Analysis of Smallholder Farmers' Perceptions of Climate Change and Adaptation Strategies to Climate Change: The Case of Western Amhara Region, Ethiopia

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Declaration

I, Weldlul Ayalew Lemma, hereby declare that the dissertation, which I hereby submit for the degree of Doctor of Philosophy in Environmental Management at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution. I declare that the dissertation does not contain any written work presented by other persons whether written, pictures, graphs or data or any other information without acknowledging the source.

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Abstract

Ethiopia is an agrarian country dominated by subsistence farming which is highly vulnerable to climate change. This study was therefore carried out to assess smallholder farmers' perceptions of climate change and adaptation strategies followed to prevent vulnerability to climate change in the Medium and Upper highlands of the Amhara region of Ethiopia. Data was collected from 300 sample smallholder farmers using questionnaire, key informant interviews, and Focus Group discussions with farmers and experts. The survey result showed that households differ in terms of asset endowments, vulnerability, and coping and adaptation capability to climate change. About 87.3% noticed climatic change and their perception of climatic variable attributes indicated about 75% felt a decline in the amount of rainfall, 52.6% stated early onset, about 66.6 % showed late on set, 84% expressed poor distribution of rainfall, high temperature (83.7%) and desiccating wind (52.7%). The major adaptation strategies employed by the majority of small holder farmers included enhancing traditional irrigation, use of drought tolerant and early maturing varieties, converting farm land to tree growing and relay cropping immediately after harvesting. The coping strategies to climate variability are largely related to migrating to urban areas, engaging in daily work, selling of fuel wood and asset while mitigation measures have focused on ecosystem rehabilitation. "Multi Nominal Logit" (MNL) model analysis indicated gender, education, off farm activity, farm size, ownership of oxen, farmer to farmer extension, access to credit and information on climate change as determinants of adaptation to climate change and variability. Institutional support to farmers' efforts to adapt to climate change is generally weak. The overall analysis leads to conclude that despite the presence of awareness on climate change and its likely impacts on livelihoods of the smallholder farmer, development intervention at local level are not systematically designed to address the problems of the resource poor farmers and environmental challenges. In the immediate future there is an urgent need to capitalize on existing awareness, document, package and disseminate successful adaptation interventions to farmers. As a long term solution it is recommended that institutions in charge of climate change need to develop a national drought and climate change management strategic plan with full accountability to facilitate ecosystem development, resilience against climate change and ultimately improvements in the livelihood of farmers. Such interventions could potentially be achieved by taking practical measures on policy support and Institutional building for climate change, knowledge management on adaptation to climate change, filling technological gaps related to agriculture including livestock husbandry in the context of climate change, applying innovative local level participatory land use planning and promoting livelihood diversification initiatives that could enable small holder farmers create assets to enhance their livelihoods.

Key Words: Climate change, Climate Change Perception, Vulnerability to Climate Change, Coping and Adaptation to Climate Change, Climate Change mitigation, Climate Change Institutions.

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Abbreviations and Acronyms

ACCRA - Climate Change Resilience Alliance

AIACC - Climate Change Assessment in Africa

ANRS - Amhara National Regional State

BoFED - Bureau of Finance and Economic Development

BoA - Bureau of Agriculture

CARE - Africa Climate Change Resilience Alliance

CSA - Central Statistics Authority

DA - Development Agent

ECA - Economic Commission for Africa

EDHS - Ethiopia's Demographic and Health Survey

EDRI - Ethiopian Development Research Institute

EFAP - Ethiopian Forestry Action Programme

EPA - Environmental Protection Authority

EPACC - Ethiopia's Program of Adaptation to Climate Change

FAO - Food and Agriculture Organization (United Nations)

ICPAC - Climate Change and Human Development in Africa.

GEF - Global Environmental Facility

GHG - Green House Gas

GDP - Growth Domestic Product

ICRA - International Centre for development Oriented Research in Agriculture

IFPRI - International Food Policy Research Institute

IPCC - Intergovernmental Panel on Climate Change

KA - Kebele Administration

LDCs - Least Developed Countries

masl - meter above sea level

MEDaC - Ministry of Economic Development and Cooperation

MNL- Multi Nomial Logit

MoA - Ministry of Agriculture

MoEF - Ministry of Environment and Forest

MoFED - Ministry of Finance and Economic Development

MoA - Ministry of Agriculture

MoWR - Ministry of Water Resources

NAPA - National Action Plan for Adaptation

NGO - Non Governmental Organization

NMA - National Metrology Agency

NMA - National Metrology Agency NAPA-National Action Plan for Adaptation

NMSA - National Metrological Service Agency

PA - Peasant Association

RCS- Regional Conservation Strategy

SPSS - Statistical Package for Social Scientists

UNDP - United Nations Development Program

UNEPEI - Environment Initiative (PEI) Of the United Nations Program(UNDP) and the United Nations Environment Programmed (UNEP).

UNFCCC - United Nations Framework Convention for Climate Change

UN-ISDER - United Nations International Strategy for Disaster Reduction

USAID - United State Agency for International Development

WB - World Bank

WFP - World Food Program

WMO - World Meteorology Organization

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Ethiopia is a mountains country located in east Africa and situated between latitudes 4^0 and $15\ ^0$N and longitudes 32^0 and 48^0E (Friis *et al*., 2010). The country covers about 1.126 million Km^2 and has an estimated total population of more than 90 million (CIA-World Fact Book, 2015). The major physiographic features of the country are a massive highland complex of mountains and plateaus dissected by the Great Rift Valley and surrounded by low lands along the periphery. The diversity of the terrain is fundamental to regional variations in climate, natural vegetation, soil characteristics and settlement patterns.

In Ethiopia, areas with altitudes above 1500 meters above sea level (masl) are categorized as highlands and account about 37 % of the land area and over 90% of the country's economic activities (Friis *et al*., 2010). These areas are the source of water, crop production, animal feed and are dwelling places for humans. They accommodate about 90% the country's total population, over 95% of the regularly cultivated lands, and about 66% of the livestock population (Adugnaw, 2014). The economy of Ethiopia is highly dependent on agriculture, which accounts for around 41% of the GDP while industry accounts 13 %, and services about 46 % (MoFED, 2010). According to IFPRI (2008) and Deressa (2010) about 85 % of the population gains its livelihood directly or indirectly from agricultural sector while in urban areas the bulk of economic activity is in the informal sector.

The agricultural sector is predominantly in the hands of smallholder farmers which practice traditional farming system that is largely dependent on rainfall. Annual agricultural production shows variability due to wide variation of rainfall in magnitude and distribution both in space and time. Moreover, the agriculture in Ethiopia is practiced under the condition of diminishing farm size, high soil degradation, imperfect agricultural markets and poor infrastructure, absence of improved agricultural technologies, and lack of adequate financial services (Challa and Tolosa, 2012).

As a result, agricultural productivity in Ethiopia appears to be poor and highly susceptible to minor climate change or climatic variability and such occurrences have made the country vulnerable to famine and food insecurity. Rain failures have contributed to crop failures, reduction in crop and livestock yield, deaths of livestock, hunger and famines in the previous decades. Even relatively small incidents during the growing season, like too much or too little rain at the wrong times, can result in disasters (NMA, 2006). Small farmers and cattle herders, who are already struggling to cope with and manage the impacts of current climate variability and poverty, could face daunting tasks to adapt to future climate change. Over the years, recurring chronic food crisis and famine resulting from frequent droughts, environmental degradation and decline in food production had severely damaged the country's economy many times and still remain major challenges to the country (NMA, 2006; Aklilu and Alebachew, 2009).

Droughts and floods are very common phenomena in Ethiopia with significant events occurring every three to five years (NMA, 2006; World Bank, 2006). According to the same source the country has experienced at least five major national droughts since the 1980s, along with dozens of local droughts. The frequency of droughts and floods has increased in many parts of Ethiopia resulting in loss of lives and livelihoods (Mesfin, 1984). Other reports also indicate increasing trends in the incidence of meteorological drought episodes, food shortages and climate related human and crop diseases particularly in the northern highland and southern lowland regions of the country (World Bank, 2009; 2010; Aklilu and Alebachew, 2009; UN-ISDR, 2010). Climate change is expected to exacerbate the challenges of rainfall variability and the accompanying drought and flood disasters in Ethiopia (NMA, 2006).

Climate change is essentially a sustainable development issue that requires serious attention of governments. Key natural resources and ecological systems (e.g. forests, pastures, water bodies, wetlands and natural habitats), all of which are key to sustainable development, are susceptible to changes in climate and climate variability. EPSILON International (2011) argued that climate change represents an additional stress on the natural resource base of Ethiopia, which was already affected by growing resource demands, ineffective management practices and environmental degradation. These stresses are expected to reduce the ability of some environmental systems to provide, on a sustained basis, goods and services needed for effective economic and social development including adequate food and feed supply, decent health, water and energy supplies, employment opportunities and social advancement. It is well recognized that the most vulnerable and marginalized communities and groups are those who will experience the greatest impacts (IPCC, 2007), and are in the greatest need of support and adaptation strategies. In this regard the role of government and civil society is crucial for enabling efficient adaptation methods; and development policies and programs having synergy effect with climate change initiatives help adapt with the changing climate better (Nath and Behera (2011).

Farmers are key stakeholders in the issue of climate change, on the control and management of land and land based resources, particularly in the context of agriculture and related activities, forestry and grasslands, hydrology and water resources and human settlements. The land based resources are the primary sources and sinks of Green House Gases (GHGs) and are at the same time largely vulnerable to variations in climate parameters. Policies or strategies directed to bring about proper management of land resources are most likely to have direct effects on climate change. Indeed, an increased food demand, due to rapid population growth (Bielli, 2001) especially in the highland areas of Ethiopia, has exerted pressure on land resources and this calls for policies and strategies directed to facilitating practices that could enhance adaptation and mitigation to climate change effects.

According to NMA (2007) in recent years environment has become a key issue in Ethiopia. The main environmental problems in the country include deforestation and soil erosion leading to land degradation, loss of biodiversity, desertification, recurrent drought, and flood hazard and scarcity of water. The National Adaptation Program of Action (NAPA) is a mechanism within the United Nations Framework Convention for Climate Change (UNFCCC), designed to help the Least Developed Countries (LDCs) including Ethiopia to point out their urgent adaptation needs to climate change. Within the framework of the above, various studies and assessments have identified agriculture as one of the most vulnerable sectors that will be affected by climate change, and recommended that more systems be developed to match crop species and cultivars to environmental conditions, namely soils, climate and farming systems (Deressa, *et.al.*, 2008; GRN, 2002). This rational would however become more useful and tangible when complemented by local level studies that could generate empirical evidences that could be packaged and disseminated to potential stakeholders dealing with issues of climate change.

The agro-ecology of Ethiopia is diverse and includes arid, semiarid, sub-moist, moist, sub-humid, and humid and hyper-humid ecological setups (MoA, 2000). In these diverse agro-ecological settings, mean annual rainfall and temperature vary widely. Mean annual rainfall ranges from about 2,000 millimeters over some pocket areas in the south west to less than 250 millimeters in the Afar low lands and in the north east and in the Ogaden area in south-east. Mean annual temperatures also vary from about 10^0C over the high plateau lands of the north- west, central, and south-east to about 35^0C in the northeastern edges. Such climate variations associated with altitudes have substantial influence on agricultural development.

Understanding how and why farmers have responded to past climatic change is a necessary step to informing how to support current and future adaptation. In this regard Vincent (2007) pointed out that a vital starting point in evaluating adaptive capacity is to know how current changes in the climate are experienced, interpreted and responded to at the local level. Evaluating perception of and response to climate change includes exploring what these perceptions are, how they are formed and how perception affects response (Vedwan and Rhoades 2001). To facilitate further understanding of decision making on adaptation Broadhead and Howard (2009) underlined the significance of using accumulated local climate knowledge. Likewise Banjare (2015) acknowledging the vitality of enhancing policy towards tackling the challenges that climate change poses to farmers, stressed that it is important to have an understanding on their perceptions of climate change, potential adaptation measures and factors affecting adaptation. The same author also advised to make further examination the extent to which farmers' perceptions on climate change coincide with actual climatic data.

Rainfall being an important climatic element, the assessment of climatic variation and the consequent impact on farming systems is of paramount importance as information in this regard is scanty. Accordingly, this dissertation was profoundly designed to study linkages between perception on local climate change, adaptation and mitigation measures adopted by smallholder farmers in the Upper and Mid highlands of Western Amhara region of Ethiopia. Institutional issues at local and higher levels were a prime focus of the study to look into their impacts on the sustainability of development interventions in the context of climate change.

Taking note of the issues expressed in the preceding paragraphs the study has explored awareness and perception matters as related to climate change and the factors that affect farmers' choice for adaptation method for climate change and the barriers to adaptation as well as the methods used for mitigation measures.

1.2 Problem Statement

Ethiopia is an agrarian country which is challenged by both social and natural problems. The main social problem is poverty which is largely associated with high population growth, a low level of institutional and infrastructural development and a limited use of agricultural technology (Admassie and Adenew, 2007). Widespread land degradation associated with deforestation and soil erosion and loss of biodiversity coupled with climatic variability and recurrent drought in many places has severely damaged agricultural productivity and the livelihood of the farming community; and the cumulative effect has been manifested in food insecurity. In Ethiopia, the agriculture sector being predominantly dependent on rainfall the connection between drought and crop production failure is widely known. The available scientific evidences indicated that the climate of Ethiopia which has remained relatively static for years has now become very dynamic and unpredictable and has brought worst effects on the agriculture sector by affecting the two most important direct agricultural inputs, precipitation and temperature (Desehenes and Greenstone, 2006). Acknowledging the challenges arising as a result of erratic and variable rainfall and severe soil erosion due to torrential rainfall, continuous efforts are being made by the Ethiopian government to curb the challenges through environmental awareness campaigns and rural mass mobilization for soil and water conservation and tree planting programs. The vast majority of rural households however being illiterate or being less conscious on environmental variables, they tended to associate problems related to rainfall variability and drought as a curse or wrath of God. Moreover, although millions of farm households are mobilized to contribute free labor for soil and water conservation works every year there is no clear evidence showing that people are contributing their share because they were aware of environmental problems, including the problem of climate change, and feeling that they would achieve improvements in their livelihoods. Under these circumstances one can raise questions such as: To what extent do local communities in rural areas perceive that climate change and environmental degradation are largely human induced incidences? How do developmental organizations sensitize the local community to be guardian of the natural environment and enhance their livelihoods? One can argue that the level of awareness and perception matters on climate change at local level is still not definitely known; and how developmental organization organize their campaigns on environmental awareness seems not fully researched and hence demands a well-designed investigation.

Agriculture which is the dominant livelihood in most parts of the world is believed to be most sensitive to climate change impacts, and this equally applies to Ethiopia. As a response over the millennia, human societies worldwide have developed diverse and sophisticated strategies for adapting their cultural systems to climatic variability and the natural environment (Roncoli, 2006). This makes it imperative to understand the actual dynamics of climate change impacts at the lowest levels of society, such as farm households and communities (Deressa *et al.*, 2008). It is evident that adaptation mechanisms differ to the changing environment and climate. However, how individuals and communities living in different ecological settings formulated adaptation strategies at local level are not exhaustively studied and documented. The fact that the vast majority of the people in the study area and the country at large live in rural areas and urban economy is still not well developed, rural people have little option to migrate to urban areas looking for alternative livelihoods sources in times of climatic adversity. Hence, in reality rural people endeavor to adapt to the situation through indigenous knowledge and technologies and the social capital they have developed over the ages. As stated above, globally there are diverse climate change adaptation mechanisms documented and many of them provide insight on how to approach the problem in general terms. Using these highlights as an entry point it was of paramount significance to investigate the problem in specific socioeconomic settings with full involvement of the local community and the household. In a country like Ethiopia with high multicultural and ecological diversity one can expect local people to have developed their own indigenous adaptation mechanisms. These are however not fully explored and the knowledge base on factors governing farmers' decisions to adapt climate change and the impact of these decisions on crop yield and productivity of their livestock are not formulated in the specific context where this study was carried out. Developing the knowledge and the skill in these dimensions is particularly important for designing effective adaptation strategies to cope with the potential impacts of climate change as stated by Mahmud *et al.* (2008). In line with the above premise diverse and critical questions could be raised in the context of the study area, viz., how do rural communities cope with calamities associated with climate change? What local knowledge and social capital have rural communities developed to adapt to changing environment?

A further account on the issue of climate change shows that there is variation in vulnerability depending on location, adaptation capacity and other socio-economic and development factors (Collier *et al*., 2008; Tol and Yohe, 2007). It is therefore argued that research interventions to unveil climate change effects are particularly important for designing effective adaptation strategies to cope with the potential impacts of climate change (Mahmud *et al*, 2008). However, answers for questions such as ''how is the trend of climatic variability in the study area over the past decades? Which segment of the rural community is highly vulnerable to climate change? And, what influences adaptive capacity of smallholder farmers to climate change were still not elaborated. Although there are reports indicating the ill effects of climatic variability on the livelihood of the community in Western Amhara region of Ethiopia where this study was carried out, there is lack of research output and credible empirical evidence clearly depicting the trends of climate change or variability over the years and how local farmers are endeavoring to adapt to the situation. Generating baseline information on climatic variables in the study area helps to guide future adaptation practices; hence it seems imperative to understand the actual dynamics of climate change effects at the lowest levels of society, such as farm households and communities as clearly asserted by Deressa *et al*. (2008) and also identify the determinants of vulnerability and adaptive capacity to climate change as argued by Brooks, *et al.* (2005).

Recognizing that climate change is a serious national threat to the development of Ethiopia's economy, the Ethiopian government formulated a climate resilient green economy strategic framework to protect the country from adverse effects of climate change and to build a green economy. To this effect efforts were being exerted throughout the country including the study area to carry out natural resources development and environmental protection. However, questions such as ''what are the institutional arrangements, including laws and regulations put in place from top to bottom to provide effective and sustainable natural resources development guidance in the context of climate change?'' seem not yet addressed through research. The knowledge base on effectiveness and sustainability of natural resources development and environmental protection interventions by the government and other stakeholders was hardly researched in the context of climate change, institutional sustainability and rural livelihoods improvement in the study area and elsewhere.

In sum the critical investigations carried out in the framework of this study generated vital information that could be used as an input to enhance climate change adaptation, and sustain ecological stability and rural livelihood improvements.

1.3 Justification of Study

Ethiopia is one of the least developed countries in the world with a total population of over 90 million and its economy is largely dependent on agriculture. The farming system is dominated by small-scale mixed crop and livestock production and it is characterized by very low productivity. The sustainability of the country's economy is very much influenced by the productivity of its arable land, grazing and forestland resources and the hydrological systems. These resources are however highly degraded due to a number of anthropogenic and natural factors. The agricultural practice in the country is predominantly rain fed; irrigated agriculture is still at its infant stage. Any deviation from the normal rainfall pattern and amount is therefore a serious constraint to the agricultural economy, which supports the livelihood of the majority of the people (85%) in the country. Smallholder farmers who are the prime target group of this study are prone to risk of environmental calamities related to climate change and variability that severely affect crop productivity and livestock husbandry. To minimize risks associated with climatic variability/climate change appropriate adaptation practices have to be put in place. This can only be achieved through generation of empirical data and synthesis of information on climate related variables, rainfall patterns, and the resulting impact on farming systems, perception matters and rural livelihoods adaptation practices in diverse agro ecologies as presented in this study. The knowledge base in this regard is however lacking. The findings of this study will, therefore, serve as an input in the process of designing a climate resilient green economy that could enhance environmental stability, food security and poverty reduction. In explicit terms carrying out this the study helps to establish facts indicating level of awareness and perception matters as related to climate change and the factors that affect farmers' choice for adaptation method for climate change and the barriers to adaptation as well as the methods used for mitigation measures.

As stated above a high trend of human population growth in Ethiopia has led to a continuously increasing food demand. The dire need to satisfy the food demand forced the poor and the landless to encroach into fragile ecosystems and the heavy pressure exerted on almost all cultivated lands, without due consideration to conservation measures, led to severe land degradation and the problem has become rampant. In view of the sheer dependence of Ethiopia on rain fed agriculture, one can easily discern the potential danger associated with the incidence of climatic variability. The reality on the ground therefore calls for immediate actions that could curb the potential impacts of climate change on rural livelihoods and the environment. To this end development efforts should focus on contriving effective adaptation mechanisms to climate change and mitigation measures that could enhance smallholder farmers' livelihood and environmental productivity and this can largely be achieved through studies of this kind.

Experience to date showed that farmers naturally have indigenous knowledge and local coping strategies to problems associated with climatic shocks. The valuable practices developed by farmers can serve as a starting point for contriving adaptation and mitigation plans at household and community level. Despite the existence of diverse knowledge within the local communities on coping mechanisms for climatic variability and extreme weather events, there are no well documented and systematically synthesized climatic adaptation and mitigation mechanisms for the unpredictably changing climatic conditions, hence it seems of utmost importance to document and upgrade local knowledge through scientific research of this kind and disseminate or transfer the knowledge and skill gained to all stakeholders within and outside the country.

The findings in this study will also be beneficial to researchers and academics involved in climate linked research activities. Scientific publications that will be produced from the study will serve as vital instruments to initiate academic discourse among the research and academic community including students of higher learning institutions.

One of the most important gaps observed on policy makers is failure to make decisions based on empirical evidences generated through scientific research. The findings of this study will therefore be of vital importance to government and development partner institutions to carry out evidence based policy advocacy and public awareness on climate change adaptation and mitigation. More specifically the research output will equip policy makers with needed information for appropriate legislation regarding agriculture and climate change.

In sum, the aim of the study is to contribute knowledge about the influence of climate change in rural livelihoods and strategies adopted. Although the study focused on specific areas of West Amhara region of Ethiopia, the results of this study will be relevant and helpful to many areas of the country as well as other countries with similar climatic and socio-economic settings. Essentially the research is important because understanding of the trend of current climate change, its impacts on livelihoods, current response strategies and identification of vulnerabilities and stressors help to predict the likely future changes, impacts, coping strategies and social vulnerability. Furthermore it can also provide input to efforts to formulate policy, programs and activities that could accelerate adaptation strategies at household and community level. The study can also serve as baseline information for further studies especially about community perception on climate change impacts and response strategies. It may also add knowledge to the scientific world through publications. In explicit terms examining the current influence of climate change impacts and internal and external responses and predicting future adaptive capacity and constraints of the communities lays a good foundation to clearly map the communities' ability to cope with climate change and to enhance the viability of internal and external agency development interventions.

1.4 General Objectives

The general objective of the study was to assess climate change trends and small holder farmers and development institutions perception of climate change and also investigate adaptation strategies and mitigation measures practiced by smallholder farmers and the community in Western Amhara Region of Ethiopia.

1.4.1. Specific objectives

- To assess smallholder framers, local community and development institutions perceptions on the trends of climate change in the study area.
- To identify the major variables indicating the occurrence of climate change in the study area and analyzing climate change trends using climatic data (rainfall, temperature,) in the study area.
- To identify the impacts of climate change on smallholder farmers livelihoods and natural resources (water, grazing land and woodland) utilization.
- To investigate local and introduced adaptation mechanisms and coping strategies to climate change adopted by farm households and the community and the challenges encountered to do so.
- To examine the mitigation measures taken by the local community to avert problems arising due to climate change.
- To assess institutional arrangements (both at grass root level and at higher levels)

put in place to prevent climatic shocks in the study area and review their impacts on sustainability of development interventions aimed to minimize climate change impacts in the study area.

1.4.2. Major Research Questions

- How do smallholder farmers, local communities and development institutions perceive climate change?
- What are the major variables indicating the occurrence of climate change in the study area?
- How do changes in climatic variables affect the livelihoods of the rural households, the community and natural resources (forest, soil and water)?
- What are the response/adoption strategies to climatic shocks designed by smallholder farmers, the community and government and how effective are they from sustainability point of view?
- What are the mitigation measures taken by local community to avert problems arising due to climate change?
- How effective are institutional arrangements put in place to avert climatic shocks and ensure the sustainability of development interventions in the study area.

1.5 Research hypothesis

Assuming that there are a number of interacting internal and external factors influencing smallholder farmers' perception of climate change and adaptation to climate change the research hypotheses were stated as follows.

- There is a well-established perception on climate change within farmers, community groups and development institutions.
- The farmers in the highlands of Ethiopia particularly in East and West Gojjam are vulnerable to the negative impacts of climate change.
- The degree of vulnerability of farmers to climate change varies across different farm household characteristics and agro-ecological settings.
- Choice of farmers' adaptation strategy to climate change varies across agro ecology and asset endowment of farmers.

- Access to basic economic infrastructure, functioning social institutions, farm assets and technology are critical factors for enhancing farmers' adaptive capacity and reduce vulnerability to climatic risks.
- Local level institutional arrangements in the study area are structured to effectively to avert climate shocks and enhance sustainable development.

1.6 Scope and Limitations of the Study

As indicated in section 1.4 this study aimed to investigate climate change impacts and adaptation strategies adopted by smallholder farmers, the community, and also assessed external agency interventions in handling climate change impacts in the mid and high latitude agro ecological zones. To this effect, a wide range of data as related to farm households' demographic characteristics, asset endowments, farming practices, land use and institutional issues, coping and adaptation matters as well as weather variables indicating climate change and its trends were secured from relevant sources using different data collection tools. The analysis of the study largely focused on assessing climate perception, coping and adaption strategies followed at local level and also the institutional support provided. Much of the socioeconomic data was subject to descriptive and some relevant issues were treated with inferential statics.

Although efforts were made to secure data for most of the study variables, absence of well-organized meteorological data for quite long periods in many of the meteorological stations was a setback to provide a full account on climatic variability trends. Likewise plan to collect data on annual income of farm households for carrying out comparison of the outcomes of adaptation efforts could not be realized due to lack of recorded data at household level; hence only qualitative data was used for analysis. Poor documentation of the impact of development interventions on the livelihoods of smallholder farmers in the study sites hampered efforts to get a true picture of past and ongoing development initiatives and achievements made to date. To see the real effects of climatic variability it would have been better if the data collection had been carried out across seasons and repeated interactions with the local community. However, limitation in resources and time made it difficult to do so and much of the data was collected in a period covering part of the dry and wet seasons. Despite the limitations faced efforts were made to capture the data from different sources and triangulations were carried out to confirm and clarify the research issues; hence, the impact of the stated weaknesses on the conclusion made was minimized.

1.7 Organization of the Study

This study is structured to contain eight chapters supplemented with a list of references and appendices. In the first chapter, general background of the study, statement of the problem and objectives and significance of the study are presented, Chapter two presents review of related literature. Under this part basic concepts related to climate change and climatic variability, its impact on rural livelihoods and on the physical environment and adaptation strategies practiced by rural households are documented. The third chapter deals with description of the study area in the context of the research objectives to develop an understanding of socioeconomic characteristics of the rural community and also to have insight on the physical environment, the land use land cover, development interventions and the farming system. It also addresses the research design that guides the overall research activity and the research method that depicts the techniques and tools applied to collect data and the data analysis methods. The fourth chapter presents major findings and discussions on the demographic and other socioeconomic attributes of the sample respondents in the context of the study. Chapter five addresses perception of respondent farm households and experts of development institutions on climate change and climate variability and its impact on crop production and livestock husbandry. Chapter six provides results on climate change coping and adaptation strategies practiced by respondent smallholder farmers. Chapter seven demonstrates institutional arrangements put in place to enhance rural households' resilience against climatic shocks. Chapter eight is a synthesis chapter that integrates and discusses the major empirical findings of the study and ultimately outlines conclusions, recommendations and issues requiring further research.

1.8 Summary

The economy of Ethiopia is highly dependent on agriculture and the agricultural sector is predominantly in the hands of smallholder farmers who practice traditional farming system that is largely dependent on rainfall. Annual agricultural production shows variability due to wide variation of rainfall in magnitude and distribution both in space and time.

Moreover, agriculture in Ethiopia is practiced under the condition of diminishing farm size, high soil degradation, imperfect agricultural markets and poor infrastructure, absence of improved agricultural technologies, and inadequate financial services. As a result, agricultural productivity in Ethiopia appears to be poor and highly susceptible to minor climate change/climatic variability. Such incidents have made the country vulnerable to famine and food insecurity. Rain failures have contributed to crop failures, reduction in crop and livestock yield, deaths of livestock, hunger and famines in the past. These incidents are widely observed in the Amhara region where this study is carried out and demand designing strategies to avert the problems that would be encountered due to climatic shock. The climate change induced problems therefore led to raise research questions related to awareness on the cause of climatic change, how rural communities cope up with calamities associated with climate, what local knowledge and social capital rural communities have developed to adapt to changing environment, what trends are observed on climate variables, which segment of the rural community is highly vulnerable to climate change; what influences adaptive capacity of smallholder farmers to climate change and what institutional arrangements are put in place to enhance adaptation to climate change. The general objective of the study is therefore designed to assess climate change trends and small holder farmers and development institutions perception of climate change and also to investigate adaptation strategies and mitigation measures practiced by smallholder farmers and the community in western Amhara Region of Ethiopia.

In sum Chapter one provided and articulated the background and rationale of the study, the statement of the problem, and research questions and hypothesis to be addressed. It also included a conceptual framework that guides the overall research. The following chapter provides review of related literature to the research theme and establishes the theoretical and empirical foundations on concepts of climate change, impacts of climate change and coping and adaption strategies adopted by farmers. The theoretical and empirical elements in the literature review are used to make critical comparisons and discussions against the findings in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides the general background to the more specific literature covered in the result chapters that follow. The first part of the literature review provides an over view of the causes of climate change and variability, its adverse effects on socioeconomic development activities giving due focus on agriculture globally and to the African and Ethiopian context. This is followed by issues addressing perception on climate change and adaptation systems practiced globally. Issues indicating the relevance of sustainable land management and indigenous knowledge as related to climate change are also part of the review. The later sections dwell more on the Ethiopian context addressing issues related to agriculture and climate change, climate and weather systems, agro ecological features of the country, past and future trends of climate change in the country, climate risk management and coping mechanisms and finally on Ethiopia's response to climate change are reviewed.

2.2 Climate Change in the Global context

According to the definition of the Intergovernmental Panel on Climate Change (IPCC, 2007), climate change is ‘’*any change in climate over time, whether due to natural variability or as a result of human activity.*’’ IPCC (2014) has further given a more elaborated definition to climate change stating that climate change is "*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.*" Both definitions acknowledged that climate change is attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. Climate change also embraces the observed and projected rise in average global temperature, and the related impacts, including: an increase in severe weather incidents; glaciers and sea level rise, melting of icebergs, and changes in the timing and amount of rainfall (CARE, 2009).

Emissions of greenhouse gases, such as carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) that are warming the planet, affect the earth's climate. Most of the warming is driven by increasing atmospheric concentrations of CO_2 released by burning fossil fuels. There are also other Green House Gases (GHGs) which are entirely human-made and are identified as hydro fluorocarbons (HFCs) and per-fluorocarbons (PFCs). There is much information that suggests human activity is responsible for the high concentration of greenhouse gases and the associated changes in climate. In this respect, the IPCC Fourth Assessment Report (AR4) (IPCC, 2007) boldly states that global warming since 1750 is the net effect of human activity. Consequently most of the observed increases in globally-averaged temperatures since the mid-20th century are believed to be due to the observed increase in anthropogenic greenhouse gas concentrations. The rise in the greenhouse gases has induced a rise in the amount of heat in the atmosphere as the heat that would normally be emitted back in to space is trapped in the atmosphere. This increase in heat has led to the greenhouse effect, resulting in changes in the attributes of the climate.

Climate models are important tools to simulate a changing climate (IPCC, 2013). The model simulations are compared with observations focusing on the actual global temperature rise during the last century up to the present. The comparisons clearly show that the observed temperature warming trends can only be expounded when greenhouse gas emissions from human activities are included in the climate models (IPPC, 2013). According to the Intergovernmental Panel on Climate, temperature is likely to rise between 2°C to 4.5°C by 2100 showing a two-fold increment of the carbon dioxide in the atmosphere. For the continent of Africa, the warming in this century is likely to be greater than the global average (3°C) (ibid).

The main features of climate change are increases in average global temperature (global warming); in cloud cover change and the overall precipitation; in melting of ice caps and glaciers and in decreasing snow cover; and rising in the ocean's temperatures and acidity. Temperature increases drive other environmental changes in precipitation and atmospheric moisture. Changes in atmospheric circulation and increased evaporation and water vapor result high precipitation, strong storms and sea level rise. A rise in temperature could be accompanied by changes in climate. It is now clear that global warming is largely associated to man-induced emissions of greenhouse gases (mostly CO_2) (UNFCCC, 2007). Global warming is deeply changing the world's climate. For example in Africa, noticeable sign in the shrinking of the glaciers and snowcaps on Mount Kilimanjaro's ice has been observed since 1912; and with the current recession rate the majority of the remaining glaciers on Kilimanjaro is expected to vanish in the next decade (UNEP 2005a, cited in UNEP, 2012). Likewise the oceans have become warmer, having warmed 0.31^0C (0.56^0F) in the upper 300 meters (1,000 feet), 0.06^0C (0.11^0F) to a depth of 3,000 meters over the past 45 years (Rhein, *et al*., 2013). Climate change is also warming the oceans, with serious consequences on Africa. The effect of El Nino oscillations in the Pacific Ocean, which is now more intense and recurrent due to the global warming, translates into changes in rainfall patterns, floods and droughts in Africa. These days climate change, being a fundamental governance issue, appears to have predominantly concentrated on the development of global climate change regime agreements, the UNFCCC and the Kyoto Protocol, and the implementation of the values contained in them.

Although there is big global concern on climate change governance at the international level there is a tendency to overlook governance issues on climate change at national level. Few studies in developing countries have examined the role national governments can play in setting up of policies, institutions, plans and actions to promote mitigation, and adaptation to climate change; rather available studies indicate that such institutional issues have mostly addressed environmental governance of climate change in developed countries (Meadowcroft, 2009). Meadowcroft further argues that climate change governance requires governments to play an active role in initiating shifts in interest and perceptions so that stable societal majorities in favor of fostering a dynamic mitigation and adaptation policy regime can be maintained.

2.3 Adverse Effects of Climate Change in the African context

Climate change is expected to have adverse ecological, social and economic impacts. Climate change affects many institutions and productive sectors including agriculture, forestry, energy, and coastal zones, across the world. The economy of developing nations will be more affected by climate change, partly due to their greater exposure to climate shocks and also because of their limited adaptive capacity. However, no country is immune (World Bank, 2009) and of the developing countries, many in Africa are seen as being the most vulnerable to climate variability and change (ACCRA, 2011; Mahmud, *et al.*, 2008; Morton, 2007). Poor agricultural productivity is one of many factors driving vulnerability of developing countries. Climate change will create large incremental risks (UNDP, 2007) and a small incremental risk of more droughts can lead to large human development setbacks.

Studies indicate that Africa's agriculture is negatively affected by climate change (Pearce *et al*. 1996; Mertz *et al*., 2009); particularly sub-Saharan Africa is likely to face the most severe challenges on food security due to climate change and other pushing factors of global change (Easterling *et al*. 2007). Fischer *et al*. (2005) estimated that as a result of climate change, agricultural GDP in Africa is expected to fall between 2 to 8 percent. Many farmers in Africa are likely to experience net revenue losses as a result of climate change, particularly as a result of increased variability and extreme events. Dry land farmers, especially the poorest ones, are expected to be severely affected. Kurukulasuriya and Mendelsohn (2006a) estimated that a 10 percent rise in temperature will lead to visible loss net incomes that could be gained per hectare; that is on average 8.2 percent for rain fed production. On the other hand, irrigated farmers are likely to have better gains in productivity (as higher temperatures support yield increment in most of Africa as long as sufficient water is available). This suggests that irrigation might be an effective adaptation strategy.

During extreme El Niño years (drought years), productivity in southern Africa is expected to drop by 20 to 50 percent, and the most severe negative effect being on agricultural crops (Stige *et al*., 2006). According to the same authors crops and regions that are likely to be adversely affected from climate change include maize and wheat in Southern Africa, groundnuts in West Africa and wheat in the Sahel. Fischer *et al.* (2005) even suggest that by 2080 suitable land for wheat might completely disappear in Africa. However, these predictions do not take into account improvements in crop technologies and changes in farm management practices, and thus might overestimate adverse impacts. On the other hand, it is argued that these predictions are likely to underestimate the potential effects of extreme events, including storms, fires, and floods, and are not well suited to model on the long-term effect of droughts on river flows and groundwater availability.

According to Fischer *et al*. (2005), most climate model scenarios indicate that African countries in the sub-Sahara Africa including Ethiopia, Sudan, Nigeria, Senegal, Mali, Burkina Faso, Somalia, Ethiopia, Zimbabwe, Chad, Sierra Leone, Angola, Mozambique and Niger are likely to lose cereal production potential by the 2080s. These countries account for about 45 percent (87 million people) of the total number of undernourished people in sub- Sahara Africa (SSA). On the other hand, Zaire, Tanzania, Kenya, Uganda, Madagascar, Ivory Coast, Benin, Togo, Ghana and Guinea (accounting for 38 percent of the undernourished population in SSA) are projected to gain cereal-production potential by the 2080s (Fischer *et al*., 2005). The livelihood of the rural poor is likely to be disproportionately affected by climate change due to the limited capacity to withstand climate risk through using assets or accessing the financial market (Brown *et al.*, 2008). It is therefore vitally important to clearly identify the strengths and gaps of the resource poor segment of the community and avail the resources needed for adaptation measures to climate change.

Efforts geared towards adaptation to climate change follow a two-stage process (Apata, 2011; Maddison, 2006): first, the household must perceive that the climate is changing or not and then identify useful adaptation options and implement them. As the objectives of this study are partly coined to critically investigate these processes the following section provides insights on farmers' perception of and adaptation to climate change that are helpful for policy making.

2.4 Farmers' perception of climate change and adaptation

Farmers' perception of climate change governance and adaptation is pivotal for future plans aiming to deal with challenges arising as result of climate change. However, in many parts of the world climate change awareness, mitigation and adaptation mechanisms are marginally known. The spatial behavior and behavioral responses of individuals and communities are often shaped around their perceptions of problems (Getis *et al.*, 2000; Nzeadibe and Ajaero, 2010) and this urges scholars to investigate the problem of climate change in the context of particular socioeconomic settings.

Generally, studies on farmers' perception and/or adaptation to climate change have elicited significant research interest in Africa. In this regard Maddison (2006) notes that perception of climate change appears to hinge on farmers' accumulated experience and the provision of free extension service specifically related to climate change. In another study, Gbetibouo (2009) argued that farmers with access to extension services are likely to perceive changes in the climate because the extension support provides information about climate and the current weather. Consequently, awareness and perceptions of a problem shape motivation to act or not to act on the problem related to climate change (Speranza, *et al.*, 2009). It is noted that perceptions of risks by rural communities are also important in configuring the climate risk as it can shape the variety of adaptive actions taken.

Adaptation to climate change refers to adjustment in natural or human systems in response to real or predictable climatic inducements or their effects, which moderates harmful effects or make use of beneficial opportunities (IPCC, 2001). Historically, people whose livelihoods are dependent on agriculture have developed ways to cope with climate variability in their own way. For example farmers in Southern Ghana are adapting and coping with climate variability in various ways that are manifested by the diversity of resource management and cropping systems, which are based on indigenous knowledge of management of the fragile and variable environment, local genotypes of food crops, intercropping, and agroforestry systems. These coping mechanisms do not only help meet the farmers' subsistence needs but also encourage biodiversity conservation (Altieri and Koohafkan, 2008). The currently observed speed of climate change is likely to modify known variability patterns to the extent that people will be challenged with situations they are not equipped to handle (FAO, 2008).

Adaptation to climate is not an unusual phenomenon. Undeniably, throughout human history, societies have adapted to natural climate irregularities by changing settlement and agricultural activities and other facets of their economies and lifestyles. Human-triggered climate change lends a complex new facet to this long-standing challenge (Burton *et al.*, 2006). The multitude of climate stresses and other factors in Africa make adaptation not an option but a necessity (Thornton *et al*., 2006; AIACC, 2004). A growing number of studies are thus emerging on adaptation to climate variability and change in Africa. The strategies that farm households are currently adopting to acclimatize to changing levels of climate variability can be classified as follows (Agrawal, 2008):

a) *Agricultural techniques* to adapt to changes in rainfall regime (e.g. seed selection, modifying planting dates, fertilizer application, livestock feeding techniques, improve food storage facilities, change pastoral system);

b) *Water management techniques* to adapt to changes in rainfall regime (e.g. use of water harvesting techniques, rehabilitating terraces, improving irrigation techniques, developing watering sites in pastoral areas);

c) *Diversification techniques* aimed to diversify income sources (e.g. seasonal or permanent migration, use of different fuel wood sources, home-garden agroforestry, changes in consumption patterns or reductions in livestock herds); and

d). *Communal pooling techniques* that are geared to enhance reforestation, rangeland preservation, communal storage facilities for grain or developing rules for water management.

Likewise Bryceson's (2004) report showed that diversification of livelihood activities, institutional arrangements (including rules, regulations, and norms of governance), changes in farming practices, income generation projects and selling of labor and the moving towards off or non-farm livelihood incomes surface repeatedly as key adaptation options in many parts of Africa. It is however noted that adaptation is believed to be successful and sustainable when linked with effective governance systems (Brooks *et al*., 2005).

Developing approaches and methods for sharing of risks between countries will strengthen adaptation techniques and strategies, including management of disaster, risk communication, emergency evacuation, and collaborative water resource management. Many African countries are principally vulnerable to climate change because of low level adaptive capacity, due to extensive poverty, frequent droughts, unfair land distribution, and reliance on rain fed agriculture (MoA, 2011). Adaptation in general is one of the policy options for reducing the negative impact of climate variability and change (Adger *et al.*, 2003; Kurukulasuriya and Mendelsohn, 2006a) where consideration of alternative options have to be considered depending on the ecological and socioeconomic set up.

The role of migration as an adaptive action, principally as a response to drought and flood is well known. Recent evidence, however, shows that people's migration is not only driven by periodic climate stress; it is also driven by a number of other potential factors. Migration, be it seasonal or long term, is a critical source of income for livelihood and also a strategy and an option to climate change (Barett *et al.*, 2001). The remittances obtained from migration provide key coping mechanism in times of climatic adversity and other calamities (Devereux, 2001).

A detailed study of current crop selection as an adaptation strategy to climate change in Africa shows that in the cooler regions farmers select sorghum and maize-millet varieties; in the moderately warm regions maize-beans, maize-groundnut and maize are selected; and in the hot regions cowpea, cowpea-sorghum and millet-groundnut are selected (Kurukulasuriya and Mendelsohn, 2006). The study further showed that farmers choose sorghum and millet-groundnut when conditions are dry; cowpea, cowpea-sorghum, maize-millet and maize in medium-wet conditions, and maize-beans and maize groundnut when very wet. Following the rising temperature and increasing heat farmers incline to shift towards more heat-tolerant crops. In general, depending upon the availability or shortage of precipitation, farmers shift towards water loving or drought tolerant crops, respectively (Kurukulasuriya and Mendelsohn, 2006).

In Africa, biotechnology research also yields tremendous benefits leading to drought and pest resistant/tolerant crops such as rice, maize, millet, sorghum and cassava, among other crops (ECA, 2000; Hulme *et al*., 2002). In Egypt the yield of wheat cultivated under varying temperature (for example, increases of 1.5 and 3.6°C) brought to light a number of possible adaptation measures, including various technological options that may be required under irrigated agriculture system (Abou-Hadid, 2006).

The design and use of proactive rather than reactive strategies can also enhance adaptation. Proactive, *exante*, interventions, such as agricultural capital stock and extension service in Zimbabwe (Owens *et al*., 2003), is assumed to increase household welfare and heighten resilience during non-drought years. Access to capital and extension support can also increase net crop gains without crowding-out net private transfers. The other factors that could be studied to improve resilience to shocks such as droughts include: national grain reserves and future markets, weather insurance schemes, food price, cash transfers and school feeding schemes (Devereux *et al*., 2003). In sum knowledge of the adaptation methods and factors affecting farmers' choices enhances policies designed and directed toward solving the challenges that climate change is imposing on farmers.

The existence of functional institutional arrangements for climate change is critical for understanding and better informing policies and/or measures for enhanced resilience to climate change. This is because interventions linked to governance at various levels (state, region and local levels) are deemed to enhance or hinder adaptation capacity (Batterbury and Warren, 2001). Micro-financing and other social safety nets, as a means to speed up adaptation to current and future shocks and stresses, may be successful in overcoming such constraints if supported by local institutional set ups on a long-term basis (Ellis, 2003; Chigwada, 2005). To this end, countries liable to the ill effects of climate change need to focus on increasing adaptive capacity to climate variability and climate change over the long term. *Ad hoc* responses for example short-term responses, process lacking coordination, and isolated projects are merely one type of solution (Sachs, 2005).

Adaptation to climate change is very much influenced by adaptive capacity which is defined as "*the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change*" (Smith and Pilifosova, 2003). Adaptive capacity is based on access to diverse resources such as technology, knowledge, skills, stability and infrastructure; and stability and management capability (IPCC, 2011; Bohle *et al*.,1994). As related to community, adaptive capacity is determined by the socioeconomic characteristics of the communities and their capability in responding effectively. The capacity to adapt to climate change varies across regions, countries, and wealth groups and will differ over time. The most vulnerable regions and communities are those that are highly made vulnerable to the changes anticipated in the climate and have limited adaptive capacity. Countries with low economic resources, poor levels of technology, weak information and skills, poor infrastructure, unstable or weak institutions, and weak empowerment and limited access to resources have little capacity to adapt and are highly vulnerable (Below *et al.*, 2010; IPCC, 2001). Extensive reviews made by Below *et al*. (2010) and accounts of IPPC (2001) further underlined that adaptation depends significantly on the adaptive capacity or adaptability of an affected system, region or community to be able to cope effectively with the impacts and risks of climate change. Likewise CARE (2011) advocated the need for giving vulnerable people a voice in decision-making will ensure that adaptation initiatives are responsive to their needs, priorities and aspirations. This is critically important in the development of National Adaptation Plans if they are to be effective in reaching the most vulnerable populations with adequate and appropriate support.

The high vulnerability of people in developing countries particularly in Africa to climate variability and or change is ascribed largely to their low adaptive capacity, which results from deteriorating ecological resources, unequal land distribution, extensive poverty and high reliance on the natural resource base. Improving adaptive capacity is therefore important in order to reduce vulnerability to climate change (Elasha *et al.*, 2010). Similar views are expressed by Thomas and Twyman (2005) who contend that developing countries are generally considered most vulnerable to the effects of climate change than more developed countries, largely because of their often limited capacity to adapt.

The vulnerability of a system increases as adaptive capacity decreases, indicting an inverse relationship with each other. In most studies on adaptation to climate change scholars argue that human, social, physical natural and financial factors shape individuals, households and communities adaptive capability (Nardi, 2014; Temesgen *et al*, 2014; ILO, 2011; Ellis, 2003). Human aspect includes knowledge of climate risks, conservation agriculture skills, and good health to for productive labor. The social aspect refers to women's savings and loans groups, farmer-based organizations. Physical aspects include irrigation infrastructure, seed and grain storage facilities. Natural aspect includes reliable water source, productive land while the financial aspect include diversified income source. Where communities are well endowed with these resources it is likely that there is better adaptive capacity provided that other governance issues influencing adaptation are also made available.

Social networks increase awareness and use of adaptation options. Social capital as a public good can reduce transaction costs and enhances the exchange of resources and information between and among individuals and management units and also facilitates innovation and capacity to learn. In his analysis of ''*the role of social capital in building adaptive capacity to climate change*'' Berberyan, (undated) contended that social relationships on reciprocity, trust and cooperation form the core social capital. Adger (2003) also clearly demonstrated that social capital is a fundamental asset to building the adaptive capacity to climate change. More importantly he further elaborated that self-organized communities that effectively use their social networks become more sustainable, effective than those with adaptation mechanisms designed and impose by external entities. Networks of community groups, local savings schemes based on regular membership fees as useful financial stores drawn down during times of stress are also very important adaptation strategies (Ellis and Bahiigwa, 2003).

Ethiopia is highly vulnerable to climate change impacts because it is predominantly an agrarian country and agriculture is severely impacted by the changing climate. The country's geographical location and topography is also reported as a potential reason leading to high vulnerability to the impacts of climate change (World Bank, 2010). The recurrence of drought in Ethiopia has pushed many rural households in to poverty traps, including agro-pastoral and pastoral households, constantly hindering efforts to build up assets and increase income (UNDP, 2007). This implies that there is a serious need for contriving ways to adapting to the changing climate. However, adaptation to climate change or variability seems to be hindered by lack of adequate and timely information on climatic data as well as provision of technological packages.

In Ethiopia climate projections are hardly available or when such projections are available they are associated with a high degree of uncertainty, hence developing national as well as local level indicators of vulnerability and capacity to adapt to climate change is of paramount importance (Brooks *et al.*, 2005). In this regard Admassie and Adnew (2008) suggested that adaptation measures are better integrated into the country's development process to further mitigate the adverse effects of climate change. They further noted that as part of the development process, social and physical infrastructure are to be improved and institutions in charge of climate-related matters such as the meteorology agency need to be strengthened to increase the country's adaptive capacity. In addition, water resource development, land management, food security, health, and education are taken as the key development interventions being practiced to address the adverse climatic impacts. There is also a need to expand non-agricultural employment opportunities and provide skills training, particularly in rural areas.

In general as adaptation is a process, it is required that the ongoing learning, analysis, planning and adjustment should respond to an evolving context and changing risks. This again needs to be complemented by provision of appropriate, timely and locally relevant climate information such as weather forecasts, seasonal forecasts and early warnings for climate hazards that have to be made accessible to the people and institutions that need it, including the most vulnerable groups within communities.

2.5 Sustainable land management (SLM), cropping practices and adaptation to climate change

Sustainable land management (SLM) measures are among the important approaches that rural households can use to adapt to climate vulnerability and change. Ethiopia considers soil and water conservation techniques a key strategy to adapt to global warming (Deressa *et al*., 2008). SLM measures can also help to mitigate GHG emissions and climate change by sequestering carbon in the soil and vegetation, or by reducing emissions of carbon dioxide, nitrous oxide or methane caused by poor land management practices. However, climate change adaptation strategies that do not involve sustainable land management approaches, such as farm and grazing land expansion into forest areas or disproportionate agricultural input applications, including pesticides, might worsen land degradation and contribute to GHG emissions. For instance, in the Morogoro region of Tanzania, environmental degradation has increased as a result of farmers' responses to droughts and other environmental stresses, which had involved agricultural intensification and intensification, livelihood diversification and migration (Paavola, 2004, 2008). While these strategies were instrumental for farmers' survival, they had also contributed to increased deforestation, soil nutrient depletion, soil erosion and reduced water retention. Short-term adaptation strategies adopted to cope with current climate changes may increase the vulnerability of the population to future impacts of climate change.

Intercropping and cultivation of different crops in successive years facilitate differential nutrient uptake and use between cereal (sorghum and millet) and leguminous crops. Leguminous crops such as groundnuts, beans and cowpeas enhance soil fertility, reduce reliance on chemical fertilizers, and improve nutrient availability to subsequent crops (Conant, 2010), and this leads to increased crop yields (Woodfine, 2009). For example, Hine and Pretty (2008) showed that in the western and North Rift regions of Kenya yields of maize sown after leguminous crops increased to 3,414 kg/ha (71% increase in yields). Cases of crop yields increment after a fallow period have been widely reported (Agboola 1980; Prinz 1987; Palm *et al.*, 1988; Conant 2010), though the extent of yield increment after each successive fallow is variable.

Research report of the International Centre for Tropical Agriculture (CIAT, 2008) showed that the introduction of new improved bean varieties in seven African countries brought an average yield increment by about 44% in 2004-2005, although the income generated varied widely across countries, stretching from 2% in Malawi to 137% in western Kenya.

Proper water management can help capture more rain water (Vohland and Barry, 2009), making more water available to crops, and using water more efficiently (Rockstrom and Barron, 2007) and this is crucially important for increased agricultural production (Conant 2010; Rockstrom *et al.*, 2010). Soil bunds and Tied Ridge Systems generate higher yields, particularly where soil moisture is a key constraint (Lal, 1987).

Agro- forestry is a land use practice in which woody perennials are purposely integrated with agricultural crops and grazing lands. The integration varies from very simple and sparse to very complex and dense tree-crop-livestock systems and provides diverse economic and ecological benefits. Agro-forestry practices can improve land productivity by providing a favorable micro-climate, permanent cover, improved physical soil structure and organic carbon content, increased water infiltration and enhanced soil fertility (WIIAD, 1997). All these physical impacts reduce the need for mineral fertilizers (Louis *et al.*, 2007). Rao, *et al*. (2007) and Schoenberger (2008) also contended that agro-forestry apart from the above benefits helps to generate income from carbon sale, wood sale, reduces human impacts on natural forests and most of these benefits coupled with those mentioned above deliver direct benefits for local adaptation to climate change while contributing to worldwide endeavors to control atmospheric greenhouse gas concentrations.

2.6 Indigenous Knowledge Systems and climate change adaptation

In many rural communities indigenous knowledge developed over the years is the foundation for decision-making at local level. Indigenous knowledge has value not only for the cultural scenario in which it evolves, but also for intellectuals and planners striving to improve conditions in rural localities (Ajani *et al.,* 2013). Integrating indigenous knowledge into policy frameworks for climate change can lead to the development of effective adaptation strategies that are profitable and sustainable (Ajani *et al.*, 2013; Nyong *et al.,* 2007; Robinson and Herbert, 2001). Communities and farmers in Africa always strive to withstand the changing environments. They have the knowledge and practices to cope with basic environmental conditions and climatic and other natural shocks. The development of indigenous capacity is a fundamental intervention for local community empowerment and effective participation of the community in the development process (Leautier, 2004*).* In many parts of Africa local farmers apply farming practices such as the use of zero-tilling in cultivation and mulching. Use of mulches moderates soil temperatures, suppress incidence of diseases and damaging pests, and retain soil moisture (Dea and Scoones,, 2003). Local adaptation strategies that are practiced by pastoralists include the use of emergency fodder in times of droughts, multi-species composition of herds to survive climate (Ajani *et al.,* 2013).

Depending on the farming system, rural communities devise indigenous coping and adaptation strategies to climate change. Accordingly, a study on evaluation of climate change indigenous coping and adaptation in the agro-pastoral based livelihoods in Kenya (Kimani *et al*., 2014) revealed major actions including livestock relocation to wet or dry season grazing areas; diversification of both livestock and crops; herd adjustments through sale or herd splitting; use of local crops seeds; specialized food storage methods and controlled food rations during food insecure periods.

Local farmers across the world, as stated above, have developed several adaptation techniques and actions that have assisted them to minimize their susceptibility to the changing climate variables. One vital measure in reducing the vulnerability to climate shocks is the development of an early warning system for the forecast or prediction of climatic events using a wealth of local knowledge (Ajibade and Shokemi, 2003). In this process, farmers developed intricate systems of gathering, organizing, prediction, interpretation and decision-making in relation to weather. For example a case study carried out to assess how farmers use indigenous knowledge for weather forecasting in Teso sub region of Uganda indicated that farmers observe the intensity of blowing winds from east to west, and also use the color of the cloud to predict rainfall conditions (Egeru, 2012). Traditional climate forecasts in general are deemed useful to the farmers in handling their vulnerability to climate change variables. In this regard, farmers are known to make decisions on cropping arrangements based on local predictions of climate, and decisions on planting dates based on complex cultural models of weather.

2.7 Overview of the Agricultural sector and climate change in Ethiopia

2.7.1 Farming Systems in Ethiopia

In Ethiopia, areas with altitudes above 1500 meters above sea level (masl) are categorized as highlands and account about 37% of the land area and over 90% of the country's economic activities (FAO, 2012). These areas are the source of water, crop production, animal feed and are habitats for humans. They accommodate about 90% of the country total population, over 95% of its regularly cropped lands, about two thirds of its livestock population (Deressa, 2006).

The highland agriculture of the country is characterized by mixed type of farming and where both animal and crop productions are very significant and managed under the same land management unit. The varied agro ecology prevailing in Ethiopia's environment is capable of growing wide range of crops, pulses, oil seeds, spices and herbs, vegetables fruits, etc (MEDaC, 1999). Over 90% of the food supply comes from rain fed subsistent agriculture operated under rain fed condition and rainfall shortage or total disappearance of rainfall means loss of major livelihood source that always accentuate food deficit (Adgolign, 2006 cited in Rediet, 2011).

Variations in agro ecological settings, has led to the development of five major farming systems in Ethiopia (Befekadu and Berhanu, 2000). These are the highland mixed farming system, the lowland mixed agriculture, the pastoral system, shifting cultivation/bush fallow, and commercial agriculture. The study areas in this research practice the highland mixed framing system. In the diverse farming systems, different varieties of crops are produced and species of livestock are reared. The main crops cultivated include cereals, pulses, oil seeds, spices and herbs, stimulants, fruits, sugarcane, fibers and vegetables including root and tuber crops. The major livestock species raised include large ruminants such as cattle, small ruminants including sheep, goats, equines (camels, donkeys, horses, mules) and poultry.

The potential for growing different varieties of crops and rearing livestock across the different farming systems of Ethiopia is high. About 66 percent (73.6 million hectares) of the country's land mass is estimated to be potentially suitable for agricultural purposes (MEDaC, 1999) of which about 16.5 million ha (22%) is cultivated. Even though such a massive area exists in the country, Ethiopia has remained unable to feed its people for many years due to a number of factors related to social, economic, political and institutional issues. According to MEDaC (1999) major socioeconomic constraints include declining farm size and subsistence farming due to population growth; land degradation due to cultivation of steep slopes; removal of the woody vegetation, and over cultivation and overgrazing. Land tenure insecurity, weak agricultural research and extension services, poor agricultural marketing system, inadequate transport networks, and low level use of improved agricultural technologies are the other constraints. Likewise the livestock sector development is hindered by inadequate feed and nutrition, limited veterinary services, incidence of diseases, poor genetic makeup, limited infrastructure, and limited research on livestock. The major environmental problems in both crop and livestock production are erratic rainfall, recurrent droughts, incidence of hailstorms, floods, and pests (Befekadu and Berhanu, 2000).

2.7.2 Land and the performance of the agricultural sector in Ethiopia

Agriculture is the most important sector in the Ethiopian economy for the following reasons (I) it directly supports about 85% of the population for its employment and livelihood sources and food security; (II) it contributes about (41 %) to the country's gross domestic product (GDP); (III) it generates about 90 % of export earnings; and (iv) it supplies around 70% of the raw material requirements of agro-based industries (MoFED, 2008, 2010). In addition agriculture plays a key role in generating extra capital to accelerate the country's overall socio economic development (MoFED, 2008, 2010). Despite Ethiopia's huge land resources and labor, it is still categorized among the poorest countries in the world. The country has important growth potential but this potential is not sufficiently realized due to a combination of natural and other factors (World Bank, 2004) Due to a more favorable climate with higher rainfall, Ethiopian agriculture developed mainly in the high lands, with a system of rain fed mixed farming, using plant residue and animal manure, crop rotation, fallowing, selection of crop varies etc to maintain soil fertility. World Bank (2004) argues that this worked well when the highlands population was much smaller, household plots much larger and there was adequate arable land for the population size existed that time. However, huge population increment over the past half-century, coupled with highly violated traditional ratios between various land use types including cultivated fields, forests, meadows, pastures, wetlands, water bodies and soil erosion have led to degradation, and made the system increasing in less viable.

Reviews by Samuel (2006) indicates that the agriculture in Ethiopia is practiced under the condition of diminishing farm size and a survey in the 2000 cropping season revealed that about 87.4% of rural households were holding less than 2 hectares; whereas some 64.5% cultivated farms less than one hectare; while 40.6% operated land size of 0.5 hectare and less. The same source indicates that the average farm size in the highlands (in 2004) was fragmented into 2.3 plots, each with 0.35 hectares; and about one third of surveyed farms consisted of 3 or more plots. Likewise World Bank (2005) noted that per capita land holding in rural areas in the highlands has fallen from 0.5 hectare in the 1960s to only 0.2 hectare by 2005, and the marginal productivity of labor is estimated at close to zero. The abundant human labor of the country is unemployed or under employed, and concentrated in the rural highlands.

Population pressure has led to encroachment for cultivation into forest areas and steep slopes prone to soil erosion. This creates serious effects on the environment, which, together with fluctuation in rainfall, has made agricultural production very vulnerable to weather shock. Farm fragmentation has increasingly emerged as one of the key problems of subsistence farming of Ethiopia and the average farm size is considered by many to be small to allow sustainable intensification of smallholder agriculture. It is also noted as one of the factors that constrains farm income and the level of household food security (Samuel, 2006).

2.7.3 Ethiopian Agriculture in the context of climate change

Climate variability and change poses serious challenges to development in Ethiopia. This is due to the fact that the Ethiopian economy is largely dependent on rain fed agriculture, which is heavily sensitive to climate variability and change. About 70% Ethiopia is arid, semi-arid, or categorized as dry sub-humid; these areas are prone to desertification and drought (NMA, 2007). The same source further expounds that the Ethiopian highlands are fragile because of inappropriate cultivation, overgrazing, severe erosion, and excessive deforestation. Historically Ethiopia has been prone to extreme weather variability. Rainfall has become exceedingly erratic and much of the rain falls with high intensity and shows variability when and where it falls. In the years to come the country is expected to experience irregular patterns of rainfall, increased temperatures inducing high evaporation rates, and flooding; these will again lead to high levels of land degradation, transmission of infectious disease, and loss of ground and surface water potential.

The production of crops in Ethiopia is dominated by small scale subsistence farmers (CSA, 2013). The same source also indicated that these small-scale farmers on average account for 95% of the total area under crop and for more than 90% of the total agricultural output. About 94% of the food crops, and some 98% of coffee are produced by small holder farmers, and the remaining food crops (6%) and that of coffee (2%) is generated from commercial farms (state and private). The majority of farmers still practice traditional way of farming i.e. ploughing of the land is done with oxen-drawn ploughs, the fertilizer applied is little and pesticide and improved seeds use is low. Field crops production is vulnerable to a number of biotic stresses (weeds, insects and diseases) and abiotic factors including drought, low soil fertility, water logging, and low level of technology. Climate change also indirectly affects agriculture by inducing emergence of crop pests and livestock diseases, exacerbating the frequency of adverse weather conditions, reducing water supplies and irrigation, and enhancing severity of soil erosion (Watson et al., 1998; IPCC, 2001).

Although Ethiopia is now in the path of rapid economic development it is still known as one of the poorest countries in the world. Degradation of natural resources is widespread throughout the country and it is an important factor destabilizing livelihoods (Adugnaw,

2014) and the effect becomes more severe under unpredictable climatic events. The dependence of the national economy on subsistence farming is considered as one of the major reasons for this high poverty. MoA (2011) underlines poor performance of crop production in Ethiopia is largely associated with declining farm size (due to population growth), land degradation, recurrent drought and poor adoption of improved agricultural technologies. Likewise Desressa *et al*. (2010) also argued that factors such as land tenure insecurity, weak agricultural research and extension services, lack of agricultural marketing, poor transport network, limited use of fertilizers, improved seeds and pesticide as well as the use of old traditional farm implements contribute to the low productivity of crop production. Agricultural productivity is further aggravated by ineffective policy and poor climatic conditions, especially reoccurring drought (Deressa *et. al*., 2008; Deressa, 2007).

Ethiopia has the highest number of livestock population in Africa and it stands as the tenth largest in the world (Aleme and Lemma, 2015). Livestock is a vital source of diverse social and economic values such as food, draught power, fuel, cash income, security and investment across ecological zones extending both in the highlands and the lowlands/pastoral farming systems. The country also secures substantial foreign exchange from the livestock sector. Despite the huge potentials to benefit from livestock resource, the sector is characterized by low productivity due to a number of constraints (MoA, 2011) including: inadequate feed, low level of veterinary care, poor genetic structure, inadequate budget allocation, limited infrastructure, limited research on livestock and recurrent drought.

The country's major economic sectors including water and range resources, food security, biodiversity and human and animal health are vulnerable to current climate variability, and will be affected even more by future climate change (NMA, 2001, 2007). The same authority also indicated that the extreme sensitivity of the country's agro ecosystems to temperature and precipitation variability, low adaptive capacity to respond to shocks and hazards, and several others have left Ethiopia without any given chance except being vulnerable to local and global climate change impacts. For this reason it is often stated that even a minor change in climate may bring a huge impact on the socio-economic status of the country.

In Ethiopian context as it is true elsewhere in the globe a multitude of adverse effects of climate change are manifested (NMA, 2007), including shortening of maturity period and decrease in crop yield, change in livestock feed availability, impoverished animal health, declining of forage crops quantity and quality, change in distribution of diseases, reductions in pastoral zones in many parts of the country, expansion of tropical dry forests and the disappearance of lower montane wet forests, expansion of desertification, flood and drought impacts and expansion of malaria to highland areas. Failure to develop a strategic climate change management plan that enhances aversion of the adverse impacts of climate change is likely to aggravate the vulnerability of rural households and the national economy as a whole.

2.8 Climate Systems in Ethiopia

2.8.1 General

The important weather systems that cause rainfall over Ethiopia are Sub Tropical Jet (STJ), Inter Tropical Convergence Zone (ITCZ), Red Sea Convergence Zone (RSCZ), Tropical Easterly Jet (TEJ) and The Somalia Jet (NMSA, 1997 cited in Seifu 2004). The same source also indicated that STJ, ITCZ, RSCZ, TEJ and the Somalia Jet influence region A of the country; ITCZ along with some of those which influence region A cause rain in region B; the ITCZ causes rain in region C as indicted in Fig 2.1. In each of these regions the rainfall amount and its variability is quite different. This is mainly associated with the movement and/or position of rain causing mechanism with reference to a given region in different seasons and or graphic conditions.

2 8.2 The general rainfall pattern in Ethiopia

Season is defined meteorologically as, a period when an air mass characterized by homogeneous weather elements such as temperature, relative humidity, wind, rainfall etc, dominate a region or part of a country (NMSA, 1996). In Ethiopia, the seasons and rainfall regimes are classified based on mean annual and mean monthly rainfall distribution. There are three main rainfall regimes in Ethiopia (Fig. 2.1) and they are delineated as:

a. Mono-Modal (Single maxima)

b. Bi-modal type-1 (Quasi-double maxima)

c. Bi-modal type-2 (Double maxima).

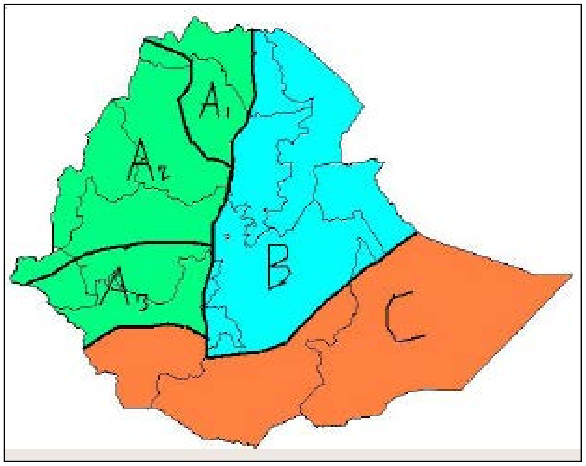

Figure 2.1 Rainfall Regimes of Ethiopia (NMSA, 2007)

2.8.2.1 Mono modal rainfall pattern

The area designated as region B (Figure 2.1) is dominated by single maxima rainfall pattern. However, the wet period decreases northwards from about ten months in the south west to only about four month in the north. Thus region-B is sub-divided into three parts designated as b1, b2 and b3, where the wet period runs from February/March to October/November, April/May to October/November and from June/July to August/September, respectively. This part of the country is likely to suffer more from climate change as possibilities for another cropping chance is limited.

2.8.2.2 Bi-modal type-one

The area designated as region A (Figure 2.1) is characterized by quasi-double maxima rainfall pattern, with a small peak in April and maximum peak in August. The central and most of the eastern half of the country is included in this rainfall regime. The two rainy periods are locally known as '*Kiremt'* (June to September) and '*Belg*'(February to May), which are the long and short rainy periods, respectively. The Short 'dry 'period, which covers the rest of the year (i.e. October to January), is known as *Bega.* These days *Belg* season is highly characterized by erratic rainfall and in severe cases total failure of the rain.

Farmers who used to grow crops during the *Belg* season are suffering from repeated crop failure or total abandoning of crop production.

2.8.2.3 Bi-modal type-two

The area identified as region C dominated by double maxima rainfall pattern with peak during April and October. The southern and the southeastern parts of Ethiopia are included in this rainfall regime. Two rainy periods are from March to May and from September to November. Two dry periods are from June to August and from December to February.

2.9 Weather System in Ethiopia

The weather system that causes rainfall for each season in Ethiopia is well described by the National Meteorological Services Agency (1996) as described below. During *Bega* (dry season), the country predominantly falls under the influence of warm and cool Northeasterly winds. These dry air masses originate either from the Saharan anticyclone and/or from the ridge of high pressure extending into Arabia from the large high pressure over Central Asia (Siberia). However, very occasionally, northeasterly winds get interrupted when migratory low pressure system originating in the Mediterranean area move Eastwards and interact with the equatorial/tropical system resulting in the rainfall over parts of Central Ethiopia. In addition to this occasional development of the Red sea convergence zone (RSCZ) affects Costal areas.

The *Belg*, short rain season coincides with the domination of the Arabian high pressure as it moves towards the north Arabian Sea. Major systems during the season are the development of thermal low over south Sudan; the generation and propagation of disturbance over the Mediterranean, sometimes coupled with Easterly waves; development of high pressure over the Arabian Sea; some of the interaction between mid-latitude depression and tropical systems accompanied by troughs and the subtropical jet; and occasional development of the RSCZ.

During “*Kiremt*” (the rainy season) , the airflow is dominated by a zone of convergence in low-pressure systems accompanied by the oscillatory Inter Tropical Convergence Zone

(ITCZ) extending from West Africa through Ethiopia towards India. Main rain producing systems during the season are Northward migration of ITCZ; development and persistence of the Arabian and the Sudan thermal low along 20^{o}N latitude; development of quasi – permanent high pressure systems over south Atlantic and south Indian ocean; development of tropical Easterly Jet (TEJ) and its persistence; and the generation of low level 'Somali Jet' that enhances low-level southwesterly flow.

2.10 Agro ecological Features of Ethiopia

Climate in Ethiopia is highly controlled by the seasonal movement of the Inter-tropical Convergence Zone (ITCZ), which follows the position of the sun relative to the earth and the associated atmospheric circulation. Furthermore, it is also highly influenced by the country`s complex topography (NMSA, 2001). According to Yohannes (2003) the traditional, the Köppen's, the Throthwaite's rainfall regimes, and the agro climatic zone classification systems are the different ways of classifying the climatic systems of the country. However, the traditional and agro-ecological classifications are the most common ones (Deressa, 2010). The traditional classification, based on altitude and temperature shows the presence of five agro climatic zones (Table 2.1).

Table2.1 Physical characteristic of Agro climatic zones

Traditional Climatic Zone	Altitude (meters above sea level)	Average annual temperature (^{0}C)	Rainfall (mm/year)
Wurch /cold highlands/	$\geq$3200	>11.5	900-2,200
Dega /upper highlands/	2,300-3,200	11.5 – 17.5	900-1,200
Weynadega/mid highlands/	1,500-2,300	17.5- 20.0	800-1,200
Kolla /lowlands/	500-1,500	20.0 – 27.5	200-800
Berha /desert/	below 500	>27.5	under 200

Source: IFPRI, CSA, and EDRI 2006

Alternatively, the agro-ecological zone (AEZ) classification system combining growing periods with temperature and moisture regimes grouped the country ecological zones into 6 major categories which include the following (MoA, 2000):

- Arid zone: This zone is less productive and pastoral and occupies 53.5 million hectares of land (31.5% of the country)
- Semi – arid: This agro – ecology is less harsh and occupies 4 million hectares of land (3.5%of the country).
- Sub – moist: occupies about 22.2 million hectares of land (19.7% of the country), and severely threatened by erosion.
- Moist: - This zone covers an estimated area of 28 million hectares (about 25% of the country) which is the most important agricultural land suitable for crop production.
- Sub – humid and humid: These zones cover 17.5 million hectares of land (15.5% of the country) and 4.4 million hectares (4% of the country), respectively. These areas provide the most stable and suitable conditions for annual and perennial crops and for forestry development.
- Hyper- humid: This agro – ecology covers about 1 million hectares of land (close to 1 % of the country) and is suited for perennial crops and forests.

Climate conditions differ extensively across these AEZs; and the annual mean rainfall ranges from about over 2000 millimeters in some isolated areas in the southwest to less than 250 millimeters in the lowlands of Afar, in the northeast and Ogaden in the southeast while mean annual temperature ranges from 10^0C over 0^0C the high plateau lands of northwest, central and southeast to about 35° C on the north- eastern edges (NMA, 2007; Deressa, 2010).

2.11 Past and Future Trends of Climate and Impacts in Ethiopia

2.11.1 Past Trends of Climate and its Impacts

The climate of Ethiopian is described by incidents of climate extremes, such as drought and flood, and rising temperature and declining precipitation and irregular patterns. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia (Lautze *et al*. 2003; NMS 2007). The country had suffered seven major droughts since the early 1970s and five of the droughts compounded by a number of local droughts had led to severe food insecurity and devastating famine (World Bank, 2010; UNDP, 2007; Belay & Abebaw, 2004). Even though drought is not a new phenomenon in Ethiopia, its occurrence frequency has increased in some areas and likewise the variability in rainfall patterns (Evangelista *et al*., 2013, cited in Skambraks, 2014).

Vulnerability to drought in Ethiopia is associated to a number of factors and one of the reasons is related to the exceedingly low level management of water resources either in the form of watershed management or investment in water infrastructure (World Bank, 2006). On an aggregate level, Ethiopia's economy will remain highly vulnerable to exogenous shocks, mainly because of its dependence on primary commodities and rain fed small-scale and subsistence-oriented agriculture.

Studies indicate that temperature and precipitation have been changing over time. Accordingly minimum temperature has been increasing by about 0.37 degrees Celsius every decade during the past 55 years. The average annual rainfall of the country has recently shown a very high level of variability (NMS, 2007). For the past five and half decades a few years were characterized by dry conditions, resulting in drought and famine, whereas others are characterized by wet conditions. Droughts do not only reduce agricultural production, but also result in starvation, death, and foreign aid dependence. Droughts are a key reason for Ethiopia's large dependence on food aid. As shown in Table 2.2 the recurrent drought in the country over decades has affected the lives of millions of people.

Table 2.2 Chronology of the effect of drought and famine on Ethiopia, 1965–2009

Affected region	Occurrence	Number of people affected
Tigray and Wello	1964–1966	About 1.5 million people affected
Tigray and Wello	1972–1973	About 200,000 people and 30 percent of livestock died
Southern Ethiopia	1978–1979	1.4 million people affected
All regions	1983–1984	8 million people affected,
All regions	1987–1988	7 million people affected
Northern, eastern	1992	and About 500,000 people affected southern regions
Tigray and Wello	1993–1994	7.6 million people affected
All regions	2000	About 10.5 million people affected
All regions	2002–2003	About 13 million people affected
All regions	2008–2009	About 5 million people affected

Sources: Quinn and Neal 1987; Degefu 1987; Nicholls 1993; Webb and von Braun 1994; Disaster Prevention and Preparedness Agency (2009).

Currently (2015/16) Ethiopia is facing the brunt of drought due to El Nino effect in the eastern and northern regions and over 10 million people are in need of food support. And, the overall scenario signals that the country faces a complex problem associated with climate change and the drought incident. This year, (2015/2016), can be taken as a serious signal that puts heavy pressure on the government of Ethiopia to rethink about the problem and design a national drought management strategy to find a lasting solution for the recurring drought and climate change challenges. In this regard FAO (2016) in its analysis of climate change and food security strongly advocated the need for investing in systems to assess risks, vulnerabilities and adaptation options and also strengthening adaptation through policies and institutions.

2.12 Future Climate Change over Ethiopia

The results of IPCC mid-range emission scenario showed that compared to the 1961-1990s the average mean annual temperature across Ethiopia will increase by between 0.9 and 1.1°C by the year 2030 and from 1.7 to 2.1°C by the year 2050 (NMA, 2006). The temperature across the country is predicted to rise from 0.5 to 3.6 °C by 2080, while the precipitation is expected to show some increment (NMA, 2006). In contrast to the temperature patterns showing defined trends, it is hard to notice long-term rainfall trends in Ethiopia, due to the high variability across inter-annual and inter-decadal periods. According to NMA (2006) between 1951 and 2006, there was no statistically significant trend observed in mean annual rainfall variation in any particular season. The results of the IPCC mid-range emission scenario indicated that there will be a change of rainfall between 0.6 and 4.9% and 1.1 to 18.2% for 2030 and 2050, respectively (NMA, 2006). The percentage change in seasonal rainfall is expected to be up to about 12% over most parts of the country (ICPAC, 2007). The IPCC mid-range emission scenario shows that the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 – 2.1 °C by 2050 and in the range of 2.7-3.4 °C by 2080 over Ethiopia compared to the 1961-1990 normal. A slight increase in annual precipitation is expected over the country, and other sources of data have also validated the variability of climate and its trends in a more or less similar ways. Estimates made on the national average annual minimum temperature between 1951 and 2006 show that temperature has been increasing by approximately 0.37 °C per decade between 1951 and 2006, while the national average annual rainfall has largely remained constant (NMA, 2007). Other projections made by Cline (2007) indicate that in Ethiopia the mean daily rainfall amount will decline to around 1.97 mm for the duration of 2070-2099. The decrease in rainfall amount will be worsened by increased evapotranspiration rates caused by likely mounting temperatures and dry conditions. The mean annual temperature will increase to 26.9 ºC during 2070-2099 (Cline, 2007). On the other hand, the NMA (2001) revealed that in Ethiopia climate variability and change in the country is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature.

Rainfall is historically highly variable and there is no clear trend in the quantity of rainfall over time (McSweeney *et al*., 2008; NAPA, 2007). Studies of localized meteorological data in three sites alongside community perceptions indicate that seasonal change may already be occurring as there are declining and increasing trends in certain months of the year in each of the three sites (ACCRA, 2011). Future climate projections taken from a 2008 study highlight that mean annual temperature is projected to increase by 1.1 to 3.1°C by the

2060s, and 1.5 to 5.1°C by the 2090s. Under a single emissions scenario the projected changes from different models span a range of up to 2.1°C. (McSweeney *et al*., 2008).

Projections of change in the rainy seasons April, May, June (AMJ) and July, August, September (JAS) rainfall seasons which affect the larger portions of Ethiopia are more mixed, but tend towards slight rises in the south west part and decease in the north east direction (McSweeney *et al.*, 2008).

Ethiopia is in general vulnerable to climatic variability due to its low adaptive capacity that is principally associated with the low level of socioeconomic development, high population growth, inadequate infrastructure, lack of institutional capacity and high dependence on climate sensitive natural resource-based activities (NMA, 2007). The vulnerability of the community is aggravated due to the long standing environmental problems of forest destruction that leads to land degradation. In addition, about 70 % of the country is dry, sub-humid, semi-arid or arid and in consequence vulnerable to desertification and environmental degradation.

2.13 Climate risk management and coping mechanisms in Ethiopia

In Ethiopian both farm households and the government undertake climate risk management through mitigation and coping practices to reduce the damages from climate change. Risk-mitigation strategies at the household level include diversifying crops, mixing crop and rearing of different livestock species, and accessing of rotating credit arrangements. According to Deaveux and Guenther (2007) there are a number of coping strategies at the household level including: selling productive assets, selling livestock and agricultural products, reducing current investment and consumption, employing child labor, temporarily or permanently migrating, mortgaging land, and using inter household transfers and loans. Community-level risk aversion and mitigation strategies include water harvesting, resource conservation and management, irrigating, partaking in voluntary resettlement programs, using household extension packages or agro ecological packages, and joining productive safety net programs. Important government-driven coping strategies include food distribution of food mainly obtained from food aid, and food-for-work programs (MoFED, 2007; Devereux and Guenther, 2007). In fact, food aid has become one of the most important coping strategies for fighting drought and famine.

In general, poor performance in the agricultural sector is associated with poverty where there is inadequate investment in institutions, infrastructure and agricultural technology generation, and all these make farmers become liable to climatic distress such as droughts.

2.14 Ethiopia's Response to Climate Change

Ethiopia being determined to combat climate change, has suitably reacted by ratifying pertinent international conventions and the necessary steps are being taken to implement the two categories of responses to climate change, mitigation and adaptation. With this respect, the country ratified the UNFCCC and its related appliance, the Kyoto Protocol, presented its initial national communications to the UNFCCC in 2001, and also its first Climate Change National Adaptation Programme of Action (NAPA) in 2007 to the UNFCCC (MoFE, 2015). Accordingly the following interventions are given due consideration:

- Ethiopia set target to build carbon neutral economy by 2025.
- The country presented its Nationally Appropriate Mitigation Actions in 2010.
- Sectoral adaptation plan of action and other associated activities are also being prepared.

Existing national policies and sectoral programs targeted towards environmental rehabilitation, socio-economic development, and ending poverty addressed the issues of climate change either directly or indirectly. Among others, the following are notable:

- Conservation Strategy of Ethiopia
- Environmental policy of Ethiopia
- Policy and Strategy on Agriculture and Rural Development
- Integrated Watershed Management
- Water Resources Management Policy

- Disaster Prevention and Preparedness national policy.
- National Policy on Biodiversity Conservation and Research
- National Plan for Accelerated and Sustainable Development to End Poverty (PASDEP)
- Growth and Transformation Plan (GTP) which is now the second phase is under way.

In spite of this fact, considering the ever increasing threats of climate change, Ethiopia still requires a standalone climate change policy and even a specific institution watchful to address the complicated unforeseen impacts.

2.15 Conceptual framework

This study examined climate variability and change impact on agriculture and the adaptation strategies that were adopted by the highland farming communities in north- west Ethiopia particularly in east and west Gojam zones. The conceptual framework that guides the study was adapted from the works of Portier *et al.* (2010) and it helped as a strategic tool to better understand the interaction between environmental systems, climate change and adaptation strategies (Figure 2.1). The conceptual framework takes in to consideration the climatic variability theory that links climatic variations to environmental changes. Atmospheric changes in greenhouse gases concentration and other drivers change global climate and this again alters agricultural output.

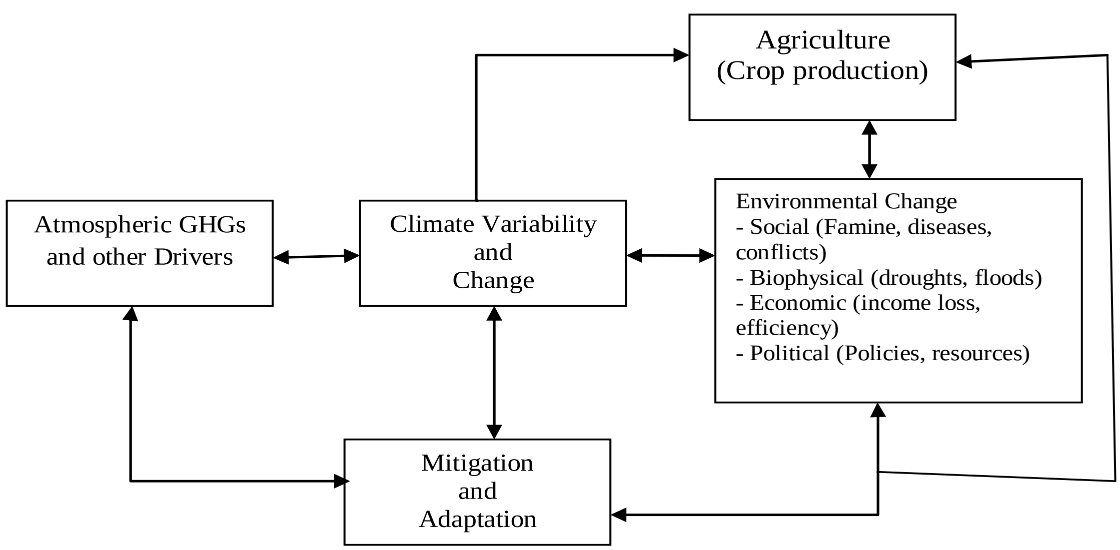

Figure 2.1 Interactions between Environmental systems, climate change and Adaptation Strategies. (Adapted from Portier *et al*. (2010).

It is asserted that mitigation interventions modify the climate whereas both mitigation and adaptation change the environment. The predominant impact on agriculture comes through environmental changes as a result of climate change although there are direct impacts from both climate changes and mitigation/adaptation. The weather patterns and decreased availability of water influence adaptation and mitigation strategies.

The four domains of the physical and socioeconomic environment namely social, economic biophysical and political variables influence the environmental change. Each domain corresponds to a system that has its own distinct driving forces, objectives, and indicators. The biophysical domain focuses on sustaining the resilience and integrity of ecological systems. The economy is geared largely towards improving human welfare, principally through increase in the consumption of goods and services. The social domain gives due emphasis to the enrichment of human relationship and achievement of individual and group aspirations. The political domain on the other hand focuses on power, policies and sharing of resources. All the four domains are affected by climate variability and change and the balance among the four domains is critical to designing effective adaptation and mitigation strategies' to climate change.

Appropriate mitigation and adaptation strategies positively affect both climate change and the environment, and thereby inducing positive effect on agriculture. In addition, some adaptation activities directly improve agriculture through changes in land management such as maintaining the traditional ratios between forest cover, grazing land, wetland, farm land, water bodies and conservation areas.

2.16 Summary

This chapter highlighted the concepts of climate change and its triggering factors and also its impacts on the physical, biological and socio-economic components of the planet earth. It is clearly demonstrated in the review that that climate change is largely caused by anthropogenic factors and its impact on the biophysical and socioeconomic environment has become severe. Emission of greenhouse gases, such as carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) is warming the planet and this affects the earth's climate.

Globally a multitude of adverse effects of climate change are manifested in the form of loss of crop production, poor livestock productivity, expansion of desertification, decrease in river flow, decrease in energy production, flood hazards, etc. Most climate model scenarios indicate that African countries in the sub-Sahara Africa are likely to face the most severe challenges on food security due to climate change and other pushing factors of global change.

Farmers' perception of climate change governance and adaptation is pivotal for future plans aiming to deal with challenges arising as result of climate change. However, in many parts of the world climate change awareness, mitigation and adaptation seem marginally known. Climate change demands to develop coping, adaptation and mitigation strategies. Coping strategies at the household level include selling productive assets, selling livestock and agricultural products, reducing current investment and consumption, temporarily or permanently migrating, mortgaging land, and using inter household transfers and loans. Community-level risk aversion and mitigation strategies include water harvesting, resource conservation and management, irrigating, partaking in voluntary resettlement programs, using household extension packages or agro ecological packages, and joining productive safety net programs.

Climate change adaptation refers to adjustment in natural or human systems in response to real or predictable climatic inducements or their effects, which moderates harmful effects or make use of beneficial opportunities. Historically, people whose livelihoods were dependent on agriculture, have developed ways to cope with climate variability in their own way. The strategies that rural households are currently adopting to acclimatize to changing levels of climate variability are classified as Agricultural techniques, Water management techniques, Diversification technique, and Communal resources pooling techniques. It is however noted that adaptive capacity is based on access to diverse resources such as technology, knowledge, wealth, and socio-ecological attributes, infrastructure, access to resources, stability and management capabilities. Likewise sustainable land management (SLM) measures are also among the important approaches that smallholder framers can use to adapt to climate vulnerability and change. In the SLM effort integrating indigenous knowledge on land and climate change management helps to enhance adaptation strategies pursued by farmers.

Climate systems in Ethiopia show that there are three main rainfall regimes, identified as mono-modal regime where there is only one big rainy season and bi modal regime where there two production seasons are enjoyed. Currently however areas enjoying bi modal rainfall are facing unpredictable rain fall pattern and in many places more crop failures are encountered in the short rainy season.

The past and present climate of Ethiopian is described by incidents of climate extremes, such as drought and flood, and rising temperature and declining precipitation and irregular patterns that have inflicted severe damages in human lives. The future prediction shows a potential rise in temperature and more erratic rainfall which will potentially affect the livelihood of communities. The issues mentioned above are supported by a conceptual framework which is used as strategic tool to better understand the interaction between environmental systems, climate change and adaptation strategies.

In sum Ethiopia is highly vulnerable to climate change impacts because it is predominantly an agrarian country and agriculture is severely impacted by the changing climate. There is a serious need for contriving ways to adapting to the changing climate. However, adaptation to climate change or variability seems to be hindered by lack of adequate and timely information on climatic data as well as provision of technological packages. Therefore, the existence of functional institutional arrangements for climate change is critical for understanding and better informing policies/measures for enhanced resilience to climate change. Despite the weaknesses in handling climate change challenges, Ethiopia being determined to combat climate change, has suitably reacted by ratifying pertinent international conventions and the necessary steps are being taken to implement the two categories of responses to climate change, mitigation and adaptation.

Taking note of the rationale of the research, major research questions and objectives and the research hypothesis and the theoretical and empirical assertions expounded in the literature review, the following chapter (Chapter III) provides a clear description of the study areas and the philosophy of the research design, methods of data acquisition and analysis.

CHAPTER 3

MATERILAS AND RESEARCH METHODS

3.1 Introduction

This chapter addresses a full account of the study areas and the research methodology adopted in the context of the research objectives. Accordingly the first part of the Chapter provides description of the study area giving due emphasis to the physical attributes, socioeconomic activities, land use features, and administrative organs that relate to the theme of the research. It also presents a brief explanation of activities of institutions having a stake on handling climate change related development interventions in the study region. The second part of the chapter gives a clear explanation of the philosophy of the research methodology, the rationale of study site selection, sampling procedures, and data collection tools and data analysis techniques to address the research questions of the study.

3.1.1 Description of the study area

This study was conducted in 6 villages, hereafter called Kebeles, located in six districts Sinan, Shebel Berenta and Machakel districts in East Gojam and Jabitehnan, Dembecha and Bahir Dar Zuria districts in West Gojam) of the Amhara region of Ethiopia (Fig. 3.1). In Ethiopia areas lying above 1500 meters above sea level (masl) are generally known as highlands; and in this study with the intention of assessing of altitudinal effects on climate change and/or variability three study kebeles were selected in high altitude areas found between 2300 and 32000 masl and the other three Kebeles lying between 1500 masl and 2300 masl. This chapter therefore provides a description of the study areas at the regional, zonal and Kebele level.

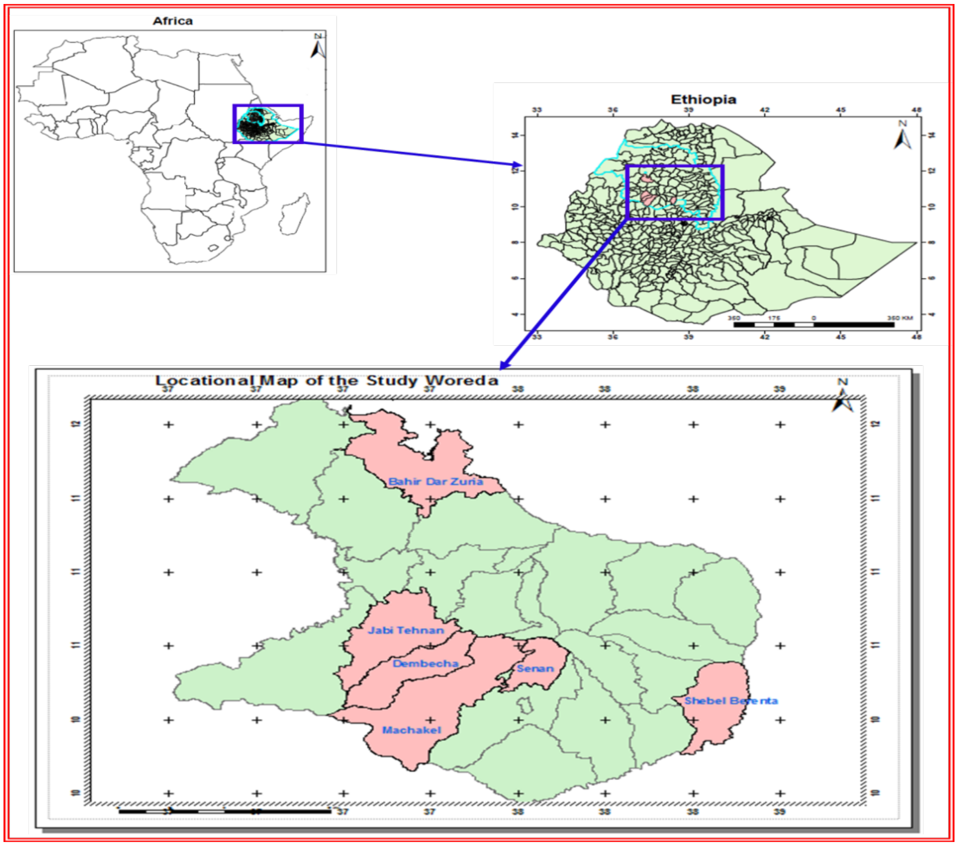

Figure 3.1 Map of the study area: (Source: Bureau of Finance and Economic Development, 2014)

3.1.1.1 The Amhara National Regional State

The Amhara region is one of the regional states in Ethiopia located in the north-western part of the country and accommodates about 20 million people of which more than 82 % live in rural areas (BoFED, 2014). The region occupies an estimated area of 172,000 $km^{2.}$ with altitudes ranging from 600 masl to over 4000 masl. Ethiopia's complex topography is also a major feature of the Amhara region and has tremendous impact on the thermal and rainfall patterns and conditions (EFAP, 1994). Traditionally in Ethiopia including the Amhara region a distinction is made between five thermal zones based on altitude, namely the alpine climate (*wurch*) (above 3200 masl), cool thermal zone (*dega*) (2300 to 3200 masl), medium cool to warm thermal zone (*woina dega*) (1500 to 2300 masl), and warm to hot thermal zone (*kolla*) (500 to 1500 masl), very hot thermal zone (*berha*)
(below 500 masl).

The part of the region that lies above 1500 masl and classified as highland occupies nearly 50 % of the landmass and it has a high potential for agriculture and forestry development. As a result the highlands in the region support the livelihoods of 80% of the population and about 70% of the livestock is found in this area (RCS, 1997).

The topography of the region is highly rugged with about 60% of the area with steep to very steep slopes. The highlands suffer from severe soil erosion with an estimated annual soil loss of 1.1 billion tones of soil (RCS, 1997). High forest cover in the highlands has been severely degraded and it is estimated below 3% while the annual loss was estimated at 20,000 to 30, 000 ha (CEDEP, 1999). Currently however there are claims by the government that the forest cover on degraded woodlands is showing improvement and the annual soil loss due to water erosion is gradually declining as result of mass mobilization (BoA, 2013). Using the productive potential of the natural resources the region is divided in to high and low potential zones. Areas categorized as low potential zone are characterized by severely degraded ecosystem and most of the time facing drought and irregular rainfall and hence chronic food insecurity. High potentials zones are known to be agriculturally productive and with better rainfall amount and distribution. However, the rate of land degradation mainly loss of fertile top soil has become a severe problem and since the recent past the rainfall distribution, onset and cessation has become irregular and hence the high potential zones are not immune from climatic variability and in some incidents largely facing agricultural drought.

Agriculture is the mainstay of the regional economy and provides employment for more than 82 % of the population (BoFED, 2014). The rural people are predominantly subsistence farmers practicing mixed framing (i.e., crop production and livestock husbandry). Agricultural productivity is low; the average grain yield does not exceed 0.18 tons per ha (BoA, 2013). The region owns about 17.8 million livestock (about 33% of the national livestock resource). The productivity of livestock is depressed due to severe feed shortages and high stocking densities and poor veterinary services (BoA, 2012). Livestock feed deficit is estimated at about 40% and hence livestock pose tremendous pressure on remnant woodlands (EFAP, 1994). Biomass is the dominant source of domestic fuel (99%) and construction. Current estimates of sustainable annual supply of woody biomass show that less than a third of the regional demand is supplied from existing woody vegetation resources, implying that the region has to embark on extensive tree plantings. The above attributes of the region are largely shared by the study districts and Kebeles.

3.1.1.2 East and West Gojam Zones

The study area Gojam, which is divided as East and West Gojan Zones for administrative purpose, is located in the Amhara region, northwestern part of Ethiopia, between 10°58’20.09”N and 37°29’23.68”E. It covers an area of about 28,076 km^2 and a population of 4,260,394 (CSA, 2007). Gojam shares boundaries with Gonder in the North, Wolo in the East, Awi in the West, Welega and Shewa in the South.

3.1.1.3 Topography of the study area

The large part of Gojam zone lies in the highlands with altitudes of more than 1500 masl and some part of the land in the south east lies in altitudes below 1500 masl. The topography comprises areas that are highly rugged with continuous chains of mountains and plateaus land mass as high as 4152 meters above sea level (masl) in the Choke Mountains and also vast expanse of plain to undulating land. Ethiopia is particularly vulnerable to accelerated soil erosion because of rugged topography. About 79% of Ethiopia’s land mass has a slope of greater than 16%, and of the total area classified as having more than 16% about 25% lies within a slope of greater than 30%. Compared to the national and regional scenario, Gojam zone where the study districts and Kebeles are located have a relatively better slope classes that are suitable for crop production as shown in Tables 3.1, 3.2 and 3.3.

Table 3.1 Slope class of the study Zones

Slope %	East Gojam		West Gojam	
	Area in ha	% of area coverage	Area in ha	% of area coverage
< 5	616485.1	43.65	810732.3	60.76
5-8	199320.9	14.11	201325.8	15.1
>8-15	355883.7	25.20	254188.5	19.1
>15-25	215031	15.22	66498.1	4.98
>25	25740.2	1.82	1499.7	0.11
Total	1,412,461.3	100	1,334,244.4	100

Source: Extracted from satellite images by the Author

Table 3. 2 Slope classes of the study Districts in the Upper highland (East Gojam)

Slope%	Machakel District		Sinan District		Shebel Berenta District	
	Area in ha	% area coverage	Area in ha	% area coverage	Areas in ha	% area coverage
< 5	110323.339	55.01	12564.8	32.7	12090.4	14.23
5-8	28930.487	14.42	8755.2	22.8	9334.7	11
8-15	40239.425	20.07	12950.8	33.7	29516.6	34.74
15-25	18954.012	9.45	33976.8	10.34	30141.6	35.5
>25	2080.025	1.04	203.91	0.53	3873.1	4.6
Total	200,527.288	100	38451.5	100	84957.24	100

Source: Extracted from satellite images

Table 3. 3 Slope classes of Mid highland districts: West Gojam

Slope%	Bahir Dar Zurai District		Jabi Tehnana District		Dembecha	
	Area in ha	% area coverage	Area in ha	% area coverage	Area in ha	% area coverage
< 5	139,579.5	88.2	92117.3	76.5	51472.1	60.1
5-8	11363.9	7.2	15423.6	12.8	15569.4	18.17
8-15	6871.9	4.3	12617.5	10.5	14398.4	16.8
15-25	509.8	0.32	269.2	0.2	4298.7	5.0
>25	0	0	0	0	0	0
Total	158,325.1	100	120487.6	100	85683.6	100

Source: Extracted from satellite images

3.1.1.4 Soil Types

A vast expanse of land in the study area has fertile soils which are related to their geological formation and basaltic parent material. However, there is an indication that soil acidity is becoming a major problem across Gojam and elsewhere due to excessive leaching of soluble salts. The dominant soil types in the study zones are Nitisols (reddish brown), Luvisols (brown), Acrisols (red), Vertisoils (black), Cambisols (brown), Phaeosoms (gray/black), majority of the soils are sticky and vertic characteristics. However, due to the serious erosion problem that is taking place in the study areas, Lithosols and Regosols cover many of the steep and undulating parts of the highlands.

3.1.1.5 Climate of the study areas

The study area (East Gojam and West Gojam) largely receives mono-modal rainfall pattern with erratic nature. When the rains come a few weeks late or stop a few weeks early, crops are likely to fail or the yield is much reduced. Due to this reason, the existing subsistence farming system in most of the study areas is recognized as unsustainable. This is particularly aggravated by the accelerating population growth and encroachment into the fragile ecosystems. The rainfall and temperature conditions affecting vegetation and land use in the study area described below.

3.1.1.6 Rainfall

Plant growth and crop yield are closely related to the amount and distribution of moisture available during the growing period. The rainfall pattern in the study area depends very much on the position of the Inter-tropical convergence zone (ITCZ).The whole part of Gojjam is situated on the wind ward side of the rain bringing summarily monsoons which reach the area from the south westerly to westerly direction.

The study area, East and West Gojam lies in the belt of single growing season that extends from May to October; that means the length of growing season extends up to 180days. The first short period of rain fall is usually received from February to May and provides little rain that is very important in tillage operation. If the rainy period is delayed or not sufficient for the tillage operation crops that are regularly sown such as maze (*Zea mays*) are replaced by others crops that could give better yield.

The variability in the length and frequency of the rains from February to May is much greater than that of main rains occurring in June, July, and August and sometimes to the mid of September. The average annual rain fall is estimated varying from 800 to 1200 mm (MoA, 2012).

3.1.1.7 The thermal Zones

The thermal zones classification is made based on the classification criteria by Krishnan and Singh (1972) cited in MoA (2000). In this classification out of the four thermal zones that are identified in Ethiopia only two thermal zones are found in the study areas. These are:

I. Mid thermal zone (Mid highland)

This area lies between altitudes of 1500 to 2300 meters above sea level (masl). The annual average temperature in this zone is between 20°C and 25°C and the mean minimum temperature is above 12°C. On the other hand, the mean maximum temperature is about 28°C.

II. Cold highland thermal zone (The Upper highland area)

The cold highland areas are characterized by cold climate and the altitude ranges between 2300 to 3200 masl. The annual average temperature here is between 10°C and 20°C. The mean annual minimum temperature varies from below 8 °C to the above 10°C. The mean annual maximum temperature, on the other hand, varies from18°C to 24 °C. The summary of the rainfall and temperature conditions are indicated in Table 3.4.

Table 3. 4 Traditional climatic zones and their physical characteristics

Thermal Zone	Altitude (masl)	Rainfall (mm) /year	Average annual temperature (°C)
Dega/Upper highland/	2,300-3,200	900-1200	>11.5
Weyna Dega /Mid Highland/	1,500-2,300	800-1,200	20.0 – 16.5/17.5

3.1.1.8 The land use land covers conditions of the study areas

According to Hurni, *et al.* (2010) in many parts of the study area (Gojam province) the natural forests cover has been lost. For example it is reported that Dembecha district , one of the study areas, had a long history of land degradation where the natural woody vegetation cover was about 27% in 1957 and reduced to 2% in 1982 and 0.3% in 1995 (Hurni, *et al.*, 2010). The scholars also indicated expansion of agricultural land by about 78% between 1957 and 1982 and the expansions were recorded on steep slopes of up to 30% gradient which have to be used in principle for perennial cops or for forestry/agro-forestry.

Due to the high fragmentation of farmland, currently the average number of plots per household in the districts is 3.49 (EPLAUA, 2014). Land holding fragmentation is commonly attributed to population growth and farmers aspiration to avert risks related to frost and other natural incidents. Land holding per farm household in the study districts ranges from 0.7 to 2.75 hectares; many rural households with small land holdings face a severe food deficit (RCS, 1997). There are reports indicating that quite a number of rural households who are nearly landless and/or having no land engaged in collection of fuel wood and making of charcoal from remnant woodlands to generate income and purchase supplementary food and also cover other household expenditures (BoFED, 2014). Some farm households in the study area also practice seasonal migration to supplement their livelihoods. Expansions of farmlands into fragile ecosystems to produce enough yields and population pressure have played a big role on natural resources degradation in the area (RCS, 1997).

3.1.2 Administrative structures and rural institutions

Administratively the Amhara region is structured at four levels: region, zone, district and kebele. The regional state council, the highest administrative body, has the authority to formulate and enact regional development proclamations, policies and laws. Procedurally, policies and regulations formulated by government institutions in the region shall be reviewed and approved by the Regional council. Any climate resilient development initiative with a policy implication, therefore, has to be approved by the regional administrative council before implementing agencies can implement it. The Zonal and District level administrations are organized with different social and economic sectors and facilitate grass root level implementation of social services and development programmes.

Kebele Administration (KA), the smallest political administrative unit in the hierarchy, has an administrative structure and a Kebele council that deliberates on the overall issues affecting the Kebele development. The Kebele Administration (KA) is composed of sections dealing with affairs, namely rural development, community mobilization, dissemination of information, security, capacity building, youth, culture and sports. Of these sections the rural development and community mobilization sections are directly involved in the implementation climate resilient development interventions such as soil and water conservation and forestry development that can improve crop and livestock productivity and reduce the degree of vulnerability to climate shocks. Currently in the Amhara region there are nearly 3148 Kebeles (BoELAU, 2014).

KAs are further divided into sub KAs and each sub KA is subdivided into *gotts* (small villages or hamlets) consisting of up to 60 to 80 rural households. These subdivisions are primarily intended to enhance development programmes and administrative matters. In principle the Kebele administration together with the agricultural development office has to carry out development planning at a micro watershed level and this has to be discussed by the community for approval. This arrangement has an important bearing on disseminating climate related issues.

3.1.3 Institutions supporting climate related development activities in the study Region

3.1.3.1 The Bureau of Agriculture

The Bureau of Agriculture (BoA) is the principal organization promoting agricultural and natural resources development. The zonal and district agricultural and natural resources and livestock experts/staff work in collaboration with agricultural extension agents, hereafter Development Agents (DAs), stationed at Kebele level. The DAs handle agronomy, horticulture, livestock, soil and water extension services and forestry development. The issue of climate change is handled as across cutting matter where DAs are expected to sensitize farmers on environmental degradation such as soil erosion, deforestation, degradation of grazing lands, drying up water bodies such as springs and ponds, water conservation, soil fertility management, livestock feed development, etc. In this process the issue of climate change and variability is also treated as important problem that aggravates the socioeconomic activities of the rural community and hence the rural community has to embark on improving the natural resource base to reduce the negative impacts of climatic variability.

3.1.3.2 Nongovernmental organizations

There are a number of non-governmental organizations (NGOs) in the region that contribute to natural resources development, small scale irrigation, water harvesting, tree planting among others. These institutions teach local communities on how to maximize use of available rain fall and other water resources to avert problems related to environmental variability. They also participate in technology provision.

3.1.3.3 The Kebele Administration

As described in section 3.1.2 Kebeles are formal institutions working on administrative and development programmes at local level. The KA has the authority to adjudicate on land resources within its jurisdictions. The soil and water conservation activities, tree plantings, communal woodland and grazing land management, water harvesting interventions, access to credit are all facilitated by the Kebele Administration supported by DAs.

3.1.3.4 The Ethiopian Meteorology Agency

This institution provides information on weather and climate issues. It organizes and disseminates weather forecast across the seasons. The information is made available to the Federal Ministry of Agriculture and that of the regional Bureau of Agriculture to sensitize farmers and development partners to make every possible caution and minimize/avoid damages that could be inflicted by incidences of climate variability (agricultural and metrological drought).

3.1.3.5 The Bureau of Land Administration and Use

This Bureau is in charge of administering rural land and it provides land holding certificates to ensure land tenure security and proper land management. The Bureau is also in charge of developing land use plans to enhance effective use of land and agricultural productivity. The activities of this institution has an important bearing in efforts to counteract climate change issues as the impact is more severe in areas where the land is poorly managed and has lost its fertility and natural vegetation cover.

3.1.3.6 Amhara Region Disaster Prevention and Preparedness Commission

This is a governmental institute in charge of providing services to the rural community to avoid damages that could be inflicted by climate change and other calamities. The Agency provides early warning information to relevant stakeholders such as the Bureau of Agriculture, Bureau of Water and the political leadership so that the government could makes the necessary provisions to avert the repercussion of climate related and other hazards. The agency also supports the Productive Safety Net Programmes (PSNP) that are designed to enable the poor generate asset by involving them in natural resources development and small and micro enterprises.

3.1.3.7 Institute of Agricultural Research

This organization is in charge of developing and disseminating diverse and improved agricultural technologies that could enhance crop productivity, natural resources management, forest development and livestock husbandry. The recurrence of shortage of rainfall, erratic and uneven distribution of rainfall and also excessive rain incidences are important variables demanding the research institutions to avail technologies that could fit into the prevailing conditions. This research attempted to explore to what extent the agricultural research centers designed their activities to avail agricultural technologies that could counteract climatic variability.

3.1.4 Description of the study Kebeles

3.1.4.1 Location, population and physical features

As mentioned in the above sections this study was conducted in 6 Kebele Administrations located in six districts of East and West Gojam zones. The three study Kebeles namely Gedamawit, Amanuel and Yeduha in East Gojam Zone are found in upper highlands above 2300 masl and are located in Senan, Machakel and Shebel Berenta districts respectively. The other three Kebeles are located in mid highlands (1500 to less than 2300 masl) of West Gojam and include Yibab Kebele in Bahir Dar Zura district, Aratu Ensisa Kebele in Jabi Tehnan district and Wad Kebele in Dembecha district. All the study kebeles have only one major rainy season (June to September).

The topography of study kebeles, more specifically Gedamawit, Yeduh, Amanuel kebeles, is more rugged and prone to soil erosion compared to other study Kebeles in the mid highland namely Yibab, Wad and Arbayitu Ensisa (Table 3.5). Soil and water conservation activities are widely carried out in the study Kebeles by mobilizing the rural community. However, the sustainability of structures constructed and trees and shrubs planted is weak due to problem of open grazing.

Table 3.5 Slope of land in the study Kebeles lying in Mid and Upper highlands (Extracted using topographic Map and GIS Techniques)

Slope %	Mid Highland Kebeles (Total area- 7406 ha)	Upper Highland Kebeles (Total area- 10249 ha)
	% area coverage	% area coverage
< 5	85	40.2
5-8	10	14.3
8-15	5	27.1
15-25	0	16.3
>25	0	2.1

Records in the KA and DAs office indicated that the total number of rural households in the study kebeles is 6508 of which 16.1% are headed by women; and the total population is about 30,587. Population projections made on the study kebeles by using the national annual population growth rate of 2.26 (CSA, 2012) showed that the population will increase to 37,497 by 2025. The current population density is calculated as 128 persons per km^2 showing a heavy pressure on available land.

3.1.4.2 Land use patterns and agricultural production

The overall land use land cover in the study Kebeles indicated that about 50.69 % of the land is used for cultivation, 20.56 % for grazing and some 11.01 % delineated for forestry and the remaining is unproductive land and settlement area (Table 3.6). The natural woody vegetation is highly degraded in almost all the study Kebeles although tree plantings mainly eucalypts are more commonly observed in Gedamawit Kebele than the other study Kebeles. Wad kebele has relatively better and well stocked woodland compared to others. Grazing land in terms of area coverage and quality of forage is relatively better in Wad and Arbaytu Ensisa. However, grazing lands in many of the Kebeles are highly degraded and small in area coverage. Private grazing resources are nearly absent.

Table 3.6 Land use land cover in the study Kebele in hectare

Study Kebeles	Land Under Cultivation in ha	Land Under Grazing	Forest/ Woodland	Constru-tion Purposes	Unprodu-ctive land	Total (ha)
Yibab	925	240	130	86	60	1441
Arbaytu Ensisa	1350	250	75	85	25	1785
Wad	2100	1455	450	145	30	4180
Amanual zuria	1209	800	415	56	150	2630
Yedwuha	2120	159	490	570	400	3739
Gedamawit	1245	725	384	98	1428	3880
Total	8949	3629	1944	1040	2093	17,655

Source: Agricultural Development Offices at the study Kebeles

Records of land holdings at the Kebele level indicated an average per capita arable land holding of the six study Kebeles is 1.37 ha; where maximum land holding is about 2.5 ha and the minimum holding is a quarter of a hectare. The majority of smallholder farmers (55%) own less than one ha. The maximum land allowed to be held by one household in the highlands is three hectares. Although land redistribution was carried out in 1997 there are about 1800 landless young people in the study Kebeles; and this is nearly an equivalent of 15 % the total households living in the study Kebeles (Data from KAs and DA records).

The majority of farm households in the study Kebeles are engaged in subsistence farming. Both the landless and those with small land holdings participate in share cropping or renting land from farmers who are not able to cultivate their land. Many of the family members in the landless and nearly landless group practice firewood collection and charcoal making and are engaged in daily labour to generate income for livelihoods (reports from KAs and DAs).

The average grain yield under farmers' traditional practice is low. For example yields for wheat and barley do not exceed 2 tons per ha (BoA, 2012). Use of improved agricultural technologies such as improved seed, chemical fertilizers, insecticides and herbicides is gradually increasing however, not so many farmers are applying the technologies. Data from the DAs offices indicate that on average not more than 75 % of the smallholder farmers utilize fertilizer, and the quantity used per ha is far below the recommended rate. Five year Data (2009 - 2014) from all the study kebeles show that fertilizer used per ha of cultivated land was 52 kg per annum.

3.1.4.3 Livestock husbandry in the study Kebeles

Livestock are an integral component of the farming system in the study Kebeles. They are major source of food, draught power, fuel, manure and social security. Almost all livestock in the kebeles are the local breeds. DAs record shows that only few farm households (less than 2%) have access to improved breeds of dairy cows, sheep or chicken.

Data on available grazing land and livestock population in the study Kebeles indicated an average stocking of 4.5 TLU per ha; (of which 79 % are cattle, 18.5% sheep/goat and about 2.5 % equine). Oxen are a vital source of draught power but it is about 63 % of farmers have a pair of oxen. There is a chronic shortage of livestock feed and straw of cereals such as teff (*Eragrostis teff*), barley and wheat is the principal supplementary feed for oxen and lactating cows. Some fodder trees for livestock such as Sesbania and Tree Lucerne are grown around homestead and on some farm bunds.

3.1.4.4 Natural resources development practices in the study Kebeles

In many of the study Kebeles particularly Gedamawit, Yeduha, and Amanuel Ziria land degradation is a serious problem due to severe soil erosion; hence soil and water conservation activities are being carried out on farm lands by mobilizing the rural community. Likewise similar activities and tree plantings are implemented on common degraded woodlands. All these interventions are deemed to boost ground water storage and improve flow of springs and other water bodies. As part of the effort to gain resilient and sustainable ecosystem and also to counteract the effects of climate change the regional government has given due focus to natural resources development, however; none of the development interventions in the micro watersheds are supported by participatory local level land use planning.

3.1.4.5 Off farm employment

Off farm activities and employment opportunities are rare in most Kebeles, except Yibab Kebele which is close to the regional capital city, Bahir Dar. In general very limited number of farm households are engaged in petty trade, wage labour, i.e households in the low wealth category and the landless attempt small handicraft, weaving, embroidery, blacksmithing and woodwork to supplement their subsistence needs.

3.1.4.6 Communication networks and access to markets

Road transport facilities were in general poor in the region. However, these days through the Universal Rural Road Access Program many of the rural kebeles are connected to main and feeder roads. The average time to reach the road access is 1.15 hours. Almost all the study Kebeles have good access to markets and the average distance to the nearest big market is 5 km.

3.2 Research Design and Methodology

This study was carried out to investigate perceptions on climate change, impacts of climate change on rural livelihoods and adaptation strategies adopted by smallholder farmers, hereafter are also called rural households or farm households to avert vulnerability and also assess government and non-government institutional supports to enhance adaptation capacities and ultimately indicate sustainable strategies to cope with the problem. The study has therefore generated primary data through information gathering from a wide sector involving rural households, Key Informants, women group, and government and non-government staff working at local levels and through field observations. This was again complemented by gathering secondary data from relevant literature and government and non-government reports. Climatic data for at least three decades was also critically analyzed to see general climatic variables trends and also to assess the likely developments in the future. The study was also supported by rapid rural appraisal method to further substantiate issues that were raised in the household survey, for example land development work done and its suitability; i.e. soil and water conservation, agroforestry, community ponds and individual household's water harvesting structures, fodder development, etc. Capturing the required data and generating valuable information demands profound understanding of the theoretical grounds of the research design and methodology and clearly defining the dependent and independent variables as described in following paragraphs.

As this research has focused on examining the perceptions, values and attitudes of rural households, community groups, and government staff on climate change and adaptation strategies being exercised by rural households and communities a survey or cross sectional research design (Bryman, 2001) was used to capture relevant data and generate appropriate information. The literature states that a cross sectional design requires the collection of data on many cases and at a single point in time in order to gather a body of quantitative or qualitative data in connection with two or more variables, which are then examined to find out patterns or associations (Bryman, 2001). In this regard many of the household variables were used to analyze association with vulnerability and adaptation mechanisms.

Complementing the research design with the appropriate research methods helps to enhance acquisition of valid data for analysis (Bryman, 2001; Oppenhiem, 1992). Hence, a mixed research method that generates quantitative and qualitative data was adopted for the study. Quantitative research is a research strategy that emphasizes quantification in the collection and analysis of data and it entails a deductive approach to test theories while qualitative research predominantly emphasizes an inductive approach to generate theories (Bryman, 2001). Quantitative data was therefore collected on a set of rural household variables, asset ownership, economic activities and development interventions such as soil conservation, tree planting, water harvesting, etc and they were employed to assess associations between farm households variables and activities that are being undertaken by the household while qualitative data was used to assess institutional and technical issues and evaluate their integration to the quantitative data. Taking note of these issues into account and considering the nature of the research a broad base of information was required to address the stated research objectives. To this end multiple source of evidence – survey questionnaires, semi structured interviews (group discussions and in-depth interviews with key informants, survey of grey literature, participant observation were used.

Data acquisition in this study was reinforced through triangulation or the combination of methodologies including quantitative and qualitative approaches as stated by Patton (1990). Patton argued that triangulation is a powerful solution to the problem of relying too much on any single data source or method as it tends to affect the validity and credibility of findings. Similar issues were treated across data generation methods (*i.e*. in the questionnaire, group discussions, and in-depth interviews) to validate data secured from different sources and also to cross check for disparity or convergence of thoughts expressed by different groups.

The data collection in this study was also supported by a Participatory Rural Appraisal (PRA) technique. In this exercise farmers were involved in the classification of the study community into different wealth groups, identification of problems associated with climate change, classification of land uses in the locality and listing of problems in land use, etc. In this process the researcher acted as a learner and facilitator. In sum data generation tools were organized giving due emphasis to the above philosophical approaches and the data collection activities in the research process are outlined in the following sections.

3.2.1 Field work

The field work for this study was carried out from August 2014 to May 2015. The initial field activity was a reconnaissance survey of the study area to establish background information on agro ecological condition, livelihood activities, land use systems, natural resource base, development activities being implemented in the context of climate change. Interactions were carried out with government and non-government institutions working in the district and at zonal level and selected individuals having knowledge of their localities to enrich the reconnaissance survey. In this exercise issues related to climate change/ variability incidences, development interventions on agriculture and natural resources management/environmental protection activities designed to avert problems arising due to climatic variability were points of concern. The overall activity in this regard has helped the researcher to establish a good picture of the study areas and prepare relevant questions in each data collection tool such as questionnaire and interview guide for group discussion and Key informant interviews.

3.2.2 Selection of Study localities and sample size determination

The study was carried out in 6 rural Kebele Administrations (KAs) (the lowest political administrative units in Ethiopia), equally distributed between East and West Gojam Zone of the Amhara Region, Ethiopia. The study areas in east Gojam represented the Upper high lands with areas above 2300 masl, and West Gojam Zone represented areas in the Mid highlands located below 2300 and above 1500 masl. Both study areas are located within the highlands and this was purposely done based on the fact that the highlands account about 37% of the country's land mass and accommodate about 90% of Ethiopia's population; and any deviation from the normal rainfall pattern causes serious challenges as crop production loss in this part of the country has severe implications in the national food security (RCS, 1997).

The study districts and the specific Kebeles for data collection were selected based on a set of variables differentiating one district/kebele from other. Principally variables related to physical attributes- topography, altitude, soil degradation, land use practices, woody vegetation cover, access to roads, electric power, irrigation water use, exposure to erratic rainfall pattern, access to markets and credit services, agricultural extension support, proximity to big urban centers, etc have served as a basis for selection. To enhance selection of the specific districts and rural Kebele administrations, districts and rural Kebeles were stratified based on similar attributes and representative districts and Kebeles were selected purposely considering the above variables.

The sample size of respondent farm households was determined by using Cochran's (1977) formula. Independent samples of rural households were calculated from a sampling frame (number of HHs in each stratum). Sample size calculation for selection of households from strata considered: (i) the proportion (p) for the different variables of investigation to be (p=0.5); (ii) design effect of 2 to make an adjustment for non-random effect; (iii) 10% margin of error at 95% confidence; and (iv) 5% non-response rate (Cochran, 1977). The formula used to calculate sample size is given as.

$$no = \frac{z^2 pq}{d^2} \Rightarrow \quad n = \frac{no}{1 + \frac{no - 1}{N}}$$

Where: *no* = the desired sample size when the population is greater than 10,000.

N = Total number of population.

n = Sample size when population is less than 10,000.

Z = 95% confidence limit i.e.1.96.

p = 0.1(proportion of the population to be included in the sample i.e. 10%).

q = 1 – 0.1 i.e. (0.9).

d = margin of error or degree of accuracy desired (0.05).

Based on the above formula the sample size was calculated as follows:

$$no = \frac{z^2 pq}{d^2} \Rightarrow \; no = .96^2 * 0.1 * 0.9/0.332 = 318$$

Assuming that the population is less 10,000 or less, the sample size is further calculated as:

$$n = \frac{no}{1 + \frac{no - 1}{N}}$$ ➔ 318/1+ (318-1/10,000) = 308

Although the formula indicated a sample size of 308, considering that the calculated number is an estimated and indicative figure and more importantly the data sources used for the research were diverse using 300 sample farm households was considered adequate. In this regard it should be noted that apart from addressing questionnaire to farm household heads, data was also gathered from vital sources including Key Informant Interview, Focus Group Discussions, Field Observation and Documents produced by the relevant sectors on climate change perception and adaptation. As the number of respondent farm households across the six study *gotts* (hamlets) in the selected study Kebeles did not show marked difference (Table 3.7), the sample size was equally distributed across *gotts* (i.e. 50 respondent farm households per the respective *gotts* in each study Kebele). Male headed and female headed farm households were proportionally included in the sample based on data obtained from DA's office. At each stratum, sample households were chosen using simple random sampling techniques from the list of farm households in each *gott*.

3.2.3 Socioeconomic Classification of Farm Households in the Study Areas

In this exercise rural households who have lived for many years and having a good knowledge of the locality were used to set a locally accepted criteria to stratify the households in the *gott* (hamlet) in different wealth strata. This was basically done to make analysis of perception, vulnerability to climatic shocks, adaptation capacities and other variables against wealth status.

Rural households and the community were used as the primary and secondary unit of analysis respectively; hence representative rural households and community groups were selected from the sample kebeles. In the selection of sample rural households the list of households in the Kebele Administration was used as a sampling frame. As indicated in section 3.1.2 the current Kebele Administration is structured to contain many *gotts* (hamlets) comprising from 60 to 80 farm households. Taking note of similarities in the attributes of farm households across the Kebeles and also to avoid difficulties of reaching sample households scattered across large areas of the Kebele, two adjacent *gotts* were first merged and sample *gotts* were randomly selected in each study Kebele.

Before the actual sample household selection stratification of the rural households in the selected *gotts* was carried out based on asset/wealth endowments using criteria adopted by the local people. Bereket Kebede (2007) in his study of community wealth ranking has noted that traditionally participatory methods of analysis like wealth ranking exercises were favored mainly by sociologists and development practitioners though he still advocates for practicing an integrated approach for wealth ranking. Other authors such as Terefe (2001) in his study of Land Tenure and Environmental Degradation in the Oromiya Highlands of Ethiopia and Tadesse (2004) in his study of Community based rehabilitation of degraded woodlands in the Amhara region of Ethiopia used participatory wealth ranking method where farm households who have good knowledge of their community classified farm households in to different wealth groups by setting local criteria. In this process however Mikkelsen (1995) underlined the need for acknowledging differences and inequalities among members of a community in their socioeconomic standing, access to resources, literacy level, etc. as all these variables are helpful in making comparisons and analysis of issues across a cross-section of the community.

Experience in the region indicated that endowment of land, livestock, household labour, and farm and non-farm income generating activities, are associated with a rural household's capability to generate wealth. However, reviews by Terefe (2001) cautioned that classification or differentiating of sample households using a single asset such as land holding size, or number of livestock ownership as an indicator has to be used making sure that it is the chief resource in the creation of assets. Taking note of the problems that may arise in using a single asset as a major criterion, in this research classification of the study subjects into socioeconomic categories was done on traditionally accepted classification norms established by the local community. To this effect, knowledgeable rural households, the Kebele leadership, and agricultural development agents were consulted in each study Kebele to set variables that can be used for the classification. The group identified variables such as livestock ownership, land holding, surplus production, ownership of bee colonies, capability to employ labour, use of improved agricultural inputs such as chemical fertilizer and herbicide as indicators defining asset endowment. Using a combination of these variables the informants classified the households in the study Kebeles in wealth categories namely as rich, medium rich and poor.

In the study Kebeles (Arbaytu Insisa and Amanuel) where farmers have access to irrigation infrastructure land holding stood as major indicator of wealth complemented by oxen ownership, in others, livestock holding, mainly oxen and cows, stood out complemented by land holding size. The overall classification process in general has considered a combination of all the variables as the informants knew very well each and every household. Farm households classified as rich were those having two pairs of oxen or more, sufficient farm land not less than 1.5 ha, and surplus crop production. The Medium rich wealth group owned a pair of oxen or an ox, two or more cows, few sheep or goats, and nearly one ha farm land. The Poor category are those having an ox or not having an ox, owning few small ruminants, having less than half or less than half of a hectare and hardly producing adequate grain for the family and mostly generating complementary income by wage labour and practicing seasonal migration. It was noted that many of the Rich and Medium Rich rural households in Arbaytu Insisa and Wad Kebeles were identified depicting much more endowment than what described the Rich and Medium Rich category in Gedamawit and Yeduha Kebeles. This clearly indicates that perception of informants on wealth category classification is a relative decision considering local socioeconomic realities reflected by farm households. Using the list of farm households in the 6 selected *gotts* households were categorized in wealth groups by knowledgeable informants (Kebele leaders, *gott* leaders, key informants, DAs). The details are shown on Table 3.7.

Table 3.7 Proportion of farm households in different wealth categories across the study Kebeles

Kebele/*Gott*	Total households in the *gotts*	Number and percent of households in each wealth category					
Kebeles in the Mid Highland		Rich (No.)	Percent	Medium (No.)	Percent	Poor (No.)	Percent
Yibab Kebele/Gott	120	10	8	43	36	67	56
Arbyiu Ensia	126	38	30	63	50	25	20
Wad	140	40	28.5	74	53	26	18.5
Upper Highland Kebeles							
Gewdamawit	130	6	4.6	59	45.4	65	50
Amnuel	110	26	24.5	52	47	32	29
Yeduha	147	25	17	50	34	72	491

From the list of rural households in each *gott,* selection of sample households proportional to the percentages of each asset group was carried in each Kebele using a systematic random sampling technique. In this exercise it was found out that the number of households in the 6 study Kebele *gotts* did not show marked difference where the highest number of farm households (147) was recorded in Yeduha Kebele and the least was in Amnuel Kebele (110) (Table 3.7). Owing to these facts it was decided to take equal sample size in each study Kebele.

3.2.4 Data collection tools

3.2.4.1 Household questionnaire

The household questionnaire was designed in line with stated objectives and research question, and it includes diverse issues that could provide an understanding of the socio economic attributes of the study farm households and their perception of climate change, the impact of climate change on their livelihoods, strategies adopted to climate change and motivation of households to adopt mitigation measures that reduce climate change impacts. In addition institutional variables influencing development interventions at local level from the perspectives of climate change are included (Appendix I). Before setting the questions an extensive reading was made on literature related to the preparation of survey questions (Fink 1995a, 1995b, 1995c, 1995d; Gilham, 2000; Oppenheim, 1992). After setting the questionnaire a pilot test was carried out on 20 farm households having the same socioeconomic background to check the ease with which respondent households answer the questions, and to make sure that the questions are meaningful and also to estimate the time needed to complete one questionnaire.

The questionnaire was divided into eight parts. Part I of the questionnaire deals with demographic and socioeconomic characteristics of the respondent farm households largely addressing household variables such as age marital status, family size, literacy, livelihood activities that are deemed important in analysis on perception on climate change. Part II addresses livestock husbandry which is an integral component of the farming system and insurance for the household in time of adversity; Part III, addresses land holding and crop production activities of farm households, and land management practices to increase agricultural productivity. The issues treated in these sections were used to establish endowments and livelihood systems pursued by households. The variables were used to assess how the study subjects differ in terms of asset endowments and also test association between household variables and perceptions on climate and adaptation strategies and capabilities.

Part IV and V cover issues pertaining to perceptions on land use land cover change over the years and institutional support to farming and climate change related activities. The land use land cover change focuses on forest, grazing land and woodland management. The objective here was to assess how smallholder farmers perceive the land use change and efforts made to sustain land productivity. Institutional support refers to technical support on agricultural development and implementation of natural resources management activities that could enhance adaptation to climate change incidents.

Part VI, II and VIII deal with climate change perception assessment, investigation of adaptation and coping strategies to climate change. In these sections major indicators of climate change/variability, trends in climate change variables, major problems encountered due to climate variability, causes of climate change were assessed from household's perspective. Likewise Assessment of adaptation strategies and coping options to climate change and barriers faced, adjustments made in the farming practice, and off farm options and their relevance were treated from household's perspective and institutions providing development services. The household variables and asset endowments and development support were investigated against the adaptation and coping strategies and vulnerability to climate change.

3.2.4.2 Involving the Agricultural development staff and other institutions having Stake on climate change

The agricultural development experts are the major technical agents assisting farmers to improve crop production, livestock husbandry, conserve soil, harvest water, grow trees and manage communal grazing and woodland. They also provide awareness on climate change issues. Accordingly the regional, zonal, district and Kebele experts who have direct and indirect involvement were interviewed and their responses were carefully recorded. Likewise discussions on climate change and institutional support were held with experts working in the Bureau Environment and land administration, Meteorological Agency, Agricultural Research Centre, and Disaster Prevention and Preparedness Commission.

3.2.4.3 Key Informant Interviews (KI)

According to Kumar (1989) key informant interviews involve interviewing of knowledgeable individuals who are likely to provide the required information, ideas and insights on a particular subject. Key informant selection involves inquiring who the experts are (Chambers, 1992); hence, individual key informants were identified carefully with the help of rural households that took part in focus group discussions, Agricultural Development Agents and members of the Kebele leadership. A total of 18 key informants (three per Kebele) were used for the study. Efforts were made to include the elderly who have lived in the study areas for quite long period. Key informant interviews were conducted at convenient places chosen by the Key informants using a check list of open ended questions (Appendix II). The major topics discussed include information about the general trends of climate change (rainfall, temperature, soil fertility, forest, wildlife, crop and livestock productivity, rivers and floods); the impacts of climate change on crop production, livestock husbandry, livelihood options and various coping and adaptation strategies and climatic mitigation measures practiced at local level and the issue of their sustainability.

3.2.4.4 Focus Group Discussions (FGD)

Group discussion using semi structured questions allows researchers to look into more deeply into issues and develop new lines of inquiry that arise during interviews (Denscombe, 2007; Gilham, 2000). Group discussions compared with formal questionnaire interviews allow sensitive issues to be more freely discussed in groups when individual are reluctant to discuss them alone with a stranger (Krueger, 1994). Group interviews compared to questionnaire interviews allow sensitive issues to be more freely discussed in groups when individuals would not wish to discuss them alone with a stranger (Chambers, 1992; Krueger, 1994).

Taking note of the above theoretical foundations semi structured interviews were conducted to complement and compare information that was generated in the household questionnaire and interviews with key informants. In the group discussions individuals who are familiar with development activities in their localities, and those assumed to having information on the local adaptation measures against negative effects of climatic change in the study Kebeles were included. Accordingly the discussions were carried out with selected groups i.e. male headed households including Kebele leadership; women headed households, and youth group (male and female together).

Agricultural and land administration experts working at Kebele, District and Zone level were the other groups for focus group discussion. The agricultural development staff are the major technical agents assisting farmers to improve crop production, livestock husbandry, conserve soil, harvest water, grow trees and manage communal grazing and woodland and they also provide awareness on climate change issues. The discussion with experts focused mainly on institutional matters pertaining to climate change, policy framework, local level organizational set up and validity of the intervention programs. The main objective here was to examine the validity of the development interventions on climatic change from the staff's perspective and also assess the strengths and weaknesses of the development interventions in the context of climate change adaptations.

In Focus Group Discussions (FGDs) ideally group members should contain six to eight people but can be as high as 12 and if more is required needs to be supported with good reasons (Denscombe, 2007; Walker, 1985). In this study group size for discussion with rural households varied from 8 to 18 with an average of 12 participants. To increase the quality of information introductory questions were followed by key questions to the core topic and summary questions as suggested by Krueger (1998). It was attempted to make sure that a few individuals do not monopolize the conversation and do not suppress or distort the views of others, and all members were encouraged to share views (Walker, 1985). Various scholars stated that competency in moderation of the discussion is important for alleviating the problem and enhancing balanced flow of ideas (Denscombe, 2007; Walker, 1985; Patton, 1990; Kreguer, 1994, 1998).

The questions directed for the different groups were arranged to suit each group (Appendix III). In all cases perceptions on climate change and variability in their respective localities, impacts of climate change or variability on the livelihood of the local people, smallholder farmers, community and government and non-government efforts to enhance adaptation to climate change and mitigation measures to climatic change and indigenous knowledge applied were given due consideration. Key issues raised in each group discussion were screened the same day of the discussion and new ideas important for further discussion were incorporated in the following group discussion. In the whole exercise the researcher was supported by an assistant note taker while the researcher performed as major facilitator of the discussion.

3.2.4.5 Rapid Rural Appraisal (RRA)

Rapid Rural Appraisal (RRA) including transect walks, was fundamentally an extractive, external-driven process that helped the researcher get information about the area under study based upon the knowledge of the communities about their own life conditions (Chambers, 1992). The use of these kinds of tools enable researchers to get useful information about the sites, and also help to get closer to the people in the village and gain some confidence for the future work. The rapid rural appraisal included activities of a reconnaissance assessment of the land use land cover, land management practices, local institutional setups from environment and social issues management perspectives, etc. Preliminary information was also collected on incidences of climatic variability, challenges faced by the community, adaptation and mitigation mechanisms attempted by the community.

3.2.4.6 Vulnerability assessment and response strategies to adverse climatic-Impacts

Vulnerability in this study was understood as the likelihood of rural households and communities in the study area suffer from climate adverse impacts on their means of living and their incapability to respond to stresses resulting from the impacts. This understanding basically stemmed from the definition of IPCC (2001) and vulnerability refers to "the degree to which a system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes". To assess vulnerability of rural livelihood strategy in the context of shocks and other stressors Ellis (2000) used indicators such as asset land holding, market, biological resources, availability of water, labor or human capital, social interconnectedness, saving and credit availability, social interconnectedness, institutions and organizations. Thornton *et al*. (2007) also used the social, natural, human, financial and social capital to analyze vulnerability. As this study was exploratory, the identification of indicators of vulnerability was based on the analysis of responses from farm households and the community giving due focus on how and why they are vulnerable.

Societies are dynamic and they use all possible strategies to reduce vulnerability to climatic impacts. The resilience or robustness of adaptation strategies differ depending on the availability and ability to access resources and use technology (Adger *et al*., 2003). In this study local adaptation strategies were assessed from the data collected from different sources.

3.2.5 Theoretical Model for the analysis of the determinants of farmers' choice of adaptation to climate change in the study areas

As one of the objectives of this study is assessment of adoption strategies practiced by smallholder famers to avert the impact of climatic variability or change, the empirical estimation of the determinants of adaptation strategies takes into account various factors. Some of these factors (section 3.2.5.1) are considered as explanatory variables in the model to help assess their impact on the propensity of adoption of various adaptation strategies.

The decision to use any adaptation option could fall under the general framework of utility and profit maximization. A rational farmer who seeks to maximize the present value of expected benefits of production over a specified time horizon must choose among a set of *j* adaptation options. The farmer *i* therefore decides to use *j* adaptation option if perceived benefit from option *j* is greater than the utility from other options (say, *k*). This assumption is depicted as:

$$U_{ij}(\beta_j' X_i + \varepsilon_j) > U_{ik}(\beta_k' X_i + \varepsilon_k), k \neq j, \text{ ……………………………………………….. (1)}$$

Where Uij and Uik are the perceived utility by farmer i of adaptation options j and k, respectively; X is a vector of explanatory variables that influence the choice of adaptation : βj and βk are parameters to be estimated; and ε_j and ε_k are the error terms. Under the revealed preference assumption that the farmer practices an adaptation option that generates net benefits and does not practice an adaptation option otherwise, it is possible to relate the observable discrete choice of the practice to the unobservable(latent) continuous net benefit variables Yij =I if Uij > 0 and Yij =0 if Uij < 0. In this formulation, Y is a dichotomous dependent variable taking the value of 1 when the farmer chooses an adaptation in question and otherwise 0.

The probability that the farmer i will choose adaptation j among the set of adaptation options could be defined as follows:

$$P(Y = 1/X) = P(U_{ij} > U_{ik}/X) \text{ --------------------------------------- (2)}$$

$$= P(\beta_j' X_i + \varepsilon_j - \beta_k' X_i - \varepsilon_k > 0/X)$$

$$= P((\beta_j' - \beta_k') X_i + \varepsilon_j - \varepsilon_k > 0/X)$$

$$= P(\beta^* X_i + \varepsilon^* > 0 / X) = F(\beta^* X_i)$$

Where έ* is a random disturbance term, β* is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing adaptation, and F (β*Xi) is the cumulative distribution of έ*Xi. Depending on the assumed distribution that the random term follows, several qualitative choice models such a linear probability, logit, or probit model could be estimated (Greene, 2003). The logit and probit models are the most common models used in the literature. Indeed, they have desirable statistical properties as the probabilities are bound between 0 and 1 (Greene, 2003).

Given that several adaptation choices are investigated, the appropriate econometric model would, thus, be either a multinomial logit (MNL) or multinomial probit (MNP) regression model. Both models estimate the effect of explanatory variables on a dependent variable involving multiple choices with unordered response categories.

The main attractive feature of the MNP model is that it allows a rather general covariance structure for the alternative-specific errors. However, because observed choices only reveal information regarding utility differences, and because scale cannot be determined, not all parameters in an arbitrary MNP specification may be identified (Bunch, 1991). With recent advances in computational methods, some researchers have developed techniques for the estimation of the MNP.

$$\text{Pij} = \text{Prob (Y=1)} = \frac{e^{x'\beta}}{1 + \sum_{j=1}^{j} e^{x'\beta}}, \; j = 1......j, \quad \text{……………………..} \; (3)$$

Where β is a vector of parameters that satisfy ln (Pij / Pik) =X′ (βj-βκ) (Greene, 2003)
Unbiased and consistent parameter estimates of the MNL model in Equation 3 requires the assumption of Independence of Irrelevant Alternatives (IIA) to hold. Specifically, the IIA assumption requires that the likelihood of a household's using a certain adaptation measure needs to be independent of other alternative adaptive measures used by the same

household. Thus, the IIA assumption involves the independence and homoscedastic disturbance terms of the adaptation model in Equation 1. The validity of the IIA assumption could be tested using Hausman's specification, which is based on the fact that if a choice set is irrelevant, eliminating a choice or choice sets from the model altogether will not change parameter estimates systematically.

Differentiating Equation 3 with respect to each explanatory variable provides marginal effects of the explanatory variables given as:

$$\frac{\partial P_j}{\partial X_k} = P_j(\beta_{jk} - \sum_{j=1}^{j-1} P_j \beta_{jk}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

This study used a Multinomial Logit model to analyze the determinants of farmers' decisions because it is widely used in adoption decision studies involving multiple choices. Accordingly household characteristics, farm characteristics, institutional factors were hypothesized to explain the dependent variable and the study considered the following variables as potential factors affecting farmers' decisions to adapt to climate change.

The specified Multinomial logit model for this study is thus:

Adapt = f(Sex of the respondent (SEXRE), Age of the respondent (AGE), Educational level of the respondent (EDUCEN), Experience that he/she lived in the community (HOLOLINC), Total family size of the respondent (TOIFASIZ), Farm size held by the respondent, (FARMSZ), Productivity of the soil without fertilizers (HPRODUCT), Access to agricultural extension service (AGRISERV), Farmer to farmer extension service (FARMERTO), Access to credit (ACTOCRED), Access to information on climate change (ACCINFORM), Awareness on declining of rainfall (ADECRF), Knowledge on poor distribution of rainfall (KPORDRF), Acknowledging that temperature is increasing (ATEMPRINC), Agro ecology of the study area (AGROECO), Off-farm employment opportunity/migration of the family members of the respondent (MIGSEWOR), Wealth status of the respondent (WEALTHST), Having a pair of oxen for the respondent (PAOXPLOL).

The Multinomial Logit model expressed using the codes of variables are as follows:

Aapt = f(β'X)=f(SEXRE+ EDUCEN+ +HOLOLINC+ TOIFASIZ + FARMSZ+ HPRODUCT + AGRISERV + FARMERTO + ACTOCRED + ACCINFORM + ADRF + KPDRF+ ATEMPRINC + AGROECO + MIGSEWOR + WEALTHST+ PAOXPLOL+μ_i…

3.2.5.1 Definition and justification of model variables

Dependent variable (adapt)

The study used binary dependent variable taking the value 1 if the farmer adapted to climate change and 0 otherwise. This is done to distinguish between farmers who adapted and those who did not in the study area. A farmer is considered to have adapted to climate change if he/she has employed at least one of the adaptation strategies such as enhanced use of traditional irrigation schemes, used improved crop varieties, improved animal rearing, shifting planting date, implement soil conservation techniques, and diversify from farming to non-farming activities.

Independent variables

The choice of independent variables used in the study is influenced by literature reviewed on factors that influence farmers' decisions to adapt to climate change, previous research findings and the knowledge about adaptation to climate change in the mid highlands and upper -highlands of the study area in the Amhara region of Ethiopia.

1. Gender of the respondent/ SEXRE/

Gender of the household head is hypothesized to influence the decision to adopt changes. It is also asserted that women possess distinctive knowledge and skills that should be accredited and utilized to develop resilience against climate change shocks and other development activities. A recent study in South Africa by Nhemachena and Hassan (2007) reported that female-headed households are more likely to take up climate change adaptation methods. According to the authors, the possible reason for this observation is that in most rural smallholder farming communities in the region, men more often look for jobs in towns, and much of the agricultural work is done by women. Therefore, women have more farming experience and information on various management practices and how to change them, based on available information on climatic conditions and other factors such as markets and food needs of the households (Glwadys Aymone cited Gbetibouo, 2009). On the other hand Asfaw and Admassie (2004) argued that male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households. This study therefore assumes that gender of a household head could have influence on adaptation to climate change.

2. Age/AGE/

Age of the head of household can be used to capture farming experience and its influence on adaptation to climate change. For example Obayelu, *et al* .(2014) in their study of factors affecting farmers' choices to climate change in Nigeria reported that age has an influence on farmers efforts to adapt to climate change. Similar views were also expressed on effect of age on adoption of improved agricultural technologies (Gbegeh and Akubuilo, 2012).

3. Farming experience /HOLOLINC/

Farming experience is the total number of years the household head has spent making farming decisions and the variable is continuous. The more experienced the farmer is, the better informed he/she is about temperature and precipitation changes in the study areas and the more he/she is likely to employ adaptation measures that reduce the impact of climate change on his/her agricultural activities. Hassan and Nhemachena (2008) contended that it is farming experience that matters more than merely the age of the farmer when it comes to adaptation to climate change.

Studies by Maddison (2006) and Hassan and Nhemachena (2007) indicate that more farming experience increases the probability of a farmer adapting to climate change. In this study this variable is hypothesized to be positively and/or negatively correlated with climate change adaptation.

4. Educational level/ EDUCEN/

Education as a continuous variable measured in years of formal schooling of the household head. The number of years of schooling achieved by the household head is used as a proxy for managerial input. Education plays an important role in the adoption of innovations/new technologies. Maddison (2006) argued that education diminishes the probability that no adaptation is taken. Therefore, in this study, education level of the household head is hypothesized to be positively influencing farmers' decisions to adapt to climate change.

5. Family size of the household /TOIFASIZ/

Household size is measured by the number of members in a household. It is assumed to represent the labour input to the farm. While Mano and Nhemachena (2006) contended that large household size is mostly inclined to divert part of its labour force into non farming activities, Hassan and Nhemachena (2008) challenged this view arguing that the opportunity cost might be too low in most small holder farming systems as off farm opportunities are difficult to find in most cases. On the other hand Gbetibouo (2009) reported that household size enhances the farmers' adaptive capacity to respond to climate change. In this study therefore the variable is assumed to have positive or negative impacts on climate adaptations.

6. Farm Size/FARMSZ/

Farm size helps to practice alternative crop production as a means to satisfy the needs of the family. The bigger the farm size, the more likely the farmer is to adopt suitable strategies. In this study a positive or negative relationship is expected between farm holding size and climate change adaptation.

7. Soil fertility status /HPRODUCT/

Soil fertility includes the soil quality on the farm where the farmers carry out their farming activities. Poor soil fertility is hypothesized to increase the probability of a farmer to make conservation decisions in order to adapt to climate change impacts.

8. Wealth status of the respondents/ WEALTHST/

Wealth is believed to reflect previous achievements of farm households and their ability to accept risks. Thus, households generating better income and having adequate assets are better placed to adopt new farming practices (Shiferaw and Holden, 1998). Therefore, the variable wealth status is likely to be positively or negatively related to climate change adaptation.

9. Off-farm employment/ MIGSEWOR/

Off-farm employment may pose a constraint to adoption of technology because it competes for labour and time needed for on-farm activities (McNamara *et al*., 1991). Therefore in this study the variable off farm employment is likely to be positively or negatively related to climate change adaptation.

10. Access to Extension Service (AGRISERV)

This refers to the number of contacts with extension agents that the respondent farmers made in a year. Most authors have documented positive correlation between extension contact and adoption decision of farmers (Maponya and Mpandeli, 2013; Obayelu, *et al.*, 2014, Shongwe *et al*., 2014). In fact, agricultural extension is an important source of information, knowledge and advice to smallholder farmers in Ethiopia. Subsequent provision of technical supports (extension services) will increase farmers' knowledge, skills and awareness towards new innovations. Therefore, extension contact is hypothesized to influence farmers' adaptation to climate changes negatively/positively.

11. Farmer to farmer extension service (FARMERTO)

Having access to farmer-to-farmer extension service increases the likelihood of using different agricultural technologies. It also helps to increase adoption of most of the adaptation methods. This variable is hypothesized to influence farmers' climate change adaptation positively or negatively.

12. Access to credit (ACTOCRED)

Access to credit service is an important factor to narrow the financial gap of the farmers so that they could purchase the required farm inputs and technologies that are useful for improving agricultural production and also to carry out income generating activities other than farming (Komba and Muchapondwa, 2015). This variable is therefore assumed to influence farmers' adaptation efforts to climate change either positively or negatively.

13. Access to Information on climate change (ACCINFORM)

Availing accurate information on climate change is not an easy task. The presence of well-functioning weather stations and proper processing of weather data and dissemination of weather forecasts as well as acceptance of the information by users is assumed to influence adaptation efforts to climate change (Ayesha, *et al.*, 2012).

14. Awareness on changing patterns in rainfall and temperature (ADECRF),

Awareness on the declining trend and poor distribution of rainfall as well as incidence of rising temperature by farmers is assumed to affect framers motivation to carry out climate adaptation options. This is reported by a number of authors who carried out adoption studies in different countries of Africa and Asia (see Chapter Two).

3.2.6 Data summarizing and analysis

3.2.6.1 Survey data

In this research a mixture of qualitative and quantitative data was collected; hence, a combination of data analysis methods was employed. The qualitative data gathered from group discussions were summarized the same day the discussion was held with the assistant note taker. Due emphasis was given to screen exceptional and prominent issues that were reiterated by specific category of farm households during the discussion. Similarly the views of experts were processed immediately and vital issues requiring further reflections were identified and presented in the following group discussions. Contradictory and converging ideas on particular issues that were reflected in the process of the discussions were identified and used for analysis in line with the stated research objectives.

Most of the variables in the questionnaire used for analysis were categorical, nominal or ordinal and the numeric or measurement variables were not normally distributed. Hence, non-parametric tests Chi Square (X^2) tests, were used to see the association between independent variables (sets of household, community, and institutional variables) and farmers perceptions on climate change and motivation to take alternative actions to avert climate change risks. An association level of 0.05 was chosen as the minimum significance level.

It is assumed that farmers consider alternative technologies to avert the risk inflicted by climate change and the decision on whether or not to adopt a new technology by farmers takes place when the perceived utility or net benefit from using such a method is substantially greater than is the case without it (Temesgen, *et al.*, 2008). The analysis of the determinants of farmers' choice of adaptation methods and perception on climate change were considered under the general framework of utility or profit maximization as indicated in the works of Temesgen *et al*. (2008) and Misganaw *et al*. (2014).

According to Temesgen *et al.* (2008) adaptation to climate change undergoes a two-stage process: first, perceiving or realizing the change and, second taking or not taking decision to adopt particular measures. It was assumed that only those who perceived climate change adapted alternative technologies, hence this study applied Heckman's sample selectivity probit model as used by Maddison (2006) to analyze farmers' perceptions and adaptation to climate change.

In the overall data analysis of the farmers' perception of climate change and adaptation of technologies to climate change was analyzed using Multi Nominal Logit (MNL) model and where applicable the Chi Square test was carried out as stated above. The analytical tests were in many places supported by descriptive statistics. This involves computation of percentages of single variables, the median and average outcomes. SPSS version 20 statistical software was used for analysis. Prominent views of discussion participants on particular issues gained from semi-structured interviews were used to corroborate the interactions.

In establishing analytical models a number of explanatory variables including household variables such as education, household size, gender of household head , age of household head, farm income, nonfarm income, livestock ownership, extension on crop and livestock, information on climate change, farmer-to-farmer extension , credit availability, farm land size , distance to output and input market, agro ecology, awareness on rain fall variability, access to irrigation, temperature, etc were used in the analysis as explanatory variables to see how they affected dependent variables. The dependent variables treated in the analysis include the adaptation methods such as use of new crop varieties that are more suited to drier conditions, irrigation practice, crop diversification, mixed crop livestock farming systems, change of planting dates, and diversification from farm to nonfarm activities.

3.2.6.2 Analysis of meteorological data

The meteorological observation data were grouped based on the respective agro-ecology (in this study Mid Highland and Upper highland) and the representative data were taken for climate trend analysis of the study area. Precipitation and Temperature data showed a long-term change of data or some pattern changes in the given temporal scale series. XLSTAT software was employed to analyze the trend analysis and to consider the seasonal component of precipitation at the same time. Hence, to describe a trend of time series Mann-Kendall trend test was used to see whether there is a decreasing or increasing trend. Mann-Kendall statistics (S) is one of non-parametric statistical test used for detecting trends of climatic variables. It is the most widely used methods since it is less sensitive to outliers (extraordinary high values within time series data) and it is the most robust as well as suitable for detecting trends in precipitation.

Different software such as SPSS and Microsoft excel were used for trend analysis and significant test. As these software are very sensitive to outliers (extraordinarily high values), Mann- Kendall trend test was used to detect the trend and normalized Z-score for significant test. A score of +1 is awarded if the value in a time series is larger, or a score of -1 is awarded if it is smaller. The total score for the time-series data is the Mann-Kendall statistic, which is then compared to a critical value, to test whether the trend in rainfall or temperature is increasing, decreasing or if no trend can be determined. The strength of the trend is proportional to the magnitude of the Mann-Kendall Statistic (i.e., large magnitudes indicate a strong trend). Data for performing the Mann-Kendall Analysis was set in time sequential order. The first step was determining of the significance (sgn) of the difference between consecutive sample results. Sgn(Xj – Xk) was an indicator function that results in the values 1, 0, or –1 according to the significance of Xj – Xk where j > k, the function was calculated as follows:

- $sgn(\mathrm{Xj} - \mathrm{Xk}) = 1 \text{ if } \mathrm{Xj} - \mathrm{Xk} > 0,$
- $sgn(\mathrm{Xj} - \mathrm{Xk}) = 0 \text{ if } \mathrm{Xj} - \mathrm{Xk} = 0$
- $sgn(\mathrm{Xj} - \mathrm{Xk}) = -1 \text{ if } \mathrm{Xj} - \mathrm{Xk} < 0$

Where Xj and Xk are the sequential precipitation or temperature values in months J and K (J>k) respectively and a positive value is an indicator of increasing (upward) trend and a negative value is an indicator of decreasing (downward) trend.

Let X1,X2,X3………….. Xn represent data points (Monthly), Where Xj represents the data point at time J. Then the Mann-Kendall statistics (S) is defined as the sum of the number of positive differences minus the number of negative differences as expressed in the following formula.

$$S = \sum_{k=1}^{n-1} \sum_{j=k+n}^{n} sgn(Xj - Xk)$$

Where $sgn(\mathrm{Xj} - \mathrm{Xk}) = 1 \text{ if } \mathrm{Xj} - \mathrm{Xk} > 0,$

$sgn(\mathrm{Xj} - \mathrm{Xk}) = 0 \text{ if } \mathrm{Xj} - \mathrm{Xk} = 0$

$sgn(\mathrm{Xj} - \mathrm{Xk}) = -1 \text{ if } \mathrm{Xj} - \mathrm{Xk} < 0$

Trends considered at the study sites were tested for significance. A normalized test statistic (Z-score) was used to check the statistical significance of the increasing or decreasing trend of mean precipitation and temperature values. The trends of temperature were determined and their statistical significance were tested using Mann-Kendall trend significant test with the level of significance 0.05 (Z_α/2 = ±1.96).

$$Z = \frac{n-1}{\sqrt{var(S)}} \text{if S} > 0$$

$$Z = 0, \qquad if\ S = 0$$

$$Z = \frac{n+1}{\sqrt{var(S)}} \text{ if } S < 0$$

Hypothesis testing Ho=μ= μo (there is no significant trend/stable trend in the data)

HA= μ_ μo (there is a significant trend/ unstable trend in the data); If $-Z_{1-\alpha/2} \leq Z \leq Z_{1-\alpha/2}$ accept the hypothesis or else Reject Ho. Strongly Increasing or Decreasing trends indicate a higher level of statistical significance.

3.3 Summary

This chapter gave a description of the study area in terms of physical and socioeconomic attributes. The study was carried out in six districts of the Amhara region of Ethiopia, and all of them are located in the highlands. However, to assess influences of altitudinal differences three of the study Kebeles are located in the Mid Highlands lying between 1500-2300 masl and the other three in the Upper Highlands located between 2300 to 3500 masl. The study sites in the two altitudinal zones differ in terms of topography where those in the Upper Highlands are more rugged and prone to more severe soil erosion. These features are also reflected in the six study kebeles. All the study areas practice mixed farming where crop production and livestock husbandry are carried out in the same management unit. Incidences of erratic rainfall though a cross cutting problem it is more severe in some of the study Kebeles such as Yibab. The research design adopted for this study is a survey design more specifically known as a cross sectional design which gives an opportunity to gather data from different sources at one point in time. Accordingly data was generated from 300 sample farm households using survey questionnaire, Focus group discussion, in-depth interviews with Key informants, Rapid rural appraisal. Purposive sampling was adopted to select the study districts. In this process attributes such as exposure to repeated climate variability, access to water for irrigation, proximity to large urban center, altitude, topography, etc were used to select the study districts and the study Kebeles as well. In addition, weather data was collected from 10 Meteorological station located across the study areas.

In this research a mixture of qualitative and quantitative data was collected; hence, a combination of data analysis methods was employed. As most of the variables in the questionnaire used for analysis were categorical, nominal or ordinal and the numeric or measurement variables were not normally distributed, non-parametric tests Chi Square (X^2) tests were used to see the association between independent and independent variables.

In the overall data analysis of the farmers' perception of climate change and adaptation of technologies to climate change was analyzed using Multi Nomial Logit (MNL) model and where applicable the Chi Square test was carried out as stated above. The analytical tests in many places were supported by descriptive statistics, and this involved computation of percentages of single variables, the median and average outcomes. SPSS version 20 statistical software was used for analysis.

The meteorological observation data were grouped based on the respective agro-ecology (in this study Mid Highland and Upper Highland) and the representative data were taken for climate trend analysis of the study area. XLSTAT software was employed to analyze the trend analysis and to consider the seasonal component of precipitation at the same time. Hence, to describe a trend of time series Mann-Kendall trend test was used to see whether there is a decreasing or increasing trend. Mann-Kendall statistics (S) as a non-parametric statistical test was used for detecting trends of climatic variables.

The following chapter focuses on analysis of the socioeconomic attributes of study subjects in the context of climate change and the output served as a vital input to the other three result chapters addressing perception of climate change, adaptation to climate change and institutional issues for climate change management.

CHAPTER 4

SOCIOECONOMIC ATTRIBUTES OF THE RESPONDENTS

4.1 Introduction

In this chapter the demographic characteristics and economic activities of the respondent farm households, and infrastructure provisions in the study area are highlighted in the context of climate change variables. The household variables analyzed include age, sex, education, family size, marital status and education, proximity to urban centers, access to land resources, irrigation, asset endowment, exposure to drought incidences, etc. These variables have implications on smallholder households' perception of climate change, vulnerability to climate change, adaptation to climate change, access to credit services, access to markets, livelihood strategies followed, etc and they are used as background information for the succeeding chapters.

4.2 Results and discussions

4.2.1 General characteristics of farm households

The sample farm households interviewed (n=300) equally divided between Mid highlands and Upper highlands appear to be representative of the population in the highlands of the region being sampled following the standard statistical procedure. Of the total fram households interviewed in the study, 89 % were male-headed households and the remaining 11% were female headed households. The family size of the respondents was generally high with an average of 5.2 persons and standard deviation of 2.56; and the average family size was greater than that of the national average 4.3 and the regional average 4.5 (CSA, 2010). About 62 % of the respondent households had a family size between one and five and the remaining 32.8 % having more than five. The mean family size however differed across gender where male headed households had more family members than female headed households ($p<0.001$). During the FGDs most participants were of the opinion that having more children is an asset though it is tough for them to bring up more children. In this regard Silvestri *et al.*, (2012) argued that having large family enables to have higher labour that is needed to carry out different farm activities.

The marital status of the respondent indicated that about 90.4% were married, 0.7 % unmarried, 5.3 % divorced, 2.3% windowed, and 0.7 % were widower. The figures in general showed that there is a stable marriage situation in the study area where as a study by EDHS (2012) showed an 11% divorce or widow situation at national level. Comparison of family size showed that there is no visible difference across mid and upper highlands.

The farm households represented in the study encompass age groups ranging from 20 and above with a mean age of 46.5; standard deviation of 11.55 and Standard error of 0.66. As depicted in Table 4.1 about 51.7% of the household heads are between 20 and 47 years of age, while those aged between 48 and 60 years account for 36% and those above 60 comprise about 12%. About 60 % of the respondents have children below 10 years and about 40 % have children above 10 years. The predominance of a young population in the study area implies that population density is increasing at a very fast rate and may pose stress on the environment. Hence, it seems logical to strengthen family planning activities already in place in the district albeit in limited extent. On the positive side, mobilizing this immense work force for productive activities can bring tremendous development.

Table 4. 1 Age classes of survey household heads (N=300)

Age Category	Count	Percent
20-30	27	9
31-35	33	11
35-45	95	31.7
46-55	81	27
56-65	42	14
66-72	22	7.3
Total	300	100

Classified by asset endowments 16.3% of farm households are rich, 50.3% medium and 33.3% are poor. Family size was also analyzed across wealth groups and it was found out that the better off households have more family members compared to the resource poor farmers ($p<0.001$). That is poor households tended to have smaller families, and fewer people contributing farm labor than the richer households. Distribution of wealth classes across the study Kebels and altitudinal zones is depicted in Table 4.2 and 4.3.

Table 4. 2 Wealth Status of respondents across study Kebeles

Study Kebele	Wealth Class		
	Rich	Medium	Poor
Amanuel –Machakel /East Gojam	8	25	17
Yeduha/Shebel Berenta/East Gojam	5	21	24
Gedamawit/Sinan East Gojam	6	18	26
Wad-Dembeha/West Gojam	11	34	5
Arbaytu Ensisa/Jabi Tehnan/West Gojam	12	28	10
Yibab-Bahir Dar Zuria/West Gojam	7	25	18
Sub Total	49	151	100

Table 4. 3 Wealth Status of respondents across Altitudinal zones (n=300)

Wealth Class	Mid highland	Upper High land
Rich	30	19
Medium Rich	87	64
Poor	33	67
Total	150	150

Among the study Kebeles Arbayitu Enssa has access to irrigation and this seems to have resulted in better wealth classes and likewise the fertile soil and better grazing land resources in Wad kebele seem to have contributed to better wealth status. The statistical test has indicated a significant difference of wealth status across altitudinal zones ($p<0.001$) where about 65.3% of the poor live in the Upper Highland compared to the Mid Highland. Regarding income generating activities farm households supplement their family income through petty trade, daily labour, and on a limited scale through handicraft production and sale. Petty trade activities include marketing of grain, livestock and retailing of consumer goods in rural markets after buying from urban markets. These activities are largely carried out by the poor and medium rich as revealed during the FGDs.

4.2.2 Education

Of the household heads surveyed 45.8 % are illiterate, 35.7 % are able to read and write and 18.5% have attended formal education of which only few reached secondary school.

This data reflected the reports of the study area districts' education offices. The levels of literacy across the altitudinal zones revealed that about 51.5% of household heads in the mid highlands and 45.8 % in the upper highlands could neither read nor write (Table 4.4). The difference is largely associated with problem of access to school in the 1970 and early 1980s as noted by the respondents. The literacy level in general is low and even those claiming being literate farmers are not supported by functional literacy that helps them to improve their livelihood activities. The general trend shows there is no significant difference in literacy level across the study zones ($X^2 = 28.3$, df=2 P=0.87). However, comparison of literacy level between male headed and female headed farm households indicated a significant difference ($p<0.001$) where more female headed households (62%) are illiterate while the illiteracy level for male headed households is about 38.2%. A positive trend however observed in respondent households is that most parents are sending their children to school. Nearly 78% of female children and 89% of male children are attending and/or attended formal education, indicating that the future generation will largely be literate. This will indeed have a positive implication to promote technologies that could enhance environmental and agricultural management and adaptation to climate change as argued by Uddin *et al.*(2014) in their investigation of factors affecting farmers adaptation strategies to environmental degradation and climate change at farm level in Bangladesh.

Table 4.4 Literacy Status of farm households by altitudinal zones (Midland and Highland)

Variable	Mid Highland		Upper Highland		Total	
Educational Level	Count	Percent	Count	Percent	Count	Percent
Illiterate	66	44	67	44.7	133	44.3
Read and write	60	40	57	38.0	117	39.0
Formal Education (primary to secondary)	24	16	26	17.3	50	16.7
Total	150	100	150	100	300	100

In recent years, in the Amhara region and the country at large attention is given to the need for strengthening links between economic growth and human resource development to counter poverty. To this effect it seems rational to improve the knowledge and technical capabilities of the rural mass though functional literacy and where feasible through formal education. Scholars argue that where farmers are provided with the opportunity to get a functional and basic education, they can adopt agricultural technologies, protect environment and manage their household income properly (Below *et al.*, 2010). Conversely it is argued that illiteracy may aggravate vulnerability of farm households and communities to climatic and other natural shocks and reduce their coping capacity.

4.2.3 Religion

All the respondent households were Christians and the survey result revealed that 97% of the Christian households observe as many as 11 to 16 non-working days including weekends, (on average 13 days) in a month. Furthermore, it is revealed that the illiterates account 56.8% out of the households who largely observed non-working days. In group discussion the impacts of observing so many non- working days in the life of the people was carefully discussed and there were mixed feelings by households. Some farm households stated that observing a local holiday does not mean sitting idle, rather some other activities related to small constructions, conducting community meetings, carrying out off farm activities such as petty trade, collecting fuel wood, etc. are carried out. Many conservative farm households however insisted that households should refrain from farming activities. Doing otherwise was thought to bring curse to their lives. From this scenario it can be argued that conservative views and/or faith of households tend to deter rural households from engaging in productive economic activities and hence negatively affect efforts to avert adverse effects of climate change and the livelihood of the people.

Literacy campaigns and community level discussions need to be strengthened to bring a shift in thinking and use available family labor productively. Literature on faith and environment protection indicates that all sects have to give due consideration to environmental protection, hence religious leaders have to play pivotal role in magnifying the importance of environmental protection. For example the Holly Bible stipulates the need for preserving God's creation by stating: *"The LORD God took the man and put him in the Garden of Eden to work it and take care of it." Genesis 2: 15.''* Similarly the Jews, Muslims, Hindus all acknowledge the need for environmental protection and religious leaders have tremendous influence on their followers to act in a responsible manner (www.dw.com/en/topstories/rligion and climate change/s-100334).

4.2.4 Livelihood activities of respondent households

4.2.4.1 Crop Production and Use of Agricultural technologies

Crop production and livestock raring are the major livelihood activities undertaken in the study areas. According to the survey the dominantly cultivated crops in the upper highland include barley, wheat, potato, beans while teff, maize, barley and beans are the dominant crops cultivated in the mid highlands of the study kebeles. The production of oil seeds has declined across the highlands and this is attributed to preference of land holders to produce more grain to feed their family as their land holding is small. About 57% claimed that they produce adequate to feed their family all year round. However, farmers mainly in Sinan and Shebel Berenta districts and many of the poor farmers in other study kebeles are not able to produce adequate and they have to fill the gap through purchase (17.7%), wage labour (73%) and the remaining engaging in petty trade and handicrafts.

With regard to the utilization of agricultural inputs, about 95% of the sample households used commercial fertilizer, and some 54% claimed using improved seeds and about 21% reported using herbicides. Though farm households claim that they use improved agricultural input, mainly commercial fertilizer, reports at the agricultural development offices indicated that the per capita use is small not exceeding 50 kg per ha. Farm households in located in Shebel Berenta district, which frequently face erratic rainfall distribution, used the least amount per year as moisture stress hinders crops response to the chemical fertilizer applied. Farm households in Sinan district where there was adequate rainfall were reluctant to use chemical fertilizer on the ground that crops response to fertilizer was seen not encouraging. Discussion with the Sinan district agricultural development office revealed that the soil in the study area is highly acidic and there is a need for liming. It is however encouraging to see that many farmers in almost all the study areas started to prepare and utilize compost as this organic fertilizer apart from being source of plant nutrients has multiple benefits such as enhancing of water infiltration and conservation of moisture in to the soil, reducing soil erosion, improving physical and chemical properties of the soil (Woodfine, 2009).

Secondary data collected from the Bureau of Agriculture of Amhara region indicated that productivity of cereal is in general low in the region and the problem is more critical in the upper highlands that are characterized by poor soil fertility and soil acidity (BoA, 2014). The regional average grain yield per hectare for wheat is not more than 2 tones, for barley 1.5 tones, maize 2.5 tones, teff *(Eragrostis tef)* 1.2 tones, sorghum 1.8 tones. The productivity of pulses is also low not exceeding one ton per heater on average, and the productivity of oil crops is even worse. It was also noted that the crop yields were relatively better (15% more) in the mid highlands compared to upper highlands and this was attributed to better soil fertility and gentle slope topography in the mid highlands (see Table 3.5). Where farmers use improved seed, chemical fertilizers and pesticides and under conditions of adequate rainfall amount and good distribution, the grain yield has showed an increment by about 40% (BoA, 2014).

Respondent households indicated that crop production in the study areas is constrained by a number of problems at varying scale including erratic rain fall/moisture stress (drought) (47%) lack of plowing oxen (32 %), lack of money to buy agricultural inputs (54%) lack of adequate land (78%) and poor soil fertility (85%). The problem of weeds and insect pests were also expressed by about 15% of the respondents. Shortage of land was a cross cutting problem identified in all the study Kebeles. Post-harvest crop loss was also indicated by some respondents. In this regard literature showed that about 20 to 30 % of the total harvest in Ethiopia is lost during post-harvest period principally due to lack of appropriate storage facilities and poor transport systems while the report for developing countries is in the order of 35-50% (Babu and Sanyal, 2009). All the above factors make many farm households in the study areas liable to food insecurity, hence many resource poor farmers mainly in Yedukha (Shebel Berenta district) and those in Gedamawit (Sinana District) and those in Yibab (Bahir Dar Zuria District) have to involve in other off farm activities; and about 5.7% of the family members (mainly the husband and grown up children) seasonally migrate up to six months to other areas to generate income.

4.2.4.2 Livestock production and grazing resources

Livestock play a crucial role in providing draught power for tillage, farmyard manure, fuel, dietary supplements and security against famine (Benin, *et al.*, 2001). This view was unanimously reflected by farm households during group discussions and in the survey questionnaire. The survey data revealed that in the study Kebeles the average number of livestock holding (cows, bulls/oxen, sheep and goats) per household was about 5.71.

Disaggregated figures indicated that about 20 % of the sample farm households do not own a cow and about 61% have either one or two cows. Likewise about 14% have no oxen, 16% one ox and about 33.7 % have a pair of oxen, and some 20% have three or more oxen. About 51% and 42% of the households lack heifers and calves respectively. Among the farm households lacking a pair of oxen, 8.7% satisfy their plowing oxen needs by hiring oxen, 51.7% through oxen sharing, 22.6% through labor for oxen exchange, and 16.9% through other means.

Although small ruminants such as sheep or goat are vital sources of income for smallholder framers about 56.7% have no sheep or goat. Likewise most farm households lack equine (49.7%) and it is only 36% of the respondents have a single equine and about 11% have two equines. Livestock composition showed about 76% are cattle followed by goats/sheep (21%) and 3% equine. These findings are nearly equivalent to most of the data kept at the development agents' offices in the study kebeles and in the district agricultural development offices (Chapter 3 Section3.1.4.3).

Surprisingly rural households' involvement in apiary is extremely low and households' failure to get involved in traditional poultry farming is a discouraging situation when analyzed in the context of livelihood diversification to withstand the vagaries of climate shock. Almost all farm households keep local breeds of livestock and during the FGDs farmers appreciated the quality of their livestock breed because of their ability to withstand stresses such as feed shortage and disease compared with improved breeds.

In the study areas and the region at large where land resources are limited, engaging in small ruminant husbandry could help the poor and the landless to secure their livelihoods. The literature on the value of small ruminants to food security or income generation showed that small ruminants play a significant role in providing food and financial security for rural populations, especially in developing countries (Alhaji and Odetokun, 2012). The small size of sheep and goats has distinct economic, managerial, and biological advantages. Reviews made on the subject by Alhaji and Odetokun, (2012) also showed that small ruminants can be conveniently cared for by women and children. Sheep and goats need little housing space, consume low amounts of feed, and can supply both meat and milk in quantities suitable for immediate family consumption. In the same vein, Isaac *et al*. (2012) contended that the total income share of small ruminants tends to be inversely related to size of land-holding, suggesting that small ruminants are of particular importance for landless people especially women. These contentions have vital implication in efforts geared to tackle climate change challenges. Similarly the value of bee keeping is reported by many households that the landless and poor households can make a living by engaging themselves in this activity.

Average number of livestock ownership across altitudinal zones shows significant variation ($p<0.001$) and whereas the mean figure for the upper highland is 4.67, it is 6.14 for the mid highland (Table 4.4A). The livestock number variations between the altitudinal ranges may be attributed to lack of grazing land and possibly farm households in the upper highlands are resource poor compared to those in the mid highlands. Likewise livestock ownership differed significantly across wealth groups ($p<0.001$) indicating the average holding of the poor being 2.4, the medium rich having 6.75 and the rich owning 10.44 heads of livestock. Similar trends are observed across gender where male headed farm households owning on average 6.4 heads while women headed households owning 3.76 ($p< 0.001$).

Table 4.4A Livestock population and area of grazing land in the study *gotts*

Study Kebele/got	Cattle (No)	Cattle in TLU	Sheep/ goat	Seep/ Goat in TLU	Equine	Equine in TLU	Total TLU in the *gott*	Grazing land in the *gott* (ha)	TLU[1] per ha
Upper Highlands									
Gedamawit	120	84	80	8.0	8	5.2	97.2	39	2.49
Yeduha	149	104.3	17	1.7	6	3.9	109.9	30	3.66
Amanuel	264	184.8	50	5.0	7	4.55	194.35	54	3.6
Mid Highland									
Yibab	151	105.7	49	4.9	7	4.77	115.37	35	3.29
Wad	285	199.5	78	7.8	11	7.15	214.45	85	2.52
Arbayitu Ensisa	264	184.8	66	6.6	10	6.5	197.9	75	2.64
Total	1703	1171.8	485	48.5	180	115.0	1316.51	329	

[1]TLU (Tropical Livestock Number) refers to livestock numbers converted to common unit. One TLU is =250 kg live weight of an animal. The conversion factor for Cattle=0.7; Sheep/Goat=0.01; Horse= 0.8, Donkey= 0.5 (Source: Wilson, 2003).

Although livestock is insurance against drought and other social obligations, the prevalence of many farm households in the study area with limited or no livestock and lack of livestock feed makes households more vulnerable to adverse natural conditions including climatic shocks. A study on vulnerability, climate change and livestock by Thornton, *et al*. (2007) has indicated that this is a wide spread problem observed in many African countries.

Rural households have expressed that lack of plowing oxen greatly debilitates their ability to produce enough for the family and also decreases their coping capacity to the effects of unfavorable climatic conditions. This assertion is shared by many authors. For example, a review made on a vulnerability profile in South Gondar of Amhara region, Ethiopia by Rediet (2011) showed that shortage of oxen in many cases forces smallholder farmers to lease out their land; and where households opt for oxen rental arrangements or make labor exchange for oxen late land preparation and planting are common features and this scenario impairs crop productivity.

Since land is not a private property in the Amhara Region and the country at large livestock is taken as the single most important asset on which households have complete command. FGD participants indicated those who have financial resources show high interest to keep more livestock to maintain their economic advantage; and even the poor have strong desire to keep few heads of livestock (group discussion). Although livestock is a vital component of the livelihood system of the respondent households in the study area, feed shortage or lack of grazing land seems to have caused reduction in the number of livestock from time to time (FGD participants). Similar results were reported in a study which assessed grazing land and livestock feed balance in Gummara-Rib Watershed in Ethiopia (Tadesse and Solomon, 2014). Livestock feed shortage is indeed an acute problem acknowledged by Thomas and Twyman (2005) who stated that in the tropics livestock feed would remain a critical constraint on livestock production and enhancing crop productivity can be a useful proxy for feed availability in most regions in the tropics.

In the study villages, major grazing sources for livestock are the common grazing lands and communal woodlands. The dominant grazing system in all the study Kebeles is open grazing (99%) and only very small number (1.7%) claimed practicing stall feeding. About 30% of the respondents reported that they designate part of their land holdings to grow grass. In this regard the average area of land used for this purpose is not exceeding 0.07 ha. The common woodlands are also used as a source of livestock feed and about 68% of the respondents claimed contribution of woodlands as a source of livestock feed is quite important. Grazing shortage in general was voiced by about 95% of the respondents having livestock and the problem was expressed as severe in Sinan, Shebel Berenta, and Bahir Dar Zuria districts (FGD discussants). Season wise grazing shortage was reported as acute problem during the dry season (43.3%), during wet/rainy season (25%), during both seasons (30.7%).

Analysis of the livestock population in the study Kebele *gotts* and the available grazing land showed that the average TLU in the upper highlands is 3.25 ha while it is 2.82 TLU for the mid highlands. The total TLU in the three *gotts* is about 929.17 and the average TLU per ha is 2.92. A study on livestock husbandry by Helina and Schmidt (2012) showed that the average TLU per hectare in the Amhara region is 1.43 and when this figure is compared with the stocking rate in the study areas it can be argued that the grazing lands in the study areas are overstocked. Given that the grazing lands are not managed and grazed all year round the biomass growth was highly suppressed and it was inadequate to maintain the growth and development of the livestock. Due to this fact farm households in all the *gotts* are largely supplementing their livestock with crop residue and after math grazing/grazing on stubble. In this regard most farm households stated feed shortage is a serious problem in livestock husbandry though the problem was felt differently across wealth groups ($p<0.001$) where the rich (27.9%) and medium (31.6%) have experienced the problem more than the poor (40.5%).

Grazing shortage means woodlands are also used for grazing almost year round and this has hampered regeneration and the quality of the wood land is in the process of degeneration (personal observation). The degradation of woodland resources affects the ecological stability and loosens efforts to tackle problems associated with climate change and variability.

Grazing shortage means woodlands are also used for grazing almost year round and this has hampered regeneration and the quality of the wood land is in the process of degeneration (personal observation). The degradation of woodland resources affects the ecological stability and loosens efforts to tackle problems associated with climate change and variability.

Apart from naturally available grazing resources, the most common method of satisfying livestock feed is through crop residues and purchasing. Although feed is considered a major limitation in livestock husbandry, 80% of the sample household respondents still feel a need to keep more livestock in the future. This has a strong bearing in that livestock are considered means of livelihood security in time of adversity and a liquid asset to be disposed of as need arises as argued by many scholars (Barrett *et al.*, 2001; Ashely and Nanyeenya, 2005; Aleme and Lemma, 2015).

In FGDs conflicting views were put forward on the need for managing communal woodland resources to improve their grazing quality. Most smallholder farmers in the rich and medium rich group were in favor of keeping woodlands open for grazing than were the poor households. The poor were of the opinion that part of the woodland should be distributed to the poor and the landless so that they could benefit from selling fodder and fuel wood including small poles. This difference of opinion has a very important message to institutions dealing with natural resources management. The conflict between forestry and grazing is in general a common feature perceived by most of the farm households as environmental degradation is progressing at an alarming proportion in the study districts creating a harmonized land use system such as agro forestry becomes decisive.

4.2.4.3 Off farm activities

In all the study kebeles off farm activities are very limited and only 15 % of the total sample households responded that they are engaged in off farm activities to supplement their family income. Of those who practice off farm activities about 20% are engaged in petty trade, 60% reported daily labour, and on a limited scale (7%) in handicraft production and sale, and very few in seasonal migration. Although bee keeping is a potential source of income for the poor in Ethiopia including the study areas (Legesse, 2014), it is only a minute fraction of the respondents that are engaged in bee keeping. Petty trade activities are largely marketing of grain, livestock and also retailing of consumer goods in rural markets after buying from urban markets. The role of off farm activities in reducing vulnerability of farm households from climatic variability and change has been reported by a number of scholars (Below *et al.*, 2010) who made a review of selected research on micro level practices to adapt to climate change for African small scale farmers.

4.2.4.4 Land holding of respondent farm households

The average land holding in the study Kebeles is 1.26 ha. However, just nearly half of the respondents (49.9%) have one or less than one hectare (Table 4.5). Disaggregated figures indicated that the average land holding in the mid highland zone is 1.47 ha while it is 1.05 in high altitude areas and shows a statistically significant difference of mean land holding ($p<0001$). There is also a mean land holding difference between female headed (0.91 ha) and male headed households (1.37 ha) and indicating a statistically significant difference ($p<0.001$). The relatively larger mean land holding size in the mid highlands is largely attributed to the prevalence of more arable land due to the more favorable topography and slope (see Chapter III, Tables 3.2, 3.3. 3.4 3.5).

Table 4.5 Land holding of respondents (ha) (n=300)

Area of Farm land held by a household (ha)	Percent of respondent farmers
< 0.5	16.9
0.5-1.0	33.0
1-1.5	18.1
1.5-2	12.2
2-2.5	8.3
2.5-3	8.6
>3.0	2.3

FGD participants indicated that what matters is not only the size of land holding, but also the fertility of the land and the growing number of landless family members who are sharing the same land holding. The fertility status of farm land was rated by respondents as low by about 40%, medium by 58 % and good by about 2%. Comparison of perception on soil fertility across altitudinal zones indicated that soils in the mid altitude areas are more fertile than in the upper highlands. During FGD most participants complained that a declining trend in the soil fertility is hampering crop productivity. And, this is affecting their food security (43%). A key informant in Amanuel Kebele described the problem of soil fertility in a sarcastic way stating that ''*the farm land, like corrupted individuals is seeking bribery; that is it has become addicted to chemical fertilizer and without fertilizer it has refused to give any good yield.*'' Accordingly about 80% of the respondents indicated that crop productivity without fertilizer is too low. Of the total respondents 75% practice only rain fed agriculture while the remaining respondents have access to limited irrigation water, and these are farmers in Arbaitu Insisa and Amanuel Kebeles. As it is true in the study area there is in general an increasing landlessness and small land holdings by farm households in Ethiopia and this has triggered illegal encroachment into grazing and woodlands. In this regard AGRA (2013) indicted that the cultivated land in the country has increased by 5,143,000 hectares (which is about 48.8% of the already cultivated land) from 1990 to 2011. Unless farm land expansion is supported by a policy frame work that would ensure that land and land based resources are accessed, held, used, and managed efficiently, unplanned and informal farm land expansion is likely to aggravate deforestation and its implication to climate change challenges will be severe (CSA, 2012).

The majority of smallholder farmers (87.7%) cultivate their land by their own labour and the remaining practicing either share cropping or renting out land. About 94.7% of the respondents have land holding certificate, however about 58% of certified farmers do not feel that the land belongs to them and their family indefinitely. Despite clear stipulations on the rural land law about security of land holding rights (Zikre Hig, 2006) this lack of tenure security may hinder households from investing on their land management.

About 35% of the respondents disclosed that their land is plain, some 59.3% stated moderate slope and very steep slope (3.3%) and requires soil and water conservation structures. These features were noted during field observation and the problem was more prominent in Gedamawit (Sinana District), Amanuel (Machakel district) and that of Yeduha (Shebel Berenta district) (see Table 3.2 in Chapter III).

4.2.4.5 Challenges in Crop production

Respondent farm households have recognized diverse challenges to crop production. The summary of their perceptions on the challenges constraining crop production are indicated in Table 4.6.

Table 4.6 Response of respondents on variables constraining crop production

Constraining Variables	Percentage response	Remark (taken from FGD and Field observation)
Erratic Rain fall /drought	60	More common in Shebel Berenta,Bahir Dar Zuria
Land shortage	80	In all study Kebeles
Lack of Oxen	30	In Sinan, and Shebel districts
Poor soil fertility	40	Common in all the study kebeles
Insect Pest	36	Common in highlands growing pulses (e.g. in Sinan)
Lack of credit to purchase farm inputs	60	Common in all study areas. (in this case there is a tendency by farmers to seek credit even if they have financial resources

4.2.4.6 Perception on land use changes

The majority of respondents (93%) felt that the forest or the wood land cover has been changing over the years and the change is in the declining trend as perceived by about 86% of the respondents. Similar trends are observed in the grazing land resource where almost all (99.7%) acknowledged the deterioration of grazing land due to overstocking and lack of management inputs.

Multiple responses on the major reasons associated with woodland decline are illegal encroachment (56%), excessive cutting of trees and shrubs (40%), and overgrazing and trampling of seedlings (25%). During FGDs it was repeatedly reiterated that there are no strong institutions monitoring the management of communal woodlands and grazing lands. And, even farmers in the Kebele leadership instead of being role models they tend to show malpractice and there are cases where some members of the leadership were found encroaching into woodlands and annexing part of the grazing land with their farm land holdings.

Perception on the presence of land use plan at Kebele level indicated that about 60% of the respondents were unaware of the existence of any land use plans and the remaining stated that they were informed about the boundary of the farm land, woodland, grazing land and areas to be used for infrastructure development such as schools and clinics.

About 89% confirmed that they grew trees and the preferred site for tree growing is homestead (57%), farm land (20%), and on gully sites, river/stream banks (23%). Much of the tree plantings are however not at commercial scale except in Sinana, Dembecha, Bahir Dar Zurai. The most common tree planted is eucalypts despite its negative impacts on the environment (Gesse and Erkossa, 2011). As land holdings are small integrating trees in the agricultural landscape in the form of agroforestry is a very important intervention (Jose, 2009; Mercer, 2004). Accordingly, there are vestiges of traditional agroforestry in many of the study Kebles though more prominent in Wad and Arbayitu Ensisa. As part of the effort to combat land degradation and the impact of climate variability or drought it seems vitally important to promote both conventional and traditional agroforestry practices. During the FGDs there were some reservations to appreciate agroforestry fearing that it occupies farm land and harbors crop damaging birds. Tree growing was however applauded as a safety valve and source of cash when farmers face loses in crop production. This was boldly stated by farm households in Sinan district who have largely converted their land to eucalypts woodlots and benefited from eucalyptus pole sales to cover the food need of the family.

4.3 Conclusion

Assessment of the profile of the respondent households in the study Kebeles revealed that their socioeconomic set up is weak as a substantial number of the respondents are lacking adequate resources that are needed to generate adequate income. The prevalence of resource poor and subsistence farmers means there is a dire need to design strategies which could enable this segment of the community to get out of poverty. Although literacy plays vital role in enhancing adaptation of improved and new technologies there is prevalence of illiteracy in the study Kebeles and even those who claim are literate lack skills on improved agriculture and on off farm activities. Absence of functional literacy in the study areas seems to be an obstacle to farmers efforts to change their livelihood, including adaptation to climate change.

Whereas farmers in the study areas are in short of farm land and landlessness is in the increasing trend, the age distribution in the study areas shows that there is high potential for population growth. Unless family planning practices are put in place it will have severe implication to development efforts.

Crop production and livestock raring are the major livelihood activities undertaken in the study areas. Crop production in the study areas is however constrained by a number of problems at varying scale including erratic rain fall/moisture stress, lack of plowing oxen, lack of money to buy agricultural inputs, lack of land and poor soil fertility, and problem of weeds and insect. In the face of unpredictable climatic condition these are serious challenges that affect the food security of the farming community.

In the study Kebeles livestock play a crucial role in providing draught power for tillage, farmyard manure, fuel, dietary supplements and are sources of cash income. Livestock productivity is however impaired by lack of adequate feed and poor veterinary services and access to improved breeds is limited, forage development interventions are weak.

Although it is asserted that raring of small ruminants (goats and sheep) and bee keeping better fits to areas with farm land and grazing shortage, involvement of limited number of farm households in the study kebekes remains as a key question that needs to be addressed soon.

Although off farm activities play vital role in reducing vulnerability of farm households from climatic change it is only very limited number of farmers engaged in such activities indicating the need to investigate how it will be possible to promote livelihood diversification.

Farmers have clear perception on the drastic change in land use in the study villages, and this can be taken as a good opportunity to make awareness on the consequences of the land use changes on the climate in general. Tree planting has become a common practice on farm lands owing to the lucrative economic gains and its low susceptibility to moisture stress. The wide spread conversion of farm land into eucalypts woodland however needs to be seen with caution as land is a scarce resource.

In sum assessment of the socioeconomic variables and asset endowments namely household gender, education, religion, livestock and land ownership, off farm employment, capacity to use improved farm technologies, grazing and wood land resources, etc. in the study kebeles indicated that there are a number of key socio economic issues that should be given due consideration in the national, regional and local efforts to promote mitigation and adaptation measures to climate change.

Developing a good understanding of the socioeconomic settings in the context of climate change trends and how farmers perceive climate change patterns is an integral component in the process of addressing climate change issues. The next chapter therefore deals with assessment of the perception of farmers on climate change trends and analysis of weather data with a vital aim of comparing farmers' perception of climate change against empirical evidences on climate data and also to provide insights how perception of climate change influences motivation of farmers to pursue adaptation measures on climate change.

CHAPTER 5

CLIMATE CHANGE TRENDS AND FARMERS' PERCEPTIONS OF CLIMATE CHANGE

5.1 Introduction

Climate change is a global problem that poses a serious challenge to humanity and the ecosystem, hence; various efforts are made to curb the problems associated with it. There are a number of issues treated on the causes of climate change and its implication on environmental and socioeconomic variables across the world (Chapter Two). As a result global, regional and national dialogues are being carried out to design and implement climate mitigation measures and adaptation strategies. This chapter provides an overview of the climate change variables at a global and national scale. More specifically it analyses the rainfall and temperature trends using meteorological data collected over the past three decades or so in the study area. Moreover, the perception of farmers on trends of climate change is compared against the climatic trends obtained from the analysis of the meteorological data. The perception of farmers is also analyzed how their perception affects their motivation and dedication to engage in climate adaptation activities and also in devising coping mechanisms. Similar assessment is also carried to get an insight how institution's perception of climate change has complemented to farmers' efforts to cope with the problem.

5.2 A further overview of climate change in Ethiopia

The climate of Ethiopia is characterized by high variability annually, seasonally and geographically. More specifically the seasonal distribution and amount of precipitation have become difficult to predict, while rainfall distribution during the cropping season is an important factor influencing crop yield (Evangelista *et al.*, 2013; cited in Skambraks, 2014). Ethiopia's agriculture is highly influenced by these climatic conditions and has a long history of coping with severe weather events (Bewket & Conway, 2007).

Increasing temperature and higher variability in rainfall will influence Ethiopia's agriculture and is expected to worsen the existing conditions, which could lead to further increase of land degradation, soil erosion, deforestation, loss of biodiversity and desertification (Bewket and Conway, 2007). However, the damage will not be the same throughout the country, but vary across different agro-ecological zones (Chapter II, section 2.10) where some agro ecological zones (AEZs) can benefit from a slight increase in temperature during the right time of the season, whereas others will experience detriments. Likewise, change in precipitation will affect different AEZs differently (Deressa and Hassen, 2009 cited in Skambraks, 2014). The Amhara Region, where this study was carried out, is expected to encounter an increase in mean maximum temperature and a decrease in annual rainfall (Ayalew *et al*., 2012; Bewket and Conway, 2007).

In general, Ethiopia is highly vulnerable to current variability and there are also signs showing that climate change will increase rainfall variability which will likely increase losses from rain-fed agriculture. Therefore, all adaptation decisions must identify "no regrets" options which strengthen resilience to current variability and accommodate additional variability in future. The ecosystems of Ethiopia as well as its community are highly disposed to climatic variability. In addition to what is stated in Section 2.11, Chapter 2, Ethiopia's vulnerability to climatic variability is associated with its low adaptive capacity owing to low level of socioeconomic development, increasing of population growth, lack of or limited institutional capacity and high reliance on climate sensitive natural resource-based activities (NMA, 2007). The vulnerability of the community is exacerbated due to long standing environmental problems such as deforestation and land degradation. In addition about 70 % of the country is dry, sub-humid, semi-arid or arid and in consequence vulnerable to desertification and environmental degradation (ibid).

The fact that climate has been changing over the years and continues to change in the future suggests the need to understand how farmers perceive climate change so that strategies for adaptation in the future could be guided in the right directions. Various studies indicate that farmers perception of climate change and efforts to reduce the negative impacts of climate change is increasing from time to time and taking adaptive measures are influenced by different socio-economic and environmental factors (Maddison, 2006; Hassan and Nhemachena, 2008; Akter and Bennett, 2009; Semenza *et al*., 2008; Mertz *et al*., 2009).

As the specific objective of this chapter is to investigate the trends of rain fall and temperature in the study area using data from ten Meteorological stations (Table 5.1) and also assessing of the perception of respondent farmers and institutions on climate change, the findings are presented in the following sections giving due emphasis on implication of farmers' climate change perception on motivation to devising coping and adaptation strategies on climate change.

5. 3 Results on Rainfall and Temperature trends of the study area

5.3.1 Rainfall trend analysis in the Upper and Mid Highlands

The analysis of rainfall and temperature trends in the study areas was based on the data collected from meteorological stations located in East and West Gojam zones that lie in the upper highland (*dega* climatic zone) and mid highlands (*woina dega* climatic zone) of Western Amhara region respectively. The findings and discussions provided in the following sections though expressed as a comparison between East and West Gojam zones, it needs to be understood that the findings are reflecting the climatic features of the upper highland (*dega*) and mid highland (*woina dega*) climatic zones of the Western Amhara region.

Bahir Dar Meteorological station in West Gojam located in the upper highland and Debre Markos stations in East Gojam representing upper highland recorded long years of rainfall data (covering more than 50 years, Table 5.1). In these stations it was found out that the period from June to September is the major rainy season (*Kiremet*), during which period 87 to 96% of the annual rain fall is received. In East Gojam, some amount of rainfall has occurred during the other months. The months of July and August are with the highest rainfall in both East and West Gojam. After *Kiremet* season is over, the remaining rainfall usually occurs during the winter season (*Bega*), and in spring (*Belg*) season, while in case of West Gojjam, the rainfall during the winter and Belg season is very little (Figure 5.1).

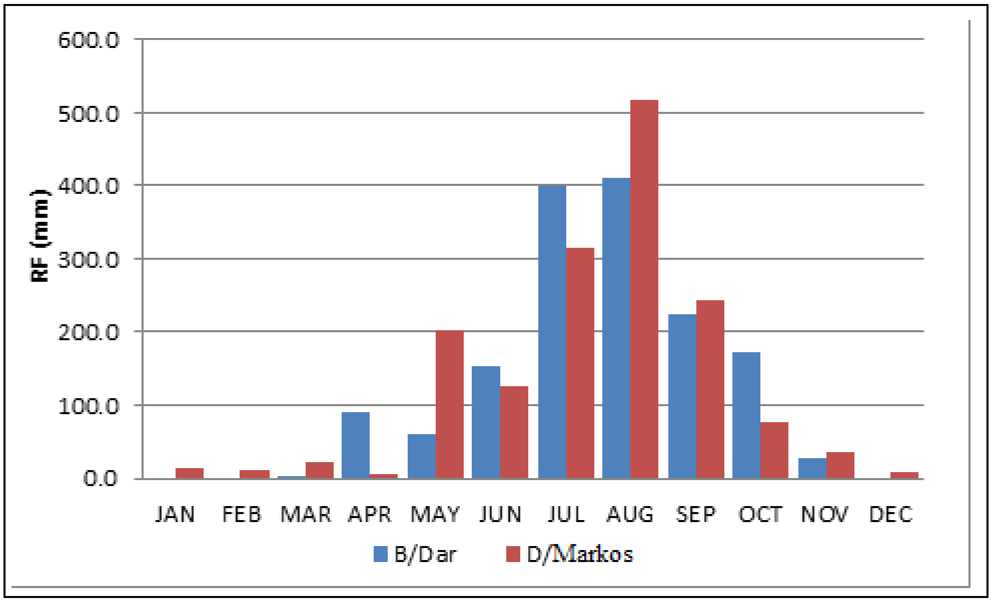

Figure 5.1 Monthly rainfall distribution in in Debre Markos (East Gojam) and Bahir Dar (west Gojam zones)

The annual mean rainfall for the ten meteorological Stations in the study area is presented in Table 5.1, along with its descriptive statistics.

Table 5.1 Mean annual rainfall of Meteorological stations in East Gojam (Upper Highland) and West Gojam (Mid Highland) with descriptive statistics

Station	No years	Min (mm)	Obs year	Max (mm)	Obs. Year	Mean	Sd	Cv	r	S
B/Dar	53	894.6	1982	2036.9	1973	1429.6	223.88	0.16	-0.24	-3.57
Merawi	33	719.3	1991	1345.0	1982	1023.9	174.43	0.17	-0.41	-7.41
F/selam	44	1000	2005	2216.6	1985	1475.1	316.10	0.22	-0.28	-6.81
Zeghie	34	823.6	1991	1896.7	1999	1499.7	247.8	0.17	-0.26	-10.1
Dangila	35	1181.2	1968	1960.1	1999	1556.4	223.5	0.14	-0.12	-6.9
Adet	32	721.0	2011	2123.5	1983	1215.6	371.6	0.31	-0.43	- 16.9
D/Markos	39	767.5	2012	2319.4	1980	1400.3	422.2	0.30	-0.32	-11.6
Injibara	30	1612	2005	2828.9	1999	2181.1	281.1	0.13	-0.42	-13.1
Sekela	32	1187	1981	2383.7	2006	1795.7	344.8	0.20	-0.27	-22.3
Gundil	31	1798	1995	2721.1	2005	2348.3	268.4	0.11	-0.45	-26.4

Sd= standard deviation, Cv= coefficient of variations, r= Correlation Coefficient, S=slope

Analysis of the rainfall records in the Meteorological stations revealed that there is a general declining trend of the annual rainfall during the last 3 to 4 decades. Almost all stations recorded minimum annual rainfall during the third decade and the highest annual rainfall was recorded in the first and second decades. The range of annual rainfall also indicated a high variability of annual rainfall in most of the stations. Among the West Gojam stations, the minimum mean rainfall was recorded at Merawi (1023.9 mm) and the maximum annual rainfall received in Dangla (1556.3 mm). Similarly, in East Gojam, the minimum mean annual rainfall was recorded at Debre Markos (1400.3 mm) and maximum at Gundil (2348.3mm). The Mean Annual Rainfall of the study area had a range from 719.3 mm at Merawi station (Mid high land) to 2828.9 mm Injibara station (Upper highland). These values indicate that there is high annual rainfall variability across ecological regions in the study area.

During the past 3 to 4 decades, the rainfall deviated annually by a maximum of 422.2 mm from the mean in the case of Debre Markos station (East Gojam) and a minimum deviation of 174.43 mm in the case of Merawi station (West Gojam). The trend on the decadal basis was also analyzed to determine the changes over time within the study periods. In order to detect statistically significant changes in the annual rainfall across stations in East (Upper High Land) and West Gojam (Mid High Land), a time-series study was undertaken. The parameter estimate of the slope was then tested for statistical significance using the paired sample t-test at a 0.05 level of significance. As shown in Figure 5.1A the slope of the trend line is negative 3.988 which implies that the long years average rainfall is declining.

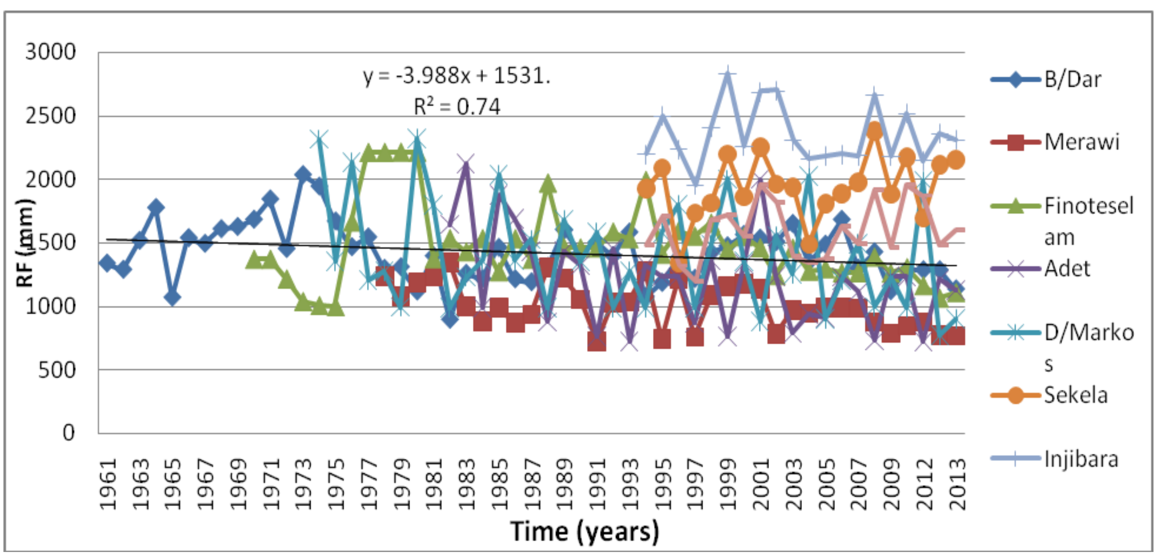

Figure 5.1A Rainfall time series graphs of the study area

To explain the descriptive information, the linear regression was fitted and the slope was determined and paired samples t- test was run to check their correlation. The slope showed decreasing trend of rainfall within the stated period. The slope of a line was also used as a measurement of how many units it went up or down for every year to see the change of annual rainfall conditions. As it is depicted in Table 5.1 the annual mean rainfall decreased almost for all stations and it is statistically significant at 5% level of significance. This shows that the climate was changing within the stated decades. The maximum decline was recorded at Gundil station with a slope of -26.4 in East Gojam and the minimum at Bahir Dar (-3.57) West Gojam. The negative sign indicated that decline from the slope of each mean annual rainfall record.

The coefficient of variability analysis indicates that a significant annual rainfall variation was recorded from all weather stations with maximum at Adet (31%) and minimum at Gundil (11%) station. According to Hare (1983) annual rainfall variability greater than 30% is very severe, between 20 and 30% moderately severe and up to 20% is severe. Based on this classification, among the study area stations, annual rainfall variability recorded at Adet (mid highland) (31%) and Debre Markos (upper highland) (30%) were very sever; and Finoteselam (22%) (mid highland) and Sekela (upper high land) (20%) were moderately sever and the remaining stations were severe. Significant annual rainfall variability implies that climate change is resulted in climate variability and extreme weather conditions. These are also supported by Correlation Coefficient of the annual rainfall change and variability. All of the weather stations in the study area showed a negative correlation with the time period for the last 3 to 4 decades and this was significant at $p<0.05$ (Table 5.1).

In general mean annual rainfall straight lines for all stations in the study area has slopes, which were used to examine the least-square regression lines, compared with the corresponding values of correlation coefficient and exhibited a negative value (i.e. the slope equation given by y= - 3.900 + 1531). In this analysis it could be noticed that every year the data had a negative correlation coefficient, the slope of the regression line was negative. It should be recognized from this observation that there was an apparent connection between the sign of the correlation coefficient and the slope of the least squares line and one variable confirmed the other and the annual rainfall amount in the study area clearly showed significant variability and declining trends (Figure 5.1A).

The monthly mean rainfall amount for the past three decades from the ten stations was aggregated and average values were taken for analysis for East and West Gojam. Accordingly, the mean, minimum and maximum rainfall amount was higher for the months of June, July, August and September (summer season). These months are known as summer season or monsoon rain season. The agricultural population of the study area is totally dependent on this rainfall for agricultural activities including livestock production. A slight fluctuation in the rainfall amount, intensity, and onset and cessation time directly influences the agricultural productivity (NMSA, 2007).

The monthly mean average rainfall of the study area also deviated from the mean, the occurrence being more in the summer season (Table 5.2). However, the coefficient of variations were relatively smaller and this is related to the continuous high amount of rainfall received during summer. The correlation coefficient indicated that the rainfall amount was negatively correlated in the months of April and July for study zones during the past three decades. It implies a more rainfall decline in those months as compared to others months. Almost for all the months, the computed slope coefficient was negative. This indicates that mean average rainfall amount was declining from time to time across the decades and the slope becomes steeper and steeper by the last decade. If these circumstances continue unabated the rain-fed dependent farmers in the study area are likely to suffer from water shortages.

Table 5.2 Mean monthly rainfall of aggregated rainfall data descriptive statistics

Stat.	Monthly average rainfall statistics for the last 3 decades of West Gojam stations (Mid Highlands)											
Stat	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min.	0.00	0.00	0.00	0.00	1.20	66.00	224.00	217.53	106.21	0.00	0.00	0.00
Max.	13.3	26.9	85.6	104.3	237.5	437.2	636.4	654.0	269.2	209.6	65.3	16.9
Mean	1.65	2.21	8.31	24.84	70.62	181.52	381.97	376.14	172.08	81.62	11.22	2.10
SD	3.22	5.87	16.60	27.27	55.88	72.95	117.06	112.30	46.48	53.56	13.96	3.99
CV(%)	2.29	3.31	2.49	1.18	0.90	0.47	0.31	0.32	0.31	0.71	1.50	2.18
R	0.15	0.20	0.12	-0.09	0.01	0.01	-0.27	0.41	0.24	0.12	0.45	0.04
Slope	0.00	-0.04	-0.07	-0.27	0.40	1.34	-9.55	-5.36	-2.66	-0.65	-0.02	-0.03
Monthly average rainfall statistics for the last 3 decades of East Gojam stations (Upper Highlands)												
Min.	0.00	0.00	0.00	5.50	10.30	73.00	234.00	190.20	80.10	2.90	0.50	0.00
Max.	81.40	81.10	98.00	118.30	211.50	345.00	592.10	628.50	321.00	305.00	76.20	82.50
Mean	5.46	7.99	34.65	49.94	92.49	151.70	396.59	375.94	188.53	74.90	22.78	11.86
SD	13.99	18.30	33.42	33.51	67.25	59.43	83.57	92.09	55.53	65.51	17.30	15.96
CV(%)	2.56	2.29	0.96	0.67	0.73	0.39	0.21	0.24	0.29	0.87	0.76	1.35
R	0.26	-0.04	-0.23	0.22	0.32	0.19	0.17	0.40	0.33	0.21	0.05	-0.12
Slope	0.31	-0.37	-0.77	-0.51	-0.88	0.41	-4.46	-5.07	-0.84	-1.51	-0.19	-0.06

Based on the above result, it is of immense significance to visualize the socio-economic and ecological impacts that could result if decreasing rainfall trends continue in the future. For rural farmers who are vulnerable to drought, water stress and erratic nature of rainfall, appropriate adaptation strategies have to be designed and implemented. The vulnerability of rural households might further be worsened if the rainfall continues showing drastic declining trend in the future as this incident results in drought and severe loss of the water resources due to evaporation and over exploitation.

5.3.2 Temperature trends

The mean monthly temperature was analyzed across the East and West Gojam zones using the data recorded over the years. The temperature data collected in Meteorological stations located in East Gojam Zone was computed and mean monthly temperature value was aggregated and representative single mean value was taken for this analysis. Accordingly, mean temperature across all months over the last 53 years in the East Gojam Zone is presented in Table 5.3. The slope of the whole months shows a positive value implying an increase in the mean monthly temperature. The mean, minimum and maximum temperature were recorded in the months of January and May respectively in the East Gojam Zone. Moreover, December and January were the months that showed significant variations in the mean monthly temperature recorded. December was the month of high deviation of temperature occurrence. There was also a positive correlation between the monthly mean temperature recorded and the time period. This might lead to assert that the continuous temperature rising in East Gojam Zone could be attributed to the global climate change.

Similarly the data in West Gojam Zone stations were aggregated and analyzed for the long year's monthly mean trend analysis. In the case of the West Gojam Zone, the minimum and maximum temperature was in the months of January and April respectively. The coefficient of correlation indicates that months of April and May showed relatively higher positive correlation to the time period for the past 40 years. Similar to the East Gojam Zone, the West Gojam Zone temperature records also had a positive slope value indicating a successive mean monthly temperature change for the past 40 years (Table 5.3).

Table 5. 2 Monthly mean temperature descriptive statistics

West Gojam (Mid Highland) (53 years)												
Stat.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	14.4	14.8	17.3	18.5	18.9	18.2	14.5	15.4	15.6	16.4	15.1	14.5
Maximum	18.9	21.3	23.2	24.1	24.7	22.1	20.5	20.2	20.9	21.0	20.6	19.6
Mean	17.1	18.6	20.7	21.6	21.6	20.4	18.8	18.7	19.0	19.4	18.4	17.0
SD	1.2	1.4	1.2	1.6	1.1	1.0	1.1	0.9	0.9	0.9	1.1	1.3
CV (%)	7.3	7.5	6.0	7.2	4.9	4.9	5.7	4.7	4.7	4.8	6.0	7.7
R	0.46	0.70	0.61	0.61	0.68	0.74	0.55	0.69	0.96	0.85	0.81	0.82
Slope	0.04	0.06	0.04	0.07	0.04	0.34	0.02	0.03	0.03	0.04	0.04	0.05
R2	0.21	0.38	0.26	0.44	0.26	0.28	0.09	0.28	0.25	0.45	0.28	0.36
East Gojam (Upper Highland) (40 years)												
Minimum	14.30	12.82	14.60	16.08	15.50	14.55	13.44	13.35	13.54	13.49	13.38	13.50
Maximum	16.75	18.03	22.00	19.71	19.12	17.65	15.60	17.14	16.05	16.05	16.00	15.56
Mean	15.31	16.32	17.20	17.40	17.22	16.10	14.40	14.42	14.73	14.78	14.75	14.71
SD	0.62	1.13	1.35	0.97	0.90	0.69	0.43	0.69	0.59	0.62	0.57	0.53
CV (%)	4.1	7.0	7.9	5.6	5.2	4.3	3.0	4.8	4.0	4.1	3.9	3.6
R	0.55	0.77	0.55	0.79	0.75	0.57	0.09	0.463	0.59	0.45	0.62	0.41
Slope	0.01	0.04	0.03	0.04	0.04	0.02	0.00	0.03	0.03	0.02	0.02	0.01
R2	0.05	0.18	0.05	0.22	0.22	0.09	0.01	0.25	0.38	0.10	0.24	0.06

As indicated in Figure 5.2 there was a general increasing annual maximum and minimum temperature change from 1961 to 2013. The trend line shows that the average annual maximum temperature increased approximately by a factor of 0.0326. This value is indicated by the slope equation given y= 0.0326x + 25.94. To the average, the annual maximum temperature is found to be 25.94 ^{0}C, however; this value is not kept constant because of the change in climate (Figure 5.2).

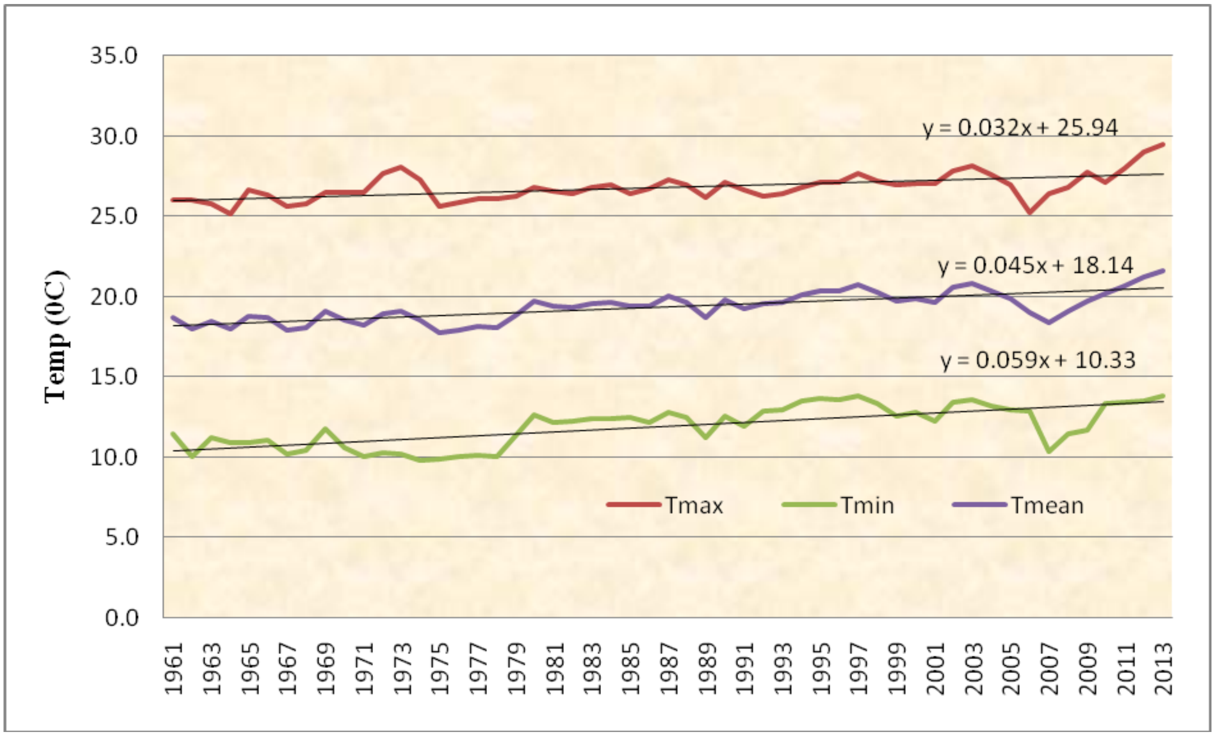

Figure 5.2 Annual minimum, maximum and mean temperature trend in the West Gojam Zone

Similarly, there is a general increasing annual minimum temperature change as indicated by the trend line. To the average, the annual minimum temperature is found to be 10.118^{o}c, however; this value is not kept constant as a result of the change in climate by a factor of .059^{0}C.This value is also computed by using the slope equation, "y=0.059x + 10.33". Consequently, the change in annual minimum temperature change is found to be 2.16 ^{0}C. The annual minimum temperature shows a great difference compared to the annual maximum temperature change.

Similarly, at East Gojam Zone stations the average record indicated a general increasing annual maximum and minimum temperature change from 1974 to 2013. The trend line equations showed positive slope value, which indicated a general increasing trend (Figure 5.3).

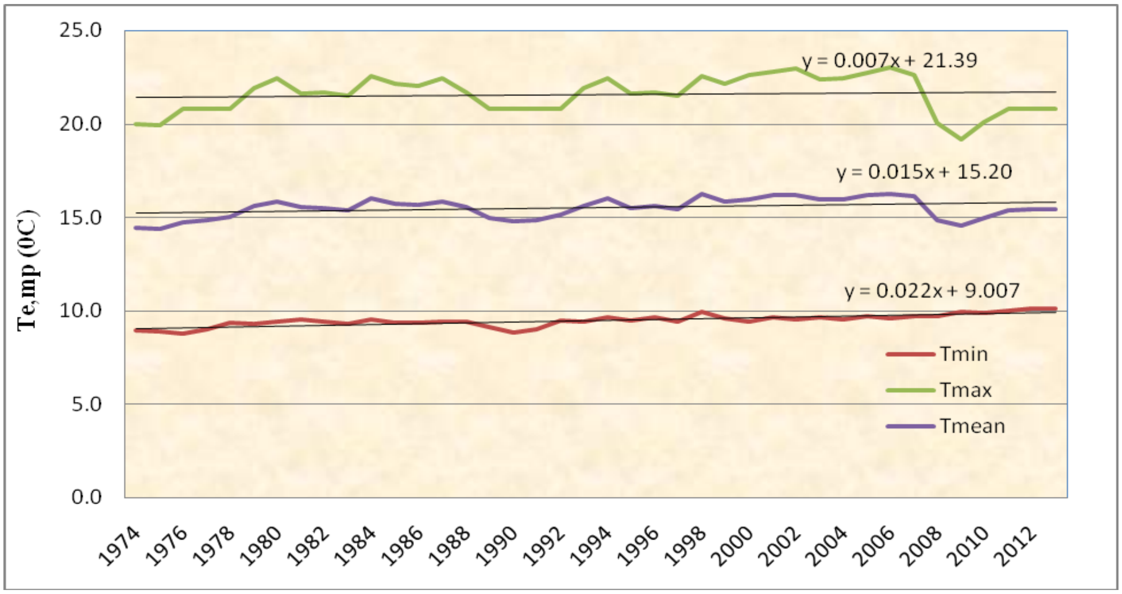

Figure 5.3 Annual minimum, maximum and mean temperature trend in the East Gojam

For the temperature data recorded in the study area, the average values were analyzed using the MK test and the results revealed that there is an increasing trend for the mean temperature in the East Gojam Zone as the calculated p-value is lower than the significance level alpha=0.05; one should reject the null hypothesis H0, and accept the alternative hypothesis Ha. It implies that MK test is statistically significant for the mean temperature which shows an increasing trend. However, the minimum and maximum temperature increasing trend analysis was not significant as the computed p-value is greater than the significance level alpha=0.05; one cannot reject the null hypothesis H0. In other words, the minimum and maximum temperature increasing trends are not significant in the study areas (Table 5.4).

Table 5. 3 Mann-Kendall trend test of annual temperature

Station	No Years	Mann Kendell's test, (H0: There is no trend)				
West Gojam		Mann Kendell stat (S)	Var.(S)	Kendall's tau	P-value	Alpha
Tmax	49	96.000	4165.333	0.182	0.141*	0.05
T min	33	-55.000	4548.333	-0.098	0.423*	0.05
T mean	44	392.000	16991.333	0.285	0.003**	0.05
East Gojam						
Tmax	34	35.000	7351.000	0.045	0.692*	0.05
Tmin	35	264.000	7346.000	0.342	0.002**	0.05
Tmean	32	143.000	7363.667	0.184	0.098*	0.05

*As the computed p-value is greater than the significance level alpha=0.05, one cannot reject the null hypothesis H0

**As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha

In the case of the East Gojam Zone, the minimum temperature shows a significant increasing trend as the calculated p-value is lower than the significance level alpha=0.05. It becomes essential to understand how this may affect the incidence of malaria, plant and animal diseases and pests as a result of the changing minimum temperature in the East Gojam Zone. This result is in line with the research outputs of the National Meteorological Agency (2007) and Solomon (2014). At national level the average annual mean minimum temperature indicates an increase of 0.37^{0}C every decade (NMA, 2007). On the other hand the maximum and the minimum temperature shows no significant increasing trends as the computed p-value is greater than the significance level alpha=0.05, hence it is difficult to reject the null hypothesis H0. A fitting of linear trend lines shows that there is an increasing temperature trend for all stations although slopes are small in magnitude (Figure 5.4).

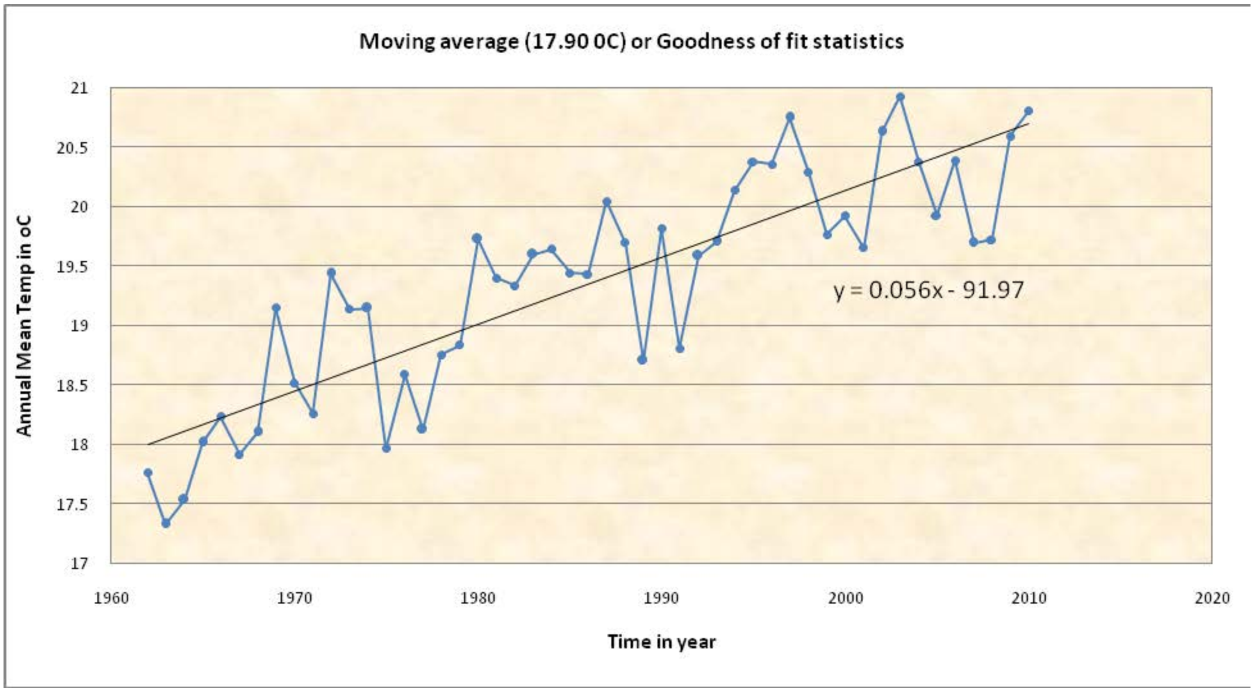

Figure 5.4 Linearity relationship graph of annual mean temperature

5.4 Results on perception of climate by farmers and institutions working on climate change in the study Areas

5.4.1 Farmers perception of climate change

Clear understanding of the level of perception of temperature and rainfall pattern by farmers is assumed as an important element to guide future actions on climate adaptation endeavors. For any kind of climate change adaptation including agriculture, natural resource management and health, farmers who perceive the change in climate are hypothesized to make adjustments in their farms to reduce climate change impacts unless they face difficult barriers. However, identifying agricultural adaptation options to climate change is not an easy task as there are no adaptation interventions for climate change purpose alone. Most adaptation options have values of broad spectrum which can be undertaken as an adjustment to climate change, market policy, demography, economic condition, resource availability, and technology. Thus, it is important to have an insight of farmers' views on temperature and rainfall trends in advance to dig out locally available climate change adaptation technologies on the ground.

Farmers' perception of climate change and variability in the study areas (East and West Gojam High and Mid highlands areas) are therefore analyzed considering altitudinal differences, gender, asset endowments, education and the results are stated in the following sections.

Farmers were asked to compare the current weather conditions with that of 20 years ago and the analysis results showed that the majority (90.7%) have perceived drastic differences of climatic condition over the years. Perception on the details of climate change indicators as related to rainfall and temperature are indicated in Table 5.5. Accordingly, the majority of the respondents have indicated that the rain fall amount has decreased (this might be associated with the poor distribution of the rainfall), the rainfall pattern has become irregular and the temperature has increased and few farmers felt that the rainfall amount is the same (12%) (Table 5.5). Similar trends were documented in another study conducted in the North western part of the Amhara region of Ethiopia by Solomon and Rao (2013). A significant number of farm households confirmed that early onset of rain fall, late on set of rain fall, early cessation of rain fall, poor distribution of rain fall, frequent and high volume flood and strong wind have become evident features of the climate and it is affecting crop production.

Table 5. 4 Respondent farmer's perception of climate change during the past two decades in the Upper Highland (*Dega*)

	Response (%)	
Climate change indicators in the study Kebeles	Yes	No
Rain fall amount has increased	26.7	73.3
Rain fall amount has decreased	70.7	29.3
Rain fall amount is the same	12.0	88.0
Early onset of rain fall	49.3	50.7
Late on set of rain fall	60.0	40.0
Early cessation of rain fall	59.3	40.7
Poor distribution of rain fall	71.3	28.7
Frequent high volume flood	30.7	69.3
High temperature	69.3	30.7
Strong wind	24.7	75.3

Similarly, in the mid-highland area farmers were asked the same questions and the results are displayed in Table 5.6. Accordingly, although most of the respondents share similar views on all attributes of the climate variables it seems that variability is more felt in the mid highland altitude zones. Particularly the responses on rainfall attributes signal important messages that should be taken up by the agricultural extension service.

Table 5. 5 Farmers perception of climate change during the past two decades in the Mid Highland (*Woina Dega*)

Climate change indicators in the study Kebeles	Yes (%)	No (%)
Rainfall amount has increased	23.3	76.7
Rain fall amount has decreased	80.7	19.7
Rain fall amount is the same	4.7	95.3
Early on the set of rain fall	56.7	43.3
Late on the set of rain fall	74.0	26.0
Early cessation of rain fall	78.0	22.0
poor distribution of rain fall	98.7	1.3
Frequent high volume flood	67.3	32.7
High temperature	99.3	0.7
Strong wind	80.7	19.3

The combined examination of farmer's perception of climate change indicators in both altitudinal zones of the study area also confirmed more or less similar results (Table 5.7). The prevalence of vast awareness on climate change among the majority of the farming community needs to be taken as an asset and further awareness campaigns must be carried out to sensitize farmers more on the issue so that they can quickly pick up adaptation strategies that fit their socioeconomic set ups.

Table 5. 6 Combined assessment results of farmers' perceptions on climate change in the Upper and Mid Highlands.

Climate change indicators in the study Kebeles	Percent Yes	No
Rain fall amount has increased	12.3	87.7
Rain fall amount has decreased	75.2	24.8
Rain fall amount is the same	8.3	91.7
Early on the set of rain fall	52.6	47.4
Late on the set of rain fall	66.6	33.4
Early cessation of rain fall	68.2	31.8
Poor distribution of rain fall	84.4	15.6
Frequent high volume flood	48.7	51.3
High temperature	83.8	16.2
Strong wind	52.7	47.3

Local climate change indicators were assessed among the households. Among the many indicators, loss of some crop varieties (mainly long maturing ones such as wheat, sorghum) increased droughty condition, irregularity of rain fall patterns, decline of agriculture yield and decreasing of available water (intermittent flow of rivers and streams, drying up of pods, wetlands) were highly perceived by most respondent farm households irrespective of wealth status, agro ecology, education and sex of the farm household head (Table 5.8); and the Chi Square ($X^{2)}$ test of association of perception of local indictors against the stated household variables showed no significant difference with p values far more than 0.1.

Table 5.7 Perception of respondents on the local indicators of climate change

Local indicators of perceived climate change	Percent of farmers' response	
	Yes	No
Loss of some crop varieties	86	14
Increased droughty condition	76	24
Irregular rainfall pattern	89	11
Decline of Agriculture Yield	96	4
Water availability reduced	87	13

In most of the focus group discussions with farmers and Key informants it was confirmed that the climatic variability particularly irregularity of rainfall and rising of temperature is negatively impacting agricultural activities including livestock production. In the course of the discussion given that farmers have claimed to have developed good awareness on climate change there was a critical debate on how farmers are responding to climate change challenges. In this regard there were mixed feelings: few were stating they are planting trees, others are claiming they practice soil conservation and water harvesting, even some indicated the use of manure to improve soil fertility, collecting crop residue for livestock, looking for indigenous knowledge, etc. Despite these assertions natural resources development work and local level institutional arrangements to facilitate these were observed to be unsatisfactory across the study kebeles.

Similarly experts working in different institutions (Chapter Three, Section 3.1.3) and having a stake in climate change have acknowledged the existence of climate change that affects farming and livestock husbandry, however; they also underlined that the level of awareness is not complemented by a well-coordinated and integrated development interventions including natural resources improvement, packaging of technologies that could enhance crop production and livestock raring, provision of credit facilities, strengthening of social capital through institutional building, etc. The occurrence of climate change perception among farmers can be taken as an asset as it may help to enhance climate change adaptation interventions. Although perceptions are important, a number of other critical factors also determine how people react to impacts. For example climate information availability can be a key component of adaptation planning (Ziervogel and Zermoglio 2009). It is also asserted by scholars (e.g. Risbey *et al*., 1999) that farmers who used seasonal climate forecasts generally secured better crop yields than those who relied on historical climate records. This suggests that if farmers give consideration to previous climate experiences or rely solely upon their social and cultural norms and perceptions of risk, they lose out the added value that the current advances in scientific experience could provide.

Farmers' perception on how fast the degree of climatic variables change indicated that about 58.5% felt severe change within the last few year, 35.5% indicated slow change and very few (4.3%) indicated no visible change and 1.3% stated no change. Many of the farmers who have lived many years in the study area, mainly those in Yeduha, Gedamawit and Yibab, were of the opinion that the climate variability has been increasing from time to time and has affected their lives. As to problems faced due to climate change about 70% stated crop failure, 82.7 % poor livestock productivity, 72.7 % deterioration of grazing land, shortage of water for domestic use and irrigation (82.7%), and malaria incidence (45%).

Arguments on the rising of temperature were substantiated by stating the occurrence of diseases such as malaria that was not common, expansion of the ecological niche of annual crops such as teff (*Eragrostis teff)*, and changes in closing style in the high altitude (*Dega*) areas. As to the cause of climate change about 26.3% perceived that it is human mismanagement of the environment, about 6.7% stated natural process, 49.9% a combination of human action and natural process, some 12% attached it to wrath of God and about 4.6% have no information. The overall result shows that perception of climate change across households of different wealth groups, altitudinal zones and institutions is restively high and it could be taken as an asset in efforts to promote adaptation to climate change.

5.5 Conclusion

The prevalence of adequate perception of climate change principally on temperature and rainfall patterns by farmers and institutions working on climate change is assumed to be an important element to guide future actions on climate adaptation endeavors. Availability of Meteorological stations helps to record data on weather variables and make analysis to see rain fall and temperature patters so that adjustments on farming activities could be made.
Analysis of climatic data recorded in 10 weather stations located in the study areas indicated that there exists variability in the temperature and rainfall condition and the general trend shows that the temperature is on the rise and the rain fall has shown a declining trend though not drastic and it is characterized by erratic and uneven distribution.

These trends are also felt by farmers where the majority of farmers have perceived that the rain fall on set and cessation and distribution has become erratic and affecting their farming practices and livestock husbandry. This is helpful to formulate suitable solutions for potential problems associated with climate change.

The presence of some segments of the community attaching climate change challenges to wrath God signals the need for launching awareness campaigns on causes of climate change and on measures that should be taken at household and community level, to bring all members of the farming community at equal footing. Despite the climate change awareness established within the community, efforts to initiate effective adaptation measures by farmers and institutions in charge of climate issues is weak indicating the need for taking prompt actions.

It is hypothesized that farmers who perceive the change in climate variables carry out better adjustments in their farming and other livelihood activities to reduce climate change impacts provided that their efforts are complemented with the necessary inputs (technical and financial). These and associated issues are addressed in the next chapter dealing with adaptation to climate change.

CHAPTER 6

FARMERS ADAPTATION STRATEGIES TO CLIMATE CHANGE IN THE STUDY AREA

6.1 Introduction

It is evident that the upsurge in Green House Gases (GHE) emissions due to human activities has resulted in further warming of the earth's atmosphere and it is likely that this will cause devastating impacts. Initial efforts to curb the problem of global warming concentrated on mitigation measures that could reduce and possibly stabilize the GHG concentration in the Atmosphere (UNFCCC, 1992). Despite the potential effects of mitigation measures, it is asserted that sea level rise and global warming are likely to continue to increase over centuries due to the inertia of the earth system. Consequently adaptation has been considered as a viable option in reducing the vulnerability associated with anticipated negative impacts of climate change. It is increasingly realized that mitigation and adaptation can yield better results if both strategies are seen as supplementing each other. In this regard Chambwera (2010) contended that adaptation to climate change needs to be seen as an integral part of a country's development planning, rather than as a separate issue, and adaptation measures that lead to better overall development outcomes are preferable to ones that focus exclusively on adapting to climate change impacts while ignoring other stresses. The chapter is therefore deemed to address the major objectives stated in relation to assessment of farmers coping and adoption strategies at household and community level; and it is finally complemented by analysis of determinants of farmers' choice of adaptation options to climate change in the study area.

6.2 Factors influencing farmers' adaptation to climate changes

Adaptation to climate change is extensively recognized as a vital element of any policy response to climate change. Studies showed that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation vulnerability can largely be reduced (Easterling *et al.*, 1993; Reilly and Schimmelpfennig, 1999; Smit and Skinner, 2002). The extent to which an agricultural system is affected by climate change largely depends on its adaptive capacity as clearly indicated in Section 2.4 of chapter 2.

Many agricultural adaptation options had suggested in the literature and they encompassed a wide range of development interventions including: scales (local, regional, global), actors (farmers, firms, government), and types: (a) micro-level options, such as crop diversification and changing the timing of operations; (b) market responses, such as income diversification and credit arrangements; (c) institutional changes, chief government responses, such as elimination or sustaining of subsidies and improvement in agricultural markets; and (d) technological advances—the development and promotion of new crop varieties and improvements in water management techniques (Smith and Lenhart 1996; Smit and Skinner, 2002). Most of these adaptation measures symbolize possible or potential adaptation interventions that could be considered depending on objective realities prevailing in the different ecological set ups.

The most common climate variability and climate change adaptation strategies in rural Africa including Ethiopia are identified by a number of scholars (Below *et al*., 2010; Gbetibouo, 2009; Maddison, 2006; Fosu- Mensah *et al.* 2010; Apata *et al.* 2009; Deressa *et al.* 2010; Seo and Mendelsohn 2006; Hassan and Nhemachena (2008). These include growing of drought and heat resistant and early maturing crop varieties, crop and livestock diversification, use of small-scale irrigation, water harvesting and storage, improved water exploitation methods, labor migration, strengthening agro-forestry practices, food storage, controlled grazing, changing planting dates, engaging in off-farm activities etc. These adoption options are thought to be developed out of necessity by the farmers themselves. However, the extent to which these interventions are effectively realized and the predicaments that are encountered in the process are not well elaborated in many cases. The evidence that is presented below therefore provides an insight on challenges faced to realize adaptation to climate change in the Ethiopian context.

Adaptation to climate change is reported occurring at two main scales: (a) the farm-level that focuses on micro-analysis of farmer decision making and (b) the national level or macro-level that is concerned about agricultural production at the regional and national scales and its connections with national and international policy (Bradshaw *et al*. 2004; Kandlinkar and Risbey 2000). According to these authors micro-level analysis of adaptation centers on strategic decisions farmers take to respond to seasonal climatic, economic and other factors. These tactical decisions are influenced by a number of socioeconomic factors including household resource endowments, access to information on seasonal and long-term climate changes and existence of formal institutions (input and output markets) for smoothening consumption. Decision making at farm level occurs over a very short period of time commonly influenced by local agricultural cycle, seasonal climatic variations, and other socio-economic factors. Macro-level analysis focuses on strategic national decisions and policies on local to regional scales considering long term changes in climatic, market and other conditions over long periods (Bradshaw *et al*., 2004; Kandlinkar and Risbey, 2000). The level of analysis for this study is the local farm-level where adaptation will be analyzed at micro level to find potential ways of improving agricultural production at the farm level (Below *et al.*, 2010).

Resource limitations and poor infrastructure limit the ability of most rural farmers to engage in adaptation measures as a response to changes in climatic conditions. Farmers with resource limitations fail to cover transaction costs needed to secure adaptation measures and at times farmers cannot make beneficial use of information they may have at hand (Kandlinkar and Risbey, 2000). Labor availability is considered an important input constraint. The assumption is that farm households having more labor are better able to take on several adaptation practices as a response to the changing climatic conditions compared to those lacking adequate labor. Likewise health factors determine the ability of the available labor force to work on different farm activities. A healthy labor force means that the household is able to take on various farm activities, adaptation of crop and livestock management practices to climate change.

Lack of market access can constrain the capacity for adaptation at farm-level. Farmers with access to both input and output markets have more opportunities to apply adaptation measures. Existence of markets availing inputs allow farmers to acquire the necessary inputs needed for their farming activities such as seeds of different varieties, fertilizers, and irrigation technologies. On the other side, availability of output markets creates positive incentives for farmers to produce cash crops that can help strengthen their livelihood resources and hence their capability to respond to changes in climatic conditions (Mano *et al*., 2003).

Information related to forecasting of climate change, adaptation options and other agricultural production activities is a vital factor influencing use of different adaptation measures for most farmers. Lack of and/or limitations in information and knowledge (on cyclic and long-term climate changes and agricultural production) increase high downside risks from failure related with acceptance of new technologies and adaptation measures (Kandlinkar and Risbey, 2000). Availability of well-organized information on climate and agricultural activities helps farmers make comparative decisions among alternative crop management techniques and this helps them to choose strategies that make them cope well with changes in climatic conditions (Baethgen *et al*., 2003).

Failure to put in to practice adaptation options and poor agricultural performances by many African farmers has been blamed on lack of information and resources (Archer *et al*., 2007). Southern Africa for example, has early warning sections and meteorological departments, but the information does not reach all intended users (Archer *et al*., 2007). Policy measures on adaptation have to consider how information concerning adaptive measures, forecasts, and timings on production schedules can best reach farmers to help them respond to changes in climate. Improving the adaptive capacity of disadvantaged communities requires ensuring access to resources, income generation activities, greater equity between genders and social groups, and an improvement in the capability of the poor to participate in local political affairs and actions (Najam *et al.*, 2006). Thus, furthering adaptive capacity in accordance with the overall sustainable development and policies helps to reduce pressure on resources, environmental risks, and increases the welfare of the poorest members of the society.

There is in general substantial literature on the factors that determine farmer’s decisions to adapt to climate change. Many of the evidences indicated in the literature are established using a variety of models including Multivariate Probit model, Heckman Probit and the Multinomial Logit model. Accordingly, research reports indicating determining factors on farmers' adaptation strategies to climate change were documented in 11 countries in Africa by Hassan and Nhemachena (2008) and Seo and Mendelsohn, 2006); in Ethiopia by Deressa et al. (2009), in Western Nigeria by Apata et al (2009), in Ghana by Fosu-Mensah et al (2010) and in South African countries by Hassan and Nhemachena (2007) and Gbetibouo (2009). The findings of these researchers highlight a number of interacting factors that have influenced farmers' adaptive capacity to climate change; and some of them are common across countries. Accordingly factors including access to credit, market, extension services and awareness of climate change, farming experience, technology and farm assets (land, labour and capital), household head sex, education, age, family size, non-farm income, livestock ownership, access to climate information, crop diversification, soil fertility, land tenure and number of relatives in the community are identified as important factors that enhance adaptive capacity of African farmers to climate change. This study has applies the Multinomial logit model to determine factors that require due attention in efforts to tackle climate change challenges by farmers in the study area and in similar socioeconomic and ecological settings.

6.3 Results and discussions

6.3.1 Respondent farmers coping and adaptation strategies to climate change

Analysis of response of smallholder farmers on adoption options practiced to withstand climatic variability showed that many have tried to use traditional irrigation schemes including water harvesting, some used drought resistant crop varieties, and improved crop varieties and many farmers shifted from crop production to planting trees while not undermining the importance of crop rotation and mixed cropping and enhanced livestock rearing (Table 6.1).

Table 6.1 Smallholder farmers adaptation practices to climate change in the study area (n=300)

Adaptation types	Surveyed Farmers Percent of farmers	
	Yes	No
Enhancing traditional irrigation schemes (including water harvesting)	38	62
Using moisture stress tolerant crop varieties	42	58
Using improved crop varieties	34	66
Shifting from crop producing to planting trees	78	22
Adjusting planting time	90	10
Enhancing livestock rearing practice	78	23

Discussions with farmers on the adoption options indicated in Table 6.1 revealed that although they showed high interest in many of the adoption options, institutional support in terms of availing the required amount of drought tolerant crop seed varieties, credit services and technical support at farm level is insignificant and this was acknowledged during discussions with agricultural development agents. In time of crop failure due to erratic nature of the rain farmers opted to use their own experience in selecting the crop variety that suited to the existing weather condition. For example farmers in mid highlands replaced maize crop with chick pea and rough pea. In this regard a study by Bewket *et al*. (2013) showed similar trends where farmers shortened the cropping calendar, and adjusted their farming practices to counteract the impacts of changes in temperature and rainfall patterns.

Despite the good perception of climate change challenges by farmers in all the study areas discussions held with farmers and experts in supporting institutions indicated that proactive measures by farmers and strategic interventions by the respective institutions (such as offices of agriculture, water resources, credit institutions), and others are still lagging behind compared to the magnitude of climate related problems. It was observed that farmers having land close to water sources attempted to use rivers and streams for irrigation in many places; however, this created social conflicts between upstream and downstream communities due to inequitable access to water.

Most rich and medium rich farmers criticized the agricultural bureau for curtailing the campaign that was started in 2000 to promote construction of water harvesting structures using geo-membrane (plastic sheet) at homesteads and on farm land. Many farmers in Gedamawit and Yeduha kebeles expressed their critiques as:

> W*hen we realize the significance of the water harvesting technology and made our minds to adopt it the supply side from the government dried up for reasons which we do not know. Had the momentum continued at full swing it would have contributed a lot in solving the water shortage encountered in this year's drought.*

During field observation it was noted that there is huge work done on soil conservation as a result of annual community mobilization. Farmers asserted that soil conservation structures enhance water infiltration in to the ground and also halt soil erosion. However, most of the physical structures are not integrated with biological conservation techniques that further enhance moisture conservation and biomass production needed for livestock feed.

In general the views of farmers and observations made in the field showed that many of the adaptation options are not implemented in a well-coordinated and organized manner. This is therefore weakening farmers' endeavors for adaptations to climate change and in some study kebeles (Yeduha and Gedamawit) there is a tendency of dependency syndrome and expecting the government to provide them essential commodities for their livelihoods.

Choice of farmers' adaptation strategy to climate change varies across agro ecology and asset endowment of farmers. A thorough analysis of data gathered from different sources; however, indicated that adaptation strategies considered by small holder farmers across agro ecologies (altitudinal zones) and adaptive capacity are influenced by fertility of the soil and resource endowments. For example in the upper highlands (e.g. in Gedamawit Kebele- Sinan district) there is a tendency by almost all small holder farmers to convert part of their agricultural land to eucalypts woodlots. Those who have adequate finance (the rich and medium rich farmers) mainly engage in petty trade, and the poor look for wage labor in nearby urban centers or practice seasonal migration. The later two practices, due to location advantage, were common phenomena reported by poor households in Yibab and Gedamawit Kebeles that are close to Bahir Dar and Debre Markos town respectively. Rich and medium farmers also attempted to exploit ground water and produce some vegetable in their backyards. In the mid altitude areas there are attempts by many of the rich and to some degree by the medium rich farmers to diversify their livelihood through livestock fattening and rearing of small ruminants.

On coping strategies discussions with focus groups, experts and key informants revealed that there are efforts to cope with adverse climate variability, however; lack of capital, shortage of land, low level of infrastructure and technologies, remain as barriers to cope with the adverse effects of climate change. Many of the respondents especially the poor used to migrate to urban areas and the overall response on coping variables such as reduction of food intake, looking for daily work, collecting fuel wood for sale, selling of assets like livestock, borrowing grain from others, borrowing money and purchasing of food on credit are indicated on Table 6.2.

Table 6. 2 Assessment of copping option to climate change and barriers faced in the time of crop failure

Climate change Copping Strategy	Percent of Respondents	
	Yes	No
Migrate to urban area	38.0	62.0
Reduce food intake	70.7	29.3
Look for daily work	60.7	39.3
Collect fuel wood for sale	57.3	42.7
Sell assets (livestock, etc.)	67.3	32.7
Borrow grain from others	73.0	27.0
Borrow money	75.3	24.7
Purchase of food on credit	72.7	27.3

During FGDs with farmers and key informants it was disclosed that farmers have a tradition of helping each other in times of climate adversity, particularly giving grain to the most affected is common by the well to do and get back the grain when the poor gets good harvest. According to farmers this tradition is gradually weakening partly because the resource rich farmers are decreasing in number and the number of people seeking help is increasing. Second, the strength of traditional social capital is being eroded due to introduction of formal institutions that lack full support of members. Regarding support from government and non-government institutions, apart from provision of credit facilities at least for some farmers, and food for work intervention (e.g. in Shebel Berenta district) farmers in all the study areas are trying to cope the problem by themselves.

Vulnerability to climate variability is a function of many variables including wealth status, where the majority of the poor (98%) and medium rich (85%) expressing that their livelihoods will be severely affected by climatic variability due to lack of reserve resources. During group discussions most of the rich claimed that they can withstand the problem for quite some time though living in a society that is highly liable to climatic shock may not give them peace and comfort. Most discussants stressed that in times of crop failure the capacity of farmers to feed their family for over six months is questionable. They further stated that it is only few farmers who may have grain reserve that lasts for a year. Vulnerability to crop failure in the study areas was more stressed in Yibab, Yeduha, Gedamawit and Amanuel Kebeles and this signals the need for designing development interventions that enable farmers to create assets that could be used in time of adversity.

Although vulnerability to climate change could be considered as a generic problem across agro ecologies variations in asset endowments such as land holding size, number of livestock owned, access to credit facilities seem to have affected the vulnerability of smallholder farmers to climate change or variability (Focus group discussion). Those farm households with better asset endowments have claimed that they can withstand failure of crop due to erratic rainfall for a relatively longer duration than those having limited resources. During the FGD however, it was stated that small land holdings, low agricultural productivity, scarcity of livestock feed, lack of irrigation facilities, poor engagement in off farm activities, etc. added up weaken the adaptive capacity of farmers and make it a great proportion of the community vulnerable to drought or climate change incidences. It was therefore suggested by farmers more efforts have to be made both by the community and the government to enhance the agricultural sector and the natural resources conservation and development so that the adaptive capacity could be strengthened and the vulnerability could be minimized. Views were also expressed on the importance of not overlooking the landless and unemployed youth. In sum the overall response of respondents indicates that farmers in the highlands are vulnerable to the negative impacts of climate change owing to the predominance of rain fed farming on small land holdings that are less fertile and this is further exacerbated due to low level of engagement of households in off farm activities.

6.3.2 Results on the Determinants of Farmers' Choice of Adaptation to climate change in the study areas

The analysis on parameter estimates of the Multinomial logit climate change adaptation model and Marginal effects from the multinomial logit climate change adaptation model are indicated in Table 6.3 and 6.4 respectively; and the combined model results showing variables significantly determining adaptation to climate change are depicted in Table 6.4.

Table 6. 3 Parameter estimates of the Multinomial logit climate change adaptation model

Variable	Enhance traditional irrigation		Used drought resistant crop varieties		Used improved crop varieties		Shifting from crop producing to planting trees		Adopt crop rotation and mixed cropping		Enhance animal rearing	
	Coef.	p-level	Coef.	p-level	Coef.	p-level	Coef.	p-level	Coef.	p-level	Coef.	p-level
SEXRE	-.209*	0.069	-.209*	0.069	-.209*	0.069	-.209*	0.069	-.209*	0.069	-.209*	0.069
AGE	.002	0.480	.002	0.480	.002	0.480	.002	0.480	.002	0.480	.002	0.480
EDULEVEN	.025**	0.028	.025**	0.028	.025**	0.028	.025**	0.028	.025**	0.028	.025**	0.028
MARITALS	.059	0.156	.059	0.156	.059	0.156	.059	0.156	.059	0.156	.059	0.156
HOLOLINC	-.004	0.152	-.004	0.152	-.004	0.152	-.004	0.152	-.004	0.152	-.004	0.152
TOTFASIZ	-.010	0.380	-.010	0.380	-.010	0.380	-.010	0.380	-.010	0.380	-.010	0.380
MIGSEWOR	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000
WEALTHST	.033	0.271	.033	0.271	.033	0.271	.033	0.271	.033	0.271	.033	0.271
FARMSZ	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000
PAOXPLOL	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000
HPRODUCT	.056	0.185	.056	0.185	.056	0.185	.056	0.185	.056	0.185	.056	0.185
AGRISERV	.187	0.174	.187	0.174	.187	0.174	.187	0.174	.187	0.174	.187	0.174
FARMERTO	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005
ACTOCRED	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002
ACCINFORMATION	-.135**	0.013	-.135**	0.013	-.135**	0.013	-.135**	0.013	-.135**	0.013	-.135**	0.013
ADECRF	.162**	0.019	.162**	0.019	.162**	0.019	.162**	0.019	.162**	0.019	.162**	0.019
KPORDRF	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000
ATEMPRIC	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028

Notes: *** significant at 1%; ** significant at 5%, and * significant at 10% probability level .

Table 6. 4 Marginal effects from multinomial logit climate change adaptation model

Variable	Enhance traditional irrigation		Used drought resistant crop varieties		Used improved crop varieties		Shifting from crop producing to planting trees		Adopt crop rotation and mixed cropping		Enhance livestock rearing	
	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z	dy/dx	P > z
SEXRE	-.209*	0.068	-.209*	0.068	-.209*	0.068	-.209*	0.068	-.209*	0.068	-.209*	0.068
AGE	.002	0.479	.002	0.479	.002	0.479	.002	0.479	.002	0.479	.002	0.479
EDULEVEN	.025**	0.027	.025**	0.027	.025**	0.027	.025**	0.027	.025**	0.027	.025**	0.027
MARITALS	.059	0.154	.059	0.154	.059	0.154	.059	0.154	.059	0.154	.059	0.154
HOLOLINC	-.004	0.151	-.004	0.151	-.004	0.151	-.004	0.151	-.004	0.151	-.004	0.151
TOTFASIZ	-.010	0.379	-.010	0.379	-.010	0.379	-.010	0.379	-.010	0.379	-.010	0.379
MIGSEWOR	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000
WEALTHST	.033	0.270	.033	0.270	.033	0.270	.033	0.270	.033	0.270	.033	0.270
FARMSZ	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000
PAOXPLOL	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000
HPRODUCT	.056	0.183	.056	0.183	.056	0.183	.056	0.183	.056	0.183	.056	0.183
AGRISERV	.187***	0.172	.187	0.172	.187	0.172	.187	0.172	.187	0.172	.187	0.172
FARMERTO	-.240	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005
ACTOCRED	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002
ACCINFOR MATION	-.135**	0.012	-.135**	0.012	-.135**	0.012	-.135**	0.012	-.135**	0.012	-.135**	0.012
ADECRF	.162**	0.018	.162**	0.018	.162**	0.018	.162**	0.018	.162**	0.018	.162**	0.018
KPORDRF	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000
ATEMPRIC	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028

*** significant at 1%; ** significant at 5%, and * significant at 10% probability level.

Table 6. 5 Variables having significant effect on adaptation to climate change after Multinomial logit and Marginal effect analysis

Variable	Enhance traditional irrigation		Used drought resistant crop varieties		Used improved crop varieties		Shifting from crop producing to planting trees		Adopt crop rotation and mixed cropping		Enhance animal rearing	
	Coef.	p-level	Coef.	p-level	Coef.	p-level	Coef.	p-level	Coef.	p-level	Coef.	p-level
SEXRE	-.209*	0.069	-.209*	0.069	-.209*	0.069	-.209*	0.069	-.209*	0.069	-.209*	0.069
EDULEVEN	.025**	0.028	.025**	0.028	.025**	0.028	.025**	0.028	.025**	0.028	.025**	0.028
MIGSEWOR	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000	-.350***	0.000
FARMSZ	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000	.097***	0.000
PAOXPLOL	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000	-.251***	0.000
FARMERTO	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005	-.240***	0.005
ACTOCRED	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002	-.326***	0.002
ACCINFOR MATION	-.135**	0.013	-.135**	0.013	-.135**	0.013	-.135**	0.013	-.135**	0.013	-.135**	0.013
ADECRF	.162**	0.019	.162**	0.019	.162**	0.019	.162**	0.019	.162**	0.019	.162**	0.019
KPORDRF	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000	-.381***	0.000
ATEMPRINC	-.140**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028	-.139**	0.028

*** significant at 1%; ** significant at 5%, and * significant at 10% probability level.

The overall results of the Multinomial logit analysis in Table 6.5 showed that sex of household head, education level, off farm activities employment opportunity, farm size, ownership of a pair of oxen, farmer to farmer extension service, access to credit, and access to information on climate change, declining of rainfall, poor distribution of rainfall and high temperature significantly influence farmers adaptation to climate change. Many of these variables are also indicated as important variables in the studies of Deressa *et al*. (2009), Maddison (2006) and McNamara, *et al.* (1991) and others cited in sections dealing with determinants of adaptation to climate change.

In the context of the study area and in many parts of Ethiopia men are the principal actors in the farming activity though women also have their own contribution. In most circumstances men headed farm households are likely to have better access to extension services and adopt agricultural technologies that could help to overcome problems related to climate change. In terms of access to resources having a pair of oxen enables a farmer to undertake the right tillage operation at the right time. This is particularly vital where farmers have to observe critical sowing time taking into account moisture availability. The problems related to lack of oxen (Section 4.2.4.2 Chapter 4) clearly signify the need for owning oxen in the farming system. Likewise farm size has an important bearing on a households' capability to produce adequate grain for the family. However, most farm households in the study area as indicated in Section 4.2.4.4 of Chapter 4 have a small farm land and to make the matter worse there are many more landless people. It is evident that as farm size increases, farmers are likely to practice diverse cropping activities and livestock husbandry that are compatible to climate change variables.

The impact of off-farm employment opportunity on adoption to climate change needs to be understood from the stand point of making available the required labour for farm activities of households and possibly the financial inputs required for purchasing agricultural inputs where households are in short of capital. The scenario in the study region implies the need for a balanced judgment on the effect of off farm employment on adaptation to climate change.

Access to credit service is an important factor to narrow the financial gap of the farmers so that they could purchase the required farm inputs and technologies that are useful for improving agricultural production and also to carry out income generating activities other than farming. Fortunately, it is a significant institutional factor that determines the use of improved agricultural techniques including livestock raring as an adaptation strategy. When there is easy access to credit, it is often obvious that farmers try to adopt strategies that require capital inputs for implementing improved agricultural technologies including traditional irrigation. In addition access to information, awareness on declining of rainfall, exposure to poor distribution of rainfall and high temperature compounded by better literacy level were also found to be complementing factors that significantly affect adoption of alternative technologies that could enhance resilience against climate change impacts.

In sum identification and recognition of factors most likely determining farmers' motivation to adapt to climate change can be considered as a beginning of the end in the efforts to curb the likely negative impacts of climate change though various adaptation strategies. What is more useful is critically looking at the factors and designing the way outs. Publicizing the potential problems to climate change adaptation to decision makers and politicians is equally important to secure the required support.

6.3 Conclusion

Climatic variability and climate change makes it essential to develop coping and adaptation strategies at local level. Success on coping up and adaptation to climate change is largely a function of a multitude of interacting factors including technological, institutional and economic endowments. Analysis of response of smallholder farmers on adoption option options practiced to withstand climatic variability showed that many have expressed their efforts to enhance traditional irrigation schemes, a large majority have shown keen interest to use drought resistant crop varieties and improved crop varieties and some farmers have converted crop lands to woodlots. The reality in the field however signals that strategic interventions by the respective institutions such as offices of agriculture and proactive measures by farmers themselves are still lagging behind in contrast to the magnitude of the climate related challenges. The overall scenario depicts resource limitations and poor infrastructure and lack of adequate technology provision and technical back up seem to have debilitated the capacity of most rural farmers to take up adaptation measures in response to changes in climatic conditions.

Although discussions on coping strategies with focus group, experts and key informants revealed age old traditions of helping each other, lack of capital, shortage of land, low level of infrastructure and technologies have remained as barriers to cope with the adverse effect of climate change. Vulnerability to climate variability or change is a function of many variables including wealth status, and access to natural resources such as irrigation water and credit facilities to run alternative economic activities and social connectedness. The prevalence of resource poor farmers in the study areas, limited access to irrigation water and widespread poor soil fertility coupled with weak institutional support and rapidly increasing rural population have become severe challenges that may hinder opportunities for reducing vulnerability of the majority of the poor.

The results of the Multi Nomial Logit analysis on adaptation to climate change revealed a number of social, economic and institutional factors influencing farmers adoption capacity. Strategic interventions initiated by development agencies to tackle climate change would therefore benefit from detail analysis of the variables under each category. As clearly explained in the socio-economic analysis section (Chapter Four), the study areas are characterized by a low literacy level, limited off-farm employment opportunity, small farm land holdings, lack of ownership of a pair of oxen. Under such circumstances it is unlikely that farmers' efforts to adapt to climate change may bring visible and sustainable output. Likewise, institutional issues related to farmer to farmer extension service, access to credit, and access to information on climate change require strategic consideration in the development efforts to make the climate change adaptation agenda a reality or success at local level.

In general from the views of farmers and observations made in the field it can be concluded that many of the adaptation options are not implemented in a well-coordinated and organized manner and this implies the existence of institutional gap that hinders farmers motivation to pursue climate change adaptation practices. Particularly failure to complement the efforts of innovative farmers with the required technological and other supports is likely to hamper adaptation efforts and may also induce tendency of dependency syndrome in the farming community. Farmers' perception of climate change and adaptation efforts to climate change are very much influenced among other factors by institutional arrangements put in place. The next chapter addresses the centrality of institutions in the context of climate change management.

CHAPTER 7

INSTITUTIONAL ARRANGEMENTS FOR CLIMATE CHANGE

7.1 Introduction

The subject of climate change is a cross cutting issue that requires involvement of a multitude of stakeholders including meteorological offices, agricultural development offices, land administration offices, environmental protection offices, industrial development institutions, politicians, administrators, community based organizations, etc. Isolated efforts of organizations in climate change issues hardly contribute to effective adaptation mechanism and reduction of climate change impacts and environmental protection. Instead integration of the mandates of these institution facilitates better ecosystem development and stable climate and ultimately improvements in the livelihood of the local community. The main objective of this chapter is to assess institutional arrangements (both at grass root level and at higher levels) put in place to avert climatic shocks in the study area and review their impacts on sustainability of development interventions aimed to prevent climate change impacts in the study area. The chapter therefore attempts to provide an insight on institutional arrangements to handle the climate change issues in Ethiopia and the Amhara region. It is then followed by an analysis on perception of farmers, the local community and experts on the performance of institution operating in the study areas to promote climate resilient economy in study area and the region at large.

7.2 Climate change institutional arrangements in Ethiopia

Ethiopia is one of the developing countries which is vulnerable to climate variability and change. Insufficient infrastructure, low level of socio-economic development, higher dependency on the natural resource base and deficiency of institutional capacity make the country more vulnerable to climatic factors including climate variability and extreme climate events (NAPA, 2007). The National Adaptation Program of Action is a mechanism within the UNFCCC designed to help the Least Developed Countries (LDCs) including Ethiopia to identify their priority adaptation needs to climate change and to communicate these needs to the Conference of Parties of the UNFCCC and other stakeholders.

NMA (2007) in its account of the National Adaptation Program of Action (NAPA) for Ethiopia indicated that a project Steering Committee was established with representatives from the

Ministries of Water Resources, Agriculture, Finance and Economic Development, Disaster Prevention and Preparedness Agency, Ethiopian Science and Ethnology, National Meteorology Agency, Addis Ababa University, Institute of Biodiversity Conservation and Research, Ethiopian Rural Energy Promotion and Development Centre and CRDA representing the NGOs. The role of the steering committee was to provide overall guidance and oversight for the projects dealing with climate change. Regional states in the country are deemed to benefit from these stakeholders.

Currently it is indicated that the Ministry of Environment and Forest (MoEF) is the National Focal Point to the Kyoto Protocol and to the United Nations Framework Convention to Climate Change (UNFCCC) (MoEF, 2015). The Ministry is mandated by the Government of Ethiopia to spearhead and coordinate environment, forest and climate change issues in the country. The Ministry prepares regulatory instruments and plays a regulatory role, ensures the mainstreaming and implementation of environment, forest and climate change issues in sectoral programmers and plans, coordinates implementation of the Climate Resilient Green Economy (CRGE) strategy across the national sectors, and it is also mandated to carry out capacity-building activities for sectoral and regional bodies.

In response to the recurrent crises such as drought, the Ethiopian government established Relief and Rehabilitation Commission (RRC) in the 1970s to facilitate support for the affected people and later enacted a policy that launched the establishment of Disaster Prevention and Preparedness commission (DPPC). This institution was again renamed as Disaster Prevention and Preparedness Agency (DPPA) and in this arrangement there is a shifting strategy from relief services only to a strategy to reduce vulnerability in the longer term. The government is also providing an early warning system to predict risks to happen particularly with the help of forecast information from National Meteorological Service Agency (NMSA).

Experience shows better environmental management helps to improve resilience to environmental risks, economic development, and livelihood opportunities, especially for the poor. To fight poverty and to preserve the ecosystems that form the foundation of poor people's livelihoods, pro-poor economic growth and environmental sustainability needs be placed at the heart of most fundamental policies, systems and institutions (UNPEI, 2009) and Ethiopia being highly affected by the recurring drought is in the process of institutional building to tackle environmental problems.

Ethiopia is particularly vulnerable to accelerated soil erosion because of existing pressures and degradations on land due to highly rugged and steep slope topography. In the Amhara region where this study was carried out about 50% of the land mass is above 16% slope and suffers from severe soil erosion (BoA, 2014). Apart from land degradation about 70% of the country is drought prone, (the Amhara region being one of the badly affected), hence institutions role in providing the enabling environment for implementing adaptations actions and improving the resilience capacity of the local community is immense as argued by IPCC (2014).

The term institution in this research is used to indicate the organizational set up put in place to handle the climate change issues. Indeed, rules and regulations that guide operational activities of an organization are also known as institution. In this regard UNFCC (2014) arguing that there is no single definition for institutional arrangements for adaptation, it interprets institutions as those structures, approaches, and practices or rules set in place by stakeholders at all levels to enhance adaptation action. These include assessment of impacts, vulnerability and risks, as well as planning for adaptation, implementation of adaptation measures, and monitoring and evaluation of adaptation.

Local institutions have a great role on how rural people respond to environmental challenges. The rural masses in Ethiopia are highly mobilized to participate in soil conservation, tree planting, protection of the grazing lands, and natural forests and woodlands. They are also the potential entities in charge of handling and putting into practice external interventions designed to facilitate adaptation to climate change. As adaptation to climate change is principally an activity centered at local perspective, it is vitally important to carefully understand the role of the local institutions that could shape adaptation and improving capacities of the most vulnerable social groups. In this regard scholars argued that compared to central government institutions, local organizations are better placed to respond to community needs (Gibson and Becker, 2000); they also played major role in building thrust between local people and government institutions, can enhance access to resources, capacity building and skill development by drawing resources from external agencies

(Ramussen and Meizen, 2001). Local institutions can also be instrumental in the provision of services such as credit or input supply, marketing support and the promotion of collective effort to common property resources development (Mosse, 1996).

Adaptation practices in general depend for their success on specific institutional arrangements. Where local institutions are weak the adaptation efforts become unsustainable. Institutional and social factors also play a key role in shaping the extent to which rural households and communities are vulnerable to different environmental risks. Institutions in general provide an enabling environment for implementing adaptations actions (IPCC, 2014).

Agrawal (2008) in his seminal article dealing with ‘’ the role of local institutions in adaptation to climate change’’ underlined that climate impacts affect the disadvantaged social segments more disproportionately, and that local institutions centrally influence how different social groups gain access to and are able to use assets and resources. The Author further suggested that adaptation to climate change is inevitably local and institutions influence adaptation and climate vulnerability in three critical ways: a) they structure impacts and vulnerability, b) they mediate between individual and collective responses to climate impacts and thereby shape outcomes of adaptation, and c) they act as the means of delivery of external resources to facilitate adaptation, and thus govern access to such resources.

Ethiopia ratified the UNFCCC (1994) and its related instrument, the Kyoto Protocol (2005), and submitted its initial Action (NAMA) plan to the UNFCCC by in January 2010. The country has completed the preparation of a new Ethiopian Program of Adaptation to Climate work program for action. Ethiopia’s Program of Adaptation to Climate Change (EPACC) is a program of action to build a climate resilient economy. To enhance the effectiveness of the climate change programs the institutional set up is claimed to be organized from federal level and cascaded down to local community level to transfer appropriate knowledge and skills. The program is also assumed to be regularly monitored, reported and verified to enhance continual improvement and generate learning from demonstration activities so that effective working procedures could be scaled up to community groups affected by climate change variables. Taking note of the above accounts on institutions and the issues indicated in the introduction section of this chapter as well as descriptions provided on institutions in Chapter Three, section 3.1.3, the findings on the perception of local communities and experts on efficiency of institutions in charge of tackling climate change issues are indicated in the following sections.

7.3 Results and discussion

As shown in Chapter III Section 3.1.3, there are a number of institutions that are directly or indirectly involved in climate change issues in the study areas. Assessment of the perception of the local community on the role of the major stakeholders (Offices of Agriculture , Environment and land administration, the Public administrations from region to kebele, Meteorological Agency, Amhara Region Disaster Prevention and Preparedness Agency, Agricultural research Centers) indicated mixed perceptions of farmers and staff working in the respective institutions on their effectiveness in enhancing adaptation to climate change as indicated in the following sections.

7.3.1 Perception on efficiency of the agricultural extension support to adaptation to climate change.

Perception on climate change and adaptation strategies were evaluated from institutional support perspectives. In this regard farmers' access to extension support, technical support on non-farm activities, etc were explored. About 96.3% of the respondent farm households stated that they have access to extension services that mainly focus on natural resources conservation, use of improved seed and chemical fertilizers. Contact to the extension worker at farm level is limited and it is only 7% who claimed to have personal contact to the extension agent once in a month at farm level.

The farmer FGD participants indicated that the Agricultural Development Agents and the local administration routinely mobilize farmers to carry out soil and water conservation structures and also advised the community to conserve the common lands (woodland/grazing lands) and that of the water body. The FGD participants in all the study Kebeles criticized the extension practice being largely pieces of advice given to many farmers at a place where actual farming practices are not conducted. Farmers stressed that there is no specific committee designated to publicize climate change issues, coping mechanisms during drought years and long term adaptation to the problem. Likewise FGDs with district and zonal level agricultural experts produced no different opinions indicating that the documents and guidelines developed on climate change issues at the national level were not cascaded to the regional, zonal and district level. And, formal discussions were not carried out to develop common understanding on how the local community has to be organized, which coping mechanisms should be crafted, what adaptation strategies lead to better resilience, etc.

Literature indicates that Public Agricultural Extension Services in Africa have played and continue to play key roles in agricultural development, in the diffusion of innovations, as medium for exchange of experiences with farmers and as a direct link between farmers and the government (Speranza *et al*., 2009). The same sources in their assessment of possibilities of adapting public agricultural extension services to climate change in Kenya argued that adaptiveness presupposes adaptive capacity and needs provision of adequate fund, and other physical resources, and extension workers with high motivation and technical competence.

Mustapha *et al.* (2012) underlined the importance of capacity building for extension agents to improve their communication abilities and also to learn from farmers' experiences. Regarding farmers it is suggested that the education given to them must move beyond technical training to enhance their abilities for planning, problem solving, critical thinking, and prioritizing, negotiating, building consensus and leadership skills, working with multiple stakeholders, and, finally, being proactive. It is also further noted by the researchers that it is important to provide farmers with information how the various options can potentially increase income and yields, protect household food security, improve soils, enhance sustainability, and generally help to alleviate the effects of climate change. Measured by these standards the agricultural extension workforce and the system in general in the study area and the region seem lacking the required skill and motivation as well as provision of the necessary inputs. Hence, it would be rational to improve the extension system and also identify technical gaps and provide continuous trainings that incorporate climate change issues while not undermining the incentive mechanism to motivate extension workers.

7.3.2 Community/Grass-root level organizations

It is true that local institutions have a great role in shaping how rural residents respond to environmental challenges and natural resources management (Gibson and Becker, 2000). Because adaptation to climate change is local, it is critically important to understand better the role of local institutions shaping adaptation and improving capacities of the most vulnerable social groups. At the local level, farmers in the study area are organized in development teams and they are mobilized to carry out soil and water conservation, tree planting, forest conservation, grazing land management, efficient use of water resources, etc. Reports of the district agricultural development offices particularly in the Upper Highlands indicated that not less than 75% of the agricultural land and communal land need soil and water conservation structures and much of the land is treated with terraces of earthen and stone bund. This was also verified during field visits to the study areas.

During FGD the views of participants indicated that most of the soil and water conservation carried out by mobilization of the community lack proper design and it is not supported by vegetative means. Open grazing is a common practice in the study areas and it has made it difficult to protect the structures from damages by livestock. As a result soil and water conservation structures were repeatedly constructed on a single plot of land and farmers could not see visible benefits. This is a serious problem that stems from lack of well-organized local level institution that carries out proper planning and continuous monitoring and evaluation of the development work. These circumstances have induced sense of uncertainty on the role of conservation structures in reducing the impact of climatic variability or drought and in improving the adaptive capacity. Under the current practice about 75% of the respondents expressed that they lack confidence that the soil and water conservation will save them from the ill effects of drought and rainfall variability.

Some experiences elsewhere in the region and the country however show that combining soil conservation and fodder production for an adaptation to climate change has become a core innovation and farmers practice a cut and carry system (Guyon, *et al.*, 2015; Figure 7.1). The success is largely associted with the presence of strong local community organzations that have comonn vision and understanding to improve the productivity of their environment and cope with climate changes impacts.

Figure 7. 1 Fodder production on soil bunds constructed on the farm and using it in a cut and carry system in southern region of Ethiopia.

Intensions to intensify and diversify farm production require multiplication and diffusion of innovations as indicated in Figure 7.1. This indeed requires supporting Farmers Training Centre, the establishment of fodder demonstration and multiplication plots and farmers experience exchange visits. Unlike the previous years the drought that severely hit Ethiopia in 2015/16 due to El Nino effect urged the Ethiopian Ministry of Agriculture and Natural Resources to rethink about the design of massive soil and water conservation packages and efforts were made to accommodate technologies that could enable farmers to adapt to climate change. This initiative is however not complemented by modification of the usual local organizational set up that is frequently criticized for its inefficiency. Institutional set up at local level should indeed be complemented by a transparent leadership and defined responsibilities to achieve the desired goal. In this regard Messershmidt (1991) contended that local organizations that have strong and representative leadership are more successful than those without. Likewise strong leadership is considered as instrumental in forging links with outside institutions and in encouraging participation (Mosse, 1996).

According to Satishkumar *et al.* (2013) institutional credit is one of the important factors which helps the farmers to cultivate land and also for adapting measures to overcome climate change effects, particularly in rain fed region. Credit services required by respondent households in the study area include finance for purchasing of agricultural inputs, fattening livestock, engaging in apiculture, handicrafts and petty trade. Most respondents (95%) claim that the agricultural bureau had been giving chemical fertilizers on credit bases for the last decade. Currently however the direction is changed and farmers having financial resources are instructed to make direct purchase on cash. Where credit provisions are made respondents stated that about 75.7% of the credit is used to purchase chemical fertilizers and improved seed; and some 24.3 % used it for livestock fattening and raring, and for petty trade. During the FGD with farmers it was disclosed that there is no provision of special credit facilities for climate adaptation and they have insisted that the government should seriously consider special financial service that could be easily accessed by the lower income group of the community so that they can get involved in livelihood diversification and improve their adaptive capacity to adverse climatic conditions.

Awareness creation on climate change and dissemination of technologies for climate change adaptation amongst the local community are some of the fundamental interventions in the effort to combat the adverse effects of climate change. This is a positive move shared by scholars. For example, Satishkumar *et al.* (2013) boldly stated that timely and requisite information is necessary to take adaptive measures for mitigating the risk caused by climate change. They further expound that the dissemination of weather information like rainfall conditions, credit information, improved varieties and management practices will play vital role in adapting different strategies to climate change.

Assessment of farm households' responds on access to information on climate change and associated issues indicated that about 30% get the information from agricultural extension agents, 29.3% on the radio and the large majority reported informal sources such as friends, neighbors and relatives. The use of radio as a means to disseminate improved agricultural technologies is suggested in Kenaya assuming it can ease resource limitations in the extension service (Speranza *et al*., 2009).

In group discussions with farmers the majority stressed that they secured climate change related information largely from agricultural extension agents and the national and regional radio broadcasts. This trend is an encouraging phenomenon that should be used as an avenue to disseminate more tangible climate related information that could be easily picked up by the majority. The reality on the ground however shows that the way how issues such as the causes and potential impacts of climate change, possible ways of coping and adaptation strategies, sustainability of environment and climate related development activities, the need for integrated approaches, etc seem not shaped considering the different target groups or stakeholders. If climate resilient services are to be provided the planning should be sound and technological packages must be identified and properly channeled through the extension service.

During the FGD with farmers it was made clear that extension agents apart from mobilizing farmers for soil and water conservation and tree planting to avert desertification and urging farmers to carry out season based farm activities, their involvement in providing well-organized information on impacts of climate change is limited. In specific terms farm households underlined limitations in the provision of moisture conservation methods during erratic rain fall, where to get diverse crop varieties to be sown depending on weather circumstances, provision of trees and shrub seedlings that could resist drought condition, how to establish community ponds for water storage for livestock and human being, etc.

Infrastructure such as access roads, health centers, schools, water points are all available in all the study kebeles albeit in varying degrees. In all the study Kebeles there are access roads (both seasonal and permanent) constructed under the Universal Road Access Program (URAP) launched by the Amhara region. Although health posts are opened in many of the study Kebeles the magnitude of the service they provide is limited. Clean drinking water points are scarce in almost all the study Kebeles though, but it is more severe in Gedamawit and Yeduha Kebeles. As access to clean water has fundamental ramification in the overall socio economic development activities it demands collaborative activities between the water institution and the local community. Where the health of people is impaired due to lack of clean water their capacity to withstand adverse condition including climate change becomes debilitated.

As described in Chapter Three, Section 3.1.2 and 3.1.2.3, Kebele Administrations (KAs) are formal institutions working on administrative and development programmes at local level. The KA has the authority to adjudicate on land resources within its jurisdictions. The soil and water conservation activities, tree plantings, communal woodland and grazing land management, water harvesting interventions, access to credit are all facilitated by the Kebele Administration supported by agricultural development agents. The Kebele administrations having administrative and political power play pivotal role in the mobilization of the rural community. They are also expected to facilitate climatic change adaptation programs and handle drought related problems. Discussion with farmers indicated that the Kebele Administrations are widely criticized for being largely political wings of the government and their capacity to enhance sustainable economic development is weak. Most respondents (80%) also stated that the contribution of Kebele administration in combating climate related problems is minimal.

For local organization, as it is needed in others, transparent and effective leadership is vitally important. It is asserted that local organizations that have strong and representative leadership are more successful than those without (Messerschmidt, 1991). Strong leadership can be instrumental to forging the links with outside institutions and in encouraging participation (Mosse, 1996). This fundamental attribute is however lacking in many of the Kebele level organizational set ups aimed to facilitate local development interventions.

The institutional set ups at the local level are largely introduced organizational arrangements by the government. These arrangements serve as political and administrative unit as well as development unit; this duality of functions seems to have created difficulties in balancing the need to respond to state directives while responding to community priorities. As stated above most key informants and farmers are critical of the KAs reluctance to listen to the voices of the people and also bitterly criticized their tendency to impose what is being ordered from above rather than making efforts to address community suggestions and demands. It is therefore argued that under the current circumstance it is difficult to accept the hypothesis that local level institutional arrangements in the study area are structured to effectively address problems related to climate shocks and enhance sustainable development.

7.3.3 The Ethiopian Meteorology Agency role in climate change as perceived by farm households and other stakeholders

Meteorological information is very important to smallholder farmers who depend entirely on rain-fed agriculture for their livelihood (Nadi, 2014). In this regard the Ethiopian Meteorology Agency is expected to organize and disseminate timely weather forecasts across seasons to the respective institutions. Discussions with the agricultural development experts however indicated that the activities on gathering weather information are not so much developed and informative. Farm households exposure to weather forecasts and using the information for farm activities was described as insignificant by most farmers in the FGDs. Some participants were reluctant to appreciate the value of weather forecast and tended to associate occurrence of rainfall is due to God's will. The presence of this kind of erroneous thinking makes it essential to sensitize famers so that they could avoid damages that could be inflicted by incidences of climate variability due to negligence of the local community to accept meteorological forecasts. In this regard Bryan *et al.* (2009) indicated that the perceived unreliability of early warning systems by farmers may point to the need for more awareness, education and training around climate change issues. In Tanzania the use of early warning systems to strengthen adaptive capacity for farmers is one amongst the most important interventions especially for smallholder farmers, whose agriculture is rain fed (Nadi, 2014). Being cognizant of this fact, the meteorology experts at Bahir Dar indicated that efforts are being made by the government to equip weather stations at national level so that more credible weather data could be captured, processed and disseminated.

Farmers also have a tradition of relying on indigenous knowledge to forecast weather conditions For example a study by Satishkumar *et al.*(2013) indicated in India farmers lacking access to weather forecasting information largely depend for weather information on their indigenous knowledge using the experience they gained from generations. During FGD discussions few farmers in Yeduha, Yibab and Gedamawit kebeles pointed out that it is possible to predict the likely weather patterns taking in to account the wind and cloud condition as well as the rainfall cessation time. Although the issue was not explicitly explained by them their claim can be considered as an opportunity to further exploit the indigenous knowledge to assist farmers to make some precaution and adjustments in their agricultural activities. In this regard Hazell and Haddad (2001) have highlighted the importance of integrating indigenous knowledge in the formal climate adaptation measures.

7.3.4 Agricultural Research Institutions role in generating technologies that could help combat climate change challenges

It is evident that the erratic and uneven distribution of rainfall and also shortage or excessive rain incidences in many parts of the study area and across the country demand the generation of agricultural technologies that counteract adverse climatic conditions. Discussions with the research staff at the Regional Research Centre indicated that there are crop varieties that could tolerate moisture stress such as sorghum, millet, chick pea, grass pea and also short or early maturing crops mainly maize, tef (*Egragrostis teff*), and sorghum disseminated to farmers. Despite these assertions by researchers availability of seed of such varieties to farmers in adequate amount is limited, and farmers during FGDs have bitterly expressed that they could not secure such types of seed in time of need and in most cases they resort to locally available varieties. The supply of crop varieties that thrive under stress condition is a wide spread problem in most drought prone areas; for example Satishkumar *et al*., 2013) reported that in some parts of India lack of drought tolerant varieties in the market has made farmers more prone to climate vulnerabilities. To alleviate the problem caused by increasing variability rate of rainfall pattern, drought and desertification in many countries, Hazell and Haddad (2001) advocated that agricultural research institutions should develop drought resistant and short duration high yielding crops through research and make them available in adequate amount to farmers.

Discussions with agricultural development agents revealed that seed provision is still a serious problem that is not yet adequately solved and preparations made to multiply and store in adequate quantities is unsatisfactory. The overall analysis in the seed system in general showed that the regional agricultural research centers have limited human power and financial resources to carry out substantial research on variety development and unless this critical gap is filled soon farmers endeavor to adapt to climate change challenges remains under question mark. Taking note of problems encountered in the Agricultural research system in Kenya, Speranza *et al*, (2009) stressed that agricultural research institutions have to strengthen the research extension farmers linkage to promote adaptive research and generate farmer friendly and low cost technologies. Similar efforts are being exerted in the Amhara region where this study was carried to use the research extension linkage as a plat form though the success is still insignificant.

7.3.5 Amhara Region Disaster Prevention and Preparedness Commission role on combating climate change

This is a governmental institute in charge of facilitating productive safety net programs to enable the rural and urban poor create asset and also it provides early warnings to avoid damages that could be inflicted by climate change and other calamities. Essentially the Agency provides early warning information to relevant stakeholders such as the Bureau of Agriculture, Bureau of water and the political leadership so that the government could make the necessary provisions to avert the repercussion of climate related and other hazards. Discussions with experts at the agency revealed that providing early warnings to the respective institutions is a day to day task and they claim that their services are reaching on time. However, differences in opinions were expressed among the staff on the quality of information and the degree to which the information is influencing decision makers to take instant measures.

7.3.6 The Bureau of Land Administration and Use and its role in managing climate change

This Bureau is in charge of administering rural land and it provides land holding certificates to ensure land tenure security of farmers and proper land management. In this regard the study indicated that the majority (95%) of the respondents were provided with land holding certificates and their land tenure security feeling increased (BoEPLAU, 2015). The Bureau is also mandated to develop land use plans to enhance effective use of land and agricultural productivity. The activities of this institution has an important bearing in efforts to counteract climate change issues as the impact is more severe in areas where the land use plans are lacking and the land is poorly managed and losing its fertility and natural vegetation cover.

Despite the clear stipulations on land holding certificates demanding farmers to operate on their land as per the land use plan approved by the land administration office, there is no any single land holder given a land use plan. Even a land use plan at micro watershed level that is recognized by the Kebele land administration office was not made available during discussion. In a region where land resources are at a premium failure to initiate an innovative participatory land use planning weakens the value of land certification and efforts to improve adaptation to climate change through agricultural productivity, and ultimately poverty reduction becomes a remote possibility. Hence, it is argued a local land use planning that is harmonized with the existing rural settlement should be conducted as stipulated in Article 13 of the Revised Rural Land Administration and Use proclamation No. 133/2006 of the Amhara National Regional State (Zikre Hig, 2006).

7.3.7 Analysis of Institutional integration for climate change management

Although there are a number of institutions having clear institutional mandates, duties and responsibilities to expedite development activities in the Amhara region. However, when it comes to activities related to climate change management there is no visible evidence showing defined integration of climate change adaptation activities and periodic monitoring and evaluation of tasks accomplished. Institutional integration among the stakeholders working on climate change issues was one of the severe drawbacks recognized by farm households and the experts themselves working in the different institutions.

For farmers to pursue effective adaptation strategies there are a number of inputs required from the different institutions including awareness creation on climate change, capacity building, provision of appropriate technologies, access to credit services and early warning system, market connectivity and enhancing social capital building among others (Gibson and Becker, 2000; Speranza *et al.*, 2009; Agrawal; 2008; Satishkumar *et al,* 2013; Hazell and Haddad, 2001). Measured by these standards what is observed on the ground is far below what is required to withstand drought or climate variability in the study region. In this regard Agrawal (2008) expressed his concerns on the need for improving institutional coordination as follows:

….Existing national plans for adaptation seem to have attended only in a limited fashion to the role of local institutions in designing, supporting, and implementing adaptation. However, if adaptation is inevitably local, there is a great need to involve local institutions more centrally in planning for and implementing adaptation policies and projects. At the very least, there must be far greater coordination between adaptation policies and measures adopted by institutions and decision makers at the national level, and their counterparts at the local level.

Likewise AgroClimate (2009) contended that effective preparation for the possible effects of climate change requires the engagement of resource managers, planners, public works officials, local managers, community development specialists, businesses, residents, and property owners. In the same vein Willems and Baumert (2003) expressing the need for a sufficient level of climate-specific capacity to get climate policy off the ground, they underlined the importance of having sufficient personnel dedicated to climate issues in the main organization responsible for climate, in other relevant agencies/ministries, in key research centres and in businesses and non-governmental organizations. They also noted the challenge to provide these diverse stakeholders with trusted, useful, science-based information so that they in turn can make informed decisions.

7.4 Conclusion

Efforts to contain the adverse effects of climate change and enable the affected community practice effective adaptation practices, require involvement of a multitude of stakeholders including meteorological offices, agricultural development offices, land administration offices, environmental protection offices, industrial development institutions, politicians, administrators, community based organizations, etc. As much of the task is to be done at the local level, promotion of coping and adaptation strategies demands coherence and synergy between adaptation program, and integration of institutional mandates helps to foster the activities. This endeavor indeed has to be complemented by the provision of adequate financial and technological resources and an overall capacity building at local level. The role played by most institutions to strengthen grass root level efforts is however found to be minimal.

Isolated efforts of organizations in change of climate change issues hardly contribute to effective adaptation mechanism and reduction of climate change impacts and environmental protection. Instead setting of clear mandates and responsibilities and integration of the mandates of these institutions facilitates better ecosystem development and stable climate and ultimately improvements in the livelihood of the local community. In sum adaptation practices to climate change largely depend for their success on specific institutional arrangements. Adaptation efforts without strong institutional arrangement are therefore likely to falter and ultimately fail to achieve intended objectives. The next chapter using highlights of fundamental issues in the literature review and findings in the proceeding chapters and issues expressed in this chapter provides a synthesis of scientific thoughts and then outlines conclusion and recommendations.

CHAPTER 8

SYNTHESIS OF MAJOR FINDINGS, CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

This dissertation dealt with analysis of small holder farmers' perception of climate change and adaptation strategies followed to avert vulnerability to climate change. The study tried to compose up-to-date thinking, arguments and concepts on climate change issues in the context of subsistence farmers in the Amhara region of Ethiopia. The whole process of the study attempted to clearly map out the socioeconomic conditions of the study subjects (farmers), their vulnerability to climate change, analysis of climatic data and perceptions on climate change, coping and adaptation strategies sought and institutional arrangements put in place to enhance climate change adaptation strategies. This chapter therefore attempts to integrate and synthesize the major findings, and then provides conclusion and recommendations and also proposes issues requiring further research.

It is axiomatic that climate change is essentially taken as a sustainable development issue. Key ecological systems and natural resources (e.g. land resources, water, wetlands and natural habitats), all of which are vital to sustainable development, are sensitive to changes in climate including the magnitude and rate of climate change as well as to changes in climate variability. Economic activities such as crop farming, livestock herding, energy production and water supply that depend on these natural resources are, therefore, sensitive to climate variations. Thus, climate change represents an additional stress on the natural resource base of Ethiopia which is already affected by increasing resource demands, unsustainable management practices and environmental degradation. These stresses will interact in different ways across the different regions but can be expected to reduce the ability of some environmental systems to provide, on a sustained basis, goods and services needed for successful economic and social development including adequate food and feed, good health, water and energy supplies, employment opportunities and social advancement (Epsilon International, 2011).

This study explored livelihood, wealth status, educational level, family size, landholding size and productivity, perception and adaptation strategies of climate change, farmers' access to infrastructure using the framework indicated in Chapter One, Figure 1.1 that depicted interactions between environmental systems, climate change and adaptation strategies. Taking note of this the synthesis of the findings, and concluding remarks and issues for policy discussion are indicated below.

8.1.1 Household variables and perception and adaptations to climate change

The analysis of farmers' perceptions of climate change indicated that most of the farmers in the study area recognized that that temperature is increasing and the level of precipitation is showing a declining and erratic trend. Rain fed agriculture is the primary source of livelihood for the large majority of sample households (Chapter Four, Section 4.2.4) and only very few farmers supplement their household income from off farm or non-farm activities. It was asserted that livelihood diversification is an important strategy to withstand climatic shocks (Lyimo and Kangalawe, 2010; Below *et al.,* 2010, Ellis, 2000). However, lack of access to non-farm and off-farm activities in the study areas seems to have constrained their capacity to lead better livelihoods and also has weakened coping and adaptive capacities of smallholder farmers in times of erratic rainfall that triggers crop failure and ill performance of livestock.

As indicated in Chapter Four, Section 4.2.4.2, livestock holding is small and particularly failure of many farmers to get engaged in rearing of small ruminants, poultry husbandry and bee keeping leads to raise questions on the efficiency of the agricultural extension service delivery. In a region where land holding is small and where farm land productivity is constrained by land degradation, failure to consider livelihood diversification aggravates the ill-effects of climatic shocks. From land use point of view, in almost all the study areas and the region at large, there is no ground, however; huge local community mobilization for soil and water conservation and tree planting is an annual event to counteract environmental degradation and as a mitigation measure to reduce the impacts of climatic variability. Mass mobilization without due consideration to identification of potential outputs from conservation activities cannot be expected to bring visible changes in the ecosystem and the community can hardly benefit from biomass production and improved surface and ground water availability.

FGD participant farmers', Key Informants' and Agricultural Experts' argument on the importance of maintaining the traditional ratios or a good combination of the forest/woodland cover, water bodies, wetlands, grazing land/pasture land and meadows as well as farm land seem to have been overlooked. Field observations in the study areas and the literature across the Amhara region showed that these land resources have become highly degraded and scarce (RCS, 1997). The problem largely stems from failure to give due consideration to the importance of applying innovative and local level participatory land use planning. Where land use planning is made an integral component of rural development strategy there is high potential for the local community to be more resilient in times of climatic shocks and other adverse incidents.

In Ethiopia, areas with altitudes 1500 masl are categorized as high lands and account about 37% of land area (FAO, 2012). These parts of the country are the source of water, crop production, animal feed, and are dwelling places for humans. They accommodate about 90% of the country's total population, over 95% its regularly cultivated crop lands, about two thirds of its livestock population (Deressa, 2006). High population growth in highlands areas is a common phenomenon and the mean family size of the surveyed farmers is 5.63 which is more than the national average, 4.65 (CSA, 2012). The high population growth seems to have negatively impacted the size of land holding of many of the farm households in the study areas as employment opportunities other than farming are limited. The diminishing farm land holding is counterproductive to efforts to adapt to climate change. Under such circumstances one of the most important options to produce adequate amount of grain is maximizing productivity per unit area. This again demands provision of improved technologies and credit services to buy improved agricultural inputs. The reality on the ground however indicates that the magnitude of improved agricultural inputs use is still at low level (MOA, 2012) and provision of moisture stress tolerant crop varieties and that of early maturing varieties is not yet well organized. This tends to make the efforts to improve rural livelihoods more challenging and elusive. In this regard it can be argued that improving ecosystem productivity has to be complemented by provision of appropriate technologies and financial services that could be accessed by millions as this will have a positive implication in efforts to tackle the challenges of climate change.

8.1.2 Effects of perceptions of climate change on adaptation strategies

Although there are some variations across gender and education level, the analysis of farmers' perceptions of climate change, as indicated above has shown most farmers good awareness on the trends of temperature and rainfall. The climatic trends perceived by farmers were corroborated by the outputs of the weather data analysis in the study districts (Chapter Five, Section 5.5.3.1). Despite this reality what farmers and the different institutions including the agricultural research have done to avert the effects of rising temperature and irregularities of the rainfall pattern is not yet clearly known. Traditionally farmers in the moisture stress and erratic rainfall areas (e.g Shebel Berenta district- Yeduha kebele) and those where the onset of the rainfall has become repeatedly late (e.g. Bahir Dar Zuria district-Yibab Kebele) have tried to use short maturing varieties and relatively moisture tolerant crops such as sorghum and millet. Despite these attempts the capacity of the research centers to develop crop varieties and the agricultural development office to facilitate the seed multiplication and dissemination have remained serious challenges across the study region and the country at large.

Some of the most important gaps that are discernible in the analysis of climatic patterns are absence of systematic analysis of the weather data across the years in defined agro-ecologies; the damages inflicted by the climatic variability and failure to package the specific coping and, adaptation strategies followed by farmers and recording of success stories. Indeed farmers indicated that to avert the problems associated with climatic shocks, they try to use different crop variety, changing and/or adjusting planting time, conserving available moisture, using ground water, practicing irrigation where water is accessible, planting fodder trees, etc., some of which are part of the local knowledge developed over the years. Likewise the copping mechanism were stated as seasonal migration to urban area, reducing daily food intake, selling assets, borrowing food from others and purchase of food on credit. These adaptation and coping strategies look attractive, and are repeatedly indicated in many studies dealing with coping strategies (Chapter VI). However; in view of the weak integration of all sectors in charge of handling climate change issues and the shear absence of strong social capital at community level (Pretty and Ward, 2001) it is unlikely that many of them could bring meaningful impact on the sustainable development of rural livelihoods. The views of Belachew and Zuberti (2015) also stressed the importance of understanding of community perception in designing policies and projects for effective adaptation strategies allowing local participation to cope with the impacts of climate change.

8.1.3 Educational Level of the surveyed farmers

Prevalence of literate community in the rural setting will indeed be an asset in efforts to promote adaptation to climate change and rural development in general. Better level of education in the rural community opens up better employment opportunity and pushes people to get engaged in non-farm activities leaving the subsistence agriculture (Maharjan and Chhetri, 2006). USAID (2006) also contended that education is one of the major demographic factors that influences behavior of individuals and hence their living conditions. Although literacy level in the study areas seems to have showed some improvement over the years, yet quite a large number of farmers are illiterate. Even those claiming to be literate apart from mere writing and or reading skills their literacy is not complemented by skill training. In this regard functional literacy which enables the farmer to have better understanding of his environment and farming practices is widely advocated in many circumstances (Ishaq *et al*., 2015; Aryeetey, *et al*., 2005)

8.1.4 Institutional support to climate change

Environmental rehabilitation and programs to promote adaptation to climate change require among other inputs availability of viable local institutions that could foster formation of strong social capital that enhances cohesion and integrity of the local community in addressing the all-pervading socioeconomic problems. Agrawal (2008) in his seminal article dealing with local institutions role in adaptation to climate change underlined that climate impacts affect the disadvantaged social segments more disproportionately, and that local institutions centrally influence how different social groups gain access to and are able to use assets and resources. Likewise Pretty and Hine (2001) argued improvements to social capital, including more and stronger social organizations at local level; new rules and norms for managing collective natural resources; and better connectedness to external policy institutions enhances development efforts at local level. The finding in this study however indicated that activities to foster institutional building at local level are minimal and this is reflected in the poor performance of many of the development interventions such as soil conservation, water harvesting, fodder development, etc. Even the social fabric and motivation to help each other seems bleak and it is likely that the resource poor farmers will be affected more in times of climatic shock.

8.1.5 Agricultural technologies and adaptation to climate change

Efforts to make agriculture or crop production resilient to climatic shocks requires the application of appropriate agronomic practices that could lead to improvements in soil fertility, moisture and soil conservation, selection of drought tolerant crop varieties and adjusting time of sowing. The farmers in the study area and across the region practice subsistence farming where agricultural technologies are quite primitive. To state it explicitly farmers use the age old traditional plow which is a sharply pointed steel that only digs the soil to a maximum of 20 cm depth and does not properly invert the soil and burry weeds and stubble (Astatke and Kelemu,1993). Over the millennia the land has been plowed using the same technology and scholars argue that there is a hard pan formation at shallow depth that hampers easy infiltration of rain water and the little capacity of the plow to bury the organic matter tends to reduce organic matter content of the soil. Increasing the thickness of the active zone of the soil helps to improve soil humus or organic matte decomposition and this is important for roots development and effective use of fertilizers by plants. To this effect agricultural mechanization research centers should appreciate the problem and take the initiative to modify the efficiency of the traditional plough and other farm implements in the context of climate change.

A crop production scheme designed to be climate resilient needs to have attributes such as use of improved crop varieties in terms of yield, tolerance to moisture stress, having short maturity period, resistance to disease and crop pests, etc. It also needs construction of water harvesting structures, application of techniques that help to reduce evapotranspiration, use of farm yard manure and compost to ameliorate the soil, planting of leguminous trees and shrubs, etc. Where irrigation facilities are available efficient crop water use needs to be put in place. When measured by these yardsticks much of the farming activities in the study kebeles are full of technical problems. Farmers however are making efforts to use their traditional knowledge mainly in crop variety selection, moisture conservation and adjusting time of sowing or use of catch crops when one type of crop fails. What are being observed in the study areas are fragmented adaptation activities that vary across wealth groups and ecological zones. As indicated in Chapter Seven, Section 7.3.1 the agricultural extension service in the study kebeles lacks many of the attributes of a well-organized and responsive agricultural extension service, hence; the possibility to consolidate the diverse climate change adaptation initiatives becomes debilitated. Much of the study area and the region's farm land at large is affected by soil acidity, soil ameliorations measures are still at an infant stage implying that a huge task is awaiting for technology generating institutions and the extension system. Even there are no site specific fertilizer recommendations developed by research centers. Currently it is a blanket recommendation that is being exercised and this will not bring increments in agricultural productivity. As identified in the study many farmers are reluctant to use chemical fertilizers fearing moisture stress due to incidences of erratic rain fall patterns, hence maintenance of soil moisture is essential to make efficient fertilizer use.

8.1.6 Livestock productivity

Although livestock is a major feature of the rural livelihood in all the study kebeles, the current livestock husbandry system is purely traditional and the livestock are not provided with adequate feed supply, veterinary services are poor, genetic improvement interventions are negligible. Efforts to promote modern livestock husbandry are limited, concentrate feed supplying enterprises for poultry or feed for dairy cows and beef animals production are in most places unavailable and even those that exit are of low scale and operate intermittently. The livestock subsector in general lacks strategic intervention (Aleme and Lemma, 2015) and if the current livestock husbandry system remains unimproved, the contribution of livestock to climate change adaptation will be insignificant.

8.1.7 Violation of the traditional ratios in the natural resource base

Land-use and land-cover changes are reported affecting local, regional, and global climate processes (Mahmood *et al.,* 2010). This study clearly indicated that the livelihood of smallholder farmers has become affected by climate variability and the overall incident across the country seems to have been aggravated by violation of the traditional land use land cover ratios that take in to account maintenance of appropriate proportion of the forest cover, grass land, arable land, wetlands, water bodies and other ecosystems. There are clear indications in the study area and elsewhere in the country that deforestation, absence of effective soil and water conservation, encroachment into wetlands, woodlands and grazing lands, etc are widespread and efforts to prepare watershed based land use planning and application of technologies that match the land use plan are rarely practiced. Today it is evident that adaptation to climate change demands proper use of land to maximize agricultural productivity and sustenance of the ecosystem. As it is observed in the study area, failure to consider a land use plan that integrates crop production with other land use types such as forestry, grazing and woodland management, preservation of wetlands and other water bodies will aggravate the impacts of climate change and disrupts agricultural adaptation efforts to climate change.

It is argued that land tenure can contribute to adaptation of technologies because farmers with secured land tenure tend to adopt new technologies more frequently than tenants (Lutz *et al*., 1994). Land ownership will also influence adoption if the innovation requires investments tied to land. In the study areas almost all rural land holders have land certification and farmers have developed sense of land tenure security. However, it seems that farmers are more aware of their land rights compared to their obligations that stipulate proper land management including soil conservation, water harvesting, and protection of woodland and grazing resources that all are vital ingredients for adaptation to climate change.

8.1.8 The challenges/determinants to adaptation to climate change in the study area

Adaptation to climate apart from other inputs requires access to adequate and fertile land holding by households. In the study areas however more than 50% of the smallholder farmers have less than one ha (Chapter IV section 4.2.4.4); and even those having small land holdings are complaining that the soil fertility is low and much of the land is operated under rain fed condition, with almost less than 2% practicing irrigation. The data gathered from FGDs and respondent households showed that there is a serious rural landlessness and many more young farmers are joining the category of landless every year.

Whereas livelihood diversification in rural areas could have given better opportunity to the landless and near landless to generate income, as it is indicated in Chapter IV, Section 4.2.4.3, involvement of the respondent households in off farm activities is minimal. Undeniably, this intervention is constrained by a number of institutional factors including credit provisions, failure to properly identify effective micro business plan, lack of technical support and in some cases poor linkage to markets. Under these circumstances it is unlikely that the coping and adaptation strategies can bring meaningful effects on the life of rural residents. To make the matter worse a substantial segment of the rural household is resource poor. Where farmers lack essential assets required for farming it is unlikely that adoption efforts to climate change could result in meaningful outcomes.

The prevalence of climatic variability and occurrence of drought makes it essential for farmers and development agencies to initiate strong adaptation and mitigation mechanisms. As observed in the study localities farmers have tried to avert the adverse effects of climate change and variability using different means related to soil conservation practices, manipulation of cropping practices, planting trees, water harvesting, use of irrigation, engage in off-farm activities, etc (Chapter VI). It was however noted that a number of factors related to lack of knowledge, lack of agricultural technologies and inputs, water scarcity, land scarcity, poverty or lack of credit or saving services, lack of information, forage and feed scarcity, and more importantly lack of adequate institutional support, lack of job opportunities, etc., were noted major barriers of adaptation. Similar findings were noted in a study carried out in the upper catchment Blue Nile in Ethiopia (Bewket *at al.,* 2013). In this study the Multi Nomal Logit Model result indicated that low education level, employment opportunity in off-farm activity, farm size, ownership of a pair of oxen, farmer to farmer extension service, access to credit, and access to information on climate change, declining rainfall, poor distribution of rainfall and high temperature significantly influence farmers adaptation to climate change. These variables signal the need for identifying key determinant issues and make discussions with farmers and development institutions so that development intervention packages and the required resources could be channeled. To further enhance coping and adaptation strategies Belachew and Zuberti (2015) noted the importance of understanding of community perception of climate change while designing policies and projects that are related to coping and adaptation strategies to climate change.

8.2 Conclusion

This study was conducted to assess the perception of farmers and other stakeholders on climate change, and also to investigate coping and adaptation strategies by farmers to climate change and looking into the efficiency of institution arrangements put in place to handle climate change issues. Farm households were characterized in terms of important variables such as demographic attributes, asset endowments, literacy level, access to credit services, access to irrigation water sources, livelihood activities, etc. Taking into consideration all the interacting factors observed in the study the following major conclusions are drawn.

Characterization of the respondent households in terms of asset endowments indicated that a substantial proportion of the local community is resource poor and their literacy level is low. Subsistence farming is a dominant economic feature and farmers' capacity to withstand incidence of drought for a reasonable period of time is limited. Unless the whole economic system is revamped with structural agricultural development policy and resources mobilization complemented by human capital development the fate of the rural poor to evade adverse climatic conditions is remarkably low.

Perception on climate variables was studied both from farmers and development institutions point of view and it was compared against the empirical findings from weather data gathered and analyzed from weather stations. The general scenario indicates that household and community level awareness on climate change is relatively high and experts of the different government institution also share similar views. Despite these findings there are no visible strategic and integrated actions taken by the development institutions and all relevant stakeholders to reduce the impact of climate change by enhancing adaptation mechanisms to climate change. This scenario is likely to negatively affect efforts to withstand climatic shocks and adaptation to climate change at household and community level.

Characterization of climatic variables indicating occurrence of climate change by respondent households indicated that farmers are aware of many of the changing variables albeit of varying degree (Chapter V). Accordingly rain fall amount and distribution, on set and cessation time of rain fall, rise in temperature, length of dry spell, failure of the short rainy season that is vital for grazing development and also for carrying out the first plowing of farm land, and frequency of drought, and decline of water bodies are perceived by the majority of farm households. There is however little effort made by farmers themselves and other stakeholder to capitalize on this awareness and look for more innovative technologies, including traditional ones. Failure to exploit the positive climate related values within farmers debilitates initiatives designed to avert climate shocks. The existence of some segments of the respondents associating environmental degradation and climate change as a natural phenomenon and also as an act of God has a damaging effect as it may pervade across the community if the problem gets worse. It is therefore argued that the prevailing awareness should not be eroded and must be complemented by activities on the ground to counteract the ill effects of climate change.

The erratic rain fall pattern, shortage of rain fall and late and early onset of rainfall are common incidents observed particularly in Shebel Berenta, Bahir Dar Zuria and Sinan districts. Many farmers, being resource poor have, faced food shortages during some months of the year; the flow of streams has become intermittent, grazing resources are deteriorated and the livestock performance is weakened. And, many farm households fall back to deforestation and charcoal making. All these incidents seem to have led to deterioration of the woodland resource bases and local conflicts on natural resource use have become recurrent problems. The very shocking incident observed in this study is that there seems no lessons learned from successive climatic variability and much of the development effort is business as usual. Under such circumstances it will be hardly possible to establish firm grip on developing effective and sustainable climatic adaptation interventions that could lead to long term solutions.

Climate change is an inevitable event that will recur in the years to come. What is now needed is to maintaining of a stable ecosystem that will enable the rural households to adapt to unforeseen circumstances. The adaptation strategies practiced by farmers are encouraging and if systematically studied and documented they can foster efforts to improve farmers' resilience. There is however a growing gap between technology demand and technology provision. Unless this discrepancy is narrowed or completely closed immediately, it is unlikely that sustainable adaptation strategies could be realized. Adaptation to alternative options is influenced by a number of household variables, asset endowments and access to other physical resources. Identification of technologies that are suited to changing climatic variables and effective understanding of variables influencing farmers' motivation to climate adaptation can foster government efforts to tackle the adaptive capacity problems in the agricultural sector.

It is true that in the study districts and the region at large there are a number of institutions in charge of handling the climate change issues. Lack of defined strategy to address the issue of climate change and absence of an integrated plan that is approved and owned by each stakeholder in the system is a common problem describing all the study areas. Much of the activity at the grass root level has a piece meal feature and there are no common platforms where issues are regularly discussed, gaps are identified and feedbacks provided for grass root level actors and the farmers. Under the current practice it is unlikely that isolated efforts will produce meaningful impact on efforts to curb climate change related problems.

8.3 Recommendation

The recommendations included here are presented as suggestions on how initiatives on climate change could be more effective and the various stakeholders involved in climate change in the region and the country at large should organize their role to increase the effectiveness and sustainability of climate change adaptation interventions. The recommendations are presented under general headings and many of the issues contained in the recommendation are interdisciplinary and most of them require further research.

Policy support and Institutional building for climate change

This study has highlighted that climate change is a potential danger that threatens the livelihood of the community particularly the poor. Hence, the capacity building for climate change adaptation and mitigation must focus primarily on land based resources particularly in the context of agriculture related activities, forestry and grass lands, hydrology and water resources, and human settlements. The Ministry of Agriculture and Forestry and Environmental Protection and the livestock sectors should prepare land use policy, norms, standards in consultation with relevant stakeholders to properly utilize and maintain the land resources.

The success on climate adaptation strategies largely depends on availability of strong and functional institutional arrangements characterized by high integration. Institutional and social factors also play a key role in shaping the extent to which rural households and communities are vulnerable to different environmental risks. The strategic plans that are crafted at federal level should be cascaded down to the grass toot level with clear mandate and accountability and provision of adequate financial resources. It is therefore recommended to identify the strength and gaps on how the different institutions are operating and how they are coordinating their activities. More importantly each stakeholder should be guided to discharge its mandate with utmost care and full accountability.

Livelihood diversification in the face of climate change

In all the study areas farmers complain that their landholding is not enough to produce adequate produce for their livelihoods. To make the matter worse there is a severe irregularity of rain fall patterns and a growing landlessness in all the study areas and across the region. In addition, there is a general inclination to depend largely on crop production as a major source of income by those having the land, and engagement of the landless in alternative employment opportunities such as off-farm activities is visibly low. Under such circumstances it is unlikely to establish a stable livelihood and climate change resilient economy. It is therefore recommended that strategies should be designed to promote livelihood diversification schemes and packages of the different options should be prepared carefully so that they could be attractive for stakeholders. Promotion of meaningful investment on the infrastructure development and strengthening of the service providing sectors both in rural and urban areas also gives employment opportunity for the landless and idle labour force and generate asset that helps to alleviate poverty and withstand the negative impacts of climate change.

Adaptation to climate change requires credit provisions that are easily accessible to the poor farmers. Use of credit indeed demands identification of viable business plan and close follow up and technical support. The current practice shows that credit facilities for livelihood diversification are limited; hence, efforts should be made by development institutions to make the credit provision easily accessible for farmers so that they can purchase productive technologies and also run small and micro enterprises.

Education plays pivotal role in enhancing societal development and also enhances efforts to promote livelihood diversification. Despite endeavors of the government to improve literacy across the country there are still quite large numbers of illiterate farm households in the study area. Even those labeled literate (including farmers and those attended formal education) lack skill based training. Hence, the regional and federal government should give due emphasis to adult education focusing on functional literacy and the formal education curriculum should be designed to address climate change as a cross cutting issue; and skill based trainings addressing the different agricultural activities and entrepreneurship issues must be incorporated in the curriculum.

Access to land holding and land use

In the highlands where this study was carried out land for agriculture is a scare resource and the chance to bring additional land under cultivation is minimal. In the study Kebeles quite a number of farm households have small plot of land commonly less than one ha. To make the matter worse the number of landless young people is increasing at an alarming rate and access to land has become a remote possibility. To help farmers satisfy their subsistence need and withstand any climatic shock one of the most important way-out is maximizing land productivity per unit area. To this effect the agricultural extension service must be structured to have adequate access to improved technologies and other physical resources. In addition policy options must be considered to thoroughly assess the land resources in the lowlands and design efficient land management system to enable the rural landless to have access to land so that they could lead a sustainable livelihood.

As land resources in the study area and elsewhere in the country are a premium, failure to initiate an innovative local level participatory land use planning weakens the value of land certification and efforts to improve adaptation to climate change. Hence, it is strongly recommended that a local level participatory land use planning that is well harmonized with the existing rural settlement pattern should be conducted as stipulated in the Regional State Rural Land Administration and Use proclamation.

In the highland areas, particularly in the study areas, perennial crops including forests should cover sufficiently large territories. Perennial tree crops including trees are important to temper the climatic and local ecological condition, to maintain the water balance in every catchment, to protect every soil against the destructive atmospheric phenomena (water and wind erosion, air temperature fluctuation), it is therefore suggested that perennial tree crops have to be a major feature of the agricultural and grazing landscape as they may help to reduce the negative impacts of climate change.

The agronomic gaps in rain-fed and irrigated agriculture

In both rain fed and irrigated agriculture there are a number of agronomic practices affecting crop productivity among which the following are worth mentioning:

- Poor soil preparation, i.e. the tillage operation which is the traditional plough does not go deep in to the soil and the active zone of the soil is not pulverized and the bulk density that is suitable for growing crops is not improved.
- Lack of site specific fertilizer recommendation
- Lack of seed and use of grain as a seed, improper crop and varietal selection, improper crop rotation cycle,
- Poor soil fertility management and absence of soil productivity index (removal of crop residue from farm lands and robbing of the organic matter due to lack of livestock feed and fuel wood shortage (i.e. violation of the law of returning).
- Absence of agro technology maps
- Poor irrigation scheduling and or failure to identify crop water requirements balance, etc.
- Limited or no use of moisture conserving techniques

These diverse agronomic gaps have to be fulfilled by improved technologies that are economically efficient, socially acceptable, environmentally sound and easily accessible. To this effect the agricultural research institutions have to be strengthened and the agricultural extension should be shaped to be responsive to farmers need and the prevailing climatic conditions. Most importantly preparation of soil productivity index and agro technology maps helps to guide proper land management that is vital for adaptation practices to climate change. In addition taking note of the increasing rate of erratic rainfall patterns, drought and desertification, drought resistant and short duration high yielding crops should be developed through research and efforts should be made to make the seed available to farmers.

In many of the study areas, there is recurrent poor distribution of rainfall and the need supplementary irrigation is high. To cope with the problem the government effort to enhance the ground water recharge system needs to continue more strengthened. Along with improvement of the traditional irrigation system, water harvesting techniques at farm level, construction of community ponds and where feasible developing artificial lakes must be promoted across the region and the country.

Shaping of livestock husbandry in the context of climate change

Livestock in the study area play vital role being a source of draught power, and cash income. The study has however reveled that many of the smallholder farmers in the first place do not have many livestock, and even those owning the productivity of their livestock is low and this is principally constrained by feed shortage. Grazing resources are highly degraded and attempts to produce hay and capacity to purchase fodder is limited. The livestock husbandry is completely traditional and efforts to provide supplementary feeds are limited. Whereas small ruminants are likely to thrive well under livestock feed stress and small land holdings, the overall picture shows that not many households are keeping small ruminants. The extension support on livestock is still weak. In the face of these challenges there is an urgent need to seriously assess livestock development activities that have been implemented in the context of climate change over the years and design strategies that enable farm households to manage their livestock in a very productive way so that they could adapt to the negative impacts of climate change.

Knowledge management on climate change

Efforts to promote adaptation to climate change require diverse local and introduced knowledge and skills. The literature shows that there is plenty of knowledge and skill across agro ecologies and community groups. It is vitally important to further investigate available indigenous knowledge and it should be used in conjunction with scientific knowledge. It is also essential to carry out research to identify success stories and failures encountered in the different agro ecologies of the country in the overall efforts to promote climate resilient economy at local, national and regional level. As the challenges induced by climate change require immediate response, identification of conditions that influence farmers' adaptation to climate change, promotion of awareness on climate change, packaging and dissemination of existing indigenous knowledge and best practices in climatic adaptation elsewhere should be taken as a prime task by all stakeholders, particularly by agricultural development agencies to enhance sustainable development.

In the study region and in Ethiopia at large problems related to climate change and drought are likely to be encountered in the foreseeable future. This scenario demands creating regional and national discussion forums to sensitize the general public and promote policy dialogue that will pave the avenue to shift from dependence on rain fed agriculture to irrigated agriculture that is complemented by effective natural resources development, management and use. The intentions to adapt to climate change challenges in Ethiopia in general call for designing a national drought and climate change management strategy based on comprehensive assessment of the experiences and empirical evidences within the country and elsewhere.

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Appendices

Appendix 3.1: Survey Questionnaire for Rural Households

This questionnaire is prepared to collect data for the research proposal entitled ‘’ Analysis of Smallholder Farmers’ Perceptions of Climate Change and Adaptation Strategies to Avert Vulnerability to Climate Change: The Case of Western Amhara Region, Ethiopia.’’ The questionnaire is designed to generate data that will be used for academic purpose only. Therefore, please feel free and share us your rational views.

Location

1. Name of Kebele ____
2. Name of Sub Kebele/gott ____
3.District______________________ Zone _______________ Region ______________________________
4. Agro-ecology: a) Upper Highland (from 2300-3200 meters above sea level (Dega)
b) Mid Highland (from 2300-3200 meters above sea level (Woina Dega)
5. Household No. ____
6. Wealth Status 1) Poor 2) medium 3) better-off/Rich
7. Date of interview ____________________

Part I: Demographic and socio-economic characteristics of the respondent household

1. Age of household head :_______________ 2. Sex of households head: 1. Male 2. Female
3. Marital status: 1). Married 2) Unmarried 3) Divorced 4) Widowed 4). Widower
4. Language: ______________________________
5. Religion: 1) Christian 2) Muslim 3) Others (specify) ____
6. How long have you lived in the Kebele? ------------- years
7. Total family size ? Female:……_Male ……. Total……….
8. Age group of family members:
   a. < 10 years of age: Male …………. Female ……..
   b. 10-14 years of age: Male ……….. Female ………
   c. 15-50 Years of age: Male ………… Female ……
   d. > 51 years of aage : Male …. ……...Female……..
9. Literacy level of the respondent 1. Illiterate 2. Only read and write 3. Formal education (grade ---)
10. Family members able to read and write: 1 Female……. 2. Male:…… 3. Total: ………
11. What are your occupation (list them in order of importance)

Type of occupation	Rank (1^{st}, 2^{nd}, 3^{rd}, etc
Agriculture	
Trader	
trader and agriculture	
wage labor	
wage labor and agriculture	
Other (specify)	

12. What are the major challenges/problems that you face in your crop production? Please indicate them in order of importance

Challenge	Rank (1^{st} , 2^{nd} , 3^{rd} etc.)
Moisture stress	
Lack of oxen	
Lack of labour	
Soil fertility,	
Insect pest	
Weed	
Lack of land	

13. Do any member of your family practice seasonal migration 1. Yes 2. No
14. If yes who is migrating from the family members 1. Father 2. Children

15. If yes for how long they migrate? 1. Less than three months 2. Up to six months
3. More than six months
16. What other skill do you have other than farming? 1. Weaving 2. Blacksmithing
3. Pottery 4. Wood work 5 .Other ………………………………………………….
17. How many local holidays do you observe in a month?.............. days .

PART II. Livestock Husbandry

1. How many heads of the following livestock do you have?

Livestock	Number	Livestock	Number
Cows		Sheep and goats	
Oxen and bulls		Equines	
Heifers		Honey bees	
Calf		Poultry	

2. What is the dominant grazing system you practice in your village? 1. Free grazing
2. Stall (cut and carry)
3. Do you have private grazing land? 1. Yes 2. No
4. If yes what is the area of the private grazing land? ……….. ha.
5. Do you use common wood land for grazing? 1.Yes 2. No
6. If yes what is the potential of these common woodlands as source of grazing? 1. Very high 2. Not so important
7. Serves only as resting place
8. Do you face grazing land shortage? 1. Yes 2. No
9. If yes during which season? 1. Dry season 2. Rainy season 3. Both
10. Do you want to keep more livestock in the future? 1. Yes 2. No
11. If yes reason/ If No reason: …………………………………………………………………

Part III: Land Holding and Crop Production

1. What is the size of your land holding? ……….. ha.
2. Do you cultivate all of your land holding 1. Yes 2. No ……….
3. If no how do you benefit from your land? 1. Share cropping 2. Rent it for money 3. Other ………………………………………………………………………………………………..
4. Do you feel that your land holding is adequate to produce enough for your subsistence?
1. Yes 2. No
5. If no how do you satisfy your land requirement? 1. Rent in land 2. Engage in off farm activities 3. Other ………………………………………………………………………….
6. Do you have land holding certificate? 1.Yes 2.No
7. Can you rent out your land for 10 or 20 years? 1 Yes 2. No (explain to your answer)
8. Do you feel that the land belongs to you and your family indefinitely? 1. Yes 2. No
9. If no who control ownership of land? ………………………………………………..
10. How sloppy is your farm land? 1. Plain 2. Medium 3. Very steep slope?
11. Have you constructed water harvesting structure on your land holding? 1. Yes 2. No
12. Have you constructed soil and water conservation structure on your land holdings?
1. Yes 2. No
13. Do you have a pair of oxen to plough you land? 1. Yes 2. No
14. If no how do you satisfy you need for plowing oxen? 1 Hire 2. Oxen for labour exchange 3. Oxen sharing
15. In which category do you classify your soil on basis of its fertility?
1. Low fertility 2. Medium fertile 3. Highly fertile
16. How productive is your land without fertilizer? 1. High 2. Medium 3. Low
17. 16. What type of agriculture do you practice? 1. Rain-fed 2. Irrigated 3. Mixed
18. Does your annual production cover the annual food need of your family? 1. Yes 2. No

19. How many quintals do you produce by crop type during good rainy season on average?

Crop Type	Yield /ha in qt	Crop Type	Yield/ha in qt
Teff		Maize	
Barley		Faba bean beans	
Wheat		Field Peas	
Sorghum		Millet	

20. If no how do you satisfy your food needs ? a. Purchase by selling livestock or other products
    b. Sell labour to generate income c. Practice petty trade
21. What are the major challenges/problems that you face in your crop production? Please indicate them in order of importance

Challenge	Rank (1st , 2nd , 3rd etc.)
Drought	
Erratic rainfall/uneven distribution of rainfall	
Lack of oxen	
Lack of labour	
Soil fertility,	
Soil erosion	
Insect pest	
Weed	
Land shortage/small land size	
Lack of improved seed	

PART IV: Land Use Land Cover Change Issues

1. Is there any change on the forest land/wood land area in your locality after the resettlement? 1. Yes 2. No 3. Have no idea.
2. If there is change in the area of woodland is it decreasing or increasing in size?
   1. Increasing 2. Decreasing 3. No change
3. Is the grazing land area cover in your locality changing in size? 1. Yes 2. No
4. If there is change in the area of grazing land is it decreasing or increasing in size?
   1. Increasing 2. Decreasing
5. If you answer that the woodland is decreasing what are the major reasons behind deforestation, please give the rank (1st, 2nd, 3rd, etc.) in its severity.

Reasons	Rank in order of severity (1st, 2nd, 3dr, etc)
-Expansion of farm land by illegal farmers	
- Cutting of trees for the purpose of contracting the house	
-Grazing encroachment	
-Other (Specify)	

6. Is there a land use plan in the Kebele? 1. Yes 2. No 3. No information.
7. If there is a land use plan, please give the details and how it was done? …………
   ……………………………………………………………………………………………….
8. What type of tree species are grown in your farm land or around the homestead or elsewhere in your locality list the major trees you are planted? (list them) ……………..
9. Do you grow trees? 1. Yes 2. No
10. If yes, how many trees have you grown? ………………………………………………….
11. List the major trees/shrub found in your locality………………………………………….
12. In your locality is there any indigenous tree that are extinct or becoming extinct because of deforestation a) Yes b) no

13. If yes list out the name of indigenous trees that are already extinct or being extinct in your locality: ………………………………………………………………………………………..

PART V. Institutional Factors

1. Do you get agricultural extension services in your area? 1. Yes 2. No
2. Do you have access to information media? 1.Yes 2. No.
3. If your answer is yes, which medium do you posses?
   1. Radio 2. TV 3. Newspaper 4. Extension agents e).Other …………………….
4. Do you have access to credit? 1. Yes 2. No.
5. Do you have market access nearby? 1.Yes 2. No
6. If your answer is yes, how far is it? ……….. km (approximately)
7. Are there roads that connect the Kebele you with nearby towns or cities? 1. Yes 2. No
8. Do you have health centers in your village? 1. Yes 2. No
9. Do you have education centers at your village? 1.Yes 2. No
10. Is there electric services in your village? 1. Yes 2. No
11. Do you have access and use improved production inputs and technologies?
    1. Yes 2. No

PART VI. Climate Change Perception Assessment

1. Is today's weather the same as the weather conditions that were 20 years from now?
   1. Yes 2. No
2. If No, what are the major indicators?

Climatic variable	Yes	No
Rainfall amount has increased		
Rainfall amount has decreased		
Rainfall amount is the same		
Early onset of rainfall		
Late onset of rainfall		
Early cessation of rainfall		
Poor distribution of rainfall		
Frequent high volume flood		
High temperature		
Strong wind		
Other		

3. How do you evaluate the trend of the climatic variables change over the last ten years?
   1.The change has become severe 2. . Slow change
   3. No visible difference has been observed 4. No change at all
4. What problems have you faced due to climatic variability?

Problems	YES	NO	Problems	YES	No
crop failure			Increases flood disaster		
Poor livestock productivity			Loss of income		
Loss of pasture land			increase deforestation)		
Loss of agricultural land			High intensity wind		
Severe soil erosion			Drying of vegetation		
Shortage of water			Drying of streams and rivers		

5. Which local indicators do you use to evaluate the temperature trend in the area? (Please support your choice with example).
   1. Prevalence of human and animal diseases that are not familiar to the area (malaria etc).
   2. Introduction of plant and animal species that were not popular in the area (goat in highland not common).
   3. Observation of physical structures and societal clothing styles (disappearance of ice cover in mountain peaks, frost damage become uncommon, drying up of rivers, streams, swampy areas ,lakes, dressing light cloths etc.
   4. Other specify ……………………………………………………………….

6. What do you say about the trend of rainfall over the last 20 years?
   1. Increased 2. Not changed 3. Decreased 4. Change in times of raining
   5. Increase in frequency of drought 6. I don't know 7. Other (specify)………..
7. Which local indicator do you use to evaluate today's rain fall pattern?
   a. Loss of some plant and animal species:...YES/NO
   b. Increased drought frequency: ……… ..YES/NO
   c. Rainfall comes early or lately:…… ……YES/NO
   d. Decline of soil productivity/fertility: ..….YES/NO
   e. Decline of agriculture yields: ……… …YES/NO
   f. Decrease available water: ,……………. ..YES/NO
   g. Other (specify)__..
8. Have you heard of the world "climate change" before? 1. Yes 2. No
9. If yes when……………………………………………………………………………
10. From which source you heard about climate change? (Multiple answers is possible)
    1.Television 2. Newspaper 3. Friends/families 4. Radio 5. School/college
    6. Government agencies/information
11. What do you think is the cause of climate change?
    1. Human actions 2. Natural process 3. Both human action and natural process
    4. Wrath of God 5. Don't know/I have no idea
12. Have you encountered any climate related disasters after 1965 ? 1. Yes 2. No
13. If your answer to question No. 11 is yes, please fill the cells of the table below.

    A. Year the incident happened: ………………………………………..………….
    B. Loss encountered in terms of crop, livestock, human lives: ……………………..
    C. Coping mechanisms applied: …………………………………………………..

(Key: 1. Climatic shock(s): a) flood b) drought c) erratic rainfall d) frost
e) pest &disease prevalence f) soil erosion g) heavy ice
h) crop logging (by wind or water), i) other (specify)
2. Coping mechanism: a): inter household transfers and loans, b) sell of household assets, c). insurance, d): begging, e): government assistance, f): reduced socialization for saving, g). Wage labor h) making local drink i)selling forest products j) Handicraft work, k). Petty trading, l)renting tools/animals, m) giving community service (food for work), n) redaction of consumption level, 0) migration in search of employment, p) mortgaging of land, q)food appeal/aid), r). Credit form merchants or money lenders ,s). other (specify)

14. Have you ever faced food scarcity to your family? a) Yes b) No
15. If your answer is yes, in which period of years was the problems were very serious?
    Rank up to 3 according to severity? (1=most severe 2= medium severe 3= less sever)

Period	Food security
1965-1980	
1980-1995	
1995-2010	

16. Have you ever faced water security to your livestock? 1. Yes 2. No
17. If your answer is yes, in which period of years was the problems were very serious?
    Rank 1 up to 3 according to severity? (1=most severe 2= medium severe 3= less sever)

Period	water security
1965-1980	
1980-1995	
1995-2010	

18. How far did you travel in search of water for your livestock?

Period	Distance travelled		
	< 2 kilometers	2-5 kilometers	Greater than 5km
1965-1980			
1980-1995			
1995-2010			

19. Which of the following options do you used to minimize the risk of feed security?
    a. Created good amount of animal feed during needed times: Yes/NO
    b. Increased water availability :…..…. Yes/NO
    c. Increased fish production: …… ….Yes/NO
    d. Enhanced food crops growth:………Yes/NO
    e. Open up new lands for farming:…. ..Yes/NO
    f. Introduction of good technology: …..Yes/NO
    g. Enhanced self-help arrangements:.. ..Yes/NO
    h. Other(specify) ……………………………………………………………………

20. Has climate change and variability created any good opportunities for you? 1. Yes 2. No
21. If Yes, Please support your answer with explanation:…………………………………..
……………………………………………………………………………………………
22. Do you practice soil and water conservation on your farm land? 1. Yes 2. No
    3. Don't know
23. Do you feel that such practices help you to reduce the negative impacts of climate change?
    1.Yes 2. No 3. Do not know

PART VII Assessment of Adaptation option to climate change and barriers faced

1. What adjustments in your farming have you made to the long-term shifts in the rainfall?
    a. Enhance traditional irrigation schemes:……………… YES/NO
    b. used drought resistant crop varieties: ………………... YES?NO
    c. used improved crop varieties: ……………………..…...YES/NO
    d. shifting from crop producing to planting vegetation:…YES/NO
    e. adopt crop rotation and mixed cropping:…………..……. YES/NO
    f. enhancing animal rearing practice : …………..……….YES/NO
    g. If there are others list them …………………………………………..……………………..……………

2. Do you think the adaptive mechanism(s) you employed for the temperature problem is the best and viable one in current and future climate change and variability? 1. Yes 2. No
3. Do you think the adaptation options listed in the Table are helpful to adapt to climate change bad effects?

Adaptation Option	Yes	No	Do not Know	Reason
1.Change crop variety				
2.Plant a different crop				
3. Diversify crops				
4. Shift planting dates				
5. Move to different sites				
6. Move to different sites				
7. Build a water harvesting scheme				
8. Implement soil conservation				
9.Plant trees for shading				
10.Change from crop to livestock Management				
11. Reduce number of livestock				
12. Change from livestock to crop				

13.Diversity from farming to non-farming Activities				
14. Lease your land				
15.Pray more or increase your ritual offerings to traditional rain makers				
16. Increase use of irrigation/groundwater/watering				
17. Other				

PART IX. Assessment of coping option to climate change and barriers faced

1. In time of crop failure what do most households do to generate income for the family?

Coping strategy	Yes	No	Reason
Migrate to urban area			
Reduce daily food intake			
Collect wild food			
Look for daily work			
Collect fuel wood for sale			
Sell assets: livestock, etc			
Borrow food from others			
Borrow money			
Purchase of food on credit			
Others			

2. What support do you get from the government and non government to complement your food needs in times of climate shocks?
   1) Direct food aid: YES/NO
   2) Provide cash: YES/NO
   3) Food for work: YES/NO
   4) Credit service: YES/NO
   5) If there are others, please list of them …………………………………..………………………….

Appendix 3.2 Guiding questions for Focus Group Discussion (FGD) (with selected farmers representing cross section of the community, women group, youth group, Kebele leaders)

Address (location) of the village: ……………………………………………………………………………..
Focus group size: ………………………………..…………………………………………………….
Focus group composition: Male headed households/Women headed households/Youth Group, Kebele Leaders

Checklist of questions

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?
2. How often is the occurrence of drought in the locality? And what are the probable causes?
3. Have you heard of "climate change"? If yes from which sources?
4. What are your traditional or local indicators to realize that there is e climate change?
5. How is the trend of the rainfall and the temperature during the past 20 to 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?
6. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?
7. Do farmers have sufficient knowledge about Adaptation options to climate change?

8. Are the crops you cultivate now the same as h the crops your father or forefather was growing? If no, reasons for changing the crops?
9. Are the animals you are raring no the same as the animals your father or forefather used to rare? If no, reasons for changing the animals?
10. What customary self-help arrangements are there to support each other in your villages during the times of climatic extremes?
11. What effect has climate change inflicted on the livelihood of the local people?
12. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
13. What effect has climate change inflicted on the livelihood of the local people?
14. Can you tell us the sowing time of common grown crops some twenty-thirty years back and what time of the year do you practice seed sowing in recent years?
15. What development interventions are carried out in the village to avert the impact of climate change? (afforetation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.
16. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?
17. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?
18. How do you evaluate the sustainability of development interventions promoted by government and non-government?
19. How do you evaluate the agricultural extension agents' role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?
20. How do you evaluate the value of tree planting to individual households' livelihood improvement and improving climate change?
21. What trainings are given to the community to reverse climatic shocks?
22. What agricultural technology and meteorological information/early warning are provided to farmers to avert climate shocks? If yes by whom?
23. Do farmers have strong organizational arrangement that could enhance local development and social cohesion? Please give your opinion.
24. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?
25. What should the government and the community do to avert the impact of climate change in the Kebele?

Appendix 3.3 Guiding question for Key Informants in the Study Kebeles

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?
2. How often is the occurrence of drought in the locality? And what are the probable causes?/How is the trend of the rainfall during the past 20 to 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?
3. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?.
4. Can you tell us the sowing time of common grown crops some twenty-thirty years back and what time of the year do you practice seed sowing in recent years?
5. What effect has climate change inflicted on the livelihood of the local people?
6. What development interventions are carried out in the village to avert the impact of climate change? (afforetation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.
7. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?
8. How do you evaluate the sustainability of development interventions promoted by government and non-government?
9. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?
10. How do you evaluate the agricultural extension agents' role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?
11. How do you evaluate the value of tree planting to individual households' livelihood improvement?

12. What agricultural technology and meteorology information system do you access regularly and during climatic extremes?
13. Do you receive early warning information on short term variations and/or long term climate change from any sources ?
14. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
15. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?
16. What should the government and the community do to avert the impact of climate change in the Kebele?

Appendix 3.4: Guiding questions for government institution staff (Agricultural Development Offices, Land Administration Offices, Meteorological Agency, Disaster Prevention and Preparedness Agency, Agricultural Research Institute)

1. What do you understand by the term climate change and climate variability?
2. What are the indictors of the occurrence of climate change?
3. How do you evaluate the climate situation in the district over the years?
4. What are the damages inflicted by climate change to the society?
5. Is climate change an important agenda for Agricultural Development Offices? If yes what are the development interventions introduced in the woreda (District or study kebeles)?
6. Are the development interventions appreciated and owned by the community? Are they sustainable?
7. Do you think that farmers are aware of climate change and variability in their localities? If yes how did they acquired the awareness?
8. What coping mechanisms do farmers use in times of drought in the woreda? Also what adaptation strategies do rural households to withstand the ill effects climate change?
9. What challenges do framers face to effectively implement coping and adaptation mechanisms?
10. What social capital has rural households to avert the dangers that arise as a result of climate change and variability?
11. How do you evaluate the impacts of climate change on rural household's livelihoods, water resources (rivers, streams, ponds), grazing lands, woodlands, farm lands.
12. Which segment of the local community more affected by climate variability/climate change?
13. Is there any local level organizational arrangement made that helps farmers to overcome the damages caused by climate change/climate variability?
14. How do you evaluate the role and strength of local level organization to sustain development interventions?
15. What assistance are they provided to make them empowered?
16. How integrated are government institutions working on activities that are deemed helpful to avert climate shocks?
17. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
18. Of the development interventions which ones are more important to reduce damages that could be causes by climate change/climate variability?
19. How does agricultural research in the region attempt to address the need for crop varieties tolerant to moisture stress and other supporting technologies to tackle climate change.
20. What are the challenges faced by the agricultural research and extension services to address climate change issues?
21. How do you evaluate the role of the Disaster prevention and preparedness office contribution to coping against climate change?
22. How does the Meteorology Agency contribute to efforts to withstand climate change and variability? Does the agency have strong institutional set up to provide adequate weather information?
23. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?

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