management		
		very sever	sever	medium	less sever	very less sever	very sever	sever	Medium	less sever	very less sever	increase	Decrease	No change
1	Flood more rainfall													
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8	Pest and disease to crop													
9	Disease to livestock													
10	New weed species in the area													

Guideline Check list for Interview

1. Who initiated the watershed management?

2. What changes you observe on the watershed management before and after implemented?
Eg. In Soil erosion ____

Flood ____

Gully ____

Crop production ____

livestock production____

Water source ____

Forest ____

Annual income ____

3. How do you perceive about rain fall and temperature as compare with 30 years back?

4.What are the climate change adaptations developed in the watershed?

5. What are the most important adaptation options in the watershed?

6. Is there difference in crop production or livestock production in size or type before and after the watershed management implemented?

7. What are the improvement in crop production in the watershed management?

8. What are the improvement in livestock production in the watershed management?

9. What are the opportunities in the watershed management?

10. What non-farm income do you get from the watershed?

11.What are the challenges in the watershed management implementation?

ANNEX 2: PHOTO GALLERY






Elder male group and medium age female group discussions

Irrigation practices in Enabered watershed April 2018

Trenches, half moons and terraces in Enabered watershed