ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

THE ROLE OF WATERSHED APPROCH IN ADAPTION TO CLIMATE VARIBALITY AND CHANGE: THE CASE OF *MARIAMSHEWITO* WATERSHED IN ADWA WEREDA, NORTHERN ETHIOPIA.

BY

MEAZA HADUSH

June, 2014

ADDIS ABABA UNIVERSITY

THE ROLE OF COMMUNITY MANAGED WATERSHED FOR CLIMATE VARIABILITY ADAPTATION; THE CASE OF *MARIAMSHEWITO'* WATERSHED IN ADWA WEREDA, NORTHERN ETHIOPIA.

MEAZA HADUSH BERHE

A THESIS SUBMITTED TO

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS (CLIMATE CHANGE AND ADAPTATION)ADDIS ABABA UNIVERSITY

ADDIS ABABA, ETHIOPIA

MAY 2014

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Meaza Hadush entitled the role of Community Managed Watershed for Climate variability Adaptation in Adwa, in the Case Of '*Mariamshewito'* Watershed and submitted in partial fulfillment of the Requirement for the Degree of Master of Art in Geography and Environmental Studies (Specialization: Climate Change Adaptation) compiles with regulation of the university and meets the accepted standards with respect to originality and quality.

Signed by the examined committee

Examiner_____signature_____date_____

Examiner_____signature_____date_____

Advisor _____signature_____date_____

_____

Chair of Department or Graduate Program Coordinator

Table of Contents

Content **page**

List of figures

List of Tables

Acknowledgements

First and for most I would like to thank the Almighty God for helping me successfully to complete this thesis and for all achievements which I have been able to attain in my entire life.

Many individuals have contributed to the success of my thesis. I would like to thank my research advisor Dr. Tesfaye Shiferaw, for his commitment, intellectual guidance and constructive comment at every stage of this study. I also thanks for his compassion and keenness whenever I need his support.

I extend my special thanks to Dr. Yohannes Gebremichael, who gave me his critical and constructive comments during my study, whose unreserved support and professional comments were quite instrumental in shaping the study. He has been kind enough to give advice and respond to all my frequent inquires by devoting his precious time.

My gratitude also goes to Addis Ababa University, for granting me study leave. The partial cost of my study was covered by Addis Ababa University.

My deepest gratitude also goes to Adwa Wereda Rural Development Office members for their advice and financial support. Without their assistance, the collection and assembling of the data would have been difficult. Moreover, I would like to give warmest thanks to Adwa Woreda Agricultural and Rural Development office members for their welcoming approach, hospitality and support during my data collection.

I am also highly grateful to thank for the valuable contributions and supports of Ato Lema Asfaw, Grant Manager of Christian Fund, for his Advise, moral and material (financial) support.

My heartfelt thanks and appreciations are extended to my parents Ato Hadush Berhe Workineh and W/ro Wahid Nega Hadgu, that enrolled me to school at my very young age and have been offering me to do this opportunity and it is impossible to achieve this without the continuous support of them. And heartfelt thanks and appreciations' also extends to my brothers, sisters and other friends for their morality and financial supports.

ABSTRACT

The role of community based watershed management for climate change, in the case of 'mariamshewito' watershed in Adwa, North Ethiopia.

Meaza Hadush

Addis Ababa University, 2014

Currently, climate change and its impacts is a key issue in Ethiopia. Adaptation to climate change is making a system suitable to moderate the impact of climate change or deal with the consequence or to take advantage of new opportunities. In line with this, the thesis has assessed the role of community managed watershed for climate variability adaptation in Adwa in the case of mariamshewito Watershed. To address the above objective, the study uses both qualitative and quantitative data type. In order to collect valuable information, semi structured questionnaire, focus group discussion, key informant guide checklist, and observation tools from both primary and secondary data sources were applied. Similarly, different statistical methods such as percentage of frequencies, bar graphs, X^2 test, independent and paired sample T-Test and one way ANOVAs were used. The key finding of the thesis presents that due to different interventions the livelihood of the community was diversified and enhanced especially; income, soil fertility, crop productivity, forest, water and food availability become improved. Even if it has some gaps in the process of implementation such as lack of linkage between sectors, lack of targeting problem to address the poor, the young and the women, weak stakeholder linkage. It is concluded that the watershed management can play a significant role to enhance household's livelihood and cope with climate change impacts. Then, to fill the gap and go along the sustainability of the watershed, the study recommended based on the findings.

Keywords: *Climate Change, Climate variability Adaptation, Watershed Management, Livelihood Diversification Index (LDI), ANOVA, Paired and Independent T-Test and Chi-Square Test.*

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Ethiopia is one of the most vulnerable countries to the adverse effects of climate change due to its geographical location, topography and heavily dependent on rain-fed agriculture, under-development of water resources, high population growth rate, low economic development level, inadequate road infrastructure in drought prone areas, weak institutions in combination with low adaptive capacity (NAPA, 2007).

Climate change influences the growth and development of Ethiopia through changes in agricultural productivity, water availability, road infrastructure maintenance and extreme events. To the amount that climate change reduces agricultural or hydropower output in a given year, it also reduces income and hence savings (EDRI, 2013)

Currently, the Ethiopian policy provides more attention to adaptation. Adaptation to climate change is making a system suitable to moderate the impact of climate change or deal with the consequence or to take advantage of new opportunities. Thus, adaptation by communities will be governed by them and facilitated by their own social capital and livelihood resources (O'Brien and Leichenke 2000).

Until the early 1970s, the issue of natural resource management was given little attention in Ethiopia. After the problem realized in 1973 and 1974, since the early 1980's, natural resource-conservation efforts initiated through the involvement of World Food Program by providing incentives for conservation activities. Dating back to the 1980's, natural resource management activities had been performed in the Ethiopian dry lands to control

degradation, increase the adaptive capacity of the area, and decrease the area's vulnerability to climate change (Temesgen et.al, 2009).

The application of watershed management is the most modern and recently developed method of land rehabilitation (Darghouth et.al, 2008). Watershed development planning in Ethiopia was started in the 1980's. Since then the government, nongovernmental organizations and local community efforts on rural development have been based on watershed development program. This approach is particularly relevant to Ethiopia given its hydro-geology, it applies equally well in several regions across the world. Participatory Watershed Development is now placed decisively at the centre of Ethiopian development policy (MOARD, 2005).

Watershed management attempts to incorporate and systematize the different uses, services, and values of water jointly in management decisions and regulatory activities rather than attempting to maximize selected resources or regulate individual negative impacts (Cobourn, 1999; German et.al, 2006; Darghouth et.al, 2008). In this multidisciplinary approach, the local people are the chief actors in the process. Watershed projects in developing countries that focus on water harvesting and soil conservation typically state three objectives: 1) conserve and strengthen the natural resource base, 2) make agriculture and other natural resource-based activities more productive, and 3) support rural livelihoods to alleviate poverty. Local people, especially the poor and disadvantaged, organize themselves with support from governmental and nongovernmental organizations to actively manage land resources (Kerr et.al 2002).

1.2. Statement of the problem

Ethiopia looks onward to take advantage of its current economic growth by becoming more resilient to the impacts of climate change through the development of community based adaptation strategies. The government, non-governmental organizations and households made an effort to adopting a variety of coping mechanisms. In the farming areas, many are shifting to more drought tolerant crops and varieties, improved watershed management practices to protect land degradation and climate change hazards. The basic approach has shifted from top-down to community-managed approaches. Watershed approach was implemented to address issues of poverty and land resource degradation in different parts of the country (Kaur, 2013).

Tigray is the most degraded region in Ethiopia. Despite this, a number of positive changes have been recorded. Different soil/water conservation, water recharging, and water harvesting structures have been constructed in the region. More than 80% of the region is now covered. The whole activity is moving from soil/water conservation to water harvesting, and other natural resources management (Kifle, 2012).

In the study area Adwa, which was known by recurrent drought and food insecurity problems in the past, many people live in conditions of chronic famine with a low average calorie supply. The combined problems of environmental degradation, irregular rainfall, high population pressure, recurrent cycle of drought, lack of diversification in economic activities and institutional factors and the topographic feature of the area, which is characterized by mountain chains, plateau, hills and small proportion of plains, threaten food security in the wereda. Currently, despite this, a number of positive changes have been observed.

In the rural areas of Adwa, the regional government, non-governmental organization and the general population have been making efforts to control the degradation of natural resources since 1992 through the development of local level participatory approach. Consequently, many watershed management measures have been initiated, at the same time for climate change adaptation, including the conservation of soil, forest and water through the construction of check dam, ponds and planting of trees. Watershed management (WM) is widely used land-management activity in Adwa.

However, except in a few cases, research in soil and water has not taken into consideration the watershed management. Few studies have examined the extent to which WM interventions have resulted in the desired effects (e.g. Pathak et.al, 2007, Assefa, 2011). Assefa (2011) examined the role of watershed management for climate change adaptation in Choke Mountain upper Muga watershed in East Gojjam of Ethiopia and results from his study indicated that as a result of the watershed management livelihood resources especially; income, soil fertility, land productivity, forest, water and food supply become improved, even if it has some gaps in the process of implementation. However, impacts of watershed management in different agro-ecological zones were different, so it needs additional study. Likewise, watershed management is a continuous process, so it needs continuous assessment. Therefore, this study tries to fill the existing research gap by focusing on the overall benefits of watershed management in the study area. If not studied the sustainability of the watershed management may be in question and in turn households were vulnerable.

1.3 Objectives of the study

The research has general and specific objectives.

1.3.1 General objective

The primary objective of the research is to assess the role of watershed approach for climate variability and change adaptation; in Mariamshewito watershed in Adwa.

1.3.2. Specific objectives

The specific objectives are to:

I. Assess household participation and watershed management practices implemented in the study area.
II. Examine the contribution of watershed approach to cope with climate variability and change.
III. Assess the impact of watershed management on female and marginalized farmer's livelihood.
IV. Identify the major challenges in the implementation of the watershed management.

1.4. Research questions

The research attempts to answer the following basic questions.

I. What are the conservation practices implemented in the watershed?
II. How households participated in the implementation of watershed management?
III. What are the incentives used in the implementation of watershed management??
IV. What are the contributions of watershed management to cope with climate variability?
V. How watershed management does impacts female and marginalized farmers livelihood?
VI. What are the main challenges in the implementation of the watershed management?

1.5. Significance of the study

This research has the following significances

I. Examine the overall advantages of watershed management for climate change adaptation.
II. Ensure the sustainability of the watershed management practices in the study area by identifying the challenges and gaps in the implementation process. Additionally it could help to extend the management practices to other unprotected watersheds in the ‘woreda’ by providing information about the benefits of the intervention that can help the policy makers, local administrators, the farmers of Adwa ‘woreda’ and in particular farmers of Mariamshewito

‘kebele’ to look for host of strategies and instrument towards the improvement of community livelihood. Similarly, it may help households to make informed decision for better practice on watershed management.

III. Besides, the result of the study may serve as a base for further comprehensive research that can be done in the area of watershed management roles for climate change adaptation.

1.6. Delimitation of the study

The scope of this paper is limited to study the role of watershed approach on climate variability and change adaptation in Adwa, in the case of Mariamshewito watershed.

1.7. Limitation of the study

Investigating the role of watershed management is a broad area of the study, which includes the direct and indirect benefits for different sectors, needs to including a number of multiple sectors. But, only the major items were included in deriving the role of watershed management for climate change adaptation in Mariamshewito watershed. Similarly, although taking the entire population is important, however the study was used selected households to collect data due to time and budget constraint.

1.8. Organization of the Thesis

This study is organized into five chapters. Chapter one deals with background of the study, statement of the problem, objectives, research questions, and significance of the study and limitations. Chapter two is mainly concerned with review of some relevant literature. Chapter three focuses on methodology employed including study design and sampling techniques, data source, data collection methods and analysis. Chapters four briefly explain the results of the study in line with research objectives. Finally, Chapter five summarizes and concludes the ideas discussed in preceding chapters and forwards the possible recommendation for policy implication as well as for the implementers of the intervention.

CHAPTER -TWO

REVIEW OF RELATED LITERATURE

This chapter deals with the most relevant literature associated to the role of watershed management to climate change adaptation. Additionally, it also closely looks at concepts of climate change, climate change adaptation, watershed management and its contribution for rural livelihood as well as challenges in development of watershed.

2.1. Trends of Climate change in Ethiopia

Mean annual temperature and rainfall variability were observed over the arid and semi-arid parts of Ethiopia in the period 1951-2006 (NAPA, 2007). According to the UNDP Climate Change Profile for Ethiopia (Oxford, 2008), the average annual temperature in Ethiopia has increased by 1.3°C between 1960 and 2006, at an average rate of 0.28°C per decade (McSweeney et al. and others, 2008).

Due to the high rainfall variability between years or decades, noticing long-term rainfall trends is difficult. No statistically significant changes of annual, Kiremt and Belg rainfall totals and rainy days over central, northern and north western Ethiopia observed in the period 1965–2002. In contrast, the annual and the Kiremt total rainfall in eastern and southern Ethiopia show a significant decline since 1982 (Seleshi and Zanke, 2004).

Likewise, Conway (2000), noted that no evidence of any long–term trend or change in rainfall in the north east Ethiopian highlands. In addition, Conway et al. (2004) marked no trend in rainfall for the period (1898-2002) in the central Ethiopian

highlands. However, Funk C. and others (2012) reported Belg and Kiremt rain fall in Southern, South western and south eastern Ethiopia were decrease by 15-20%.

Average annual minimum temperature in Tigray region has been increasing by about 0.72ºC every ten years while average annual maximum temperature has been increasing by about 0.36ºC and slight decrease in rain fall per decade over the period 1954-2008 (Gebrehiwot and Veen A., 2013). Conway (2000) also reported predominantly higher inter-annual variability in the drier areas of Wollo and Tigray. Gebre et.al (2013) also finds that rain fall in Tigray region is highly variable with non significant trend in both annual and seasonal totals.

2.2. Impact of Climate Change in Ethiopia

Climate change is the most serious and difficult to manage of all the environmental and international development problems of the twenty first century. Many aspects of human society and well beings such as their living, the way they live, the means of earn of their wage, and the way to create their recreation-still depend on a relatively generous range of climatic conditions, even though this dependence is being reduced and covered in the modern industrial societies by their wealth and technology (Dessler and Parson, 2006).

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 crisis on economic, health and safety, food production, security, and other dimensions (IPCC, 2007).

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 damaged country by drought which has experienced at least five major national droughts since 1980's. Persistent drought events in the past have resulted in huge loss of life and property as well as migration of people (NAPA, 2007).

Likewise, flood is also foremost climate hazard, which caused loss of life and property in the country. Major floods were occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 (NAPA, 2007).

Climate change especially increase in temperature have a great damage in Ethiopia. Due to temperature increase during winter, summer and spring, net revenue reduces by US$ 375.83, 1877.69 and 21.61 respectively. Likewise, increase in erratic rain fall during spring, winter and summer significantly reduces net revenue by US$ 225.08, 464.76 and 18.88 respectively (Temesgen and Hassan, 2009).

2.3. Climate Change Adaptation in Ethiopia

Climate change adaptation is incessant process or outcome of process which enable individuals to reduce damage or risk of damage, or able to achieving benefits related with climate variability and climate change (UNDP, 2005). It can thus be enhanced by i) altering exposure ii) reducing sensitivity of the system to climate change impacts and iii) increasing the adaptive capacity of the system (OECD, 2010).

For environmental friendly development adaptation planning, implementation and assessment is required for all countries, particularly for developing and least developed countries, suffering from drought and floods (UNFCCC, 2007).

Adaptation is fight back the existing climate change impacts and increase resilience to expected impacts for vulnerable populations, sectors, communities and ecosystems. It also allows increasing the coping range through modification of the critical threshold, and thus helps limit vulnerability to climate change impacts (UNFCCC, 2007).

Adaptation approaches off set the impacts of climate change by enhancing the social, economic, and environmental sustainability through reductions in vulnerability to climate-related risk, thus supporting and promoting sustainability in social and economic development. The promotion of adequate preparedness for disaster is also a function of disaster risk management and adaptation to climate change (IPCC, 2007).

Different adaptation activities are identified by the Ethiopia's National Adaptation Program of Action which includes a food guarantee program, enhancing early warning systems for both drought and floods, small scale irrigation and water harvesting systems, better management of both rangelands in pastoral areas and wetlands, community-based carbon sequestration, natural resource management which enable to improve the livelihood of the community (NAPA, 2007).

Since the 1970 the Ethiopian government implemented large national programs to mitigate the impact of climate change and resource degradation. However, these were not enough in managing the rapid rate of demographic growth within the country, rapid resource degradation, and high risks of low rainfall and drought. The government has

supported rural land rehabilitation, through the implementation of community based watershed management since the 1980 (MOAR, 2005).

2.4. **Watershed Management as Instrument for Climate Change Adaptation.**

Watershed development is the logical and communally suitable exploitation of all the natural resources for optimum production to achieve the present needs and reduce future risks through well utilization of natural resources such as land, water and environment (MOAR, 2005).

Watershed management productively used to bring back and preserve the agro-ecological feasibility and production potential of various watersheds throughout the world, using land-use management techniques that integrate across sectors and also address socio-economic concerns of local populations. Likewise, Watershed management is considered as risk management, chiefly related to landslides, storms and floods (FAO, 2006).

Because of the advantages that watershed management approach offer, few regional states have now initiated several watershed management projects and depending on the success of these more of similar development projects will be initiated. Effectiveness of the approach is assessed in terms of hydrologic impacts; changes in soil erosion rates, land and water productivity, and land cover/land use; and the level of community participation and local sustainability of the process (Oloro V., 2006)

The Opportunities for water harvesting, income generation opportunities from cash crops, bee-keeping, livestock fattening or dairy, access to road and other infrastructure are all depends on the watershed development as well as on the interactions between communities and the different levels of the watershed units. On the other hand, the

vulnerability to climatic hazards and food insecurity is depending on the capacity of the watershed to support the local livelihood (MOARD, 2005).

The major impact of watershed interventions was seen in improving the surface and groundwater availability which in turn increased cropping intensity and diversification to more extensive land use systems involving livestock, horticultural and vegetable production. Similarly, the watershed program has reduced land degradation, enhanced agricultural productivity and incomes, decreased poverty of rural poor, reduced labor migration and improved environmental quality (ICRISAT, 2007).

Watershed management contributes to all sectors (Agriculture (crop production and livestock), water availability and quality, health, ecosystem service, socio economic and all human livelihood activities) directly or indirectly through chain reaction available between sectors (MOARD, 2005).

2.5. Watershed Management Practices in Ethiopia

Ethiopia due to its geo-physical position and socio-economic context is highly prone to regular natural hazards and the impacts of climate change. Projected changes in rainfall and sea level rise and more extreme weather bring risks to the security of our water resources, agricultural systems and settlements, and to the health of people as well as animals (MOARD, 2005).

Land degradation, recurrent cycles of drought and inadequate infrastructure seriously affects livelihoods and food security of millions in Ethiopia and threatens the livelihood of many people. The main land degradation arises from (1) high soil erosion rates as a result of steep slopes, continuous encroachment and cultivation of marginal lands; (2)

long history of deforestation, overgrazing, negative coping strategies such as the burning of animal dung, extensive use of charcoal and reduced rotation periods (MOARD, 2005).

Consequently, the farming systems that exist in the country are progressively impoverished and more vulnerable to shocks. These are serious constraints to sustainable development and a main cause of unstable, poor and drought prone production systems (MOARD, 2005).

For a long time the Ethiopian government has recognized the solemn implication of implementing large national soil and water conservations to mitigate environmental degradation in the 1970s and 1980s. However, the efforts of such programs were seen to be insufficient in managing the rapid rate of demographic growth within the country, widespread and increasing land degradation, and high risks of low rainfall and drought. Since 1980, the government was initiated watershed development to supported rural land rehabilitation, through well utilization and conservation natural resource (MOARD, 2005).

In Ethiopia watershed projects were limited in number. The initiation of community based projects was supported by FAO, and was principally aimed at capacity building of Ministry of Natural Resource's technicians and experts and development agents in the highland regions of the country. As a result minimum planning on bottom–top approach were initiated. This means the projects were used the sub- watershed as the planning unit and sought the views of local technicians and members of the farming community to prepare plans for soil and water conservation. This approach was tested at the pilot stage through FAO technical assistance under MOA during 1988-1991(MOARD, 2005).

In the last decades the government in collaboration with several NGOs and bilateral organizations adopted participatory land use-planning approach in their perspectives intervention areas. For instance, GTZ succeeded with this approach in South Gondar, North and West Shoa of Oromia and in some weredas of Tigray initiated and mainstreamed the participatory element into the land use-planning and natural resources management approach introducing with biological and physical soil and water conservation measures, crops and farming practices; in North Wello and Wolaita (MOARD, 2005).

Watershed development projects in Ethiopia not only preserve river basin ecosystem but have a principal role to maintain sustainable development. This means that, watershed development would hold back the natural environment degradation and contribute to mitigating the possible outcome of climate change effects. Hence, undertaking participatory sustainable watershed management helps the nation to be able to develop electric power and expand irrigation schemes among others (Shiferaw, 2013).

2.6. Using indigenous knowledge and practices in watershed management

Rural people have abundant indigenous knowledge on natural resource management, agriculture, health, livestock management and other subjects. This indigenous knowledge should be identified and used in watershed projects. New ideas should build on what people already know so they can understand and accept it readily. Likewise, indigenous practices provided invaluable knowledge and aid in making best use of natural resources (Sharma et.al, 2009).

However, indigenous practices in environmental management in Tigray is undermined by the incentives, such as providing food or cash for community members' work in

enriching the enclosures by planting trees. Similarly, The grass root decision making and election of accountable leaders are replaced by fairly standardized regulations that seem to be suggested mainly by Das and sub district leaders, who come into office because they are literate rather than because they understand environmental and development issues (Yohannes and bayers, 2007).

2.7. Challenges in Watershed Management

Watershed management has been faced with many challenges while applied without community participation and using only hydrological planning units, where a range of interventions remained limited and post- rehabilitation management aspects were neglected (MOARD, 2005). Several insights may be drawn from the challenges faced in implementing watershed management. Formulation of appropriate institutional arrangements for more widespread application, given the separation of different disciplines – and of research from development – within existing institutions is challenge in watershed management. Integration is a frequent challenge, given the role of disciplinary biases in favoring certain viewpoints and approaches, and the institutionalization of disintegration (Hussein, 2003).

2.8. Empirical Framework of the Study

Retnareddy et.al (2004) studied participatory watershed development in Indian. His finding showed that watershed management grasps the capacity for enhanced livelihood security even in geo-climatic conditions where the watershed cannot bring direct irrigation benefits on a large scale. In such fragile environments however, watershed development is a necessary but not sufficient condition alone for sustaining rural

livelihood needs to complemented with other programs working on livelihoods, poverty alleviation, land reform, education and health issues make it easier to effectively address environmental and socio-economic issues.

Umrani (1991) concluded that wells in Kolhewadi watershed area (Maharashtra) grasp adequate irrigation and drinking water. The farmers now use improved equipment. Fertilizer use has gone up and the cropping intensity has increased by 17 percent and area under horticultural plantation increased tremendously.

Kapse and Shinde (1999) indicated that various treatments carried out in the Nannaj villages of north Solapur tahsil helped to bring remarkable changes in the household's livelihood. The proportion of area under irrigated crops was increased by two and half times as a result beneficiaries could diversify their crop activity which resulted in increase in high value crop including fruits and vegetables.

Pathak P. et.al (2007) examined Rural Prosperity through Integrated Watershed Management. His finding indicates that as a result of watershed management the socio-economic status of people significantly improved, the productivity of crops, livestock's, cereals and ruminants increased substantially due to reduction in soil erosion, reduced sedimentation and run off, increased soil moisture, rehabilitation of degraded lands and decreased the adverse effect of drought, resulting in higher profit margin.

A study for Ethiopia is done by Gebrehaweria 2007, examined watershed management in Ethiopia. His result showed that land and crop productivity and additional area for cultivation increased, as a result of land rehabilitation activities, increased availability of water for supplementary or full scale irrigation and the introduction of new agronomic

practices. Farm income, food security and access to health and education services increased.

Study for Ethiopia also conducted by Assefa (2011) examined the role of watershed management for climate change adaptation. Results from his study indicated that as a result of the watershed management livelihood resources especially; income, soil fertility, land productivity, forest, water and food supply become improved, even if it has some gaps in the process of implementation such as lack of participatory decision making process, targeting problem to address the poor, the young and the women, weak stakeholder linkage and some conflicts over utilization of communal livelihood resources (forest and range land),which means lacks for the development of social and human capital. It is concluded that the project can play a significant role to improve the adaptive capacity and livelihood condition of the local people. It also finds that the implementation of climate change adaptation mechanisms were different within the different age, sex and wealth groups. Male and better of households were better implemented the climate change mechanisms.

Study for Tigray region was conducted by Kifle (2012), examined the Costs and Benefits of watershed management. Results from his study indicated that Tigray is considered as the most degraded region in Ethiopia. Despite this, a number of positive changes had been recorded due to watershed management. Infiltration, Fertility of the soil, groundwater and microclimate around the treated watersheds improved and moisture stress within the soil and flooding reduced.

2.9. Conceptual Framework of the Study

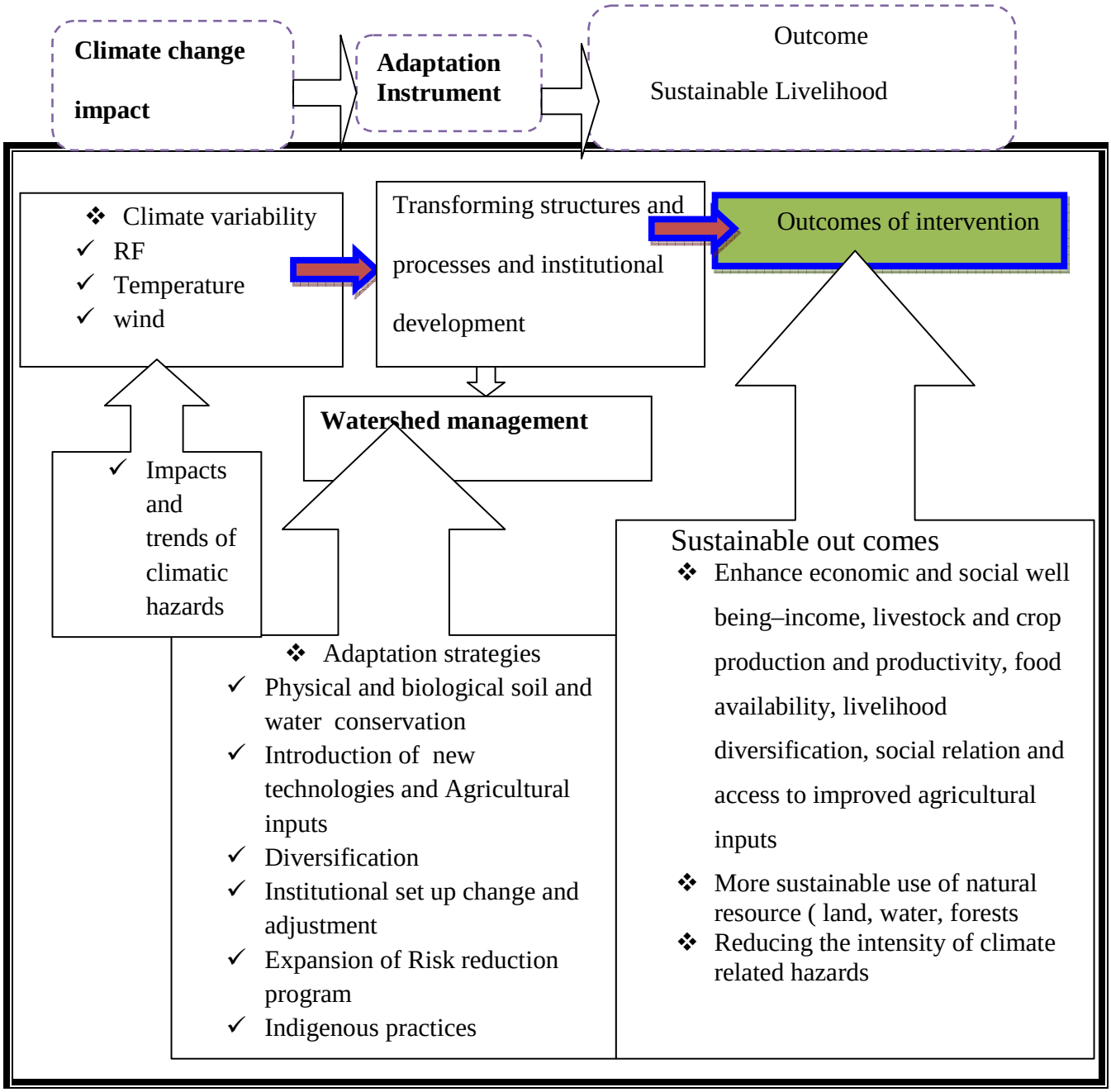
Climate change is a serious global issue; it is manifested through different process, such as increase in temperature, rise in sea level, variability on rain fall and wind and it has adverse effect on human being directly or indirectly especially in the poor countries like Ethiopia. However, In order to minimize the adverse effects of climate change governments and non-government organizations struggle to develop adaptation measures such as soil and water conservation or through watershed management.

Watershed management is the process of managing human activities and natural resources in an area defined by watershed boundaries. It is an evolving and continuous process through which decisions are made for the sustainable use, development, restoration and protection of ecosystem features, functions and linkages. Watershed management allows us to address multiple issues and objectives; and enables us to plan within a very complex and uncertain environment (Conservation Ontario 2009).

Watershed is not simply the water entity but also socio-economic-political and ecological unit, which plays a key role in maintaining sustainable livelihood to rural community (Wani et al.2008 as cited in ICTISAT,). It serves as a means to conserve resources such as water, soil, forest and pasture resources. It also enhances the agricultural production both by conserving moisture in the soil and by increasing irrigation and do have significant impacts to reduce soil erosion, better water availability and quantity, reduce deforestation, enhanced cattle milk production, improved livestock production, better crop production more bio mass and fuel wood availability (IGES, 2008).Hence, in order

to avoid the conceptual gaps on watershed management and its role on climate change adaptation or livelihood development, the logical processes and outcomes were constructed as below.

Figer1. Watershed management and climate change adaptation framework developed based on DFID sustainable livelihood framework (2014).

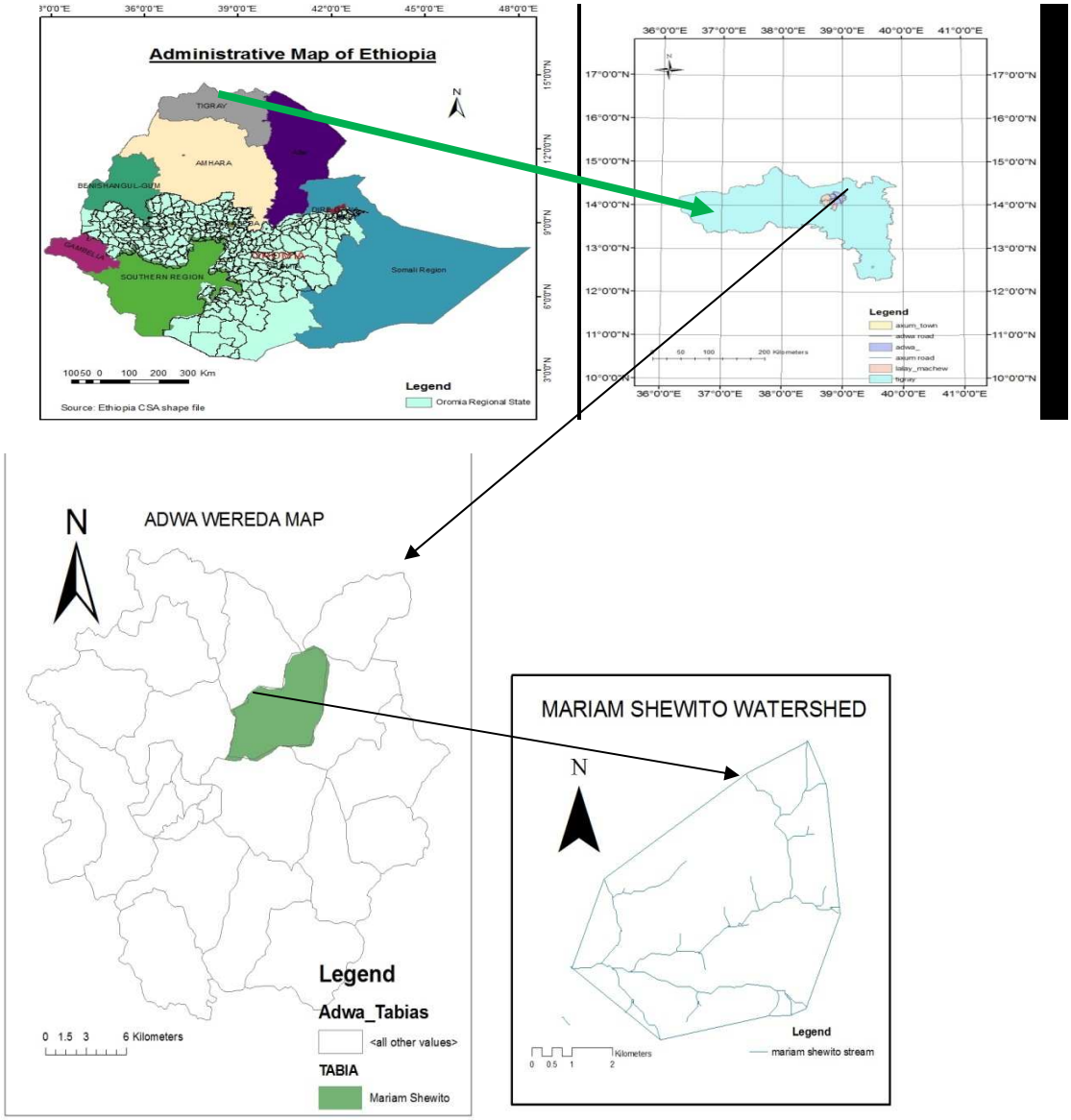


CHAPTER- 3

MATERIALS AND METHODS

3.1. **Description of the watershed**

Fig.2. Map of the study area



The study was conducted in mariamshewito watershed in Adwa. Detail description of the study area was presented as follows.

3.1.1. Location

Mariamshewito watershed is located in Adwa district, which is found in the Central Zone of the Tigray regional administration. Adwa is located some 1006kms away from Addis Ababa via Woldia-Mekelle road, in the extreme northern Ethiopia, within 14^0 15'N and 38^0 52'E geographically. Topographically, the woreda lies in midland with temperature 27, rainfall 600-850 and altitude 1890 m.a.s. The agro ecological zone of the woreda is Weina-dega (Midland), and qola 63% and 37% respectively. These altitudinal agro ecological belts are generally accepted as having land use forms suitable for crop cultivation of barley, Wheat, pulses, teff, maize and sorghum, as well as horticulture production of vegetables and fruits in the vast river side valleys of the fertile low lands (Adwa wereda Agricultural office, 2014) .

Soil types of the woreda are locally call 'walka', 'hutsa' and 'qeyih', 24.43%, 19.75% and 55.82% respectively. The total population of the woreda is 112,987 of which 56,307 male and 56,650 are female. While the household heads of woreda are 25,165 of which 17,654 male and 7,571 female.

The watershed is situated 17 km to the east west direction from the adwa town which lies between **38^o 57' 52''** E to **38^o 59' 38''** E longitude and **14^o 13' 15''** N to **14^o 15' 50''** N latitude. It is surrounded by selam & yeha tabia in the north, soloda tabia in the west, endaba – gerima tabia in the south and gendebta tabia in the east. The total area of the watershed is 3503 ha from which about 17.6% of the area is cultivated land. The

watershed contains 4 kushets (Genya, ketema, daero weyni and Erar). The total population in the ‘kebele’ is 7353 of which 3656 male, 3697 female. But the total house hold head living in the watershed are 1676, male 507 and female 1169.

3.1.2. Climate

According to the elevation of the area, the watershed is categorized under two climatic condition called “weyna dega” and “semi qola” 85% and 15% respectively with temperature 27, rainfall 650-850 and altitude 1921-2200 m.a.s. The average annual rainfall ranges from 650-850mm. On top of its inadequacy, it is uneven spatial and temporal distribution.

3.1.3. Topography

The land form of the watershed consists up and down and is dominated by rugged train. The cultivated land and homesteads are situated relatively in gentle slope. Whereas grazing and bush land area characterized by steep slopes that ranges from 30%-90%. There are many rills, gullies and torrents in all land use types. The upper part (or starting point) is from mountainous that rugged and dominated by torrents. The total length of the large gullies is about 20.5km.

3.1.4. Soil characteristics of the watershed

The watershed has different verity of soil type when we go from top to the lower part of it. On the sloppy part of it, shallow soils with low water holding capacity and low fertility are common. Whereas, relatively deeper, medium to heavy texture soils are common in the lower valleys and flat bottom land. The soil textural classes are clay to silt clay. The

soil type of the watershed is dominated by the locally called " Bae'kel" , "hutsa", "qeyh meret" 70 %, 20% and 10% respectively and the average depth of the soil ranges from 50-60cm.

3.1.5. Existing land use

The land types of the watershed include cultivated, scrub land, wood land, grazing land & homestead land. The Bush & shrub land is the largest part of the watershed consists of **2415**ha. Out of which 546 ha of the area is irrigated land in this is restricted the whole year from free grazing. The overall land use type is listed out in the following table.

Table1. Existing land use type of the watershed area (hectare)

No	Land use type	Area coverage	Percentage
1	Cultivated land	618	17.6%
2	Grazing land	194	5.5%
3	Homestead	110	3.1%
4	Bush & shrub land	2415	68.9%
5	Miscellaneous land	166	0.5%
Total area		**3503**	100%

Source: - Agricultural development office, Adwa (2014)

The cultivating land (rain fed):- The cultivating land of Mariamshewito watershed covers 618 ha that covers 17.6% of the watershed. This cultivating land found in all parts of the watershed and has slope from gentle to steep slope that is from slope 5 to 45%. The cultivating land has not uniform land form it is fragmented. In this cultivating land there

are homesteads which they are scattered and in some area which are neither used for cultivation nor grass or other type of production. The farmer says many areas that are used to separate one cultivation land from the other. The area of cultivated land is reducing every year due to severe soil erosion.

Some of the cultivating land is free for grazing animals during the dry season while most are collapsed. Therefore, they need complete maintenance & to introduce new technology on the farm land.

Grazing land: - The grazing land is found near to the lower part of the catchments (watershed) and total area of it is 194 ha, which is the smallest portion of the watershed (i.e. 5.5%) This grazing land is mostly used for the grazing of shout & pack animal especially during the rainy season.

Bush land & shrub land (BU & SH):- Bush land & shrub land is found in between the cultivating land and homestead and in a steep slope. The bush land & shrub land is the third largest of the watershed followed by cultivated and irrigated land that covers 2415ha (which is 68.9% of the watershed area). This land use is used as source of fire wood, forage (fodder) for household construction.

Home stead: - Most of the homesteads are found on and around the cultivated area while these homesteads are scattered and are found almost in all part of the watershed except in some part. The total area of the homesteads covers 110 ha (which is 3.1% 0f the watershed area).

Miscellaneous land (ML):- Miscellneous land is cosists of rivers, roads, torrents and area which is rock out. Miscellaneous land is a land which is not productive and can't change easily to productive land. The total area of the miscellaneous land covers 126 ha (which is 3.6% of the watershed area). which is the second smallest portion of the watershed followed by grazing land (0.5%). This area is charectarized by roads, rivers, roacky area and so on. Some of the miscellneous land can be changed in to productive land.

3.1.6. Farming system

Farming system of the watershed is subsistence way of farming. The major crops grow in the area are teff, millet, wheat, barley and maize. The sowing period of the area is from June to July while the harvesting period from September to November. Commonly, the community use cow dung and woodlots as their source of fuel wood. The community also gets water from spring, rivers, and hand pumps.

3.2. Research Design and sample frame

According to Dawson (2002) research design is the conceptual structure within which research would be conducted. Therefore, the researcher was used **cross sectional survey.** It assesses the overall activities at one shot.

Sample Frame

The sample frame of the study was peasant association list of households' roster.

3.3. Sampling Techniques and Sample Size

The study involved different sampling techniques. In order to select the study area and respondents for interview the researcher used purposive sampling method. Stratified sampling also used to categorize households to make comparative analyses among different groups in the community. First, categorical division is based on their wealth while the second extended category is within wealth category; there is also a need to address the gender balance in order to understand how both groups are contribute to and benefit from the management practices. After accomplishing the strata and having to the sampling frame, disproportional simple random sampling was implemented in each stratum to accomplish the whole process.

Sample Size

Care must be given to make the sample size of the study to be as representative as possible in accordance with the time and budget allocated. The rationale for deciding this sample size is based on factors like the homogeneity of population, cost of the survey, shortage of time, number of factors to be analyzed and the precision level required. The household number of the study area (mariamshewito kebele) is 1676, of which 1169 male, 507 female. Therefore, the researcher decided to select about 5% of each stratum that is 85. The sample size from each stratum was determined by using the disproportional sample selection.

3.4. Data Sources and Methods of Data Collection

Both primary and secondary data sources were used for this study. Primary data sources were household heads, ‘Kebele’ and ‘woreda’ administrators and other natural resource

or watershed experts through household survey, observation, interview, and questionnaire and focus group discussions. On the other hand secondary data sources for this study were books, internet, research papers, recorded data, journals and reports on trends of climate variability, impacts and adaptation mechanisms, published and unpublished research papers on assessment of watershed management contribution to climate change adaptation and rural livelihood sustainability. Besides, Maps and Satellite images were used to delineate the watershed using GIS tools.

In order to obtain the relevant information the researcher were used different methods of data collection such as household survey, focus group discussion, interview, observation, photograph and review documents.

Household Survey: The household general information (socio-economic) and the watershed activities, which have been implemented by community based institution with its implication to development of adaptation options or livelihood improvement, were assessed by using semi structure questionnaire.

Focus Group Discussion: Sometimes it is preferable to collect information from groups of people rather than from a series of individuals. Six focus group discussions were carried out with the stratified categories in the Kebele, which is two from the poor (one from female and one from male), the second two groups from medium(one from female and one from male) and the rest two were from the rich(better off) (one from female and one from male). This is because to capture a gender disaggregated data from the process. Each group comprises 6-8 individuals of various experiences with careful supervision to keep them on track of what is needed to be study. The main objective of this method was

to triangulate the survey method and investigate additional facts about the watershed activities and benefits that were not addressed by the survey method.

Key Informant Interview: Key informant interviews and discussions were conduct with sixteen different individuals at 'Kebele' and wereda levels. At the 'kebele' level twelve (4 male and 4 female) farmers were select, who have had expert knowledge to generate climatic data and watershed activities and benefits. Five community key informants who have had specific information about the area, (one 'kebele' administrator, one Community Based Organization leader, one agriculture developments agent and one natural resource management expert, one health expert and) were used to integrate the facts. In addition, at the wereda level one that have had expert knowledge of the area, one Agricultural and Rural Development expert who is assigned as Natural resources conservation expert and one health expert were used as key informant discussants**.**

Observation and Photographs: This method was used it to understood the overall conditions of topography, the cropland condition, patterns of the grazing land with its status, as well as how forest status and patterns are set at current times. Observations of the environment can provide valuable background information about the environment and adaptive practices. Besides, these; this method was used to investigate the main natural resources conservation mechanisms and/or methods that have been implemented by the local communities.

Document Review: To understand the watershed performances and effects, data from secondary source such as; published books from library and internet, unpublished documents at the 'kebele' and 'wereda' levels were reviewed.

3.5. Data Type

The researcher was used both qualitative and quantitative data gather from the households, stakeholders, wereda administrators and other bodies to get relevant information.

In this thesis, qualitative data was used to understood the overall benefits of watershed management for climate change adaptation whereas, quantitative data used to show comparative analysis among different age, sex, wealth and farm land size groups, of the sample households in order to understand how both groups are contributed to and benefit from the management practices.

3.6. Methods of Data Analysis and Presentation

Both quantitative and qualitative methods were used in analyzing the information collected using different instruments.

Qualitative data obtained using semi-structured questionnaire, interview, observations, FGD and document analysis were analyzed qualitatively using appropriate words. Explanation and description of different qualitative information will make as deemed necessary. Descriptive statistics such as mean, percentages and frequency were employed to analyze the quantitative data. This study also follows a kind of comparative analysis among the different gender and wealth category of the sample households using IBM-

SPSS 20 package program. Statistical tests and measures of variation were also used to analyze the involvement of different groups of the local community on the watershed management practices.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results of both quantitative and qualitative analysis of data in line with the specific objectives of the study. The chapter consists of the background information's of respondents which are related to the implementation of adaptation mechanisms such as; demographic, socio-economic characteristics of households and climate change adaptation mechanism, impacts of the watershed management and others analysis which helps to assess the role of watershed management for climate change adaptation are the main parts of this chapter.

4.1. **Socio-economic Characteristics of Households**

The subjects involved in this study were mariamshewito 'tabia' households, agriculture experts/ natural resource experts, 'wereda' administration and other stakeholders. The researcher believes that the respondents are direct stakeholders and as a result they were considered to be relevant as main sources of information for the study.

Among the sampled household heads in the study area 59 (69.4%) were males and 26 (30.6%) were females. Female headed households occur due to divorce, death of husbands and migrations of husband, etc.

4.1.1. Wealth Status of Sample Households

Regarding to distribution of sampled households within wealth status, out of 85 households, 27, 29 and 25 households were with poor, medium and better-off wealth

status respectively. Among 27 households with poor wealth status 15(55.6%) are male headed and 12(44.4%) are female headed. While; from 29 sampled household heads with medium wealth status 19(65.5%) were males and 10(34.5%) were females.

Similarly, out of 29 sampled household heads with better-off 25(86.2%) were males and 4(13.8%) were females. Generally, majority of households were male heads, in both wealth categories. Short discussion was made with 5 individuals and 3 development agents to identify the indicators of wealth category in the study area.

The researcher followed the approach followed by the Productive safety net in the study wereda to classify the household's wealth category. Based on that, size of farm land, number of oxen, cows, sheep's and goats were the major indicators of wealth status in the study area. Accordingly, a person is called rich, if he or she would have 3 timad (0.75 hectare) and above land size, 2 and above oxen, 5 and above sheep and 5 and above goats. Likewise, for a person to be medium she/he should be own 2-2.5 timad (0.5-0.62 hectare) of land size, one ox, 3-5 sheep's and 3-5 goats. Moreover, a person is considered as poor if less than 2 timed (0.5ha) land, no oxen, less than 3 sheep's and less than 3 goats.

Table2. Wealth status of sampled households with their land owned and no of oxen per household

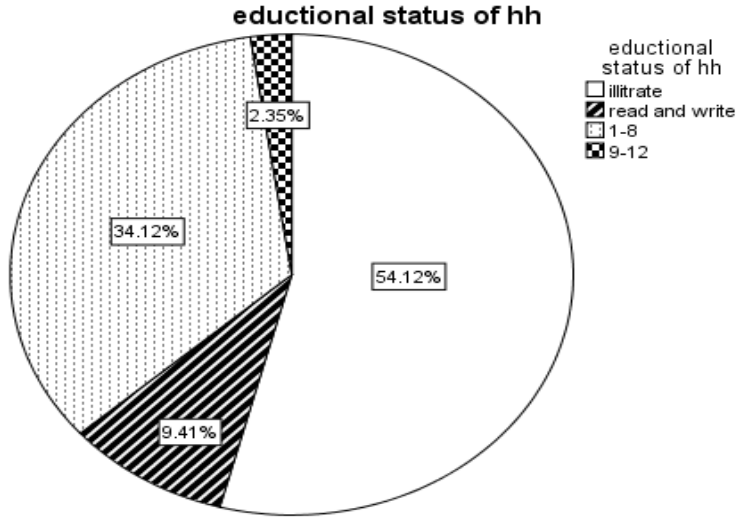
land owned by household			wealth status of household			Total
			poor	Mediu m	Better-off	
<2 timad	no of oxen per household	no oxen	23			23
	Total		23			23
2-2.75 timad	no of oxen per household	no oxen	3	0		3
		1oxen	0	27		27
		>1oxen	0	2		2
	Total		3	29		32
>3 timad	no of oxen per household	no oxen	1		0	1
		>1oxen	0		29	29
	Total		1		29	30
Total	no of oxen per household	no oxen	27	0	0	27
		1oxen	0	27	0	27
		>1oxen	0	2	29	31
	Total		27	29	29	85

Source: - Survey result, 2014

4.1.2. Educational status of households

In developing countries like Ethiopia low level of education and high level of illiteracy rate is common (Mathyalu M.,2013). Indeed, education level of households was assumed to increase participation of households in implementation of climate change adaptation mechanisms. The higher educated household heads were increased their ability to find information, better understanding and application of new technologies and in turn have better ability to cope with climatic risks. From the survey, 54.12%, 9.41%, 34.12% and 2.35% of the respondents are illiterate, read and write, grade 1-8, grade 9-12 respectively (finger 2).

Finger3. Household's educational status -% of respondents



Source:- survey result, 2014

The education level indicates resistance to a hazardous incident as better knowledge on the origin of events and about the methods to cope with them reduces the risk. Education level also has strong relation to the socio-economic status (Cutter et al., 2009). Generally,

the low educational backgrounds are found to hinder households from implementation of adaptation mechanism.

The survey result indicates that more than 50% of the respondents were illiterate. This is assumed to affect the adoption of new soil and water conservation technologies negatively and in turn reduce the capability to cope with climate change impact. However, education is very vague terminology; it needs to identify the type of education, if consider only the formal education it does not include those illiterate farmers who have had deep root experience and knowledge of natural resource management.

4.1.3. Demographic characteristics

Demographic structure is an important consideration as the elderly and youths considered as less implementers of climate change adaptation practices. The total household of the watershed were 1676 and the sample households were 85 of which 59 males and 26 females. The majority of the sample household are under the age of adult (30-60) counted 58.8% of the total sampled household. The number of household under the age of young (18-30) was computed 12.9%. Likewise, households with the age of elder (>60) were counted 28%. Therefore, more than 70% of the sampled households were under the active age group. Majority of the households have a family size of 4-6 counted 43.5% of the sampled households. Similarly, 30.6% of the households have a family size of 6-8. Besides, 21.2% of the households have a family size of <4 and rest 4.7% have a family size of >8.

Table3. Demographic characteristics of households

Sex of sampled Households			Age of sampled Households			Total
			young (18-30)	Adult (30-60)	Elder (above 60)	
Male	family size per household	<4	6	3	6	15
		4-6	2	14	7	23
		6-8	0	11	6	17
		>8	0	2	2	4
	Total		8	30	21	59
Female	family size per household	<4	2	0	1	3
		4-6	1	12	1	14
		6-8	0	8	1	9
	Total		3	20	3	26
Total	family size per household	<4	8	3	7	18
		4-6	3	26	8	37
		6-8	0	19	7	26
		>8	0	2	2	4
	Total		11	50	24	85

Source: - Survey result, 2014

The household size indicates the level of overcrowding, and thus coping capacity in a community. Household size may also be related to the socio-economic status, which

determines the capability of household to implement coping strategies. The smaller the household size, greater are the chances of people being affected. On the other hand, larger households represent critical social networks and manpower, which may be valuable in emergency situations (Cutter et al., 2003).

4.1.4. Land holding

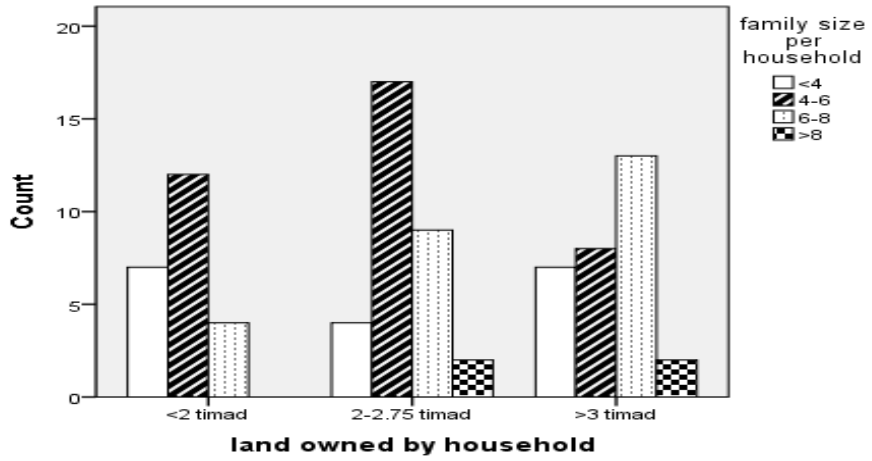
Land is important in the agrarian society like Ethiopia since it depends on agricultural production. Since the 1983 land has been under the state ownership and there had been redistributions and readjustments since then. The last land readjustment had been taken in 1983E.c in the study area. The study indicates, 27.1%, 37.6% and 35.3% of the sampled household owned <2 timad (0.5 ha), 2-2.75 timad (0.5 – 0.65hac) and >3 timad(0.75ha) respectively. The average household land holding size in study area was 0.43 hectare which is too small.

Share croping is the means to gain land for those who have shortage of land. Those who have no labour, oxen and seed was provided their lands for sharecroping and they took half of their lands production.

The study indicates, difference in involvement in sharecroping before and after the watershed management. Before the watershed management households were give a little value to their land and by providing their land for sharecroping, they migrated to other areas to involve in other activities. 30% of the sampled households of which 5% male and 25 % female household heads provided their land for sharecroping. But after watershed management the number of households involved in sharecroping reduced and only 10%

women households were provided their land for sharecroping as a result of access to credit, agricultural extension service and shortage of land owned by the households due to high population pressure and well understanding on the advantage of land and says "*መርየትካ ዝህበካ መን ይህበካ*''.

Fig3. Land holding and household size of sampled households-% of respondents



Source: - Survey result, 2014

4.2. FARMERS VIEW ON CLIMATE CHANGE TRENDS

4.2.1. Farmers view about trend and change in temperature

To compare meteorological data with the household's perception survey on the three main indicators of climate change were conducted in the study area. These are trend of temperature, rainfall and wind. The trends of temperature were examined in two ways, hot days and hot season per year. The study indicates, 58.8% of the respondents said that there is an increased and very increased and 37.6% said there is no change in temperature. While, 3.5% of the respondents said that there is decreased and very decreased of the hot days. Moreover, 63.5% of the respondents said that there is an

increased and very increased in hot days, while 34.1% of the respondents said that there is no change and the rest 2.4% of the respondents said that there is no change and decreased and very decreased of the hot days. This indicates that more than 60% the household heads said that daily and seasonal temperatures were in increased trend.

The data from the group discussants and interviewees was also consistent with the survey. But it adds new ideas. The growth rates of different crops were increased. The time of harvesting were changed. Before 30 years the time of harvesting was from April to October but now's a day from July to September. Crops were matured earlier due to the rise in temperature. It was important opportunity to mature crops on short period and escaped from drought. Also reveals that the day time even in the rainy season becomes very hot which were not common before and the community was challenged to accomplish their activity in the day time. During the dry season many people had faced with health problem due the high temperature.

Next, the researcher nullified the hypothesis that there is a difference in explanation of trends of climate variables among the different age group farmers. The X^2 shows p=0.013-0.02 (df=4, X^2= 12.6-16.6) for different age category which has an implication of significant difference among age groups towards explanation of trends of hot day and years in the past 20-30 years. Elderly group respondents assured that there is a significant difference in the trend of hot day and season change than the Adult and youngest groups, and most of the youngest group said no change of trends.

All of the ideas presented by the households were inconsistent with the meteorological data analyses of insignificant increased trend in annual maximum and minimum

temperature. Therefore, it is generalized that even though there are contradictions in the trends of temperature in the area, there is temperature variability in the study area.

4.2.2. Farmers view about trend and change in Rainfall

For this study the trend of rainfall look at in three ways, duration, intensity and amount of rain fall. The study indicates, 17.6 %, 32.9 % and 49.4 % of the respondents said that there is an increased and very increased, no change and decreased and very decreased in the amount of rainfall respectively. Furthermore, 25.9%, 23.5% and 50.6% of the respondents said that there is an increased and very increased, no change and decreased and very decreased in the intensity of rainfall respectively. Likewise, 20%, 35.3% and 44.7% of the respondents said that there is an increased and very increased, no change and decreased and very decreased in the duration of rainfall than 30 years back respectively.

The data from the interviewees also supports the data obtained by the survey. However, it added some new ideas, in view of that the crops harvested 30 years back such as ‘chalay’, ‘kalay’, ‘gunazay’, were not harvested today since they required more rain. Similarly, the volume of rivers and streams were decreased and the water sources for irrigation from rivers were decreased. Rivers and streams flow were stay 9-10 months 30 years back but at the present time dried not stay longer than 4-5 months. Most of the respondents’ argument on rainfall variability was consistent with the meteorological data analyzed, especially the old peoples view.

The researcher also nullifies the hypothesis that there is a difference in explanation of trends of rain fall trends among the different age group farmers. The X^2 shows p=0.000 (df=4, X^2= 23.87-33.3) for different age category which has an implication of significant difference among age groups towards explanation of trends of rain fall intensity, duration and amount in the past 20-30 years. Elderly and adult group respondents assured that there is a significant difference in the trend of rain fall intensity, duration and amount than the youngest groups, and most of the youngest group said no change of trends of rainfall intensity, duration and amount. All of the ideas presented by the Elder households were consistent with the meteorological data analyses of decreased trend in annual amount of rainfall. Therefore, it is generalized that there is decrease in rainfall intensity, duration and amount in the area, since identifying these trend change require experience and long live in the area.

4.2.3. Farmers view about trend and change in wind pattern

The survey indicated that 17.6 % of the respondents said that there is an increased and very increased in wind pattern and 32.9 % respond that there is no change, while 49.4 % of the respondents said that there is no change and decreased and very decreased in the wind pattern respectively. Moreover, the data from the interviewees indicated that the growth periods of crop were changed. Before 30 years the growth period for different crops were not less than 5 months but today dry in 2-3 months due to strong wind pattern. Based on these all data's, it is concluded that there is a significant temperature, rain fall and wind pattern variability in the study area and generalized that the area is characterized by climate change. This is consistent with many findings, for example

Hadgu and others (2013) reported Tigray region was characterized by climate change which is dominantly expressed in terms of kiremt rain fall. Likewise, Assefa (2011) find that there is a climate change in the choke mountain, east Gojam particularly, temperature increases, hot seasons also becomes longer and changes observed in rainfall pattern and fluctuate in its amount, duration, intensity and variability together with occurrence of strong wind.

4.3. Status of Climatic hazards in the watershed before intervention

The data from the group discussion and interview indicates that due to unwise utilization of natural resource for construction materials, fuel wood, grazing land, primitive and continuous farming , the area were exposed to severe soil erosion, soil nutrient depletion, moisture stress, deforestation and over grazing. Soil found in the cultivating land is poor due to sheet and rill erosion on the upper catchments & gully erosion on the lower part of the land. Before the intervention, new gullies were created every year and the existed gullies were widened from year to year. There had been active and passive soil erosion in the watershed, part of the cultivated lands become out of use and rock.

The survey indicates that 65.8%, 23.5% of the households consider drought as very severe and severe respectively. While 5.5 and 5.2% of the households considered as moderate and less severe respectively, in the study area before the intervention. Almost all households sort out the flood hazards before intervention as very severe and severe and about 5.5% percent consider it as not severe to low severe. 90% of respondents also perceive that the crop damage due to erratic rainfall is severe to highly severe. Regarding, frost, human disease about half of households reported highly severity.

Likewise, the discussants and interviews revealed that climatic hazards like flood, drought, and rain fall and temperature variability were very severe impact in the study area. Flood hazards were sever in the study area due to that conflict among the upper and lower stream settlers were very common. This problem is much serious for people around the steep slope areas. The interviewees stated that before the intervention conflicts among households due to the flood hazards were very usual and even some peoples were lost their life.

The data from the interviewees with the agriculture experts from the 'Tabia, also supports the idea. Most of the people want to the wereda to report about their conflict every day. Further, there were also serious problems of boundary dispute due to flood hazards, especially, between genya which is one of the 'qushets' in mariamshewito and may'agam neighboring tabia in accessing grazing land.

Moreover, the study indicates that the farmlands are fragmented, less productive, severely degraded and the soil is infertile due to that the economic activity of the community were put at risk and unable to support the livelihood of the community. Thus seasonal migrations of family members in to western zone of Tigray were common, looking employment as daily labors to cope up with the impacts of climatic hazards.

Similarly, the main sources of drinking water for both the people and animal were rivers and streams. As a result, the qualities of drinking water were also poor and many people were with health problems. Accordingly the climatic hazards in the study area before intervention were generalized as very severe and severe. This finding is consistent with many studies for instance, NAPA, 2007, drought and flood are the most frequent climate

related natural hazards impacting Ethiopia significantly which happening every three to five years.

4.4. Analyses of the Watershed Management Practices in the Study Area

For a long time the Ethiopian government has recognized the solemn implication of implementing large national soil and water conservations to mitigate environmental degradation in the 1970s and 1980s. However, the efforts of such programs were seen to be insufficient in managing the rapid rate of demographic growth within the country, widespread and increasing land degradation, and high risks of low rainfall and drought. Since 1980, the government has initiated watershed development to supported rural land rehabilitation, through well utilization and conservation natural resource (MOARD, 2005).

In Tigray, the 1966, Farmers were familiar with traditional soil and water conservation practices in their day to day activities such as locally we call “Deret” that synonymous with ‘grass strip’ or ‘soil bund’. But, their activities were not supported technically.

Likewise, farmers were familiar with different traditional soil management practices in the study area. According to the discussants and interviewees, management practices in the study area were initiated since 1970-1980 e.c. (during the derge regim) and their main focus were on area closure and physical structures with little attention to their impact to productivity in limited areas. World food program made a significant contribution to those conservation efforts by providing food for work in the study area. This was done by small projects and these projects unite and named as MERET in 1972. However, most of the bunds constructed on the previous were destroyed by human and animal due to the

free grazing of animals and human consumption in the 1977 (during the drought period). The 1977 production year was the drought year in the whole Tigray. As a result peoples were used the area closure for fuel wood and food. Likewise they used free grazing for their animals as a result the area was very degraded.

In 1980, the FDRE were started to planning for the development of large watershed in the area. The major management practices in the study area were started in the 1988-91 by the World food program. Through experience 1992 LLPA (Local Level Participatory Planning Approach), the official name of the project now a day is known as MERET-PLUS (Managing Environmental Resources to Enable Transition to More Sustainable Livelihoods-Partnership and Land User Solidarity) were designed to integrate NRM interventions, productivity intensification measures and small-scale community infrastructure.

In many studies local methods of adapting to climate variability in rural agricultural society is widely acknowledged. As mentioned in GIZ, soil and water conservation measures have the potential to be effective in overcoming the effects of climate change, providing a more secure livelihood for the rural population and improving their standard of living.

Physical conservation measures as well as agronomic and vegetative measures, including agro forestry were implemented to prevent soil erosion, land degradation and climatic hazards, in the study area.

The main purposes of mechanical/structural/physical soil and water conservation measures were to control the movement of water over the soil surface and limit its erosive capacity.

Biological soil conservation are assets of conservation practices, which is the adequate cover of soil surface, the re-circulation of organic matter and nutrients as well as the establishment of vegetative barriers across the slope, prevent soil and moisture loss, improve soil properties and maintain /restore the productivity and stability of the agro-ecology. The increase in vegetation cover was significant to reduce the rate of soil erosion and permits percolation of rain crop in to the underground trees also re-enforces the physical structure. These are also capital assets and sources of income for the community which can be generated through proper management of these resources.

As the data from the farmers, the main physical conservation measures implemented in the watershed were soil bund, deep trench, terraces, hill side terrace, haring bonce, half moon, gabion, gully cutting and stone bund.

Table4. types of physical soil and water conservations in the study area from 1997 -2005

Year	Type of SWC practices or activities										
	Stone bund in KM	Trench in KM	Trench bund	Hill side terraces in KM	Deep trench in KM	Bench terraces in M^3	Haring bonce in no	Half moon in no	Eye borrow basin in no	Gabion	Gully cutting
1997	3	8	1	10.7	-	326	-	-	-	-	
1998	11.26	15.4	1	17.58		4985	-	-	-	-	
1999	16	29	17	11	-	2169	-	-	-	-	-
2002	5.5	-	43	91.9	-	1063	4269	3229	-	-	-
2003	-	8.5	23	-	18.6	1464.5	-	8000	-	-	-
2004	-	17	28	-	-	1544	-	3009	2778	455	3250

Source: Natural resource development office, Adwa

The physical structures are sustained when they aided (supported) by biological measures. The major biological soil and water conservation measures implemented in mariamshewito watershed are compost making, vegetative fencing, intercropping, crop rotation, strip cropping, grass strips along the contours, stabilization of physical structures and farm boundaries, fertilization(dissemination of chemical fertilizer), manuring, mulching, A forestation, area closure protection and plantation. Moreover, conserving and promoting of high yield local crop varieties, not only yield but also disease resistance, crop rotation, changing planting date and conserving indigenous forests species were implemented by the households in the study area to cope with climate change. Plantation of indigenous forest species is widely implemented in the study area.

The number of indigenous forest species planted in the study area were increased from 8,801 in 1996 to 344,451 in 2004 and 65% of the area closure was cover by forest (Natural resource development office, Adwa, 2014).

Similarly, the various water harvesting structures constructed at mariamshewito watershed are check dam, shallow well, Shallow excavation for household consumption, river diversion, motor pumping, tanker(vaska), percolation diet and spring development (see table 5).

Table5. Water harvesting structures in the study area

No	**Type of structure**	**No of structures**
1	Chek dam	24
2	Shallow well	430
3	River diversion	9
4	Motor pumping	60
5	Spring development	6
6	Vasca (Tanker)	2
7	Percolation diet (Horeye)	624

Source: Water resource development office, Adwa, 2014.

According to the data from the group discussants and interviewees, the above physical and biological soil and water conservation were implemented in private and communal land.

According to IPCC, 2001; IUCN, 2009; Kurukulasuriya and Mendelssohn 2008 as cited in Assefa, 2011, these above practices were considered as climate change adaptation mechanisms. Based on the data generated from the survey and different sources the local

communities, the watershed communities were implemented the above adaptation mechanisms.

Watershed management cannot be achieved without the willingness of local people to participate (Pretty and Ward, 2001 as cited in Tadesse). According to the group discussants, the households were participated in the planning and implementation of the conservation measures. They were contributing free labor yearly (20-40 days) on communal land management. In the survey, an effort was made to see the participation of households in soil and water conservation. According to the respondents, most of the households participate in the implementation of the above climate adaptation mechanisms.

According to the survey data, 78.8% and 60% of the households have been constructed soil bund and trace respectively. The stone bund reduces and stops the velocity of runoff and consequently reduces soil erosion and the steady decline in fertility and crop yields. They are semi- permeable structures unless sealed with soil in their upper side. They increase the moisture retention capacity of the soil profile and water availability to plants, and increase the efficiency of fertilizer applications if any.

Likewise, 65.9%, 76.5% and 72.6% of the households have implemented gully reshaping, hill side treatement and stone check dam. A stone check dam is a structure across the bottom of a gully or a small stream, which reduces the velocity of runoff and prevents the deepening and widening of the gully. Sediment accumulated behind a check dam could be planted with crops or trees/ shrubs grass and thus provide additional income to the farmer.

Moreover, 83.5%, 70.6% and 82.4% of the households adopted fuel saving stove, crop rotation, planting and protection of forest and establishment of vegetation barriers across the slope, prevent soil and moisture loss, improve soil properties and maintain/restore the productivity and stability of agro- ecosystem. And 56.5%, 35.3% and 83.5% of the households have implemented cut and carry system, grazing land rehabilitation, irrigation practices, using improved agricultural input, compost preparation and water development practices respectively.

These all indicates that most of the respondents implemented the adaptation mechanisms, especially construction of soil bund and stone trace, compost preparation, community forest protection from deforestation, using fertilizer and improved seed, implementing cut and carry system, gully reshaping and land rehabilitation were implementing more than other activities.

Next, the researcher needs to nullify the hypothesis that the implementations of climate change adaptation mechanisms within the different groups of the community, age, sex and wealth category.

Gender differential in implementation of climate change adaptation mechanisms have been investigated using the independent T-Test. The implementation status of the above-mentioned dependent variable by gender shows there is a significance difference between the two groups. The independent T-test indicated that, P=0.000(t=4.3-9.4, df=84) for all mentioned above variable has an implication of significance mean difference between the two groups.

Likewise, the analysis of the implementation of the above activities by different wealth groups indicates there is a significant difference among the wealth groups. It offered that most types of adaptation mechanisms were well implemented by the better off wealth categories. The statistical analysis of the one way ANOVA shows that p=0.000-0.041 (F=3.3-21.4, DF=2) for all performances. In addition, to this the post hock analysis of most activities shows the significance difference is existed between the poor and medium and poor and better off. However, no significance difference between medium and better off. This indicates the acceptance of null hypothesis that is adaptation mechanisms are more implemented by the better-off and medium groups than the poor with large proportion difference.

Moreover, the analysis of the implementation of the above activities by different age groups indicates that there is a significant difference among the Age groups except for crop rotation and check dam construction. The statistical analysis of the one way ANOVA shows that p=0.001-0.038 (F=3.4-7.56, DF=2) for all activities except for crop rotation p=0.106 (F=2.309, DF=2) and check dam construction p=0.124 (F=2.144, DF=2) which indicates insignificant difference. Besides, to this the post hock analysis of most activities showed that the significance difference was existed between the youngsters and Elders and Adult and Elders. However, no significance difference between Adult and youngsters. Adult and young households were more participated in the implementation than elder households.

From all the above discussion it could be concluded that, even though different management practices implemented in the study area all households were not equally

participated, especially women's and marginal farmers were less participant. This finding was consistent with study by Assefa (2011), find that there is a significant difference with in the different age, sex, education and wealth categories in the implementation of climate change adaptation mechanisms in Choke Mountain upper Muga watershed in East Gojjam of Ethiopia.

According to the respondents, the most important reason that some farmers did not implement SWC measures on their farmland is that they did not have adequate farm land. As survey result indicated that, an average land holding of the study area were 0.43ha which is too small. Likewise the women discussants revealed that they have no enough time to participate in the implementation of such intervention since they have a work load in their home and due to low economic performance.

Fig5. Household's participation in gully rehabilitation

Source:- Natural resource development, Adwa, 2014

However, according to the interviewees, household's participation in decision making was low. Most of the decisions in the watershed were made by the DAs which undermine the household's indigenous knowledge and experiences on natural resource management.

4.5. The Role of Watershed Approach for Climate variability and change Adaptation

Watershed management has been successfully used to bring back and preserve the agro-ecological feasibility and production potential of various watersheds throughout the world, using land-use management techniques that integrate across sectors and also address socio-economic concerns of local populations (FAO, 2006).

4.5.1. Impact on Crop Production

The opportunity for water harvesting, income generation opportunities from cash crops, bee-keeping, livestock fattening or dairy, access to road and other infrastructure are all depends on the watershed development as well as on the interactions between communities and the different levels of the watershed units. On the other hand, the vulnerability to climatic hazards and food insecurity is depending on the capacity of the watershed to support the local livelihood (MOARD, 2005).

Crop is the most important source of household income in the study area. The main crops in the study area were teff, barely, wheet, maize and millet. 60%, 20% and 20% of the respondents revealed that crop was contributed 60%, 50% and 40% of their incomes respectively. This indicates that most of the households were dependant on crop production as primary source of their income. Due to the different watershed

interventions the productivity of most of the crops were increased and in turn increased the household's income (see table 7).

Table6. Status of Crop production and income of sample households before and after watershed management

Before watershed management (1987)			**After watershed management(2005)**		
Crops	Average production in tone per year	Average Income	Crops	Average production in tone per year	Average income
Teff	0.08	1160	Teff	0.15	2175
Wheet	0.15	1200	Wheet	o.297	2376
Maize	0.10	570	Maize	0.05	285
Mustard(dagusha)	0.05	410	Mustard (dagusha)	0.075	615
Barly	0.025	250	Barly	0.045	450
Millet	-		Millet	0.055	412.5
Vegetable	-	400	Vegetables	-	1000
Total		3990		-	7313.5

Source: - survey, 2014

Note: - In all cases income is calculated by current price to avoid inflation effect.

These data clearly shows that crop production were much higher after the intervention compared to before the intervention in the study area and average income of sampled households from crop production increased from 3990 to 7313.5 birr. According to the

group discussants and interviews, the increasing in crop production and income were attributed to the watershed management activities like physical soil and water conservation which contributes to increased surface and ground water availability, improved crop management practices like integrated nutrient and water management, integrated pest management and improved crop varieties adopted by the farmers in the watershed.

Enhancing farm production through introduction of access to credit such as application of improved seed, fertilizers and other technologies was also the focuses of the watershed management. Access to credit reduces vulnerability by providing the poor with financial resources and opportunities for income-generating activities. Credit available is expected to ease possible capital constraints thereby encouraging the adoption of high yielding technologies which further increases the productivity of land and labor.

Credit enhance small household business start-ups and provide working capital, facilitate occupation shifts, reduce poverty, and provide insurance against bad times, increase the confidence of the poor (especially women), and empowering them to more effectively confront inequities. Similar literature stated that “Microcredit enables clients to protect, diversify and increase their income, as well as to accumulate assets, reducing their vulnerability to income and consumption shocks” (Robinson, 2002).

According to discussants and interviewees, household’s access to credit was increased in the study area, following the implementation of the watershed management and in turn increased the household’s livelihood. From the survey data, 87.1% of the households have access to credit. Comparability, percentages of households access to credit is higher

for better off which is 36.5%, medium 35.1% and the poor 28.4% of the respondents have an access to credit. Likewise, the percentage of male headed households is higher than female headed households which is 67% male and 33% female households have an access to credit. This indicates that male headed households have high access to credit than female headed households.

The poor, middle and better-off households were provided loans from 1200 to 5000 ETB which used for different purpose such as purchase of cattle, beehive and other business. The repayment period for loans is 1-5 years depending on the value of the package. All loans have a 9% interest rate and repayment begins one year after loan payout. Accordingly, sources of credit were both formal and informal institutions like: microfinance, NGO and informal lender like: Idir, Ikub, relatives and from better-off farmers.

According to the discussants and interviewees the factors that hinder households from getting credit are; low levels of income and asset accumulation, widespread poverty render poor rural households to a high risk profile which makes them less attractive to lenders, households have low assurance that the credit will be potentially profitable, if investment should turn out badly it put up household to additional risk. Another significant factor playing a role in household credit accessibility is the differences in borrowing costs among various types of lenders. Informal money lenders are usually only concerned about their own interest and charge much higher interest rates; these discrepancies in costs strongly affect the willingness of the rural poor to seek loans from informal lenders. This is expected to increase the adaptive capacity of households.

In the study area, credit can provided also in terms of agricultural inputs such as improved seeds, fertilizers and water harvesting technologies like motor pumping.

The major improved seeds distributed in the study area were teff and wheet. The distribution of improved seeds in the study area were increased teff from 4 quintal in 1997 to 7.2 quintal in 2003 and wheet from 7 quintal in 1997 to 67 quintal in 2003 (table 8). This helped households to reduce drought impact since matured earlier.

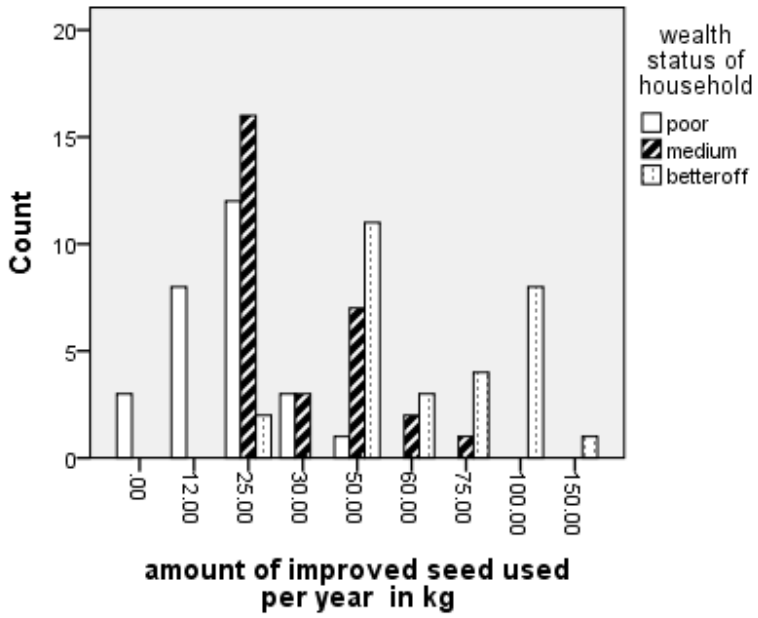
Table7. Distribution of improved seed in the study area, 1997-2003.

Year		**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Type of improved seed	Teff	4	7	5	9	9	8	7.2
	Wheet	7	11	16	15	30	28	67

Source: - Adwa agricultural office, 2014

The survey data indicates about 96.5% of the sampled farmers used improved seeds through the extension service system. Even if almost all households' used improved seed there were differences in the distribution between the different wealth status households. The mean amount of improved seed used by the poor, medium and better-off households were 19.85, 35.67, 70 kg/ year respectively.

Figure6. Distribution of improved seed among different wealth status



Source: - Survey result, 2014

The researcher nullified the hypothesis that, there is a difference in the distribution of improved seeds among the different wealth groups using one way ANOVA (see table 9).

Table8. ANOVA of improved seed distribution among households with different wealth status

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	37124.1	2	18562.0	47.9	.000
Within Groups	31747.6	82	387.166		
Total	68871.7	84			

Source: Own computation from household survey, 2014

The variation of mean within and between wealth status is statistically significant at, p=.000 (F=47.9, df =2). Given that, there is a general significant mean difference in

distribution of improved seed by wealth status. Thus, proceed and look to pair wise (Post Hoc) mean difference between dependent variable comparing to each wealth status (poor, medium and better off).

As given in table 10 a significant difference were obtained between all wealth groups, between better off and poor and better-off and medium (p= 0.000) also poor and medium (p=.003).

Table9. LSD Pair wise Post Hoc analysis of improved seed distribution as dependant variable and wealth status as independent variable

(I) wealth status of household	(J) wealth status of household	MD (I-J)	Std. Error	Sig.
Poor	medium	-15.83780*	5.26213	.003
	better-off	-50.14815*	5.26213	.000
Medium	poor	15.83780*	5.26213	.003
	better-off	-34.31034*	5.16731	.000
better-off	poor	50.14815*	5.26213	.000
	medium	34.31034*	5.16731	.000

Based on observed means,

The mean difference is significant at the .05 level.*

LSD =Fisher's Least Significant Difference MD(I-J)=Mean Difference of (I) and (J) wealth status

Source: Own computation from household survey, 2014

Likewise, there were also differences in the distribution of improved seed between the different gender groups. The mean amounts of fertilizer for male and female households were 47.74KG and 29.12KG respectively.

Similarly, the researcher nullified also the hypothesis that, there is a difference in the distribution of improved seeds among the different gender groups using independent T-Test (see table 11).

Table10. Independent T-Test analysis of improved seed distribution by Gender group

Improved seed distribution by Gender groups (male and female)		Levene's Test for Equality of Variances		T-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
amount of improved seed used per year in kg	Equal variances assumed	4.058	.047	2.880	82	.005	18.6259	6.46698
	Equal variances not assumed			3.310	68.13	.001	18.6259	5.62676

Source: Own computation from household survey, 2014

The independent T-test analysis revealed that the distribution of improved seed by gender have significance difference between the two groups and the independent T-test indicated that, P=0.047(t=2.88 df=82).

The FGD and interviewed farmers confirmed that the improved seeds used to escape from drought during the early session of rain fall since matured earlier.

Accordingly, before the watershed intervention, the household's agricultural production was poor due to erratic and unreliable rainfall and application of poor seeds. However, after the intervention, the farmers have overcome these challenges by producing food grains/vegetables more than once in a year due to increased water availability and its proper utilization of improved seeds.

Likewise, households access to fertilizer was increased which constitutes major elements of watershed management and sequentially increases in crop productivity. The major fertilizers distributed in the study area were dap and urea. The distribution of fertilizers in the study area were increased dap from 200KG in 1999 to 299.4KG in 2003 and urea from 220KG in 1999 to 336.4KG in 2003 (see table12).

Table11. Distribution of fertilizer in the study area, 1999-2003.

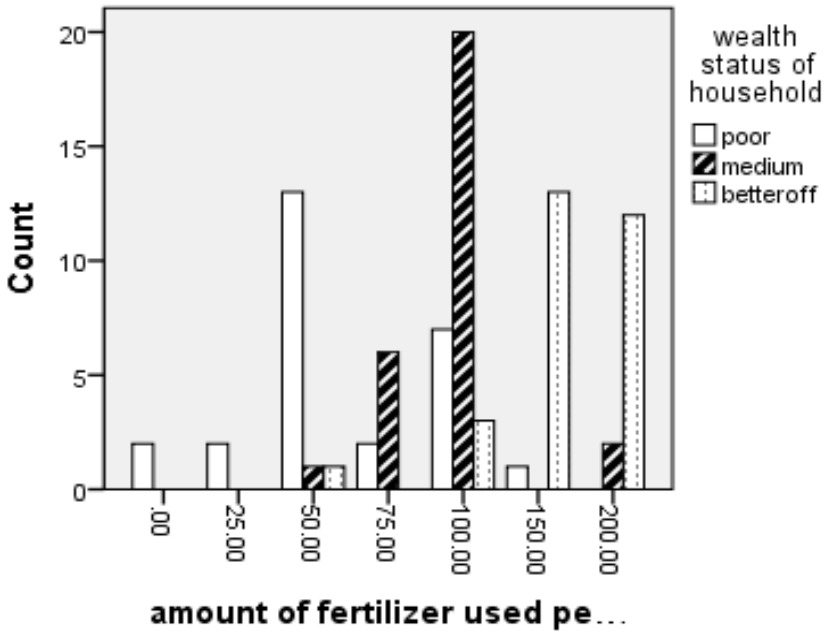
Year		**1999**	**2000**	**2001**	**2002**	**2003**
Type of fertilizer	dap	200	147	240	307	299.6
	urea	220	168	240	323	336.4
Total		420	315	480	630	636

Source: - Adwa Agricultural office, 2014

This indicates the distribution of fertilizer per year in the study area was in increased trend. This finding was consistent with the study by Umrani (1991) revealed that Fertilizer use has gone up and the cropping intensity has increased by 17 percent and area under horticultural plantation increased tremendously in Kolhewadi watershed area (Maharashtra).

About 98% of the sample farmers used fertilizer during the previous production year. Even though almost all households' used fertilizer there were differences in the distribution between the different wealth statuses. The mean amount of fertilizer used by the poor, medium and better-off households were 63, 100, 162 kg/ year respectively.

Figure7. Fertilizer distribution among the sample households with different wealth status



Source: - Survey result, 2012

The researcher nullified the hypothesis that, there is a difference in the distribution of fertilizer among the different wealth groups using one way ANOVA (see table 13).

Table12. ANOVA of fertilizer distribution among households with different wealth status

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	141231.763	2	70615.88	57.911	.000
Within Groups	99988.825	82	1219.376		
Total	241220.588	84			

Source: Own computation from household survey, 2014

The disparity of mean within and between wealth status is statistically significant at, p=.000 (F=57.9, df =2). This indicates an overall significant mean difference in distribution of fertilizer by wealth status. Therefore, continue and considering the pair wise (Post Hoc) mean difference between dependent variable contrasting to each wealth status (poor, medium and better off).

As given in table 4.10 a significant difference were obtained between all wealth groups, between better off and poor, better-off and medium and poor and medium (p= 0.000).

Table13. LSD Pair wise Post Hoc analysis of fertilizer distribution as dependant variable and wealth status as independent variable

(I) wealth status of household	**(J) wealth status of household**	**MD (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Poor	medium	-37.037*	9.338	.000	-55.6145	**-18.4596**
	Better-off	-99.1060*	9.338	.000	-117.6835	**-80.5285**
Medium	poor	37.0370*	9.338	.000	18.4596	**55.6145**
	Better-off	-62.0689*	9.170	.000	-80.3117	**-43.8263**
Better-off	poor	99.1060*	9.338	.000	80.5285	**117.6835**
	medium	62.0689*	9.170	.000	43.8263	**80.3117**

Based on observed means,

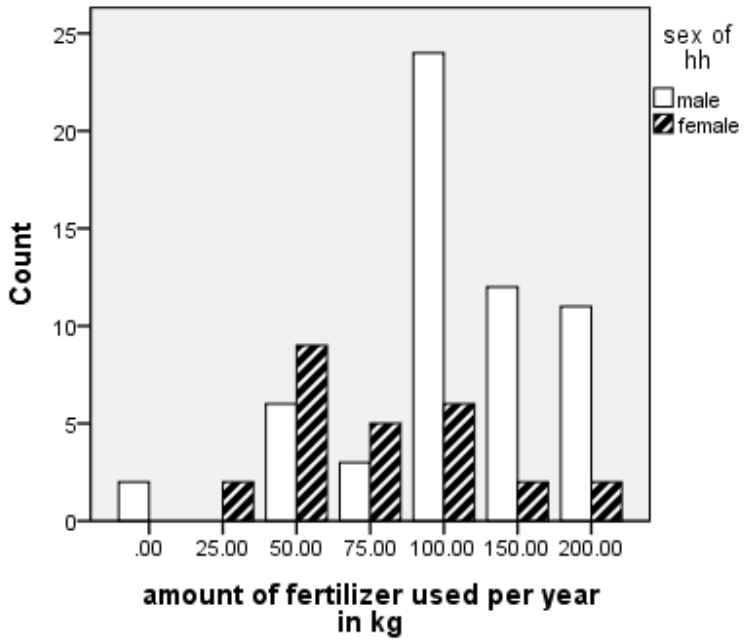
***. The mean difference is significant at the 0.05 level.**

LSD =**Fisher's Least Significant Difference MD(I-J)=Mean Difference of (I) and (J) wealth status**

Source: Own computation from household survey, 2014

There were also differences in the distribution of fertilizer between the different gender groups. The mean amounts of fertilizer for male and female households were 119.4 and 83.7 KG respectively.

Figure8. Fertilizer distribution among the sample households with different gender



Source: - Survey result, 2012

This indicates distribution of fertilizer was higher for male households than women households.

Likewise, the researcher nullified the hypothesis that, there is a difference in the distribution of fertilizer among the different gender groups using independent T-Test (see table 15).

Table14. Independent T-Test analysis of fertilizer distribution by Gender group

Fertilizer distribution by Gender group		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
amount of fertilizer used per year in kg	Equal variances assumed	1.237	.27	2.99	82	.004	35.7	11.9	11.98	59.50
	Equal variances not assumed			3.12	53.3	.003	35.7	11.5	12.75	58.73

Source: Own computation from household survey, 2014

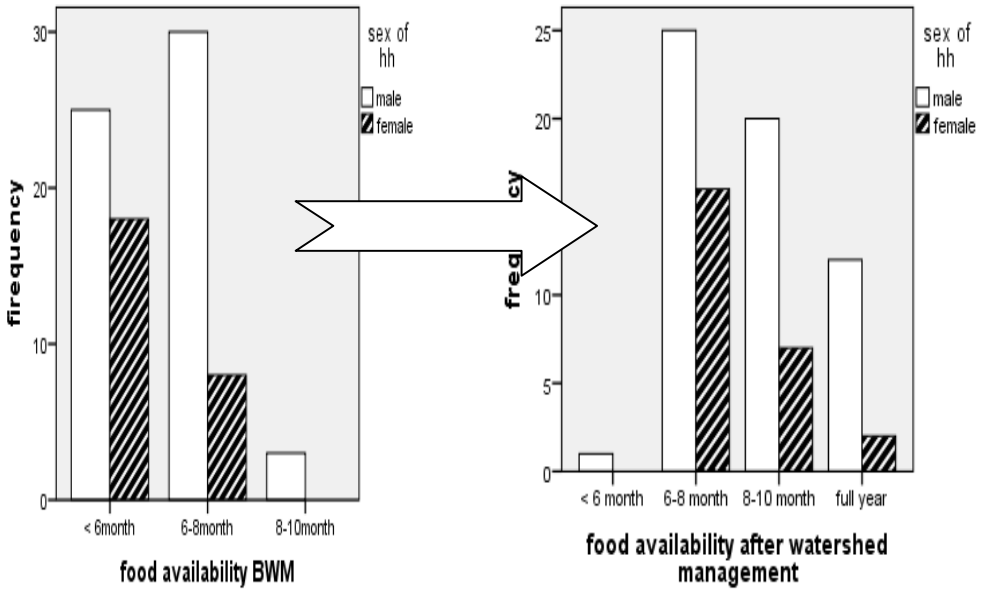
The independent T-test analysis revealed that the difference in distribution of fertilizer by gender was statistically not significance between the two groups and the independent T-test indicated that, P=0.269(t=2.99 df=82).

According to FGD and interviewees revealed that the participation of women's in all activities in the watershed due to their less economic performance. Even some of the poor women's have been sold the fertilizer and improved seed they borrowed for the better off farmers to use for consumption.

Likewise, food availability of the households was improved due to the different conservation measures and application of improved agricultural inputs. As the survey data revealed, before the intervention 38.8%, 44.7%, 5.88% of the households harvest was able to cover the household's food demand for < 6, 6-8, 8-10 months respectively. This indicates that more than 80% of the households were covered their food demand for less than 10 months from their harvest. As the data from the group discussants and interviewees, the remained food gap was supplemented by a combination of activities including food purchasing from the market or participation in government and non-government relief programs like Food for Work or Cash for Work and daily work.

However, after the intervention 3.5%, 48.2%, 31.8% and 28.2% of the households harvest was able to cover the household's food demand for < 6, 6-8, 8-10 months and full year respectively. This indicates that more than 60% of the households were covered their food demand for greater than 8 months from their harvesting.

Figer16. Food availability of sampled households before and after watershed management.



Source- household survey, 2014

The data from the discussants and interview supports the survey and added few ideas. Feeding capacity of almost all families was increased as a result of the different interventions. Before the interventions there were a sever hunger, most of the family were feed one injera for 5 to 6 family and also most of the family eat ones per day. But today, it is possible to say there is no hunger. Most of the family has feed more than 3 times per day due to the different interventions and risk reduction programs like productive safety net applied in the study area.

Table15. Paired sample T-Test on household's food availability before and after watershed management.

Food availability before and after watershed		Paired Differences			T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
Pair 1	food availability before and after watershed	-1.131	.617	.067	-16.810	83	.000

Source: Own computation from household survey, 2014

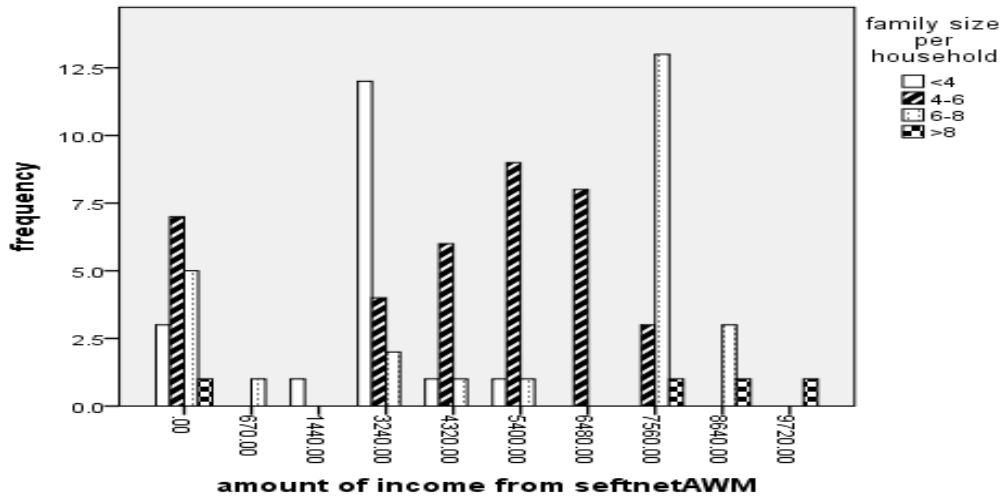
This indicates that the difference in food availability from harvesting before and after watershed management is significant (p=.000).

Productive Safety Net Program (PSNP) is a cash (food) transfer program aimed at alleviating household vulnerability to seasonal food insecurity consumption across the hunger period. It provides seasonal employment on public works in exchange for cash or food transfers to help protect household assets and smooth a shift away from emergency food aid toward a more predictable and targeted safety net.

Household's access to safety net was also widely implemented in the study area to cope with climatic hazards, following the implementation of the watershed management as incentive to introduce new technology. However, the incentive is continues for long time, which might be created dependency syndrome. From the survey data, 84% of the households have access to safety net. The distribution of safety net is depending on the

family size and wealth status of household. Comparability, percentages of male and female household's income from safety net is 4132.93 and 5358.49 ETB respectively. Likewise, the percentage of poor households involved in safety net is higher than medium and better off households since the objective is to help poor households. The poor people were used the income from safety net for consumption means to purchase food and cloth. While the medium and better off were used to start up new business and purchase agricultural inputs. The maximum family members involved in safety net were 9 (see Fig17).

Fig10. Sampled household's family size and income from safety net



Source: - Survey result, 2014

Households were graduated from the productive safety net program yearly based on the change in their economic performance. The criterions for graduation were based on the available livelihood resources of the household's crop, livestock (cattle, goat, and sheep) production, forest resource and other sources of income of the households. The mark

points for graduation were different with different areas depending on the resource availability of the area. The mark points for graduation in the study area were 5000birr.
The FGD and interviewees revealed that, the program has successfully offset households climatic risk impacts and provide households with contingency finance to cope climate-related risks.

The data from female and poor households revealed that the productive safety net was the main source of their income and if the productive safety net were phase out they are vulnerable. Accordingly, the poor and female households were used the income from safety net only for consumption.

From all these data, it is concluded that if incentives in the form of cash or grain is used strategically for limited time to introduce new technologies it might be sustainable, otherwise if it continues for long time it created dependency syndrome.

4.5.2. Impact in Livestock and Ruminant Production

Livestock is an integral part of the farming systems and they are particularly important for increasing the resilience of vulnerable poor people subjected to climatic and income shocks. This is possible through spreading risk and increasing assets. The loss of livestock, especially ox (bullock) is critical as it not only ruins the asset base, but also deprives the general productive capacity of the households.

Thus, the ownership of livestock is often used as an indicator for wealth and food security. The majority of sample households have different types of livestock. The major Livestock's in the study area includes cattle, sheep, goats, donkeys, horses and poultry.

Households' livestock ownership is measured by the average amount of Tropical Livestock Unit (TLU) (see table 17).

Table16. Distribution of the livestock population of sampled households

Before watershed management				After watershed management		
Livestock Species	No of livestock	TLU Conversion factor	Total TLU	No of livestock	TLU Conversion factor	Total TLU
Cow	85	1	85	76	1	76
Oxen	176	1	176	136	1	136
Sheep	300	0.13	39	248.3	0.13	32.28
Goats	270	0.13	35.1	189.93	0.13	24.7
Donkey	50	0.7	35	33	0.7	23
Horses	1	1.1	1.1	-	1.1	-
chicken	601	0.01	6	564	0.01	5.6
Total	-	-	377.2	-	-	297.58

Source: - Survey result, 2014

Watershed management has an impact on livestock size and type. From the survey, household size and type were decreased after watershed management. The total livestock of sampled households before and after intervention were 377.2 and 297.58 respectively. As the discussants and interviewees revealed, there were deceasing in livestock size and type due to food shortage as a result of the zero grazing. Almost all households have not own grazing land in the study area. The availability of communal grazing land after

watershed management was decreased. Even though carry and cut system were used it is not sufficient. Many animals were died due to food shortage. This indicates that the watershed management was negative impact in livestock size and type.

4.5.3. Impact on Water Availability and Qualities

The major impact of watershed interventions was seen in improving the surface and ground water availability. Increased water availability resulted in increased cropping intensity and diversification to more remunerative land use systems involving livestock, horticultural and vegetable production (ICRISAT, 2007).

According to the discussants and interviewees, the biological and physical soil and water management practices were great contribution to surface and ground water availability. There were problems of drinking water scarcity in the study area before watershed management. As a result, conflicts among the individuals were apparent for a long time in fetching water. Communities were also affected with water born diseases since they reliant on unimproved water sources such as ponds, small dugouts, streams and commonly shallow hand-dug wells. Moreover, peoples have walked too long distance to fetch drinking water since the unimproved supplies often fail in the dry season.

According to the data from surveyed households before the intervention 70% of the respondents have taken 50-60 minutes to fetch drinking water. On the other hand, 30% of the households were taken 20-30 minutes to fetch water. However, after the intervention 75% and 25% of the households have taken 10-15 minute and 20-25 minute to fetch drinking water respectively. Accordingly, the implementation of water harvesting structures were helped them to save their time and reduce their workload and water born

diseases. Similarly, it also revealed that the implementations of water harvesting structures were helped in sustaining ground water levels even in the years of shortage of rain. Most of the households affirmed that the 2006 production year was characterized by shortage of rain fall due to the late arrival and early cessation of rainfall. Rain was fall only one month in the whole year.

Likewise, revealed that before intervention most of the households used drinking water from unprotected springs and rivers. Nevertheless, almost all households used from protected sources like tap water and in turn increased the household's health after watershed management.

Irrigation together with adequate technological access makes households more resilient to climate change. According to group discussant and interviewee farmers, the implementation of soil conservation and water harvesting structures were significant contribution to increase access to irrigation. The irrigated land for vegetables doubled from 45 hectares to 524 hectares between 1997 and 2005 (See table 18).

Table17. Change in irrigated land size due to watershed management in mariamshewito

Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Irrigated land in hectar	45	48	60.75	117.5	131	335.75	501.75	521	524

Source: - Adwa water development office, 2014

The data from the survey revealed that 56.5% of the households were practiced irrigation. Irrigation and the introduced packages led farmers to grow diverse spices, crops (

like maize, and vegetables like cabbage, potatoes, onion and tomatoes during the dry season. Farmers' average income from this activity tripled from 400 ETB to 1,000 ETB. This is income in addition to their traditional rain-fed farming during the rainy season. This change was consistent with the study by Kapse and Shinde (1999) indicated that various treatments carried out in the Nannaj villages of north Solapur tahsil helped to bring remarkable changes in the household's livelihood. The proportion of area under irrigation was increased by two and half times as a result beneficiaries could diversify their crop activity which resulted in increase in high value crop including fruits and vegetables.

Fig11. An irrigated plot in mariamshewito watershed

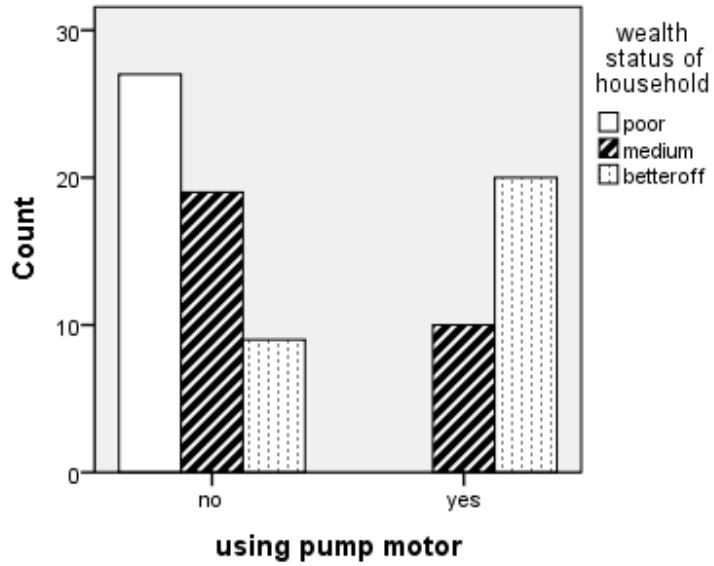
Source: - Field photo, 2014

Water sources used for irrigation purpose were shallow well, ponds, check dam, vaska, tanker, percolation diet and small streams privately and communally owned, which have not constant flow. The method of irrigation practiced by most of the farmers was shallow well by means of motor pumping to irrigate their plot and the water is distributed to the

users on a rotation basis. The households used to irrigate their parcel turn by turn in early morning after it collected tonight.

Besides, 64.7% of the households used water lifting technologies for irrigation like motor pumping, Cama, sanbardino, rovan, lawinton and cangaro. Water lifting technologies utilization is considered as an advantage to boost food security in the area. The youth now transferred into irrigation practice and they have motor pump through credit. The more the use of irrigation the more food secures likely and thus resilient households.

Figure12. Sampled household using pump motor for irrigation



Source: Survey result, 2014

According to the group discussants and interviewees, lack of natural rain fall and low economic status were constrained households from using motor pumping.

According to the group discussants, shortage of land due to population pressure, topography of land, water scarcity and poor resource base are the major factors affect

irrigation practice in the study area. Land available for irrigation is very small. Most of the households own less than 0.03 hectare of land which is too small for cereal crop production, for this reason most of the households were used to cultivate vegetables like; tomato, onion, pepper, potato, garlic, cabbage, etc used for home consumption and sold to local market. As researcher observed, small households have cultivated cereal crops through irrigation in the study area.

The result of interview done with households also supports the idea with few additional ideas; Topography and natural rain fall are the major factors affecting surface irrigation. The location and elevation of the water supply relative to the field is crucial in determining irrigation, unless the area is flat it irrigation is unlikely.

4.5.4. Impact on Employment Opportunity and Migration

The different watershed management practices were provokes households with different employment opportunity. The farmers in the watershed are well organized and increased working duration as far as they are confluent to get good return. Households involved in irrigation, trade and bee keeping activities and to start-up new businesses. Working culture of households has changed. For example, before the intervention households cultivate their land ones only before sowing but after intervention most of the households cultivating minimum 3 times before sowing as a result the impact of pesticide were reduced. The involvement of households in different activities reduced household's migration in the study area.

The relationship between watershed management and migration were complex. The implementation of watershed management can affect migration through an increase in short-term employment as well as long-term productivity gains. Due to the different activities in the watershed management migration was reduced in the study area.

Qeshi Teferi is a farmer in mariamshewito ‘tabia’ which were justified that there had been an overall decrease in migration. Before the watershed management, due to the different environmental hazards, there were large migrations from the area. According to his view, from all his ten family members, 6 of them are males and he leave the area with 5 of his boy children, and went to the western Tigray such as humera, dansha and Adwa town for 11 years to lead their livelihoods by engaging in daily laborer. But after the intervention migration was reduced and none of his family was migrated out due to livelihood diversification. He engaged in irrigation and bee keeping activities with his family and his livelihood were increased. This is consistent with the

Study by the Global theme on Agriculture, 2007, reported that watershed Management in Gokulpura-Goverdhanpura, india were enabled to achieved high success in reducing the seasonal migration rates by providing better employment opportunities to the farmers in the village itself with satisfactory remunerative work.

4.5.5. Impact in Social Interaction

Enhancing social network of households was also one of the main objectives of the watershed. The government introduced 1 to 5 household's network which have a great contribution to enhance household's social interaction and adoption of new technologies. This was worked on the assumption that if one farmer adopts a technology successfully, other farmers may learn the improvement from him/her, and share with others, thereby developing a multiplier effect Social network was from key farmers who acted as teachers or advisers to the other farmers. Likewise, the discussant and interviewees affirmed that this network improves household's participation in different activities by making competition each other.

Similarly, the female household discussants confirmed that the introduction of such networks provided us an opportunity to access information and exchange ideas and experience. Therefore, households and communities were better able to cope with climate hazards.

4.5.6. Impact on Livelihood Diversification

Surface and groundwater availability increased due to the various water storage structures and biological and physical soil conservation resulted in increased cropping intensity and helped households to find new ways to raise incomes and reduce environmental risk. The watershed management helped households to diversify their livelihood activity.

Income or livelihood diversity is important to cope with climatic risk. If one income source were lost then still have other sources of income which make households and communities better able to cope during hazards and therefore make them resilient (Adger, 1998).

Livelihood diversification index in this research is based on the Simpson index of diversity (Nicholas et al., 2006) modified by researcher in a way to fit for data available.

$SID = 1 - \sum_{n=1}^{n} Pi^2$ ~Where, Pi is proportionate contribution of i-th activity to income of household. In this research data available is regarding a number of livelihood activities that households practice. For this reason the proportionate is the inverse of the number of livelihood activities reported by a household heads.

$LDI = 1 - \frac{1}{\sum_{i=1}^{n} ki}$ LDI- Livelihood diversification index

Ki- is the number of livelihood activities practiced by household head

the value of LDI always falls between 0 and 1. As the number of livelihood activities increases, the inverse of livelihood activities practiced by households' decreases so that LDI approaches to 1. Accordingly, households with most diversified incomes

will have the largest diversification index, and the less diversified incomes are associated with the smallest index.

The livelihood diversity index for each household heads before and after watershed intervention is calculated to see the intervention effect. It indicates that livelihood diversification is the highest after watershed intervention than before.

Table18. Mean and Standard deviation of households' livelihood diversification before and after watershed management

Sex of household	Livelihood diversification before WM			Livelihood diversification after WM		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation
Male	.6629	59	.7573	.7573	59	.07448
Female	.6458	26	.7004	.7004	26	.09910
Total	.6576	85	.7399	.7399	85	.08631

Source: Own computation from household survey, 2014

The mean livelihood diversification of household heads before and after watershed management was 0.66 and 0.74 respectively. The researcher nullified the hypotheses that there is difference in livelihood diversification of households before and after watershed management using the paired sample T-Test.

Table19. Paired sample T-Test on livelihood diversification of sampled households before and after watershed management.

Crop diversification before and after WM	Mean	Std. Deviation	T	df	Sig (2-tailed)
	-.08224	.06992	-10.843	84	.000

Source: Own computation from household survey, 2014

The test result indicates that there is a significant difference in livelihood diversification of households before and after watershed management. The livelihood diversifications of household's were higher after watershed management than before the intervention.

According to the group discussants and interview, the different soil and water conservation practices were contributes farmers to engage in different activities such as bee-keeping, trade due the access of credit and irrigation etc. Accordingly, the changes in livelihood diversification were accredited to the soil and water conservation practices and application of improved agricultural inputs.

Even though there were improvements in livelihood diversification, it is different within the different wealth status. The researcher nullified the hypothesis that, there is a difference in livelihood diversification among the different wealth groups using one way ANOVA (see table.21)

Table20. One way ANOVA analysis of livelihood diversification by wealth status

Crop diversification before and after watershed management with different wealth status		Sum of Squares	Df	Mean Square	F	Sig.
crop diversification after watershed management	Between Groups	.247	2	.124	26.81	.000
	Within Groups	.378	82	.005		
	Total	.626	84			
crop diversification before WM	Between Groups	.440	2	.220	42.06	.000
	Within Groups	.429	82	.005		
	Total	.870	84			

Source: Own computation from household survey, 2014

The difference of mean before and after intervention between wealth status is statistically significant at, p=.000 (F=42.061, df =2) and p=.000(F=26.809, df=2) respectively. This indicates an overall significant mean difference in livelihood diversification by wealth status before and after intervention. Therefore, needs to look the pair wise (Post Hoc) mean difference between dependent variable contrasting to each wealth status (poor, medium and better off).

As given in table 4.10 a significant difference were obtained between all wealth groups, between better off and poor, better-off and medium(p= 0.000) and poor and medium (p= 0.001).

Table21. LSD Pair wise Post Hoc analysis livelihood diversification before and after intervention as dependant variable and wealth status as independent variable

Dependent Variable	(I) wealth status of household	(J) wealth status of household	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
crop diversification after watershed management	poor	medium	-.06536*	.01817	.001	-.1015	-.0292
		Better-off	-.13295*	.01817	.000	-.1691	-.0968
	medium	poor	.06536*	.01817	.001	.0292	.1015
		Better-off	-.06759*	.01784	.000	-.1031	-.0321
	Better-off	poor	.13295*	.01817	.000	.0968	.1691
		medium	.06759*	.01784	.000	.0321	.1031
crop diversification before WM	poor	medium	-.09802*	.01935	.000	-.1365	-.0595
		Better-off	-.17733*	.01935	.000	-.2158	-.1388
	medium	poor	.09802*	.01935	.000	.0595	.1365
		Better-off	-.07931*	.01900	.000	-.1171	-.0415
	Better-off	poor	.17733*	.01935	.000	.1388	.2158
		medium	.07931*	.01900	.000	.0415	.1171

*. The mean difference is significant at the 0.05 level.

Source: Own computation from household survey, 2014

Likewise, livelihood diversification was also different within the different gender households. The mean livelihood diversification for male and female households was .66 and .64 before intervention and .75 and .70 after intervention respectively. The livelihood diversification for male and female were increased by .9 and .6 respectively. The increasing in livelihood diversification was higher for male household heads than female household heads.

Likewise, the researcher nullified the hypothesis that, there is a difference in the livelihood diversification among the different gender groups using independent T-Test (see table23).

Table22. Independent T-Test analysis of fertilizer distribution by Gender group

Levene's Test for Equality of Variances between gender groups		T-test for Equality of Means								
		F	Sig.	t	df	Sig. (2-tailed	M D	SED	95% CID	
									Lower	Upper
crop diversification before WM	Equal variances assumed	.272	.603	.615	82	.540	.01475	.0239	-.033	.062
	Equal variances not assumed			.630	50.99	.531	.01475	.0234	-.032	.061
crop diversification after watershed management	Equal variances assumed	4.76	.032	2.91	82	.005	.05703	.0196	.0180	.096
	Equal variances not assumed			2.62	38.42	.013	.05703	.0217	.0129	.101

Source: Own computation from household survey, 2014

The independent T-test result shows that there is no significant difference in mean between the groups before intervention, p=.603. But difference is significant after intervention p=.032.

Therefore, even though the different watershed intervention enhanced the livelihood diversification of the household in the study area, but not all households were benefited equally, especially poor and female households were less beneficiaries of the watershed. This is consistent with the study by Assefa(2011) reported that poor and female

households in the Choke Mountain upper muga watershed in East Gojjam of Ethiopia were less participant and beneficiary of the watershed.

4.5.7. Impact on Female and Marginal Households

Enhancing female and marginal farmers were one of the objectives of watershed management. As discussed earlier the participation of female and marginal farmers in the implementation of climate change adaptation mechanisms and benefits from the different interventions were lower in the study area.

The discussion with the female households revealed that the main reason that female households were not participate well in the implementation of watershed were due to workload since they have internal (home) and external responsibilities and lower economic performance. Says that "**hade edi mis kilite edi maere kiserih aykielin**".

Similarly, as discussed earlier, female households and marginal farmers were lower access to Agricultural access like fertilizer, improved seeds and other technologies like motor pumping in the study area. The provisions of these agricultural inputs in the study area were not considered the poor and female households rather focus on the general household interest.

As discussants from poor households, revealed that the provisions of agricultural inputs were not consistent with the economic background of the households. For instant for the landless households forced to borrow bees or begait. So it is difficult to borrow begait for landless households due to zero grazing land. Instead, it is better when they provided with cash to introduce their own business.

Generally, the watershed performance in enhancing female and marginal farmer's livelihood were low even if some efforts were made.

4.6. Status of Climatic Hazards in the Watershed after Intervention

The data from the group discussion and interview indicates that due to the different interventions implemented, there had been improvements in resource management and utilization in the study area and in turn reduced the impacts of climatic hazards.

The survey indicates that 63.5% and 25.8%, of households consider drought as moderate and less severe in the study area after the intervention. Whereas, 5.5 and 5.2% of households as very severe and severe respectively. About 75.6% of households perceived the trend of drought decreased. Almost all households ranked the flood hazards after intervention as less severe and not severe and also perceived its trend as decreased almost all. 90% of respondents also perceive that the crop damage due to erratic rainfall is moderate to less severe. About frost and human disease about half of households reported as moderate and less severe.

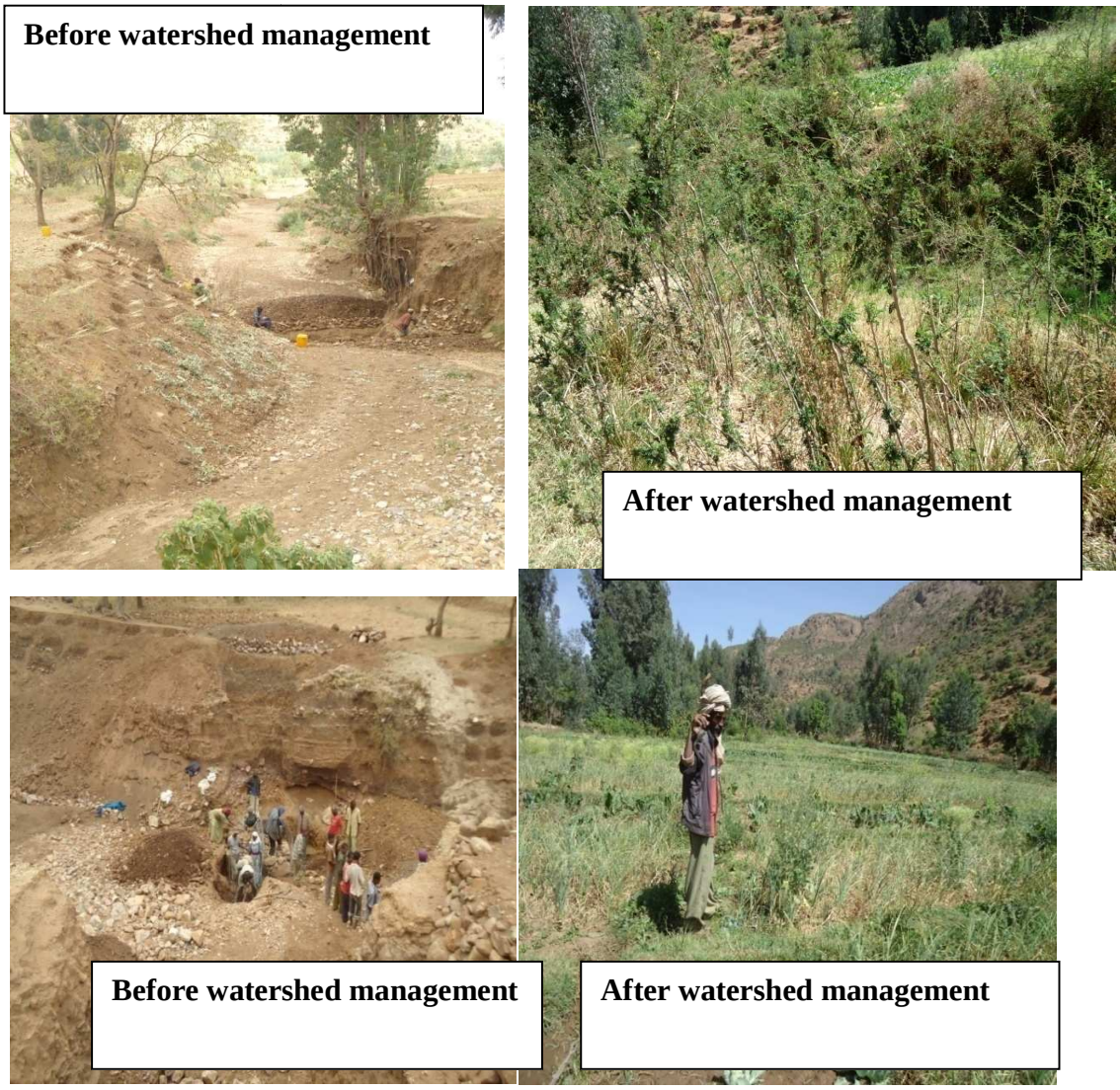
As indicated in the survey almost all households perceived the climatic hazards in the study area after intervention as moderate and less severe. As discussed earlier households perceived the impacts of climatic hazards before intervention as very sever and sever but after intervention seeming as moderate and less severe. From this it understood that the watershed management was great contribution to reduce impacts of climatic hazards.

Regarding to the status of main climate related hazards before and after the intervention was discussed by group discussants; all focus group discussions held assured that the

impacts of main climate related disasters occurring in the study area i.e, flood, drought due to longer dry spell, frost /cold/, hailstorm, land slide/erosion, rise in temperature, human and animal diseases, crop pests, flood were reduced due to the watershed interventions. This finding is consistent with Study by Assefa, (2011), reported that the status of climate hazards like flood, drought, frost, soil erosion and landslide in Choke Mountain in East Gojjam of Ethiopia were reduced and in decreasing trend due to the various watershed management practices.

The physical soil and water conservation techniques were a greater contribution to increase fertility of cultivating land and crop production. Moreover, Marginal gully were changed into productive land. From the total 29.5km tributaries in the watershed 17.1 km were treated and become source of forage and food for both animals and human.

Figer13. Gully area changed in to productive land in mariamshewito watershed



Source- NR development office,Adwa,2014 Source- Field photo, 2014

Soil conservation practices can be effective in offsetting soil erosion and increasing productivity by reducing nutrient losses and conserving moisture when appropriately implemented.

From all discussions so far, it is generalized that there has been a significant improvement in crop productivity, food availability, water status, livelihood

diversification, income, employment opportunity, social relationship, rehabilitation of degraded lands and reduction in migration and climatic hazards in the study area. These improvements were consistent with the Study for Ethiopia conducted by Assefa, (2011) examined the role of watershed management for climate change adaptation which were found that as a result of the watershed management livelihood resources especially; income, soil fertility, land productivity, forest, water and food supply become improved. These all developments enable households to cope with climate change impacts.

4.7. Challenges in the Watershed

According to the data from the group discussants and interviewees, the implementations of watershed management practices were faced with social, economic and natural limitations/ challenges. Accordingly, the major challenges in the watershed management were shortage of land, lack of awareness in resource management, disagreement between the households and local leaders, unwillingness of youngsters to participate in conservation practices due to landlessness, climate variability, lack of follow up, lack of knowledge and means of utilizing the available resource, water scarcity, low skill of using agricultural technologies and inputs, lack of integration between sectors.

A substantial proportion of farmers indicated that shortage of land is a major challenge in the area. Farmers were not volunteers to implement soil and water conservation in their farmland since their farmland size was too small. Likewise, the farmers were also not interested to adapt improved seeds and fertilizers. Suggest that the distribution of fertilizers were not matched to the land size of households and in turn affects productivity.

Similarly, climate variability is also a major challenge in the study area. Shortage of natural rain fall strongly affects the successes of watershed management practices. For instance, some of the shallow wells (water tabs) are dried during the dry season and non functional due to shortage of natural rain fall.

Another challenge in the implementation of the watershed was lack of awareness of households in the intervention. For instance, the community's were conflict with the guard hired to accessing the area closure. They tried to access the area closure at night time by hitting the guard. Trees planted in the area closure were cut illegally.

Similarly, lack of integration between sectors is also main challenge in watershed management. Sometimes programs are overlapped. Moreover, lack of technology, information and skills, infrastructure were also affects the watershed management implementation.

CHAPTER -5

CONCLUSION AND RECOMMONDATION

5.1. Conclusions

The focus of this research was to analyze the role of community based watershed management to climate change adaptation in Adwa wereda mariamshewito watershed utilizing the data collected from 85 households randomly selected from mariamshewito kebeles.

The government together with NGOs and local communities perform many activities in the study area to support the local communities to cope with climate change, such as; Physical soil and water conservation measures such as soil bund, deep trench, terraces, hill side terrace, check dams, and water diversions, compost preparation (organic fertilizer compost and manure), dissemination of chemical fertilizer, aforestation, area closure protection and management, water management (water harvesting and groundwater recharging structures such as check dam, Shallow excavation for house hold consumption and irrigation, percolation tank, spring development, irrigation practices, cut and carry system as discussed in the above. Moreover, conserving and promoting of high yield local crop varieties, not only yield but also disease resistance, crop rotation, changing planting date, conserving indigenous forests species and awareness rising to conserve natural resources.

Even though households were participated in the implementation of the various climate change adaptation mechanisms all households were not equally participated, especially

marginal and poor households were less participant. Moreover, households were less participant in decision making.

The different interventions enabled to improve crop production, food availability, water status, livelihood diversification, income, employment opportunity, rehabilitation of degraded lands and reduction in migration and climatic hazards and in turn improved household's resilience to climate change in the study area.

The impacts of main climate related disasters occurring in the study area i.e, drought due to longer dry spell, flood, frost /cold/, land slide/erosion, rise in temperature, human and animal diseases and crop pests were generalized as very severe and severe before the intervention and less severe and not severe after the intervention.

However, some gaps were observed in the watershed intervention such as lack of intention at the disadvantaged part of the community, especially youngsters, females and marginal farmers, interventions were in conflict with the household's livestock production, lack of follow up and collaboration between different sectors.

Likewise, in the implementation of such activities some challenges were facing such as shortage of land and natural rainfall, climate variability, lack of follow up, lack of knowledge and means of utilizing the available resource, water scarcity, and low skill of using agricultural technologies and inputs, lack of integration between sectors. Some of the adaptation strategies implemented particularly, using motor pump, fertilizer and improved seed may also cause mal-adaptation. Using motor pump may lead to water

shortage. At the same time, using fertilizer and improved seed may reduce the quality of water and soil.

5.2 Recommendations

Based on the finding of the study the following practical recommendations are pinpointed to overcome some of the constraints and maximize the benefits of the intervention following suggestions are provided on the basis of the finding.

- ☞ Since there had been many improvements in the livelihoods of the community as a result of the interventions, such interventions should be designed and promoted to other similar agro-ecological areas.
- ☞ The watershed interventions have in conflict with the household's livestock production due to the zero grazing many animals have died due to food shortage. Even though the cut and carry system were applied it is not sufficient to compensate the problem of food shortage. Hence, when land previously used for grazing is selected for re-vegetation or area closure, another alternative which can able to offset the problem should be developed.
- ☞ Marginal and female households' participation in the watershed management, access to different agricultural inputs as well as livelihood diversification was lower in the study area. Therefore, while watershed intervention implemented attention should be given to female and marginal farmers.
- ☞ Households' participation in decision making is low. So, it is better to consider households decision while making decisions, since they have indigenous knowledge and experiences of the area.

- ☞ Some of the adaptation strategies like using motor pump, fertilizer and improved seed may lead to mal-adaptation. Therefore, attention should be given to the appropriateness of the adaptation strategies to the area.
- ☞ Even though many interventions were implemented. Ones the interventions implemented cannot check whether these intervention are well functional or not, especially water harvesting structures. Many water harvesting structures (water tape) were poisoned and malfunctioned in the area which in turn affects the household's health. Therefore, investment in monitoring, follow up and impact assessment of such interventions should be necessary.
- ☞ The community's were conflict with the guard hired to accessing the area closure and tried to access the area at night time by hitting the guard. Trees planted in the area closure were cut illegally. Therefore, Community based training is required to sustainable watershed management to avoid future conflicts on resource utilization.
- ☞ In the study area there is no collaboration between the different sectors as a result overlap between programs were faced. Therefore, for sustainable watershed management there is a need to develop collaboration between sectors.
- ☞ Finally, although many interventions were implemented in the watershed, due to absence of baseline data it is difficult to depict the exact socio-economic and environmental effects of these activities. Therefore, training on documentation and proper management of data should be necessary.

Reference

Abebe Tadege (2007). *Climate Change National Adaptation Program of Action (NAPA) of Ethiopia.* Addis Ababa, Ethiopia.

Adger W. N., 1998. Observing Institutional Adaptation to Global Environmental Change: *Theory and Case Study from Vietnam.*Working Paper GEC 98-21. Centre for Socialand Economic Research on the Global Environment, University of East Anglia, Norwich, and University College London.

Adger, N., Huq, S., Brown, K., Conway, D., &Hulme, M., 2003. Adaptation to Climate Change in the Developing World.*Progress in Development Studies, 3(3), 179 - 195.*

Adger, W.N., Brooks, N., Bentham, G., Agnew, M. and Eriksen, S., 2004. '*New indicators of vulnerability and adaptive capacity', Tyndall Centre Technical Report 7*, Tyndall Centre for Climate Change Research Norwich, UK

Agrawal A., 2008. The role of local institutions in adaptation to climate change, World Bank, Washington, DC.

Agrawal A., 2008. The role of local institutions in adaptation to climate change, World Bank, Washington, DC

Ambaber CBO (Ambaber Community Based Organization). (2011). *Ambaber Community Based Organization Annual Report*. Shime Kebele: Ambaber, East Gojjam.

Andrew Thow and Mark de Blois, 2008. *Climate change and human vulnerability: Mapping emerging trend and risk hotspots for humanitarian actors:* Discussion paper. Geneva, Switzerland.

Assefa A.(2011). *Community Based Watershed Development for Climate Change Adaptation in Choke Mountain*: The Case of Upper Muga Watershed in East Gojjam of Ethiopia

Belay S. & Shibru T. (2007). *Improved Land Management Practices of Choke mountains to sustain Blue Nile Rivers:* A trans-boundary water management. Addis Ababa: ESAT, Ethiopia

CCF-E (Climate Change Forum for Environment), 2010. *Strengthening capacity for climate change adaptation in the Agricultural sector in Ethiopia.* Preceding from workshop in Nizrate.

Chambers,R., & Conway, G. (1992). *Sustainable Rural Livelihoods*: practical Concept for the 21^{s}. Centure. IDS Discussion paper296. Brighton: IDS,UK.

Conway, D., Mould, C., Bewket ,W., 2004. *Over one century of rainfall and temperature observations in Addis Ababa, Ethiopia. International Journal of Climatology*, 24 : 77–91. Addis Ababa, Ethiopia

Conway, D., 2002. *Extreme Rainfall Events and Lake Level Changes in East Africa : Recent events and historical precedents.* The East African great lakes: Limnology, palaeolimnology and biodiversity. Advances in global change research V. 12. Kluwer, Dordrecht. pp. 63-92.

Cutter S.L., Christopher T. E, Jennifer J. W, 2009. *Social Vulnerability to Climate Variability Hazards: A Review of the Literature,* Hazards and Vulnerability Research Institute, Department of Geography University of South Carolina, Columbia, SC 29208

Cutter S.L.,Boruff B.J.&Shirley W.L..2003. Social vulnerability to environmental hazards. *Social sciences quarterly 84(2):243-261.*

Daniel G Yirgaw, 2011.*Climate Variability in the drought prone regions of Afar and Amhara, Northern Ethiopia*.M.Sc Thesis presented toDepartment of Earth Sciences, University of Gothenburg, Sweden

Dessler, A.E. and Parson, E.A., 2006. *The science and politics of global climate change: a guide to the debate.* Cambridge University Press, UK.

DFID (Department for International Development). (1999). Sustainable Livelihoods Guidance Sheets. London: DFID,UK.

EARO (Ethiopian Agricultural Research Organization), 2013. *Present and future trends in natural resources management in agriculture*: Addis Ababa, Ethiopia.

FAO (Food and Agricultural Organization of the United Nation), 2003. *World agriculture: towards 2015, 2030 FAO perspectives,* Earthscan publication ltd, london, uk

Gebre Hadgu, Kindie Tesfaye , Girma Mamo and Belay Kassa(2013). *Trend and variability of rainfall in Tigray, Northern Ethiopia:* Analysis of meteorological data and farmers' perceptionHaramaya University, College Agriculture and Environmental Science.Dire Dawa, Ethiopia.

German, L. Hussein Mansoor, Getachew Alemu, Waga Mazengia, Tilahun Amede and Stroud, A. (2003). *Participatory Integrated Watershed Management* , Evolution of Concepts and Methods. Addis Ababa, Ethiopia

IFPRI(International Food Policy Research Institute), 2009. *Climate change: Impact on agriculture and costs of adaptation.* International Food Policy Research Institute Washington, D.C.

IGES (Institute for Global Environment Strategies). (2008). Sustainable Livelihood Based Water Management-"Watershed Plus" Approach. 1st Working Group Meeting of Eria Anindya Bhattacharya 31st July,2008,. Manila: IGES.

IPCC (Inter governmental Panel on Climate Change). (2007c). *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group 1 to The Fourth Assessment Report of the IPCC(Solomon,S.,D.Qin,M.Manning(eds)). Cambridge,UK: Cambridge University Press,.

IPCC (Intergovernmental Panel on Climate Change), *2007. Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, UK

IPCC (Intergovernmental Panel on Climate Change),, 2007. *Climate Change. The Physical Science Basis* Contribution of Work Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press. Cambridge, United Kingdom.

IPCC(Intergovernmental Panel on Climate Change),, 2001. *Impacts, Adaptation and Vulnerability,* Contribution of Working Group II of the intergovernmental Panel on Climate Change to the Third Assessment Report. Cambridge University Press, Cambridge, UK

Kerr, J., G. Pangare, and V.L. Pangare. 2002. Watershed development projects in India – an evaluation. IFPRI Research Report No. 127. IFPRI, Washington, DC, USA.

Kifle Woldearegay,(2012). *Cost and Benefit of Catchment Management and Regreening in Tigray*.Mekelle University, Ethiopia

Kaur (2013). Ethiopian green economy. Addis Ababa, Ethiopia.

McSweeney C., New M. and Lizcano G. (2008). *UNDP Climate Change Country Profiles of Ethiopia.* University of Oxford, UK.

MoARD (Ministry of Agriculture and Rural Development). (2001). *Soil and Water Conservation Manua*l, Guide Line for Ethiopia. Addis Ababa: Reviewed by Daniel et al MoA.

MOFD (Ministry of Finance and Economic Development), 2006. *Survey of the Ethiopian economy*. Addis Ababa, Ethiopia.

NAPA (National Adaptation Plan for Action). (2007). Climate Change NAPA of Ethiopia. Addis Ababa: MoWER and NMA, Ethiopia.

O'brien, K. L., & Leichenko, R. (2000). Double Exposure, Assessing the Impacts of Climate Change within The Context of Economic Globalization.

OECD (Origanization for Economic Cooperation and Development), 2010. *Climate Change and Agriculture: Impacts, Adaptation and Mitigation* , Paris: Trade and Agriculture Directorate, Environment Directorate.

Pathak P, Wani SP, Sudi R, Chourasia AK, Singh SN, Kesava Rao, AVR. 2007. *Rural Prosperity through Integrated Watershed Management*: A Case Study of Gokulpura-Goverdhanpura in Eastern Rajsathan. Global Theme on Agroecosystems Report no. 36.

PHE -E C. 2010. *Integrated Watershed Management On Gibe* - Omo Basin. Jimma University

Reid, R.K., and Y. Abebe (2003). *Community Based Watershed Management planning process at Yeku and Lenche Dima watersheds*. Internal report AMAREW project

Reij, C. and Waters-Bayer, A. (2001). *Entering Research and development in land husbandry through farmer innovation*. In Farmer Innovation in Africa. A source

of inspiration for Agricultural Development. Reij, C. and Waters-Bayer, A.(eds). Earthscan, London.3-22.

Salah Darghouth, Christopher Ward, Gretel Gambarelli, Erika Styger, and Julienne Roux . Watershed Management Approaches, Policies, and Operations: The World Bank, Washington, DC

Seleshi Y, Zanke U (2004). *Recent changes in rainfall and rainy days in Ethiopia*. Int. J. Climatol. 24:973–983

Shiferaw.A, 2013. *Integrated watershed management in river basins*.The Ethiopian herland, Addis Abeba , Ethiopia

Tagel Gebrehiwot and Veen, A. (2013) Assessing the evidence of climate variability in the northern part of Ethiopia. Enschede, the Netherlands.

Temesgen Deressa, Hassan, R. M., &Ringler, C., 2009. *Assessing Household Vulnerability to Climate Change.* The Case of Farmers in the Nile Basin of Ethiopia. *IFPRI Discussion Paper 00935.*Washington DC: International Food Policy Research Institute.

Temesgen Deressa, R. Hassan, & C. Ringler (2008). Measuring Ethiopian farmers' vulnerability to climate change across regional states. IFPRI Discussion Paper 00806, IFPRI (International Food Policy Research Institute), Washington DC.

Temesgen Tadesse (2009). *A Study on the Perception and Adaptation to Climate Change:* The Case of Farmers in the Nile Basin of Ethiopia. Centre for Environmental Economics and Policy for Africa (CEEPA), University of Pretoria, South Africa.

UNDP (United Nations Development Programme), 2007. *Climate change national adaptation programme of action (NAPA) of Ethiopia.* United Nations Development Programme

UNFCCC (United Nations Framework Convention on Climate Change), 2007. *Climate Change. Impacts, Vulnerabilities and Adaptation in Developing Countries.* FCCC/INFORMAL/84 GE.05-62220 (E) 200705.

Yohannes Gebremichael and Bayer Ann Waters (2007). Integrating environment and local development in Tigray region of Ethiopia. Iied, irrish Aid

Appendix A. Survey Questionnaire

Addis Ababa University

School of graduate studies

Department of Geography and Environmental Studies

This questionnaire is prepared for acquiring information to conduct research for partial fulfillment of Master of Arts in Geography and Environmental studies (Climate Change and Human adaptation). It has objectives; for assessing the role of watershed management to climate change adaptation and is going to be filled by sampled households reside in mariamshewito'tabia'. Significantly, it provoke local administrators, and the farmers of mariamshewito'tabia' to look for appropriate measures to meet and grasping all important area of concern in which peoples minimize the impact even eliminate the adverse effect of climate change and variability. The selection of participants is depending on random sampling not of any other personal reasons.

Respondent code:_____	Start time: ------- ----	Finishing time: -------- -------	Name of enumerator: ---------- -

Part I. Place

1.1.Zone: _____ Wereda/District_____

Kebele/Tabia: _____

1.2.Name of Watershed: _____

Part II. Socio-economic characteristics of household

2.1. Age of household head :_____(Years)

2.2. Gender of household head: Ma☐ Fema☐

2.3. Educational Status: Illiterat☐ can read and writ☐

Junior primary school ☐ High school and preparatory 9-☐

College Certificate and abo ☐

2.4. If you attended school, what is years of schooling_____

2.5. Family size:_____

2.7. Are you member of the watershed? Ye ☐ ☐

2.8. Doyou have your own farm land? Ye ☐ No ☐

If your answer is “Yes” answer question 2.8.

2.8.1. How much is the size of your farm land in timid/ hectar?

Before intervention (1997); _____

After intervention (2004/2005): _____

2.9. Do you have an access to Seftynet?

Before watershed management (1996/7); ye ☐ No ☐

After watershed management (2004/2005); ye ☐ No ☐

If your answer is “yes” how many people from your family are involved? How many kg annually or cash total are you got?

Before watershed management (1996/7); _____

After watershed management (2004/2005); _____

2.10. Would you have access to credit for your livelihood activities?

Before watershed management (1996/7); ye ☐ No ☐

After watershed management (2004/2005); ye ☐ No ☐

If your answer is “yes” what is the source of your credit? _____

Part III. Farmers view about climate changes and their adaptation mechanisms

3.1. How do you perceive the trends of the following climate elements when you compare with 30 years back?

No	Climate variables		Trend 1.very increased 2.increased 3.no change 4.decreased 5.very decreased				
			1	2	3	4	5
	Temperature	Hot days					
		Hot night					
		Hot season					
	Rain fall	Amount of RF					
		Intensity of RF					
		Erratic rain fall					
		Duration of RF					
	Wind	Strong wind					
		Drought					

3.2.How do you manage your private and communal lands (indigenous practices) before the intervention of watershed approach? What measures do you use?

3.3. What are the main climate change adaptation mechanisms implemented in the watershed?Are you participated in the adaptation mechanisms?

Implemented activities	**Response**		**Implemented activities**	**Response**	
	Yes	**No**		**Yes**	**No**
Construction of soil bund			Using fertilizer		
Irrigation			Crop rotation		

utilization					
Check dam construction			Construction of deep trenches		
Using improved seed			Plant community wood lot		
Using fuel saving stove			Participate in managing range lands		
Forest protection from deforestation			Gully reshaping practice		
Gully rehabilitation			Sowing grass		
Compost preparation			Grazing land rehabilitation		
Leveled land			Stone terrace		
Area closure			Live fence		
Water development			Cut and carry system		

3.3.1. Are you involved in sharecropping?

3.3.2. Do you use improved seed?

Before watershed management (1997); yes ☐ No ☐

After watershed management (2004/2005); yes ☐ No ☐

If your answer is “yes” How much in kg?

3.3.3. Do you use natural Fertilizer?

Before watershed management (1987); yes ☐ No ☐

After watershed management (2004/2005); yes ☐ No ☐

If your answer is “Yes” How much in kg?

Before intervention (1987); _____

After intervention (2004) ; _____

3.3.4.Do you use artificial Fertilizer?

Before watershed management (1996/7); yes ☐ No ☐

After watershed management (2004/2005); yes ☐ No ☐

If your answer is “yes” How much in kg annually?

Before intervention (1997); _____

After intervention (2004/2005): _____

Part4. Watershed impacts

4.1. What are the main sources of your livelihood? Specify in percent, in terms of their contribution to your household income?

Source of income	Before watershed management			After watershed management		
	Quantity	Percent (%)	Income Diversification	Quantity	Percent (%)	Income Diversification
Crop						
Livestock						
Vegetable						
Saftynet						
Daily work						
If any other specify						
Total						

4.2. What are the crops you cultivate? Indicate the type of crop you have cultivated during rainy/post rainy season and amount of land allocated for each crops cultivated?

	Before watershed management (1996/7)		After watershed management(2004/5)

o	Type of crop	Area coverage	Total production in KG(Qt)	Crop diversification	o	Type of crop	Area coverage	Total production in KG	Crop diversification

4.2.1. How many times you grow crops on your farm land every year?

Before WM_____

After WM_____

4.2.2. Are you use technology to increase crop production?

Before intervention: ye☐ n☐

After intervention: y☐ no☐

If your answer is yes, what are the technologies' used?

Before WM_____

After WM_____

4.2.3.For how long do you feed from your farm land?

Before WM_____

After WM_____

4.2.4. What is your total annual crop production?

Before WM_____

After WM_____

4.3. What are your main livestock possessions?

	Before watershed management (1996/7)				After watershed management(2004/5)		
	Type of livestock	No of livestock	Amount of income		Type of livestock	No of livestock	
1							
2							
3							
4							
5							
6							
7							

4.3.1. Are you participate in cut and carry system?

Before watershed management (1987/8); yes ☐ No ☐

After watershed management (2004/2005); yes ☐ No ☐

4.4.Are you participated in Bee keeping activities before / after the watershed? How much total income you earned from bee keeping in birr?

Before watershed intervention (1987/8)_____

After watershed intervention (2004/2005)_____

4.5. How much cash and food reserve you saved per year (birr)?

Before watershed management (before1987/8); _____

After watershed management (2004/2005); _____

4.6. How do you perceive water availability in your area before and after the watershed management?

4.7. How much time do you consume to fetch water?

Before WM_____

After WM_____

4.8. What are the Major Sources of your drinking water?

Before WM _____

After WM_____

4.9.Do you have irrigated land?

Before intervention (1997); yes ☐ No ☐

After intervention (2004/2005); yes ☐ No ☐

If “yes” how many hectare of your land is under irrigation?

Before intervention (1997); _____

After intervention (2004/2005): _____

4.10. Are you conflict with your neighbor?

Before watershed management yes ☐ no ☐

After watershed management yes ☐ no ☐

If your answer for Q4.11 is yes, what is the reason?_____

_____

_____

_____.

4.11.If you compare the situation before and after the watershed management, how was the impact of climatic hazards? Answer by ranking the severity of calamities in the table below and perceived trend.1. Very sever 2.Sever 3.Medium 4.Less sever 5.Very less sever

No.	Climatic hazards	Severity Ranking before WM					Severity Ranking After WM					Perceived trend after watershed management		
										4		Increa	Decr	S

												sing	easing	ame
4.12.1	Drought due to less rainfall during the rainy season													
4.12.2	Floods due to intense rainfall													
4.12.3	Crop damage due to rainfall variability													
4.12.4	Crop damage due to temprature variability													
4.12.5	Rise in temperatures													
4.12.6	Human diseases													
4.12.7	Animal or crop pests and diseases													
4.12.8	Frost													
4.12.9	Landslide													
4.12.10	Soil erosion													
4.12.11	Spreading of exotic weeds													
4.12.12	Others (specify and rank)__													

4.12. What changes do you observe on the plot level, soil fertility, Social relation (mahber, equib, one to five network of the gov't), communal grazing, access to fuel wood and irrigation after the watershed? _____

_____

_____

Appendix B, QESTIONS FOR INTERVIEW

1. How do you perceive the status and trends of temperature, rainfall and wind when you compare with 30 years back?
2. How do you manage your private and communal lands (indigenous practices) before the intervention of watershed approach? What measures do you use?
3. When the watershed management is started? By whom? Which were the implementing bodies? For what purpose do you use the watershed areas before 1963 and during Derg?
4. How do you manage your private and communal lands (indigenous practices) before the intervention of watershed approach?
5. What are the main adaptation options developed in the watershed to adapt climate change? What incentive does the government/non government use in the implementation? What are the reasons that some households were not participated in the watershed implementation?
6.
7. Either any change in your livestock and crop production size or type after the intervention?
8. What are the perceived or observed impacts of watershed management on the main sources of your livelihoods?

Crop production _____

_____.

Livestock size and type _____

__ _____

_____.

Water resource availability _____

_____

_____

_____.

Health _____

_____

_____.

Migration and Employment generation _____

_____

_____

_____.

Social linkage, _____

_____

_____.

Forest resource _____

_____

_____.

Annual income_____

_____

_____.

Annual production_____

_____

_____.

9. What was before and after the watershed (plot level, communal grazing, and access to fuel wood, access to improved agricultural input, irrigation and credit?
10. Indigenous practices and extension work in harmony and in conflict the farmers?
11. What are the main challenges in the watershed implementation?

Appendix C

Focus Group Discussion (FGD) Guiding questions

The followings are the series of questions used in focus group discussions

No	Discussion topics	Guiding questions
1	**climate change trend and variability**	How you perceive about the past and present climate trend and variability?
		How do you perceive the major climatic hazards (flood drought, human and animal disease, land slide and soil erosion etc.).
2	**Climate change adaptation mechanisms**	What are the major activities implemented in the watershed? Who are the implementers
		Do you think male households are more implementers of climate change adaptation mechanisms than female households? Why? Support your argument with reasons and with what you actually observed
		Do you think better-off households are more implementers of climate change adaptation mechanisms than poor households? Why? Support your argument with reasons and with what you actually observed?
3	**Impacts of the watershed**	What are the major contribution of the watershed to economic well being
		What are the major contribution of the watershed to health
		What are the major contribution of the watershed to environment

		What are the major contribution of the watershed to social relation, employment opportunity and migration?
4	**Challenges in the watershed management**	What are the major challenges you observed
		What are the solutions for such problems according to your opinion?

The NEXT appendices are important to clarify what's written in the main document.

Anex.1. maximum temperature data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	NA	NA	32.0	30.5	30.1	29.8	24.1	22.1	24.6	26.2	25.6	26.6
1993	26.2	26.9	29.5	28.2	29.2	29.0	26.1	25.0	26.5	28.2	27.8	28.0
1994	28.5	29.4	30.3	31.1	30.8	28.4	23.4	22.9	25.1	27.7	27.8	27.7
1995	28.0	29.1	29.6	30.5	30.6	30.5	24.0	23.7	26.1	28.3	28.5	27.7
1996	27.6	30.1	29.5	30.0	28.1	24.8	24.3	23.8	26.5	28.4	26.1	26.7
1997	27.8	29.2	30.0	29.4	NA	30.4	NA	NA	NA	NA	NA	NA
1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	31.4	30.6	23.5	NA	NA	NA	NA	NA
2000	NA	29.6	31.0	28.4	30.8	30.0	24.7	23.1	25.6	26.7	26.6	25.7
2001	26.4	29.2	29.0	31.2	31.6	27.4	24.0	23.3	26.4	27.8	25.8	26.2
2002	26.7	29.2	30.1	30.5	32.1	29.4	26.5	24.2	26.9	28.9	28.1	27.6
2003	28.3	30.1	31.5	31.8	32.4	29.5	24.1	23.5	25.9	27.7	27.6	27.3
2004	28.2	28.9	30.2	30.5	32.3	28.3	24.4	23.7	26.5	27.4	28.0	27.7
2005	27.5	30.8	30.5	30.3	30.4	29.2	24.2	24.3	26.1	27.9	27.3	27.0
2006	28.6	30.4	30.2	30.7	29.9	29.0	24.7	23.2	25.4	27.8	27.2	27.2
2007	27.6	29.6	31.3	30.1	31.3	27.6	24.0	24.4	25.5	27.4	27.1	27.0
2008	27.8	28.9	30.8	29.6	30.3	28.0	24.5	24.2	26.2	27.7	27.2	27.2
2009	28.1	29.9	31.2	31.2	31.6	30.7	24.3	24.3	27.5	28.6	28.8	28.1
2010	28.1	29.3	29.5	31.3	31.3	29.3	23.8	23.5	25.9	28.1	27.9	26.9
2011	27.6	29.7	29.1	31.4	30.2	29.1	33.3	23.8	25.6	27.7	27.6	27.8
2012	28.7	30.5	31.3	31.1	31.6	28.8	23.7	23.5	25.6	28.2	27.9	27.6

Anex.2. Rainfall data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	NA	NA	0	22.6	64	54.5	192	321.1	131.2	10.9	18	2.5
1993	3.4	2.7	42	68.1	61.2	42.2	199	176	130.3	32	0	0
1994	0	6	0	17	44.4	123	200	369.8	132.8	0	18	1
1995	0	0	30.7	31.8	79.5	39.6	213	233.7	174.2	8.5	0	11.2
1996	13.2	0	110	62.6	97	152	183	243.2	128.3	0	45	1.6
1997	0	0	27.3	0	76.6	88	186	152.4	NA	149	30	0
1998	0.8	0	13.5	3.1	46.2	104	387	360.8	121.5	17.5	0	0
1999	41.9	0	11.9	8.6	24.9	61.2	275	327.9	123.3	41.2	0	25.8
2000	0	0	1.7	91.3	29.5	33.1	183	215.9	114.3	86.1	22	9.5
2001	0	0	14.9	2.9	9.8	81.7	265	430.7	39.5	16.5	0	0
2002	0	1.5	17.3	10.8	0.9	51.7	132	236.1	80.8	5.7	0	1.1
2003	0	9.6	9.2	8.2	4.5	149	313	223.5	145	3.1	0.8	0
2004	20.8	8	0	24.4	0	105	222	272.7	24.7	24.2	1	0

2005	0	0	102	97.8	38.3	74.5	149	273	105.4	0.8	2.4	0
2006	0	0	16.9	34.6	50.8	106	191	341.9	85.2	27.7	2	6.5
2007	0.1	0	16.8	45.4	19.4	71	283	253.8	100.6	2.2	1.5	0
2008	31.8	0	0	37.7	37.5	81.5	203	172.7	91.4	2	14	0
2009	0	0.2	12	28	2.5	74.4	209	264.7	14.9	1.5	2.7	1
2010	0.9	0	17	13.5	11.2	89.7	265	244.9	251.9	12.1	0.2	0
2011	0	0	2.7	26.9	48.2	25.3	241	123.1	103.6	43	0	0
2012	0	0	0	4.3	17.3	111	183	335.7	136	32.1	61	0

Anex-3. X^2- test(Chi-Square Tests) result on farmers view on status of hot days

Age of hh * farmers view on status of hot days	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.639	4	.013
Likelihood Ratio	13.692	4	.008
Linear-by-Linear Association	7.094	1	.008
N of Valid Cases	85		

Anex-4. X^2- test (Chi-Square Tests) result on farmers view on status of hot season. Amount and intensity of RF

Age of hh * farmers view on statusof hot seasons	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.611[a]	4	.002
Likelihood Ratio	18.468	4	.001

Linear-by-Linear Association	12.838	1	.000
N of Valid Cases	85		
Age of hh * farmers view on amount of RF	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.462[a]	4	.076
Likelihood Ratio	8.157	4	.086
Linear-by-Linear Association	6.210	1	.013
N of Valid Cases	85		
Age of hh * farmers view on duration of RF	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.870[a]	4	.000
Likelihood Ratio	27.142	4	.000
Linear-by-Linear Association	22.076	1	.000
N of Valid Cases	85		
Age of hh * farmers view on wind strength	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.635[a]	6	.023
Likelihood Ratio	18.763	6	.005
Linear-by-Linear Association	2.964	1	.085
N of Valid Cases	85		

Anex-5. One Way ANOVA, on the implementation of households with different wealth status

		Sum of Squares	df	Mean Square	F	Sig.
construction of soil bund	Between Groups	.679	2	.340	2.044	.136
	Within Groups	13.463	81	.166		
	Total	14.143	83			
irrigation utilization	Between Groups	4.618	2	2.309	11.629	.000
	Within Groups	16.084	81	.199		
	Total	20.702	83			
using fuel saving stove	Between Groups	2.021	2	1.010	4.492	.014
	Within Groups	18.217	81	.225		
	Total	20.238	83			
crop rotation	Between Groups	5.019	2	2.509	14.551	.000
	Within Groups	13.969	81	.172		
	Total	18.988	83			
check dam construction	Between Groups	1.608	2	.804	4.776	.011
	Within Groups	13.631	81	.168		
	Total	15.238	83			
participate in planting forest	Between Groups	3.159	2	1.579	9.446	.000
	Within Groups	13.544	81	.167		
	Total	16.702	83			
participate in gually reshaping practice	Between Groups	1.126	2	.563	4.326	.016
	Within Groups	10.541	81	.130		
	Total	11.667	83			
participate in carry and cut	Between Groups	2.730	2	1.365	7.457	.001
	Within Groups	14.829	81	.183		
	Total	17.560	83			
grazing land rehabilitation	Between Groups	.565	2	.282	1.946	.149
	Within Groups	11.756	81	.145		
	Total	12.321	83			
participate forst protection	Between Groups	1.799	2	.900	4.889	.010

	Within Groups	14.903	81	.184		
	Total	16.702	83			
	Between Groups	2.832	2	1.416	12.087	.000
grass strip	Within Groups	9.489	81	.117		
	Total	12.321	83			
	Between Groups	6.674	2	3.337	21.950	.000
using pump motor	Within Groups	12.314	81	.152		
	Total	18.988	83			
	Between Groups	1.030	2	.515	3.181	.047
implemetation of stone trace	Within Groups	13.113	81	.162		
	Total	14.143	83			
	Between Groups	2.325	2	1.163	10.082	.000
compost preparation	Within Groups	9.341	81	.115		
	Total	11.667	83			
	Between Groups	2.325	2	1.163	10.082	.000
participate in water development practices	Within Groups	9.341	81	.115		
	Total	11.667	83			

Anex-6.Independent T-Test on the implementation of households with different wealth status

	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference

									Lower	Upper
construction of soil bund	Equal variances assumed	6.296	.014	1.355	81	.179	.132	.098	-.062	.326
	Equal variances not assumed			1.255	40.783	.217	.132	.105	-.081	.345
irrigation utilization	Equal variances assumed	.007	.934	2.653	81	.010	.303	.114	.076	.530
	Equal variances not assumed			2.645	48.168	.011	.303	.115	.073	.533
using fuel saving stove	Equal variances assumed	.101	.752	.166	81	.868	.020	.118	-.215	.254
	Equal variances not assumed			.165	47.727	.870	.020	.119	-.219	.258
crop rotation	Equal variances assumed	5.603	.020	4.302	81	.000	.443	.103	.238	.648
	Equal variances not assumed			4.043	42.060	.000	.443	.110	.222	.665
check dam construction	Equal variances assumed	26.301	.000	3.344	81	.001	.321	.096	.130	.512
	Equal variances not assumed			2.920	36.251	.006	.321	.110	.098	.544
participate in planting forest	Equal variances assumed	6.453	.013	1.480	81	.143	.157	.106	-.054	.367
	Equal variances not assumed			1.394	42.279	.171	.157	.112	-.070	.383
participate in gually reshaping practice	Equal variances assumed	3.820	.054	1.014	81	.313	.090	.089	-.087	.268
	Equal variances not assumed			.940	40.796	.353	.090	.096	-.104	.285

participate in carry and cut	Equal variances assumed	10.105	.002	2.186	81	.032	.233	.107	.021	.446
	Equal variances not assumed			2.041	41.462	.048	.233	.114	.003	.464
grazing land rehabilitation	Equal variances assumed	.132	.718	.183	81	.855	.017	.092	-.167	.200
	Equal variances not assumed			.180	46.520	.858	.017	.094	-.172	.206
participate forst protection	Equal variances assumed	6.453	.013	1.480	81	.143	.157	.106	-.054	.367
	Equal variances not assumed			1.394	42.279	.171	.157	.112	-.070	.383
grass strip	Equal variances assumed	14.868	.000	2.057	81	.043	.185	.090	.006	.364
	Equal variances not assumed			1.809	36.727	.079	.185	.102	-.022	.392
using pump motor	Equal variances assumed	20.662	.000	1.906	81	.060	.211	.111	-.009	.432
	Equal variances not assumed			2.060	58.957	.044	.211	.103	.006	.416
implemetation of stone trace	Equal variances assumed	.553	.459	-.363	81	.718	-.036	.099	-.232	.161
	Equal variances not assumed			-.370	50.885	.713	-.036	.097	-.230	.158
compost preparation	Equal variances assumed	10.001	.002	1.660	81	.101	.146	.088	-.029	.322
	Equal variances not assumed			1.480	37.710	.147	.146	.099	-.054	.347
participate in water	Equal variances assumed	3.820	.054	1.014	81	.313	.090	.089	-.087	.268

developmen t practices	Equal variances not assumed			.940	40.796	.353	.090	.096	-.104	.285