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Farmers' Perception onClimate Variability Its Impact and Adaptation Strategies: The Case of AnkobereWoreda, North Showa Zone, Amhara Region, Ethiopia

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Abinet W/Aregay

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This is to certify that the thesis prepared by Abinet W/Aregaye, entitled: Farmers perceptions on climate change, its impacts and adaptation strategies and submitted in partial fulfillment of the requirements for the Degree of Master of Arts (Geography and Environmental Studies, specialization: climate change adaptation) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee:

Advisor_____ Signature_____ Date_____

External Examiner _____ Signature_____ Date_____

Internal Examiner _____ Signature_____ Date_____

_____

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Acronyms

AFOLU	Agriculture, Forestry and Other Land Use
CDM	Clean Development mechanisms
CEEPA	Center for Environmental Economic Policy in Africa
ENMA	Ethiopia National Meteorological Agency
FAO	Food and Agricultural Organization
FGD	Focus group discussion
FEWSNET	Famine Early Warning System Network
GHG	Green House Gas
GDP	Gross Domestic Product
GTP	Growth the transformation plan
HH	House Hold
IPCC	International Panel on Climate Change
IFPRI	International Food Policy Research Institute
IIRR	International Institute of Rural Constriction
IPPU	Industrial Process and Product Use
KII	Key Informant Group
Masl	Meter Above sea Level
MOFED	Ministry of Finance and Economic Development
MEF	Ministry of Environment and Forest
NAPA	National Adaptation Program action
NMA	National Metrological Agency
UNCED	United Nation conference on Environment and development
UNDP	United Nations Development Program
UNFCCC	United Nations Frame Work Conventions on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
USAID	United States Agency for International Development
WMO	World Meteorological Organization

Abstract

All over the world Climate change is creating significant environmental, ecological, social and economic threats mainly to the farmers of the developing nations. Likely, in Ethiopia, climate change induced risks such as drought, flooding and hot temperature are rapidly increasing and causing adverse effects. Adequate level of farmer's perception about the cause, indicators and impacts of climate change and its adaptation measures to effectively cope climate change related impact is essential. Therefore, the main objective of this study was to assess farmers' perception and adaptation to climate change and variability strategies for adaptation in the future. In order to realize this objective, the study employed descriptive type, survey method Primary data were collected using questionnaire, interview, focused group discussion and observation. The study also used secondary data using literature and document review from secondary sources.The study was conducted based on the data generated from three kebeles. Namely, Ayrarakebele with 54 sample households, ZenboKebele with 60 sample households and LayeGorebel with 84 sample households. The sample kebeles was selected based on their agro ecological zones in order to represent the three main agro ecological zones. Accordingly, Ayrarakebele is fall under low altitude (Kola) Zenbokebele is fall under mid altitude (WoynaDega) and Lay Gorebel is found under the agro ecology zone of high altitude (Dega).The total sample size of the respondents were 198 households. As data shows, there is variation of temperature of the woreda in general and the sample kebele in particular showing that there is a variation of temperature by 0.48oC in the past three decades or thirty two years . Similarly, according to data gathered from Ethiopia National Meteorological Service Agency, there is variation of rainfall in the past three decades keeping that the existence of high variability. Besides, the warmest year observed in 2010 (13.73 ^{o}C) and the minimum or the coldest year observed in 1999 (12.22 ^{o}C). The results revealed that respondents' age, educational status, sex, family size, access to extension services, wealth (farm size, number of farming oxen, cattle, ruminant animals and pack animals), farming experience and significantly effect on farmers perception on climate change and adaptation. Climate change has a drastic impact on agricultural output, with total crop failure and livestock loss. To minimize the impacts of climate change and variability the farmers of the study area had use different local and introduced types of adaptation mechanisms, Like; early maturing crop varieties, water and soil conservation, rehabilitation of gullies and mountain were long term adaptation practices applied by farmers with the help of all concerned bodies.

Keywords: *Climate change/variability, Adaptation, Vulnerability,* Perception

CHAPTER ONE

Introduction

1.1. Background of the Study

In the recent years, the global climate has changed both due to natural factors and human activities (Dow & Downing, 2007). These changes in climates have resulted frequent and intense disasters such as flooding, droughts and storms within and over years. These changes have largely impacted on social, economic and environmental systems. (Fischer et al, 2002). Climate change is a long term change on average weather condition (FAO, 2008). It was in the late 1970's that climate change is recognized as a global environmental phenomenon (Abatzoglou*et al,* 2007). The changes in temperature, rainfall pattern and sea level of can affect socio-economic conditionsand natural present and future generations.

Climate variability and change present complex challenges to people's livelihoods inAfrica. Against an anticipated increase in the frequencies of extreme events such as floods and droughts under climate change, agriculture will suffer greatly (IPCC, 2007).

Climate change will have far-reaching consequences for agriculture that will disproportionately affect poor and marginalized groups who depend on agriculture for their livelihoods and have a lower capacity to adapt (World Bank, 2007).

Climate change is real and its first effects are already being felt. Climate change will compound existing poverty and is expected to have serious environmental, economic, andsocial impacts of Ethiopia particularly rural farmers, whose livelihood depend on the use of natural resources, are likely to bear the brunt of adverse impacts. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change (Glwadys, 2009).

Climate change is predicted to have major adverse consequences for the world's ecosystems and societies. The severity of the adverse effects of climate change will differ significantly across regions, countries and socioeconomic groups. Poor countries will suffer more, with the poorest countries are likely to suffer most Africa is highly vulnerable to the potential impacts of climate change and Ethiopia is often cited as one of the most vulnerable and with the least capacity to respond and adapt (Thornton *et al*., 2006).

Ethiopia already suffers from historical climate variability and extreme climatic events (Mesfin 1984, Pankhurst 1985, McCann 1987, IIRR 2007). In particular, frequent droughts coupled with environmental degradation and decline in food production are common and still remain major challenges to Ethiopia (NMA 2006,Senbeta et al, 2002, Senbeta 2006).

Droughts and floods are common phenomena in Ethiopia, occurring every 3 to 5 years (World Bank 2006). The country has experienced at least five major national droughts since the 1980s (World Bank 2006), along with dozens of local droughts (World Bank 2009). In particular, there is increased incidence of meteorological drought episodes, famines and climate-sensitive human and crop diseases in the northern highland and southern lowland regions of Ethiopia (World Bank 2009, Aklilu and Alebachew 2009, Oxfam International 2010, UN-ISDR 2011).

In many areas of Ethiopia, the frequency of droughts and floods has increased over the years, resulting in loss of lives and livelihoods (NMA, 2007, Oxfam International 2010). Climate change is expected to exacerbate the problem of rainfall variability, and associated drought and flood disasters (NMA,2006).Nowadays, different forms of environmental changes have transformed places or different topographies into rocky hills and deserts while other disappears under a flood (Barnett et al, 2010).

Climate change is real and its first effects are already being felt. Climate change will compound existing poverty and is expected to have serious environmental, economic, and social impacts of particularly in rural farmers of Ethiopia. This is because thelivelihood of the farmers are dependent on the use of natural resources for crop cultivation and animal rearing. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change, (Glwadys, 2009).

Hence, development of planned adaptation strategies to deal with these risks is regarded as a necessary complement for mitigation actions (Burton, 1996; Smith et al., 1996).Adaptation to climate change requires that farmers using traditional techniques of agricultural production firstnotice that the climate has altered. Farmers need to identify potentially useful adaptation strategy/methods and implement them.

"As communities around the world, face rapidly changing conditions driven in part by global environmental and societal changes there is an increasing need to understand why these

cumulative changes threaten human livelihoods in some cases and create opportunities for others, how communities cope with and in some cases adapt to these cumulative stresses, how public policies might reduce threats and enhance human security" (Brklacich et al, 2010).. Excessive demand and use of soil, water, rangelands, forests and wildlife result the degradation of these resources, and leads to the sharp decline of production and the quality of life for many Africans (Owen et al, 1990).

Many countries in tropical and subtropical parts of Africa are expected to be vulnerable to the impact of global climate change. Even without the impact of climate change water balance is dwindling, it makes the situation very harsh; therefore, water supply and water availability is a major problem for a number of countries in the region. The problem of sustainable water supply is a major challenge for African countries and climate change exacerbates an already existing problem of water supply in rural areas (Alemayehu, 2012). As a result countries face semi-arid and arid conditions that make agriculture very challenging (Dinar et al, 2008).

Ethiopia is one of the many countries to witness the impacts of climate change in Africa (Haakansson, 2009). According to (IFPRI,2007), "global climate change possess great risks to poor people whose livelihoods directly depend on agriculture, forestry and other natural resources "The World Bank (2012), states that Ethiopia is one of the different countries extremely vulnerable to drought and flooding, heavy rain, frost and heat weave disaster.

Therefore, a better understanding of the local dimensions of the climate change is important to develop appropriate adaptation measures and appropriate policies. Ankoberworeda in North showa zone, Amhara regional state, which is vulnerable to climate change is taken as a case study.

In this study area the impact of climate change has adverse impacts on crop production, animal rearing, health of the farmers and quality of natural resources. The existence of rising temperature and decline rain fall leads to reduce the agricultural production of the farmers. Therefore, the area is seriously affected by the climate change and weather variability. This paper asses the perception of local farmers about climate variability and adaptation strategies of the farmers against the impacts of climate variability taking AnkoberWoreda as a case study.

1.2. Statement of the Problem

Climate change is the major environmental challenges global societies. The poorest peoples of the developing countries suffer more than the others, though their contribution for the change of the climate is minimal. The economic activities of developing countries are mostly dependent on natural resources which are highly susceptible to climate change. As in other regions of the world, climatic and ecological changes caused by global warming have resulted in several adverse consequences on people's health, economy and livelihoods in Ethiopia (Eriksson, 2006).

Climate change sometimes resulted unexpected impacts and its effect varies with location, socio economic and environmental conditions. The capacity to adapt the impacts of climate change is unequal across and within societies. This fact implies that appropriate policies are relevant to strengthen the adaptation measures farmers at large and households in particular. According to (Maddison, 2007) there is a difference in the propensity of farmers living in different locations to adapt. The adaptation method differs within farmers and even within individuals. According to (Fussel, 2007) tailoring adaptation practices to specific society's farmers may make it possible to offset the adverse impact of climate change

Many study point to the increased frequency of metrological drought, unseasoned flood, human and livestock disease in many parts of rural Ethiopia. Recent drought event, flush flood anddisease ought break in the many part of Ethiopia are in sensitive conditions of how food and water scarcity and rural livelihood approach are still largely dependent on the climate system also vulnerable to its seasonal variability as well as long term change. A high dependence on natural resource and climate sensitive livelihood coupled with the existence of out of control poverty and natural variable weather pattern put Ethiopia in an extremely vulnerable position. It is expected that the country will come across impact of climate variability in the form of drought, floods, strong wind and heat waves, frost, pests with disease affecting livelihood and health of the people and the natural ecological system (NMA, 2007).

Current climate change is already impressive a large challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters (Abebe, 2007).

Repeated and extended droughts have maintained to lives millions of people contributed to the death of much life and destroyed crops. Currently; Ethiopia has supplied main concern forenvironment. The main environmental harms of the country are climate change, land degradation, soil erosion, deforestation, loss of biodiversity, desertification, repeated drought,flood and water also air pollution. Most part of Ethiopia is dry, sub-humid, semi-arid, and arid,there for it is lying on front of desertification and drought (NAPA, 2007).

Studies have shown that climate change has potential to have several negative impacts on human welfare, natural resources and development activities in the country. However, studies on farmers perception on climate change have been carried out both at macro and micro-levels, but, Temesgen (2009) impacts of climate change and adaptation options are location specific and policy for adaptation options should be area specific. As site specific issues require site specific knowledge, therefore, it is very important, to clearly understand what is happening at farmers level. Unless, the impacts of climate change are known and expressed at farmers level and understood the local people and established the right perception, it would be difficult to convince and motivate local farmers to undertake adaptation actions. To fill this gap, this research has been carried out with a focus on assessing the perceptions of local farmers, on impacts of climate change and adaptation strategies in AnkoberWereda, NorthShewazone,Amhara Regional State in Ethiopia.

1.3. Objectives of the Study

1.3.1. General Objectives of the Study

The general objective of the study to assess farmers' perception and adaptation mechanism to the impact of climate variability: Taking AnkobereWoreda, North showa zone, Amhara Regional State of Ethiopia as a case study.

1.3.2. Specific Objectives

The objectives of this research tried to:

1. Examine the trends of rainfall and temperature in the study area from 1986 G.C to 2016 G.c.
2. Understand local farmers' perception about the changes in rain fall and temperature.
3. Assess impacts of climate variability in the study area on eco system and society.

4. Identify the existing adaptation strategiesoflocal farmersto the climate variability in the study area.
5. Identify determinant factors of adaptation strategies of local farmers in the study area.

1.4. Research Questions

The study attempted to address the following research questions:

1. What has been the trend of Rainfall and Temperature in the study area?
2. How the local farmer's perceive the changes in temperature and rainfall trends?
3. What are the major impacts of climate change/variability in the study area?
4. What adaptation strategies have been adopted by different actors of the study area to cope up climate change/ variability?
5. What are the major socio-economic factors that have influenced adaptation strategies in to changing temperature and rainfall?

1.5. Scope of the Study

The scope of the study was limited to AnkoberWoreda, North Shewa Zone, Amhara Regional State of Ethiopia. To assess the level of farmers' perception towards climate change/variability, and adaptation strategies of the local Farmers and to assess some of the factorsthat determines farmers' perception towards climate change and variability and adaptation mechanisms are a number of factors that affect farmers' perception towards the climate change/variability and adaptation strategies. It constitutes the demographic, socio-economic, political, psychological, cultural experience, exposure to different sources of information. Despite the fact that, those factors are many in number they are interrelated and multiple. Determining factors such as age, sex, educational status and access to information will be taken into account for the sake of these studies. This is due to the assumption of shortage of time and budget constraints for further study of the rest of the factors.

1.6. Significance of the Study

This study was carried out for academic purpose and contribution to policy making.The findings shall contribute to deepen the knowledge of farmers' perception and attitudes on climate change/variability and adaptation mechanisms in general and the study area in particular.

Therefore, the outcomes of the study will be used in formulating future environmental policies and strategies at the local level. In addition, it will be used to identify the gap that can fill by material or by training which is required by people in the study area. Results from this study could also be used by other woreda'sin the region to improve the lives of their people and adaptation strategies.

1.7. Limitations of the Study

The study relied on three selected kebeles only, for practical reasons such as time and financial limitations, some farmers were not willing to fill questionnaires and participation in FGD.

1.8. Definitions of Climate Change and Variability Related Concepts

The following terminologies are constantly use in the analysis of this study;

Climate change: refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). USAID August (2007)

Climate variability: refers to variations in the mean state of climate on all temporal and spatial scales away from that of individual weather events. (IPCC, 200).

Vulnerability: is a function of exposure to climate situation, the degree to which a system is powerless to cope with adverse effect of climate change.(IPCC,200).

Sensitivity: is a degree to which a system is affected, either adversely or beneficially by climate related stimuli. **USAID August(2007)**

Resilience: resilience is the amount of change a system can undergo without changing state. (IPCC ,2001)

Adaptation: are actions taken to help communities and ecosystems moderate, cope with, or take advantage of actual or expected changes in climate conditions. Definitions are based on USAID August (2007).

Perceptionis: the process of accomplishing awareness or understanding of sensory information.**USAIDAugust (2007) warming;** is defined in the terms of a regular raise in the

average temperature of the earth's atmosphere and it's on the oceans, shifting the earth climate situation.

1.9. Organization of the Paper

The study was organized into five chapters. The first chapter deals about background of the study, the nature of the problem, objectives of the study, significance of the study, the scope of the study. Chapter two, deals with a review of the related literature. Chapter three explains the research design and methodological framework upon which the study has been conducted. Moreover, a detailed protocol addressing procedures, participant selection, data collection and analysis techniques as well as issues related to ethical considerations are discussed intensively. Chapter four dedicate to presentation, analysis and interpretation of the data. The last chapter consists of summary,conclusionsand recommendations of the study**.**

CHAPTER TWO

2. Review of Related Literature

A number of studies were conducted in different parts of the world regarding climate change and variability and its adaptation strategies, Climate induced hazards which have been affecting the lives and livelihood of many people across the world in general and developing country in particular. Previously studies are important for the researchers to conceptualize various methodologies used at different periods and different places and identify the existing research fill the gap.

2.1. Concept and Overview of Climate Change

Worldwide, climate change is the main challenge of the twenty-first century. Rising temperatures, changes in seasonality and amount of rainfall, rising sea levels and the associated physical impacts of climate change make threats and adversely affecting the human activities throughout the world. Poverty, poor infrastructure and lack of strong governance institutions, and too much reliance on primary sectors of production make Africa to be the most vulnerable continent. Is a change in the state of the climate that can be recognized by changes in the mean and/or the variability of its belongings and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007). Based on IPCC report, Africa is expected to face an increase of 5-8% of arid and semi-Arid landsas a result of climate change.

The Global warming refers to a regular raise in the average temperature of the. According to the scientists of the intergovernmental panel the average temperature of the earth has increase between 0.4 and 0.08^{o}c over the past 100 past years. In addition to that, the increased carbon dioxide and other greenhouse gases are resulted from land to the burning of fossil fuels, land clean-up, for agriculture and other human process are believed to be the primary sources of the global warming that has happened over the past 50 years (IPCC, 2007).

According to the IPCC fourth assessment report, Global warming is unequivocal, As it is now evidenced from observations of increases in the global average air and ocean temperatures, extensive melting of snow and ice, and rising the global average sea level due to the melting of the polar ice caps, an increasing in event and severity of storms and other severe weather events. (IPCC, 2007). On the other hand, the IPCC fourth assessment report stated that to the global average temperature has risen by 0.74^{o}c and the global sea level has increased by 17cm during the 20^{th} century, primarily due to melting of snow and ice from the high mountains and the Polar Regions (IPCC, 2007). The World Meteorological Organization (WMO, 2003) and intergovernmental panel on climate change IPCC (2007) states that the concentration of carbon dioxide has increased from 280 parts per million (PPM) in the preindustrial times (1750s) to 370 PPM at the contemporary period.This has lead the global climate change in to dangerous trend and it is expected that, with the present tendency, the concentration will range between 540 and 970 PPM and also the global temperature could be estimated top increase between 1.4 and 5.4^{o}c in the year 2100.

Similarly as part of the Global community Ethiopian is highly vulnerable to climate change. This is due to very high dependence on rain fed agriculture, which is very sensitive to climate change, the low health service provision, High population growth rate, the low economic development, the low adaptive capacity, deficient road infrastructure in drought prone areas and weak institutions (NMSA, 2007).

The Vulnerability assessment based on accessible information and rapid assessments approved under National Adaptation program of Action of Ethiopia (NAPA) has indicated that the main vulnerable sectors to climate change are agriculture, water resources and human health. Agriculture is the major key sector in the Ethiopian economy (Temesgen, 2007). Though, the productivity and competitiveness of this region is increasingly forced by temporal and spatial variability of climate change (NCCF, 2009). In addition to that, both droughts and floods are already common in Ethiopia. Climate change is expected to have adverse environmental, social and economic impacts in Ethiopia (NMSA, 2007).

Ethiopia has been affected by climate change and extremes. Such effects are Drought, food shortage and famines are the major part of Ethiopia's history which is caused by climatic and non-climatic related disasters. In addition to that, as the country is residing in very vulnerable part of the world for climate changes, which is wisely small events during the growing season, likely a lot or small amount of rain at the wrong times, this can bring disasters to the livelihood community (Alebachew et al., 2011). Also, The Climate Trend Analysis of Ethiopia which is built by US Geological Survey, USAID and the Famine Early Warning Systems raise out that there is a main reduction in rainfall and increases in temperature over the period from mid- 1970s to 2000s in various areas of the country (Keffyalew, 2011).

In addition to disparities in different parts of the country, the Ethiopian climate is also categorized by a history of climate extremes, such as drought and flood, and increasing and decreasing trends in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomenon in all over parts of Ethiopia.Although there was a long record of drought, (Lautze et al., 2003, NMS, 2007) in their studies show that the occurrence of drought has increased over the past few decades, mainly in the lowlands.

Some of Studies also indicate that mean temperature and precipitation have been changing over time. According to (NMSA ,2001), the average annual minimum temperature over the country has been growing by about 0.25oC in every 10 years, whereas the average annual maximum temperature has been increasing by about 0.1oC in every decade. The average annual rainfall of the country also showed a very high level of variability over the past years even if the trend continued more or less constant (NMS, 2007). Droughts in Ethiopia can shrink household farm production by up to 90 **%** of a normal year output (World Bank, 2006).

2.2. Implication ofGlobal Climate Change on ecosystems and societies

There is increasing evidence that the climate of the world is changing. It is probable that it will continue to change, where humans contribute to these changes. What turns this into a problem is that these changes affect the functioning of ecosystems and societies. Climate change is expected to cause serious difficulties for agriculture, especially in developing countries. According to the

Intergovernmental Panel on Climate Change's (IPCC, 2007), climate change can reduce rain-fed agricultural yields by as much as 50 percent. Global losses in gross domestic product (GDP) that ranges from 1 to 5 percent for a 4°C warming, and regional losses could be substantially higher. It is predicted that Africa is highly vulnerable to climate change since its economy largely relies on agriculture and uses low capital and inputs. Semi-arid and arid regions are expected highly affected, (Mendelson et al, 1994). It is well-established that both natural and human systems are vulnerable to climate change. Because, human systems have Owenlarger capacity to adapt than natural systems. Vulnerability depends on the type of change (e.g. temperature, rainfall, variability, occurrence of extremes), magnitude and rate of the change, exposure, and adaptive capacity. Future climatic changes will affect the level and extent of impacts. The main impact areas are public health, agriculture, food security, forests, water resources, coastal areas, biodiversity, human settlements, energy, industry and financial services (Mohan Munasinghe Rob Swart, 2005).

Furthermore, many believe that there is no need specifically to study adaptation, because it would be likely to happen anyway, without any significant costs, e.g. through natural selection or market forces (Kates, 2000). There was a lot of initial optimism that mitigation would be quite possible, probably based on the positive experiences with the internationally co-ordinated abatement of ozone-depleting substances and acidification. However, climate change appeared to be a much harder problem to address(R.A. Pielke,1998) also notes that even if climate change could be mitigated successfully, adaptation would still be very relevant, since many current developments increase vulnerability to climatic events (development of marginal lands and lands at risk to extreme events, increased dependence on highly technical interdependent systems, increased water and food demands).

"Most analysts in the less-developed countries believe that the urgent need, in the face of both climate variation and prospective climate change, is to identify policies which reduce recurrent vulnerability and increase resilience.

Prescriptions for reducing vulnerability span drought proofing the economy, stimulating economic diversification, adjusting land and water uses, providing social support for dependent populations, and providing financial instruments that spread the risk of adverse consequences for

individual to society and over longer periods. For the near term, development strategies should ensure that livelihoods are resilient to a wide range of perturbations (Rayner and Malone, 1998).

2.3. Global Responses to Climate Change

Climate change is now affecting every country in all continents. It is disrupting national economies and affecting lives, costing people, communities and countries exceedingly today and even more tomorrow. Peoples are experiencing the significant impacts of climate change, which include changing weather patterns, rising sea level, and more extreme weather events. The greenhouse gas emissions from human activities are driving climate change and continue to rise. Therefore Climate change requires an urgent international response. Governments, industries, communities and organizations across the globe are working together to develop and implement measures to reduce greenhouse gas (GHG) emissions and minimize impacts of climate change (office of climate change, 2010).

The United Nation Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at United Nations Conference on Environment and Development (UNCED) held in Rio D'Janeiro in 1992. The objective of the treaty was to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. As a framework treaty, the convention set no mandatory limits to GHG emissions for individual nations and contained no enforcement provisions. It is therefore considered non-binding. Rather, the agreement includes provisions for updates called "protocols" that would set mandatory emission limits. The principal update is the Kyoto protocol (Aklilu and Alebachew, 2009a). The Kyoto Protocol, adopted in December 1997, is an international agreement, which builds on the UNFCCC and sets legally binding targets for cutting GHG emissions of industrialized countries. Like the UNFCCC, the Kyoto Protocol aims to stabilize GHG emissions in the atmosphere.

The major distinction between the two documents is that while the convention encouraged developed countries to stabilize GHG emissions, the protocol commits them to do so. The protocol sets out emission reduction targets for developed countries because they have been responsible for the vast majority of the world's human-induced GHG emissions (office of climate change, 2010). The protocol was entered in to force on 16 February 2005. As of November 2009, 187 states have signed the protocol. The same literature adds that Copenhagen

Accord was forged at the 15th Conference of the Parties, held in Copenhagen in December 2009, towards a new agreement beyond the Kyoto Protocol. The accord is significant because it is the first global agreement on climate change, involving the major developed and developing countries. The United States and major developing economies, such as China, Brazil and India, played a key role for the first time.

UNFCCC and the Kyoto protocol have confronted numerous challenges to prosper their prime objectives of reducing emissions. For instance, despite the Kyoto protocol's ambitious goals, even countries that have shown to be its leading advocates, such as Japan, Canada, and the members of the European Union had not able to meet their targeted reductions of emissions. In addition, the Australian government still refuses to ratify this agreement and along with the United States of America remain the only Annex I countries of the United Nations Convention on climate change to not ratify the Protocol (CamWalker, 2006).

Climate change is one of the all-encompassing global environmental changes likely to have deleterious effects on natural and human systems, economies and infrastructure. The risks associated with it call for a broad spectrum of policy responses and strategies at the local, regional, national and global level. The UNFCCC (United Nations Framework Convention on climate change) highlights two fundamental response strategies: mitigation and adaptation. Adaptation means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. While mitigation is any strategy that can help to limit climate change by reducing the emissions of GHG and by enhancing 'sink' opportunities, adaptation aims to alleviate the adverse impacts through a wide range of system-specific actions (Fussel and Klein, 2002).

Although these two measures must be pursued to tackle the climate change problem and to create an effective and inclusive international climate change regime, mitigation has received greater attention than adaptation, both from a scientific and policy perspective. One plausible reason for this could be that climate change emerged as a problem related to the long term disturbance of the global geo-biochemical cycles and associated effects on the climate system (Cohen et al. 1998). Given the far-ranging adverse impacts of climate change, adaptation must be an integral component of an effective strategy to address climate change, along with mitigation. Adaptation and mitigation are intricately linked-the when we mitigate more, the less we have to adapt.

However, even if substantial efforts were undertaken to reduce further greenhouse gas emissions, some degree of climate change is unavoidable and will lead to adverse impacts, some of which are already being felt (GLCA, 2009).

2.4. Experienceof Climate Change in Ethiopia

According to IPCC (2014) the Fifth Assessment Report of Famine Early Warning Systems Network (FEWS NET) there has been an increase in seasonal mean temperature in many areas of Ethiopia. According to the UNDP climate change country profiles, the average annual temperature of Ethiopia increased by 1.3°C between 1960 and 2006 (McSweeney et al, 2010). The average number of 'hot' days and 'hot' nights per year are also increased from time to time. Based on, (McSweeney et al, 2010) expression, thereis no statistically significant trend in observed average rainfall in any season and also daily rainfall records are insufficient to identify current trends in daily rainfall. In addition that (NMA ,2007) report shows, Ethiopia experienced 10 wet years and 11 dry years over the last 55 years, indicating the strong inter annual variability.

Rainfall patterns are highly complex in Ethiopia: The seasonality, duration, and regularity of rainfall vary by both latitude and longitude (CGIAR, 2012). According to (Conway et al., 2004; IPCC, 2007b) studies indicated that since the 1970s, warming has occurred across many parts of Ethiopia, at a variable rate.

Increases in seasonal mean temperatures have been observed across Ethiopia over past 50 years, and the length of the growing season has reduced by ~15% in the region. For the past four decades, the average annual temperature in Ethiopia has been increasing by 0.37ºC every ten years, which is slightly lower than the average global temperature rising. During the second half of the 1990s temperature rise has been observed (EEA, 2008). And also temperature rise is more distinct in the Northern,North Eastern and Eastern drier and hot areas of the country.

The lowland areas are the most affected, as these areas are largely dry and exposed to flooding during extreme precipitation in the highlands. Extreme climatic and weather conditions have become increasingly common and costly in Ethiopia in the last few decades. The geographic coverage, intensity, and frequency of drought increased recently. Desertification in the lowlands of Ethiopia is also expanding due to the country's location in the Sahara desert

influence area. Over-flooding due to periodic and unprecedented over-precipitation in the Ethiopian highlands is damaging the human as well as physical capital of the lowlanders. The socio-economic and stability impacts of unprecedented flooding will continue in the future.

2.4.1. Causes of Vulnerability to Climate Change in Ethiopia

Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc (NAPA, 2007).

Vulnerability assessment based on existing information and rapid assessments carried out under NAPA has indicated that the most vulnerable sectors to climate variability and change are Agriculture, Water and Human health. In terms of livelihood approach smallholder rain-fed farmers pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are affected most by drought (NAPA, 2007).

Baseline climate was developed using historical data of temperature and precipitation from 1971–2000 for selected stations. The analysis provides the year-to-year variation of rainfall over the country expressed in terms of normalized rainfall anomaly averaged for 42 stations. The data shows that the country has experienced both dry and wet years over the last 55 years. The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country. Similarly, temperature variability and trend was analyzed (NAPA, 2007).

The year-to-year variation of annual minimum temperatures, expressed in terms of temperature differences from the mean and averaged over 40 stations, is provided. The result shows that the country has experienced both warm and cool years over the last 55 years. However, the recent years are the warmest, compared to the early years. The data reveals that there has been a warming trend in the annual minimum temperature over the past 55 years. Temperature has been increasing by about 0.37ºC every ten years. Another study made of Africa as a whole (Elasha et al., 2006) that analyzed the historical and current climatic conditions based on observed changes, reports that based on historical records a warming of approximately 0.7° Cover most of the continent during the 20th century is reported in the (IPCC, 2001). Observational records show

that this warming occurred at the rate of about 0.05°C per decade, with a slightly larger warming in the June–November seasons than in December–May.

Considerable attention has been devoted to the characteristics of systems (communities or regions) that influence their propensity or ability to adapt (as part of impact and vulnerability assessment) and/or their priority for adaptation measures (as a basis for policy development). These characteristics have been called determinants of adaptation. Generic concepts such as sensitivity, vulnerability, susceptibility, coping range, critical levels, adaptive capacity, stability, robustness, resilience, and flexibility have been used to differentiate systems according to their likelihood, need, or ability for adaptation (Sprengers et al., 1994; De Ruig, 1997; Klein and Tol, 1997; Smithers and Smit, 1997; Adger and Kelly, 1999). These characteristics influence (promote, inhibit, stimulate, dampen, or exaggerate) the occurrence and nature of adaptations and thereby circumscribe the vulnerability of systems and their residual impacts. In some literatures, these characteristics are reflected in socially constructed or endogenous risks (Blaikie et al., 1994; Hewitt, 1997). Together (in whole or part), they represent the adaptive capacity of a system.

2.4.2 Causes of Climate Change /Variability in Ethiopia

Change in the intensity of sunlight reaching the earth cause cycles of warming and cooling that have been a regular feature of the Earth's climatic history. But, the main and direct cause of greenhouse gas (GHG) emissions is carbon dioxide (70%), primarily from burning of fossil fuel (petroleum) imported other countries, while the other sources of GHG are methane and nitrous oxide caused by deforestation and agricultural activities, particularly the use of pesticides. Ethiopia's share to global GHG emission is very minimal. However, emissions from agriculture and energy sectors doubled since 1994. A MOFED, 2010 report indicates that, these two sectors are the major emitters in Ethiopia which accounting for 85% and 15% of the total gas emission respectively. This reflects the fact that livestock farming goes together with high methane emissions. The dominant position of livestock farming in Ethiopia's economy also influences the relative contribution of GHG to the total emissions. These are dominated by methane emissions, which account for 80% of the warming potential. Climate scientists now reach an agreement that the human caused pollution mainly from fossil fuels, has added considerably to global warming in the past 50 years (Stern, 2006).

Generally, there were increasing trends of greenhouse gas emissions in Ethiopia in a period of 1990-1995. The relative comparisons of increase indicated that CO2 has increased by 24% while emission of CH4 and N2O increased by 1% and 19% respectively. Aggregate greenhouse gases emissions in terms of CO2- equivalents have increased by 12 % (NMSA, 2001). Ethiopia's GHG emissions are closely linked to basic needs of the population; food production (through livestock farming) and heating. Therefore, the future GHG emissions will likely increase with the projected increase in population.

2.5. Impacts of Climate Change

2.5.1 Drought

Drought is a phenomenon of climate. It occurs almost everywhere but it's features are different between regions. Drought means scarcity of water which adversely affects various sectors of human society (Panu and Sharma, 2002). In general, drought is defined as a temporary reduction in moisture availability significantly below the normal for a specified period (Ramamasyet al., 2007). The deficiency of precipitation over an extended period time, usually a season or more is also called drought. Therefore, drought is considered as unbalance between precipitation and evapo-transpiration in a particular area in a period. It is also related to the timing, as delays in the start of the rainy season and the effectiveness of the rains, such as precipitation intensity or number of precipitation events. According to technical aspects, drought is the decrease of water availability, which might qualify when precipitation falls below about 80% of the average availability of the preceding 30 years.

2.5.2 Flooding Damage

One of the severe impacts of climate change is flooding damage and recently, the city administration experienced fluctuations with the amount of rain both in small and big rainy seasons. Sometimes very heavy and unexpected rain followed by flood hits the cities

2.5.3 Degradation of Land

Soil erosion means that the upper layer of fertile soil is removed, either by wind, rainwater, or human hands (Karup, 1991), while soil degradation means that the soil is exhausted and no

longer fertile or productive. Soil erosion is a major problem in many parts of the world, and climate changes are likely to exacerbate the problem (Boardman and Favis-Mortlock, 2000).

In addition to the difficult topography of the city administration, traditional system of land use, the absence of rain and shifting cultivation lead the land to lose its quality and to be degraded. According to the respondents and interviews the main reason for the severe impact of climate change in the Addis Ababa City Administration could be, rapid growing number of population, deforestation, over grazing of pasture land and topography of the area exposed the land to be eroded.

2.5.4 Impacts and Adaptation by Sectors and Systems

Natural and human systems are exposed to variations in climate. These include changes in average range and variability of temperature and precipitation as well as the frequency and severity of weather events.

2.5.5 Impacts of Climate Change onAgriculture

The impact of climate change on agriculture is expected to result in small changes in global income, with positive changes in more developed regions and smaller or negative changes in developing regions (Antle, 1996). Increases in mean annual temperature of 2.5◦C would increase world food prices due to the inadequate supply of food to meet demand (Antle, 1996).

2.6. Community's Perception of Climate Changein Ethiopia

As (Ban and Hawkins, 2000) define perception, it is the process by which people receive information or stimuli from our environment and transform it into psychological awareness. Peoples in any community have their own knowledge about their surrounding environment. They perceive there is an increase in temperature and decrease in precipitation but their perception about climate change not evidenced from weather monitoring stations (Maddison, 2006). In most parts of Ethiopia, people perceive declining in rainfall and increased in frequency of drought but it did not confirmed from weather station.

Research report from (Oxfam, 2010) indicated that observations on metrological stations lack congruence with local farmers' perception. This lack of congruence could be due to the fact that farmers' assess rainfall in relation to the needs of particular crops at particular times; small

changes in quality, onset, and cessation of rain over days or even hours can make a big difference, whereas meteorological data is more likely to measure totals and larger events. (Maddison ,2006) also argued that this lack of congruence between farmers' perception and meteorological records could emanate from the analysis of short term climate data and/or due to averaging of record from wider areas.

Perception level towards climate change is differ by sex, education level, age and farming experience, agro ecology and many other factors. According to Norris and Bati ,1987 and Maddison ,2006, educated persons are assumed to be more perceived than uneducated because education is associated with access to information on climate change, improved technologies and consequences on productivity. Asfaw and Admassie, 2004 also argued that female-headed households are often considered to be less likely to get information about new technologies and take risky businesses than male-headed households. Similarly, M. L. Amadouet.al ,2015 argued that, the more experience farmers have, the more likely they are to claim that temperatures have increased and the less likely they are to claim there has been no change. (Deressa et al., 2008) indicated that farmers living in lowland areas are hypothesized to be more likely to have perceived climate change than the midlands and highlands.Because lowland areas are already hotter and a marginal change in temperature can be perceived more easily.

The degree of farmers' perception on climate change also depends on its impact on farmers' livelihood, their social, institutional and economic background. Maddison, 2006 concluded that most farmers in Africa perceive increased temperature and declined precipitation. Lema and Majule, 2009 confirms similar situation in Tanzania. Temesgen et al., 2008 also indicates that majority of contacted farmers in Ethiopia are aware of climate change and perceives an increase in temperature and decrease in precipitation.

Local farmers' perception about their environment is critical because their perception fundamentally determine socioeconomic activities that can eradicate climate change in their locality.

Effective mitigating and adapting to climate change require changes in the behavior of billions of human being, who each day make individual choices that collectively have enormous impact on the Earth's climate (Brechin, 2003: cited in Adane, 2009). Local people have the knowledge and experiences about how to cope with climatic variability and extreme climatic events through

their past experience. Local coping strategies are very important elements for adaptation planning. Traditional knowledge can also help to provide appropriate, efficient and time tested methods of advising and enabling the adaptation in communities. According to UNFCCC, 2007, farmers have used many traditional techniques in order to adapt climate variability. Some of the techniques are used intercropping, mixed-cropping, agro–forestry and development of new variety of seed to cope with local climate. Furthermore, this result indicated that age of the household head, wealth and information on climate change positively influence farmers' Perception of changes in climatic attributes.

2.7. Adaptation

Numerous reasons have been given for pursuing planned adaptations at this time. Public adaptation initiatives are regarded not as a substitute for reducing GHG emissions but as a necessary strategy to manage the impacts of climate change (Burton, 1996; Pielke, 1998). Adaptation can yield benefits regardless of the uncertainty and nature of climate change (Ali, 1999). According Burton, (1996), there are six reasons to adapt to climate change now (Burton, 1996). Accordingly, Climate change cannot be totally avoided, Anticipatory and precautionary adaptation is more effective and less costly than forced, last-minute, emergency adaptation or retrofitting, Climate change may be more rapid and more pronounced than current estimates suggest. Unexpected events are possible, immediate benefits can be gained from better adaptation to climate variability and extreme atmospheric events, immediate benefits also can be gained by removing maladaptive policies and practices and climate change brings opportunities as well as threats. Future benefits can result from climate change.

Klein and Tol ,1997 also identified five generic objectives of adaptation: these are increasing robustness of infrastructural designs and long-term investments for example, by extending the range of temperature or precipitation a system can withstand without failure and changing the tolerance of loss or failure (e.g., by increasing economic reserves or by insurance), increasing the

flexibility of vulnerable managed systems— for example, by allowing mid-term adjustments (including change of activities or location) and reducing economic lifetimes (including increasing depreciation), enhancing the adaptability of vulnerable natural systems— for example, by reducing other (non-climatic) stresses and removing barriers to migration (including

establishing eco-corridors), reversing trends that increase vulnerability (also termed "mal adaptation") for example, by introducing setbacks for development in vulnerable areas such as floodplains and coastal zones and improving societal awareness and preparedness—for example, by informing the public of the risks and possible consequences of climate change and setting up early-warning systems.

2.7.1. Global Environmental Adaptation Issuesto global warming and climate change

Climate change adaptation is a response to global warming and climate change, that seeks to reduce the vulnerability of social and biological systems to relatively sudden change and thus offset the effects of global warming. Even if emissions are stabilized relatively soon, global warming and its effects should last many years, and adaptation would be necessary to the resulting changes in climate. Adaptation is especially important in developing countries since those countries are predicted to bear the brunt of the effects of global warming. That is, the capacity and potential for humans to adapt (called adaptive capacity) is unevenly distributed across different regions and populations, and developing countries generally have less capacity to adapt (Schneider et al., 2008).

Furthermore, the degree of adaptation correlates to the situational focus on environmental issues. Therefore, adaptation requires the situational assessment of sensitivity and vulnerability to environmental impacts.

Adaptive capacity is closely linked to social and economic development (IPCC, 2007). The economic costs of adaptation to climate change are likely to cost billions of dollars annually for the next several decades, though the amount of money needed is unknown. Donor countries promised an annual $100 billion by 2020 through the Green Climate Fund for developing countries to adapt to climate change.

2.8. Climate Adaptation in Ethiopia

Vulnerability to climate change in Ethiopia is highly related to poverty (loss of copying or adaptive capacity) in most of the regions, (Temesgen et al., 2008). Adaptive capacity (loss of copying/livelihood response) and vulnerability are important concepts for understanding adaptation; vulnerability can be seen as the context in which adaptation takes place. Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, in order to reduce adverse impacts and take advantage of new opportunities, (IPCC,

2007d). Those societies that can respond to change quickly and successfully have a high adaptive capacity (Smit and Wandel 2006).The social drivers of adaptive capacity are varied but may include broad structures such as economic and political processes, as well as processes which operate at a very local scale, such as access to decision-making and the structure of social networks and relationships within a community (Smit and Wandel, 2006). Adaptive capacity at a local scale is constrained by larger scale processes. For example a farmer's adaptive capacity will not only depend on access to resources (both physical and social) within the community which allow a crop to be grown successfully, but also the effect of macro-scale economic processes on the price received for the crop (Adger et al., 2005).

In Ethiopia, projections show that without adaptation, GDP is likely to fall between 2 and 10 percent by 2045, relative to the baseline growth. Climate projections show that both severe flooding and droughts will become more frequent. Agriculture, which accounts for 47 percent of Ethiopian GDP, is sensitive to these variations. Climate change will make growth rates more variable, particularly affecting the poor. The impact also varies across regions. In particular, the cereal-based highland zone will experience losses in yields, (EACC Synthesis Report, 2010).

According to FAO,2008, of all the climatic factors, the daily and inter-annual variations in precipitation are most crucial for rain-fed and runoff for irrigated production. In both rain-fed and irrigated systems, the spatial and temporal variation of precipitation is the key. The day-to-day variability of rainfall associated with weather is the major risk factor for most forms of agriculture. Soil moisture deficits, crop damages and crop diseases are all driven by rainfall and associated humidity. The variability in rainfall intensity and duration makes the performance of agricultural systems in relation to long-term climate trends very difficult to anticipate.

Ethiopia is historically prone to extreme weather events. Rainfall in Ethiopia is highly erratic, and most rain falls intensively, often as convective storms, with very high rainfall intensity and extreme spatial and temporal variability. Since the early 1980s, the country has suffered seven major droughts, five of which led to famines in addition to dozens of local droughts (Diao and Pratt, 2007). Survey data show that between 1999 and 2004 more than half of all households in the country experienced at least one major drought shock (UNDP, 2007). Major floods occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996, and 2006 (ICPAC, 2007).

Impact and vulnerability assessments in priority sectors were undertaken as part of the process of developing the Initial National Communications of Ethiopia to the UNFCCC. The (NAPA, 2007) document provided analysis of rainfall variability and trend. Baseline climate was developed using historical data of temperature and precipitation from 1971–2000 for selected stations. The analysis provides the year-to-year variation of rainfall over the country expressed in terms of normalized rainfall anomaly averaged for 42 stations. The data shows that the country has experienced both dry and wet years over the last 55 years. The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country. Similarly, temperature variability and trend was analyzed (NAPA, 2007). The year-to-year variation of annual minimum temperatures, expressed in terms of temperature differences from the mean and averaged over 40 stations, is provided. The result shows that the country has experienced both warm and cool years over the last 55 years. However, the recent years are the warmest, compared to the early years.

The data reveals that there has been a warming trend in the annual minimum temperature over the past 55 years. Temperature has been increasing by about 0.37ºC every ten years. Another study made of Africa as a whole (Elasha et al., 2006) that analyzed the historical and current climatic conditions based on observed changes, reports that based on historical records a warming of approximately 0.7°Cover most of the continent during the 20th century is reported in the (IPCC, 2001). Observational records show that this warming occurred at the rate of about 0.05°C per decade, with a slightly larger warming in the June– November seasons than in December–May. Scenarios performed for desert areas show great variation across Africa for the period 2071–2100 relative to the period 1961–1990 (IPCC, 2001).

Other regional predictions for changes in temperature and rainfall suggest the following likely effects over the next 30 years (2010–2039): i) a decrease in rainfall of 10–25 percent over the northern parts of Africa; and ii) an increase in rainfall of 10–35 percent in the western part of the continent during normally dry months. On the other hand, East Africa has displayed a stable rainfall regime. For instance, the drier areas of eastern and South Eastern Ethiopia are shown to exhibit a change in mean precipitation of 0–0.25 mm/day However some studies have indicated that, these general trends may include hidden variations within the regions, and some countries,

for example in southern Africa, may be drier in general terms, while some countries of the region may become wetter than the average.

Drought and famine, flood, malaria, land degradation, livestock disease, insect pests, and earthquakes have been the main sources of risk and vulnerability in most parts of Ethiopia. Recurrent droughts, famines, and recently floods are the main problems that affect millions of people in the country. Climate hazards, mainly droughts, have caused instability in national economic performance and have hampered poverty reduction efforts (EACC, 2010).

While the causes of most disasters are climate-related, the deterioration of the natural environment due to unchecked human activities and poverty has further exacerbated the situation (ENMA, 2007). For example the impacts of past droughts such as those in 1972/73, 1984, and 2002/03 are still fresh in the memories of many Ethiopians.

Other extreme events, like the floods in 2006, caused substantial loss of human life and property in many parts of the country. These challenges are likely to be exacerbated by anthropogenic climate change.

Cholera, associated with both floods and droughts, may increase with climate change. Increased temperatures could increase the levels of cholera bacteria in tropical seas and lakes. Changes in rainfall will affect the transmission potential and the presence (absence) of vector- and water-borne pathogens (IPCC, 2001). Studies show that increased flooding could facilitate the breeding of malaria carriers in formerly arid areas. Small geographical changes in the distribution of malaria may expose large numbers of people to infection, e.g. densely populated East African highlands (Elasha, et al., 2006). Historical and current distribution of malaria assessed by Elasha et al., 2006) shows that by 1870 malaria was prevalent in the western half of Ethiopia but by the year 2000 had expanded to the entire eastern half.

The recent IPCC Fourth Assessment Report indicates that climate change will have significant impact on crop production and water management systems in the coming decades. In addition, there is the potential for earlier negative surprises linked to increased frequency of extreme events (Tubiello, et al., 2007). The strong trends in climate change that are already evident, the likelihood of further changes and the increasing magnitude of potential climate impacts

particularly in the mid-latitudes and tropical regions (but globally also) gives additional urgency to address agricultural adaptation more coherently (IPCC, 2007).

It is generally acknowledged that communities deal with extreme weather events such as floods and droughts over varying periods of time. In this context, adaptation to both long term mean and inter-annual variability in climate is often seen as a complex phenomenon and process (Smit et al., 2004). Adaptation is widely defined as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities (IPCC, 2001).

In Ethiopia, it is assumed that the temperature has been increasing annually at the rate of 0.2°C over the past five decades. Moreover, it has led to a decline in biodiversity, shortage of food and increases in human and livestock health problems, rural-urban migration and dependency on external support. Factors compounding the impact of climate change in Ethiopia are rapid population growth, land degradation, widespread poverty, dependency on rain fed agriculture, lack of awareness by policy and decision-makers about climate change and lack of appropriate policies and legislation (ENMA, 2007).

2.9. Ethiopia Government Policy on Climate Change

Ethiopia is not obliged under the Climate Change Convention to reduce its greenhouse gas (GHG) emissions. Ethiopia's contribution (143 Mt CO2 e p.a.) to the total global GHG emissions is marginal, representing less than 0.3 percent of total global emissions (34.5 billion tones CO2) in 2012. Of the 143 Mt CO2 e in 2013, about 79% of GHG emissions came from the Agriculture, Forestry and Other Land Use (AFOLU) where agriculture produces 55%; (Cropland 26%, livestock 23%, direct and indirect emissions from managed soils and manicure managements aggregated to 6%), grassland produces 14% and forestry removed (30%). The energy and waste contribute 15% and 5% respectively and the Industrial Process and Product Use (IPPU) sector only 1% (MEF, 2015).

Even if the contribution is said to be negligible or minimum, climate change poses serious threat to agricultural production, natural resource base and the livelihood of communities. The threat is particularly sever in the dry lands. In line with this attempts are being made to mainstream potential response measures for reducing the resulting impacts. In reduction of climate change

and variability related impacts policy makers are playing an important role. Recently, many countries are mainstreaming climate change in to their development plans.

Before climate changes have got prior agenda on international level, Ethiopia already approved energy policies that address climate change in 1997. At the higher level, the government has also signed and ratified the Rio Conventions and Kyoto protocol, namely the United Nations Framework Convention on Climate Change and its Protocol, the Bio-diversity Convention and the Conventions to Combat Desertification. After these conventions, through the National Adaptation Plan of Action (NAPA), twenty priority project ideas were identified that address climate change adaptation needs of the country (Kidane et al., 2009).

More specifically, the government of Ethiopia has set adaptation measures in agriculture, roads, and hydropower. This shows that there is high potential for mitigation through these sectors. Clean Development mechanisms (CDM) measures from agriculture and hydroelectric plants, geothermal and wind turbine, conservation of energy through efficient and switching energy sources, usage of compact and fuel efficient vehicles, and usage of fuel efficient stoves are some of the strategic directions to reduce CO2 emissions that the government promoted in its policy documents.

In addition, the Ethiopian government gives emphasis to climate change adaptation and mitigation in the first five years development plan (GTP) and now in the second GTP this issue inquires more emphasis than the first. The plan has incorporated climate change issues to make national development paths more sustainable as compared to the previous plans. To achieve this plan the government gives emphasis to the construction of hydroelectric dams and medium to large scale irrigation schemes, and the development of alternative and renewable energy sources like wind, solar, geothermal and bio-fuel.

Ethiopia has sufficient amount of water resources and hydroelectric potential, capacity only less 5% of water has been developed for irrigation. That led the per capita electricity to be the least in the world with more than 80% of the population living without access to electricity and relying on firewood, charcoal dung, kerosene, gas and bio-gas which are major sources of high CO2 emission (MoWE, 2011). To address this problem many mega power generating projects are under construction.

According to MWIE, Ethiopia planned 17,347 MW electric power at the end of 2012 E.C. from hydro power including EGRD. On the other hand the ministry also plans to construct and distribute 31,400 biogas digesters, 400,000 solar home systems, 3,600 institutional solar systems and 3,600,000 small solar lamps at the end of second GTP period.

Ethiopia has also suitable land for bio-fuel development. The major targets of the government regarding bio-fuel are increasing bio-ethanol from 60 million to1, 288 million litters at the end of second GTP period, increasing bio-diesel up to 212 million litters and increasing the number of blending facility of benzene –ethanol and bio-diesel. By doing this we can reduce around 65 million ton of CO2 emission from different sources (MMPNG, 2015).

In return, the supply of energy in Ethiopia from renewable sources will reach above 20,000MW at the end of the second GTP period. In general Ethiopia planned to reduce 679.61 million metric ton carbon dioxide at the end of the second GTP period in different sectors. (MEF, 2015)

2.10. Coping Mechanisms to Climate Variability

Traditional and contemporary coping mechanisms to climate variability and extremes in Ethiopia include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid (Deressa et al. 2008).

In countries like Ethiopia, more than 85% of the people depend mainly on agriculture for their livelihoods, rendering them very vulnerable to climate variability and change. Accordingly, in recent times, a significant number of people in Ethiopia are being affected chronically by drought and/or flooding, leading to deaths and loss of assets and to an appeal for international support (Yohannes and Kifle, 2009).

2.11. Determinants of Adaptive Capacity

Adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector. This complex mix of conditions determines the capacity of systems to adapt. Although scholars on adaptive capacity

are extremely limited in the climate change field, there is considerable understanding of the conditions that influence the adaptability of societies to climate stimuli in the fields of hazards, resource management, and sustainable development.

From this literature, it is possible to identify the main features of communities or regions that seem to determine their adaptive capacity: economic wealth, technology, information and skills, infrastructure, institutions, and equity (Mohan Munasinghe Rob Swart, 2005).

2.11.1. Economic Resources

Whether it is expressed as the economic assets, capital resources, financial means, wealth, or poverty, the economic condition of nations and groups clearly is a determinant of adaptive capacity (Burton et al., 1998; Kates, 2000). It is widely accepted that wealthy nations are better prepared to bear the costs of adaptation to climate change impacts and risks than poorer nations (Goklany, 1995; Burton, 1996). It is also recognized that poverty is directly related to vulnerability (Chan and Parker, 1996; Fankhauser and Tol, 1997; Rayner and Malone, 1998). Although poverty should not be considered synonymous with vulnerability, it is "a rough indicator of the ability to cope" (Dow, 1992).

2.11.2. Technology

Adaptive capacity is likely to vary, depending on availability and access to technology at various levels (i.e., from local to national) and in all sectors (Burton, 1996). Many of the adaptive strategies identified as possible in the management of climate change directly or indirectly involve technology (e.g., warning systems, protective structures, crop breeding and irrigation, settlement and relocation or redesign, flood control measures). Hence, a community's current level of technology and its ability to develop technologies are important determinants of adaptive capacity. Moreover, openness to the development and utilization of new technologies for sustainable extraction, use, and development of natural resources is key to strengthening adaptive capacity (Goklany, 1995).

2.11.3. Information and Skills

Successful adaptation requires recognition of the necessity to adapt, knowledge about available options, the capacity to assess them, and the ability to implement the most suitable ones" (Fankhauser and Tol, 1997).

In the context of climate variability and change, this idea may be better understood through the example of the insurance industry: As information on weather hazards becomes more available and understood, it is possible to study, discuss, and implement adaptation measures (Downing et al, 1996). Building adaptive capacity requires a strong, unifying vision; scientific understanding of the problems; an openness to face challenges; pragmatism in developing solutions; community involvement; and commitment at the highest political level (Holmes, 1996). In general, countries with higher levels of stores of human knowledge are considered to have greater adaptive capacity than developing nations and those in transition (Smith and Lenhart, 1996).

2.11.4. Infrastructure

Adaptive capacity is likely to vary with social infrastructure (Toman and Bierbaum, 1996). Some researchers regard the adaptive capacity of a system as a function of availability of and access to resources by decision makers, as well as vulnerable subsectors of a population (Kelly and Adger, 1999).

2.11.5. Institutions

(O'Riordan and Jordan, 1999) describe the role of institutions "as a means for holding society together, giving it sense and purpose and enabling it to adapt." In general, countries with well-developed social institutions are considered to have greater adaptive capacity than those with less effective institutional arrangements commonly, developing nations and those in transition (Smith and Lenhart, 1996).

2.11.6. Equity

It is frequently argued that adaptive capacity will be greater if social institutions and arrangements governing the allocation of power and access to resources within a community, nation, or the globe assure that access to resources is equitably distributed (Ribot et al., 1996; Mustafa, 1998; Adger, 1999; Handmeretal., 1999; Kelly and Adger, 1999; Rayner and Malone,

1999; Toth, 1999). Some people regard the adaptive capacity of a system as a function not only of the availability of resources but of access to those resources by decision makers and vulnerable population (Kelly and Adger, 1999).

Differentiations in demographic variables such as age, gender, ethnicity, educational attainment, and health often are cited in some literatures as being related to the ability to cope with risk (Chan and Parker, 1996; Burton et al., 1998). Strengthening adaptive capacity is a key option, especially in the case of the most vulnerable and disadvantaged groups. Adaptive capacity itself will depend on the availability and distribution of: (a) economic, natural, social, and human resources; (b) institutional structure and access to decision-making processes; (c) information public awareness and perceptions, available technology and policy options, and (d) ability to spread risk.

2.12. Local Farmers Adaptation Efforts to climate change in Ethiopia

2.12.1 Mixed Farming

In the drier areas of Ethiopia, cropping is largely difficult and certainly risk full both with regards to production and environmental degradation (Cooper et al., 2008). In these areas pastoralist dominates. In other areas of the country, crop production can be mixed with pastoralist and risk can be reduced this way. CEEPA, 2006 stated that, owning livestock may buffer the farmers against the effect of crop failure or low yields during harsh climatic conditions. If the farmers have these types of resources it may function as an important safety net and also contribute to extra income, because animal products can be sold, and livestock can also be sold during difficult periods. Selling of livestock is identified as a coping mechanism to climate variability and extremes in Ethiopia (Abebe, 2007).

2.12.2. Selling of Assets

Sale of agricultural tools and other assets are identified as coping mechanism to climate variability and extremes in Ethiopia. Farmers may sell some of their resources, and this can be an important extra income, and can also function as a safety net and a coping mechanism. Material assets within the household can be seen as buffer against difficult periods (Chemeda et al., 2006; Abebe, 2007).

2.12.3. Crop Diversification

Crop diversification is well known in sub Saharan Africa. This strategy seeks to avoid risks of total crop failure rather than maximizing yields of one particular crop (UNEP, 2006). Also in Ethiopia crop diversification is widespread. Crop diversification is the most commonly used method to overcome the impact of climate change and variability in Ethiopia (Temesgen et al., 2009). Diversification is identified as a coping strategy that has evolved to deal with both expected rainfall uncertainty and seasonal fluctuations in rainfall (Cooper et al., 2008). There are many benefits with crop diversification.

It is more secure because if one variety fails, farmers probably still have some other crop varieties that are successful. Secondly, with rotating of crop varieties on each plot of land, soil fertility will be maintained and the soil will not be exhausted (CEEPA, 2006). Maintaining a high level of plant biodiversity within the farm boundaries and in the agricultural landscapes has also been recognized as a good strategy to reduce food insecurity (UNEP, 2006). Crop diversification has become more and more important when the climate is changing.

2.12.4. Irrigation

Rain fed agriculture in sub Saharan Africa will remain vital for food security (Cooper et al., 2008). At the same time, irrigation can be a valuable strategy for making agriculture more stable and safe. Types of irrigation are for example dams and ponds, hand dug wells and other types of wells, flood irrigation, sprinkler irrigation, lifting water using a petrol-fueled pump engine, and irrigation by gravity (CIA, 2011; Joto, 2009). Use of irrigation is one of the least practiced adaptation strategies among the major adaptation methods identified in Ethiopia (Temesgen et al., 2009).

2.12.5. Off-Farm Activities

Farmer's vulnerability to climate change can be mitigated if they have off-farm work on the side. Chemeda et al., 2006 found that, sale of labor was a successful coping strategy among farmers in the Upper Awash Basin of Ethiopia during drought periods because, it reduces dependency on agriculture. Traditional and contemporary coping mechanisms in Ethiopia also include increased petty commodity production (Abebe, 2007). Off-farm activities can for instance be selling of honey, or home made products like mattresses, hot food, beverages, and ropes. Where

opportunities exist, working as wage laborers and trading commodities are also common in Ethiopia (Cooper et al., 2008).

2.12.6. Tree Planting

Temesgen et al., 2009 identified that, tree planting to be one of the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia. Vegetation like trees and grass are valuable because the roots protect the soil from erosion. Trees are valuable during floods and droughts, and many trees together will give lower temperatures in the near area, a fresh air, and also shadow.

2.12.7. Soil and Water Conservation

One of the adaptation strategies found in Temesgen et al, 2009 research in the Nile Basin of Ethiopia was soil conservation. Many areas of Ethiopia are mountainous and crop fields are rarely flat. Often they are located in a hill side or in a valley side. This creates extra demand for soil and water conservation to prevent the soil and rainwater from being washed away.

Terraces are often built together with soil bunds, stone bunds, deep trenches, and special rainwater harvesting methods. Those are the most common strategies to conserve soil and water in the field. Soil and water conservation strategies are mainly used because of soil degradation and soil erosion, and because farmers due to this, want to rehabilitate their fields. Today these activities are increasingly important because climate change to some extent is accelerating these processes.

2.13 Conceptual Frame Work of the Study

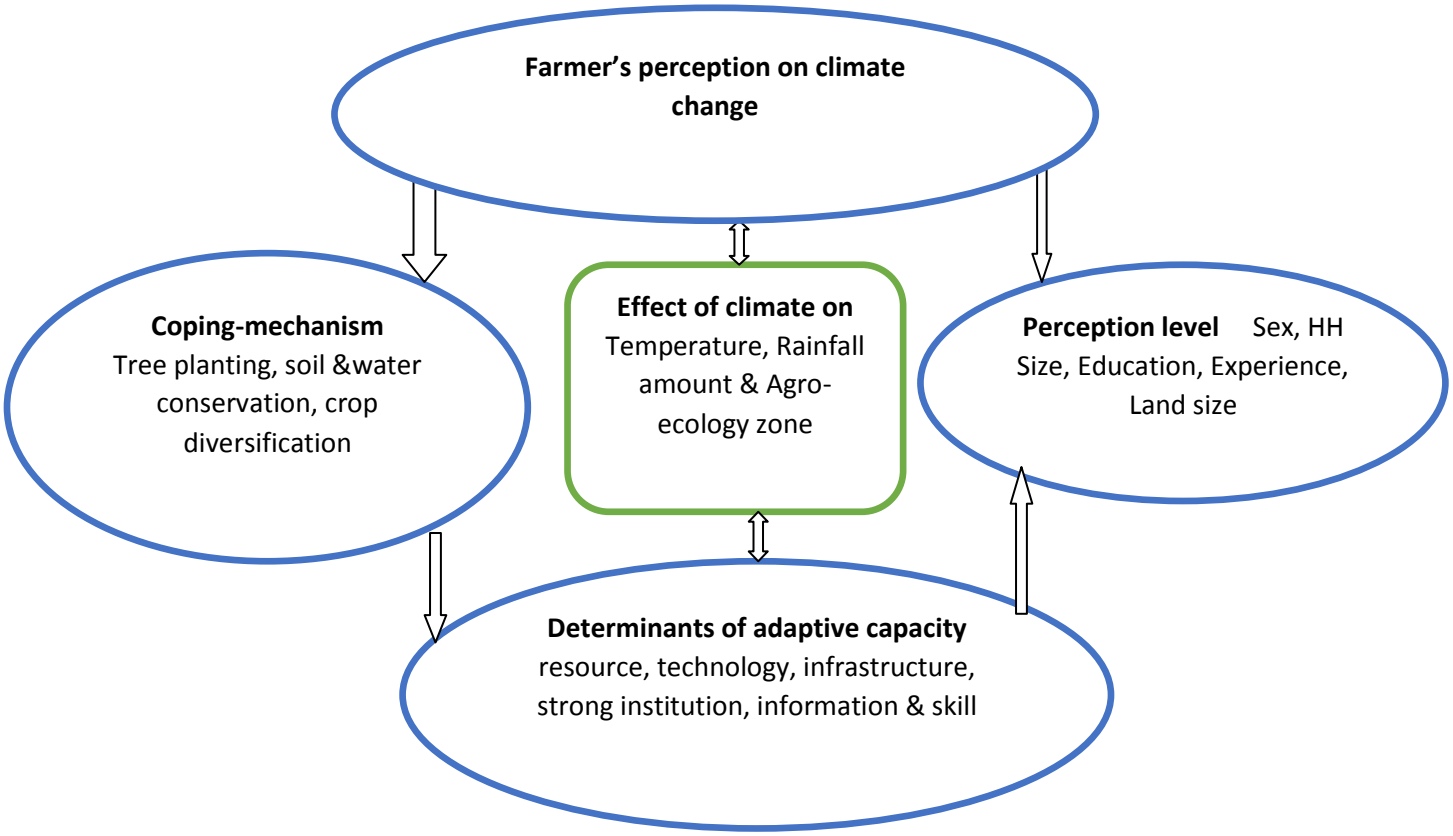

Figure 1: Relation among Farmer perception on climate change

This conceptual framework or model depicts the relationship of concepts such as farmers' perception on climate change, adaptation measures and their constraints. Due to variability and change in rain fall and temperature pattern, farmers and households faced climate change related risks and consequences such as health impact, water scarcity, shortage of food supply and fuel wood. farmers and other actors choose various kinds of adaptation strategies depending on the capacity, information and assets they have such as soil and water conservation, planting of seedlings, reforestation, agro forestry and efficient use of water. But, the perception and adaptation measures of the farmers are determined by constraints such as by lack of capacity for adaptation, information and awareness about climate change, shortage of technology and finance, inadequate policy and political support etc. Hence, the intention of this research was to assess the level of farmers' perception on climate change phenomena, indicators and risks of climate change, current adaptation strategies and their constraints or challenges.

CHAPTER THREE

3.1. Description of the Study Area

3.1.1. Location

Ankoberworeda is one of the 24 woreda's which is found in North Showa Zone of Amhara Regional state in Ethiopia. Geographically the woreda is located between 9º 21'- 9º 45' N and 39º 39' - 39 º 54'E. The Woreda has with an average elevation of 2750 meters above sea level. The woreda has 4 urban kebele's and 18 rural kebele's. Gorebela town the capital of the woreda is located at 172km Northwest of Addis Ababa and 42km from DeberBirehan. Ankober is one of the woredas in the Amhara Region of Ethiopia, Located at the eastern edge of the Ethiopian highlands in the SemienShewa Zone, Ankober is bordered on the south by Asagirtworeda, on the west by BasonaWeranaworeda, on the north by Termaberworeda, and on the east by the Afar Region. Towns in Ankoberworeda include AliyuAmba, Ankober(**Gorebela**), Gorgo and Haramba.

Demography

Based on the 2007 national census conducted by the Central Statistical Agency (CSA) of Ethiopia, the woredahas, a total population of 76,510, an increase of 14.09% over the 1994 census, of whom 38,790 are men and 37,720 are women; 4,403 or 5.75% are urban inhabitants.

With an area of 672.80 square kilometers, Ankober has a population density of 113.72, which is less than the Zone average of 115.3 persons per square kilometer. A total of 18,274 households were counted in this woreda, resulting in an average of 4.19 persons to a household, and 17,633 housing units. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 92.73% reporting that as their religion, while 7.15% of the population said they were Muslim.

The 1994 national census reported a total population for this woreda of 67,061 in 14,430 households, of whom 33,491 were men and 33,570 were women; 3,802 or 5.67% of its population were urban dwellers. The two largest ethnic groups reported in Ankober were the Amhara (92.77%), and the Argobba (7.04%); all other ethnic groups made up 0.19% of the population. Amharic was spoken as a first language by 98.94%, and Argobba was spoken by 0.9%; the remaining 0.16% spoke all other primary languages reported. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 92.52% reporting that as their religion, while 7.41% were Muslim

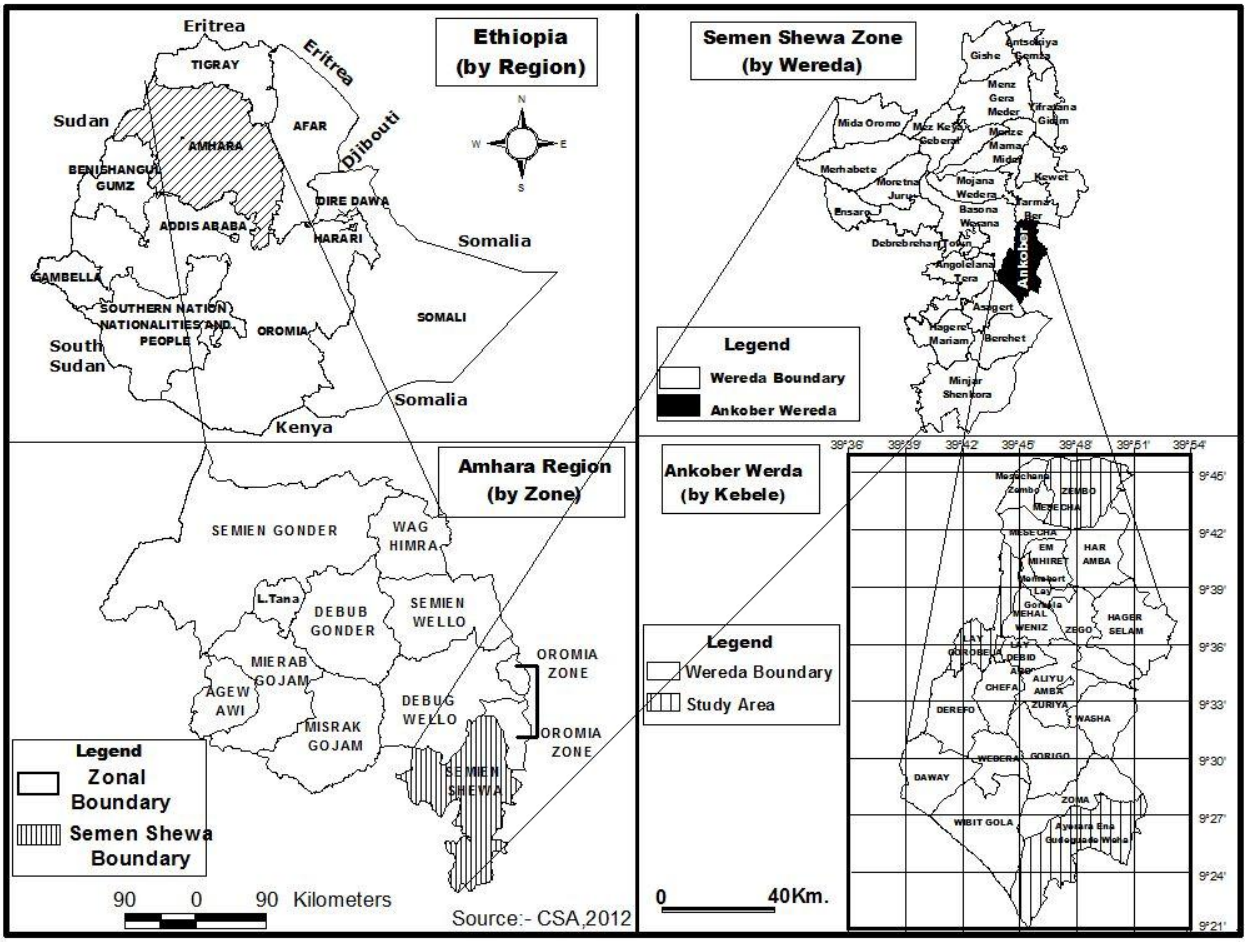

Figure 2 Map of The study area

The woreda's total land coverage is 69,306.01 hectare out of this undulating areas covers about 19% (13,138 hectares) used for agriculture 13% (9,010hectar) used for grazing,10.39%(7,198.113hectar) used for forestry, 54.11 %(39,959.897hectar) covered by bushes other 3.5 %(2,426hectar). According to the woreda administration and community classification, the woreda'skebeleagro-ecology is subdivided in to Three Degas 3 kebeles(12%), woinadega12kebeles (53%) and kola 7 kebeles(35%).

3.1.2Economic Activities of the Woreda

Most of the people in the area are engaged in mixed agriculture. Crop cultivation and livestock production are practiced. Crop production is entirely rain fed, except in very specific and small areas where vegetables are cultivated based on traditional and small-scale irrigation. There are two rainy seasons, kiremt and Belg, and they are used for the cultivation of long cycle crops. The

dominant crops of the study area are barely, wheat, teff, maize, sorghum, bean, pea, lentils and, telba, and (AWADO 2017). Land preparation is carried on using mainly ox-plowing but tilling by hand occurs in the hilly areas on steeply sloping lands. Recently crop productivity is very low. As a result, many people involve seasonal migration to Addis Ababa and other areas to subsidize their livelihoods.

The number of domestic animals found in the woreda include: cattle (56,656), pack animals (10,746), sheep (59,620), goats (29,900) poultry (56,392) and Bee hives (5,436). (AWADO, 2017). Domestic animals usually freely graze, but the middle and better off people also purchase animal feed like hay and crop residues from October to January from the very poor people. This makes the poor to be poorer.

3.1.3Infrastructures of the Woreda

Regarding distribution of towns, schools, and health services; Ankoberworeda has 2 towns. According to Woreda education office AnkoberWoreda has 19 schools, of which 17 are primary and 2 secondary school respectively. Health office also indicates that the woreda has 15 health centers and 6 clinics distributed in the kebeles (AWHO, 2017). In addition the area has 5 veterinary posts with very limited service to woreda's population. Amhara credit and saving institution the only institutions who serves credit for the communities and there is also one main road who crosses the woreda to the neighboring woredas and there is some roads to link kebeles to kebeles.

3.1.4. Soil of the Woreda

According to AWADO, the major soil types in Ankobereworeda are clay loam, clay to clay loam and clay to silt clay loam; constitutes about 31 %, 28 % and 26% and other15 %, of the total area respectively. Clay loam and clay to clay loam soils are the dominant soil type in the area.

3.1.5Climate of the Woreda

Climate is one of the elements of the physical environment which has a pronounced impact on settlement pattern, human way of life, the type of the soil, flora and fauna existed and/or developed so forth. Among different climatic elements temperature and rainfall have a considerable impact in such an agrarian country like Ethiopia and more actually in the area under

study. The temperature distribution of the study area is mainly a reflection of elevation. Accordingly, the study area comprises varied thermal zones ranging from ‘kola’ to ‘dega’. The average annual rainfall amount varies between 950 to 1200 mm and average temperature is in between 18°c-30°c.

3.1.6. Vegetation Coverage of the Woreda

According to AWADO (2017) report, forest lands are found in between the cultivating land and especially in a steep slope area of the study area. The forest land is covered the fourth highest percentage of the area which covers 10.39% of the woredas total area. This forest and shrubs are used as source of fire wood, forage (fodder) especially for goat, sheep and in the nearest time the people used tree planting of cattle fodder trees like (Saspania, Trilusern etc.) this types of trees used for two purpose as forest and their leave used as a fodder for the cattle and forest used the community for different purpose. The trend of forest land is decreased from time to time because the community use for cultivation land.

3.2. Research Design

The study was conducted to assess farmer’s perception on climate change, its impact and adaptation measures. In order to assess the overall activities**Non-Probability Sampling**method was used, with purposive sampling techniques to select kebelesand households. Questionnaire, interview, FGD**,** key informant interview (KII) and observations were used to collect primary data gridded temperatures and rainfall data were gathered from ENMSA.

3.3. Population, Sample Size and Sampling Procedure

The numbers of participants’ households in this survey are 187, which is 94.4% of response rate out of the 198 sample size is adequate to make the analysis. Moreover, the researcher has preferred to work on analysis on participants’ observation of climate changes in Ankoberworedathen the researcher purposely the study woreda named as “Ankober**”.** Hence, purposive sampling was employed in the selection of Woreda. The main reason behind this selection is the familiarity and convenient access of information relevant to the study.

As discussed in previous sections the study area has 18 rural and four urban kebeles. The researcher selected three kebeles, namely Ayerara, Zenbo and LayeGorebel were randomly

based on their different agro climatic zones and which are more vulnerable to climate and prone to risks including drought, famine, high temperatures, and erratic rainfall distribution. Using randomly technique gives each of them (respondents) an equal chance of being included in the study.

3.3. Sample Size and Sampling Technique

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Sampling technique was used to select the representative sample from the total population under the study and from the total household of the farmer's and kebelesadministration of Ankoberworeda. The study area has 18 rural and 4 urban kebeles. The researcher has randomly selected three kebeles, namely Ayerara, Zenbo and LayeGorebelwhich represents different agro climatic zones. Different Kebeles found in various agro ecological zones are more vulnerable drought, famine, high temperatures, and erratic rainfall distribution at various levels.

Table: 3.1 Sampling Kebeles, Sample size and Percentiles

No	Kebele Name	Total HHs	Sample size (10%)	Percentage
1	**Ayrara**	540	54	27.27
2	**Zenbo**	595	60	30.30
3	**Lay Gorebela**	844	84	42,42
Total		1979	198	100

Source: Survey data 2019

3.4. Sources of Data

Both primary and secondary sources of data were intensively employed. As a result (Development of Agricultural Agents) DAs, and Kebele leaders, Woreda and Zonal agricultural officers, local elder, religious leader, women and young farmers of the sample 'kebele's were considered as part of primary data collection.

Published and unpublished documents such as government offices central statics agencies were used as source of secondary data. This includes data's from governmental offices, data from central statistical agency and internet sources.

3.5. Data Collecting Instrument

Questionnaire, interview, FGD, field observation and document analysis were used to collect information regarding farmers' perception and adaptation to climate change and variability: in AnkoberWoreda.

Questionnaire

Close and open ended questions were prepared to be completed by the selected 198 sample households to generate the required data about farmer's perception on climate variability, its impact on their livelihood and adaptations practices. The closed ended format questions enabled the respondents to select one option that best meet the reviews, while the open ended question was included to give opportunity to the respondents to express their perceptions and ideas concerning the problem under study.

Key Informant Interview

Key Informant Interviews (KIIs) are aimed to obtain detail information on the issues (Mikkelson, 2005). To get detailed information, the researcher used interview. The key informant interviews were conducted with development agents (3), local leaders (3), model farmers (3) and oneworeda agricultural development office representative, about the cause and impacts of climate variability in the study area.

Focused Group discussion

Focus group discussions (FGD) generate data on from small group of respondents guide by a skilled moderator, to focus on key issue of the research topic (Mwanje, 2001). The researcher selected six respondents in each kebele based on their social status within society and are known to have better knowledge on the present and past environmental, social and economic status of the population in the study area. At each kebele, one focus group discussion washeld. The focus group discussions were made with member of selected educated person (1), local elder (2), religious leader (1), women (1) and 1 young farmers of the sample ‘kebele’s.

The main purpose of focus group discussion was to understand the level of perception of the people about the impact of climate change, its cause and their responses and adaptation strategies and barriers to employ them effectively.

Field Observation

Robson, 1995 indicates that field observation is used as a supportive technique to collect data that may complement or set in perspective data obtained by other means. In the time of staying in the study area, the researcher observes vegetation covers, topography, major development interventions, and other related things.

Figure 2.Field observation in Lye GorebelakebeleFiguru 3.Terracing practice in Gorebelakebele.

Document Review

Documents which is found at *woreda*and *'kebeles'* were reviewed and used to generate secondary data. Census reports, activity progress reports, the relationship between relief demographic characteristics, climate distribution, and economic performance were reviewed and supplemented the primary data.

3.6 Methods of Data Analysis

Data obtained from various sources were analyzed using qualitative and quantitative data analysis techniques. The quantitative information gathered using questioner survey was analyzed using SPSS Version 23.0 statistical software. Errors related to inconsistency of data were checked and corrected during data cleaning, whereas the quantitative data generated from ENMSA gridded data had been analyzed using descriptive statistics. Descriptive statistics such as mean, frequency and percentage were used to characterize farmer's perception on long-term temperature and precipitation variability as well as various adaptation measures used by farmers, and barriers they face to adapt.

3.7. Ethical Considerations

Above all the researcher was conducted the study based on professional as well as the basic principles of research. The researcher should not be identifying the respondents' personal details

and response without their consent and agreement. Ethical issues grouped into informed consent procedures, dishonesty, confidentiality towards participants or sponsors and protecting the anonymity and privacy of research participants (Sarantakos, 2005). Based on the basic principles, the researcher was proposed a set of ethical and moral procedure and informed the participants just before in depth interview, focus group discussion and filling out the questionnaire. The participants was informed that information obtained from them remains confidential. Besides the respondents were further informed that their names was not be written or exposed on report and was ever be used in connection with any of the information they revealed. The researcher also conveyed the purpose of the study to the proposed respondents as per standard research requirements. The researcher was avoided deceptive practices, and respect indigenous cultures as well as discloses sensitive inform

CHAPTER FOUR

4. Farmers' Perception and Adaptation on Climate Variability

4.1.1. Background of Respondents

In this chapter the analysis of data collected through the survey questionnaire is presented and discussed along with the research objectives and research questions. Moreover, secondary data about climate of the sturdy areas obtained from metrological sources is consolidated and presented with the participants' observation data of climate changes in the study areas.

The sample of respondents constitute 187 HHs and their HH information are compiled and summarized in the following tables: Table 4.1 below presents gender, religion and education and education backgrounds.

Regarding the gender composition, the majority of the HHs, 111 (59.4%), are male headed families; while 76 (40.6%) are female headed HH.

The majority of the HHs in the study area are Orthodox Christians; they constitute 68.4 %(128) of the sampled HHs. The Muslim households constitute 23.5%; and protestants are 15(8%) of the households participated in this study.

4.2. Characteristics of Respondents

The sample of respondents constitutes 187 HHs the sex; religion and educational background of the household heads are compiled in the following tables: Table 4.1 below presents gender, religion and education and education backgrounds.

Table 2. Sex, Religion and Educational Background

Respondent Characteristics		**No.**	**Percent %**
Sex	Female	76	40.6
	Male	111	59.4
Religion	Muslim	44	23.5
	Orthodox	128	68.4
	Protestant	15	8.0
	(No Response)	4	2.1
Education	Illiterate	52	27.8
	Read and Wright	75	40.1
	Primary Education	38	20.3
	High School	22	11.8
Total		**187**	**100.0**

Source: Survey data 2019

The above Table 4.1 shows that of the respondents sex composition, the majority of the HHs, 111 (59.4%), were male headed whereas 76 (40.6%) are female headed HHs. This could be an issue of less participant rate of female in response to question related to climate changes ,which is vital to the smooth undertaking of the real life and create awareness about the most wonted and timely issues of the century. Gender inequality is also observed in the sample kebeles and attention must be given to females in all aspects of the activities as long as the role of women's are concerned and their contribution to the overall activities of climate change.

With regards to item 2 of table 4.1, the majority of the HHs in the study area is Orthodox Christians followers and they constitute 68.4 % (128) of the sampled HHs. The Muslim households constitute 23.5%; and protestants are 15(8%) of the households participated in this study.

As to item 3 of the same table above, only11.8% have completed high school education level and 27.8% illiterate heads; and 40.1%$ of HHHs who can only read and write. The rest of the HHHs, constituting 20.3% are at primary education level, while only 11.8% are at high school education level.

From this result one can realize that significant number of respondents did not have at least basic education and leveled as illiterate. The low level of households in literacy and academic qualification yields poor and unscientific practices of climatic adaptations strategies.

Table 3. Household Family Size and Possession of Land in Hectare of the respondents

	Minimum	**Maximum**	**Mean**
Age of HH	28	69	46.79
No. of Males	1	6	3.5
No. of Females	1	5	3
Family Size	1	11	5.9
Land size (ha)	0	2	1.04
Land size/family	0	2	0.593

Source: Survey data 2019

As can be observed from the above table 4.2 of item one, the respondent age ranges from 28 to 69 years; with average age of nearly 47 years. Having reasonably matured age significantly impacts on households perception on the most wonted issues of the present climate change because these people are ready and fit to take responsibilities just to cope with the challenges may encountered due to the climate change.

In the third item of table 4.2, respondents were asked about the size of the sample households in the study area. Accordingly, the family size of HHs is nearly six people, and ranges from 1 to 11. The average male members are about 3 in 187 HHs; where the female number in 187 households is 2on average. Here again the gender composition looks fine and appropriate to deal with any issue related to climate change and its impact on their livelihood.

Regarding item 1, as shown in the table above, the land size of household's ranges from none to two hectare of land. On average, HHs in the study area possesses 0.59 hectares of land; which is nearly 0.6 hectares of land per individual resident in the study area.

Holding adequate land size by the sample households definitely attracts can give space for the new born in the family and positively contributes for the adaptation strategies to cope up with the devastating climate and marinating the all the good efforts at all times. Besides, household with relatively enough land holding try to strive and align their effort in order to bring about good climate change adaptability strategy to their community in general and for themselves in particular.

Table 4. Distribution of Households Family Size

No. HHResidents	Male		Female		No. of HHs	
1	3	1.6	25	13.4	5	2.7
2	38	20.3	57	30.5	-	-
3	66	35.3	57	30.5	10	5.3
4	63	33.7	29	15.5	29	15.5
5	9	4.8	19	10.2	42	22.5
6	8	4.3	-	-	23	12.3
7	-	-	-	-	46	24.6
8	-	-	-	-	14	7.5
9	-	-	-	-	14	7.5
10	-	-	-	-	4	2.1

Source: Survey Data 2019

4.3. Major Livelihood Activities of Sample Households

As shown in item 1 of Table 4.3, the sample respondents were asked to respond about the distribution of their households' family size. Accordingly, almost all of the sample household respondents are actively involved in rain-fed agriculture and practicing mainly in the production of certain type of crop and animal. Besides, where the male 182 (97.3%) of the households are own plots of land for their agricultural practices.

As indicated in the table 4.3, the average land size per household is about 1.04 hectares; where the households land size ranges from 0 to 2 hectares. Looking the available land per family size, there is about 0.6 hectares of land per individual resident. From the above figure one can possibly concluded that the majority of the sample respondents have relatively enough land holdings and can be promising if they continue to preserve the land as per the needed.

Table 5. Type and Purpose of Farm Land

Purpose of farm land		**No. HH**	**Percent**
Purpose of land	Crop production	82	43.9
	Mixed	101	54
	Other...	4	2.1
Type of farm land	Large size	13	7
	Medium size	146	78.1
	Small size	28	15

Source: Survey data 2019

The Households in the study areas are engaged in various activities besides crop production. The HHs engaged in different activities, other than subsistent farming, for the betterment of their living condition; which otherwise is difficult to their wellbeing and cope up the difficulties.

As shown in the table 4.5 below, households are engaged in one or more activities in addition to their agricultural practices. Accordingly, the largest number of households, 174 (93%) are reported to have engaged in mixed farming while the remaining Cattle fattening is also practiced by 173(92.5%) of the households as supplementary means in their livelihood. A considerably a significant proportion of households 73.3%, are involved in different kind of off-farm activities (none farm activities).

Renting is also found the practice by more than half of the households for their means of income; where 57.2% and 52.4% are practicing land renting and cattle renting, respectively. Moreover, crafting activity is found to be the other alternative that are practicing by 58(21%) of the sample households (respondents. Small proportion of households are practicing sales of wood and charcoal, work as Wage laborer, serve as Traditional healer, and some are pensioners.

Unlike other activities mentioned above, none of the households are engaged in trading livestock, hide and skins, animal food/ selling and remittance in the sample *kebeles*. Thus, the data implies that, many of the supplementary livelihood activities are actively practicing by the sample households as a means to survival and continue to be major tasks that should be accomplished.

Table 6.Source of Livelihood for sample households

Livelihood Activities	**No.**	**Percent**
Sales of wood and charcoal	27	14.4
Wage laborer	13	7
Crafts	58	31
Traditional healer	31	16.6
Pensioners	5	2.7
Oxen renting	98	52.4
Land renting	107	57.2
Cattle fattening	173	92.5
Mixed farming	174	93
crop production and off farm activity	137	73.3

Source: Survey data 2019

4.4 The Impact of Climate Variability/Change

As all we noticed, climate variability affected all the households in *Ankoberwereda* included the sample*kebeles.* From thequestioner for house hold heads the severity of the- effect of climate variability is extremely high in case of 42(22.5%) of the households; 91 (48.7%) of the respondents had encountered high level impact while the climate change had resulted moderate level impact to 54(28.9%) of the HHs. Based on the respondents response, one can possibly concluded that the impact of the climate change is significant severely affecting the study area in the sample*kebeles*.

As can be seen from questioner and participants on focus group discussion climate changes in the study area had caused different negative impacts and consequences on the community. The most significant impacts households identified includes:

-decrease of forage availability, as witnessed by 92% of the households' response. Other consequences of climate change are change in seeding period and change in harvesting time that 88.8% and 70% of the households witnessed…..

Considerable number of households (36.3%) had experienced decreased crop yield; while 12.9% of the households are also experienced increased pasts and weeds. As a result, one can easily guess that the sample respondents of the study *woreda* had facing the declining of hope and wealth due to the existing climate change impact.

4.5. Effects of Climate Change in Livestock

As indicated in item 1 of the bellows table, sample respondents were asked to respond the type of livestock lose/death that they encountered. Accordingly, about 182(97.3%) of the households one way or other they had experienced considerable loss in their livestock holdings. And similarly, as to the reason of livestock, 171 (91.4%) of the households refer to droughts in their respective region. Of which, 16(8.6%) of the sample respondents (households) believed that the water shortage that caused livestock loss in their *kebeles*.

Table 7. Causes of Livestock Loss

		No. HH	Percent
Encounter livestock loss/death?		182	97.3
problem of livestock production	Drought	171	91.4
	water shortage	16	8.6
	Total	187	100.0

Source: Survey data 2019

4.6. Severity of Livestock Loss

As it can be observed from Table 4.6 of item 1 below, respondents were asked to rate the level of severity that the sample *kebeles*livestock lose/death. Accordingly, in order to assess the severity of the loss, households were asked their possession of livestock presently, and five years before. Households replied about their livestock comparing the number presently to that of five years ago.

As indicated in the table 4.7 below, HHs had 3 to 8 cattle per household which presently falls to 1 to 4 cattle per household. This is a loss of, on average, two cattle per household; and amounts to the largest loss of nine cattle in some HHs and one can possibly concluded that there is a drastic decline in livestock loses observed in the sample kebeles.

Regarding donkeys, the average loss that HHs experience during the past five years amounts to 1 or 2 donkeys. This is the decreasing in the number of donkeys that falls from 3 to 1donkey in 187 HHs. This figure simply indicated that a significant proportion of the sample respondents were negatively affected by the great loss of their donkeys.

Table 8.Average Livestock Losses sample Households encountered in the past three years

Type of livestock	**Average HH No. of livestock before 5 years ago**	**Average HH Loss of livestock in last 5 years**	**Average HH Livestock Loss %**
Cattle	6	2	33.4
Donkey	3	1	33.3
Goat	5	2	40
Sheep	7	3	42.9

Source: Survey data 2019

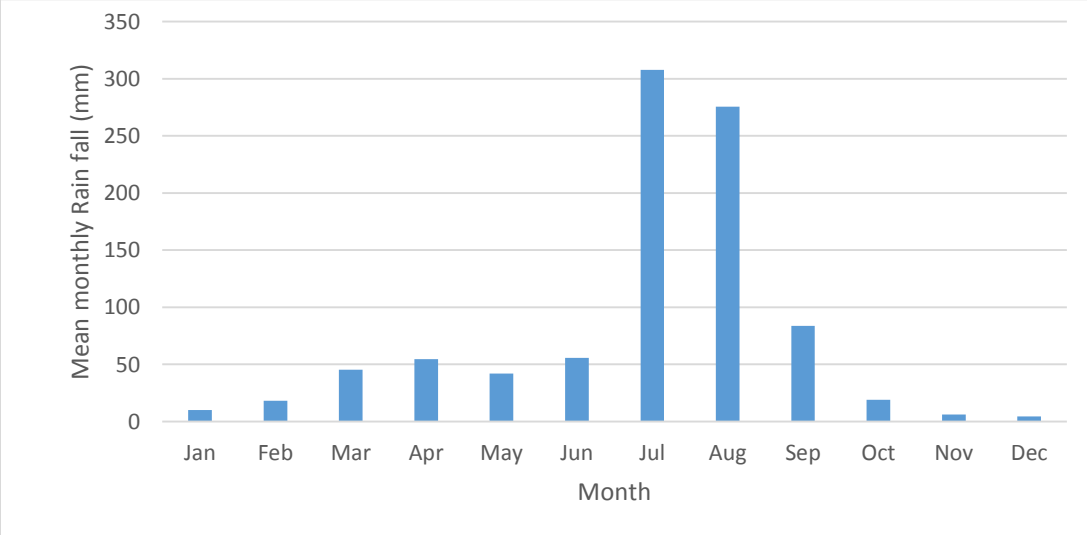
The number of sheep and goats are also declined significantly in the past five years. The number of sheep in the sample households were estimated 1274 before five years, but the number declined by 559 in 187 HHs after five years. This shows a decreasing an average number of sheep from 9 to 5 per HH in the range of five years. As to the number of goats, 1013 goats expected in 187 HHs five years ago are presently shirked to 453 goats that is a decline by 40.7%.

4.7 Climate Variability and Trend of the Study Area

4.7.1 The Annual Variation of Rain Fall and Temperature

Climate variability in the study area was described by a general trend and yearly and seasonal variation and dispersion of Temperature and Rain fall patterns as temperature and rainfall are one of the components that control weather conditions along with climate of an area. Figure 4 shows the annual distribution of rain fall in the area of study. It is evident from the figure that there are two main rain fall seasons February to May which is the small rainy season locally known as "Belg" (Spring) and June to September that is the main rainy season "keremt" (Summer). The wettest month is July whereas; the driest month lies in December, with an average monthly rain fall for last31 years were 307.9mm and 4.6mm respectively. These mean the highest range of average rainfall amount between those years (303.3mm).

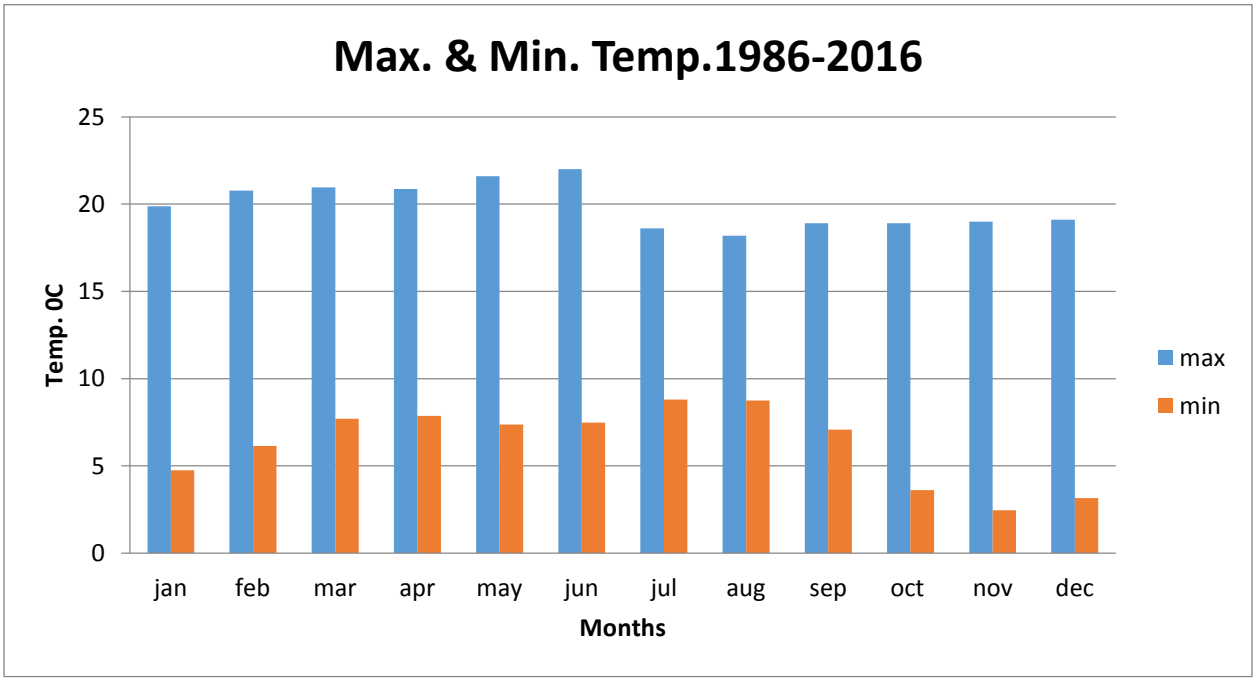
Figure 4. Mean Monthly Rainfall of study area (1986-2016)



Source: NMA 2018

The annual cycle of maximum temperature are within 31 years of metrological data, the peak month being June conversely the month of November has the lowest value of minimum temperature. During the months fromFebruary-June the drought cases have also shown an increment in the study area; it indicating a possibility of relation with the highest amount of temperature recorded. The Figure 5 below shows the annual cycle of the temperatures. As, it can be seen from the figure, July has the highest value of annual minimum temperature (8.81^0C) as

Figure 5 mean monthly temperature (1986-2016)



Source: NMA 2018

November bears the lowest value (2.45^0C). Again as it can be clearly seen from Figure5 temperature has also shown higher recordings in June (22^0C) and lowest value of annual maximum temperature (18.19^0C) was in August with in the last 31 years.

4.7.2 Trends of Temperature

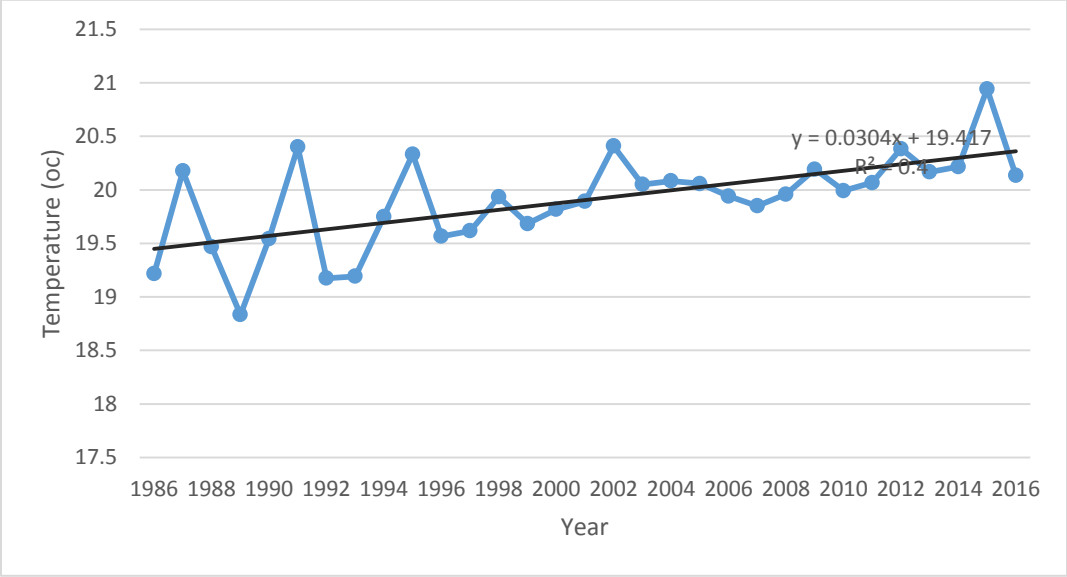
According to NMA (2007), Mean annual minimum temperature and annual rainfall variability and trend observed over the country in the period 1951-2006. Annual minimum temperature is expressed in terms of temperature differences from the mean and averaged for 40 stations. There has been a warming trend in the annual minimum temperature over the past 55 years. It has been

increasing by about 0.37 ^{0}C every ten years. The country has also experienced both dry and wet seasons.

4.7.2.1 Mean Annual Maximum Temperature

It is found that mean annual maximum temperature of *Ankoberworeda* varies between 21.13^{0}C and 18.55^{0}C. The lowest mean annual maximum temperature was recorded around the year 1988 and the highest is recorded in 2016. Mean annual maximum temperature of the study area was observed from 1986 to 2017.This implies, the mean annual maximum temperature identified that an increase of 0.9^{0}C in these 32 years, whereas the average annual maximum temperature over the country has been increasing by about 0.41^0 C over the last three decades. The trend analysis of annual rainfall remained more or less constant when averaged over the whole country (NMA 2007).

Figure 6.Time series of annual average maximum temperature (1986-2016)



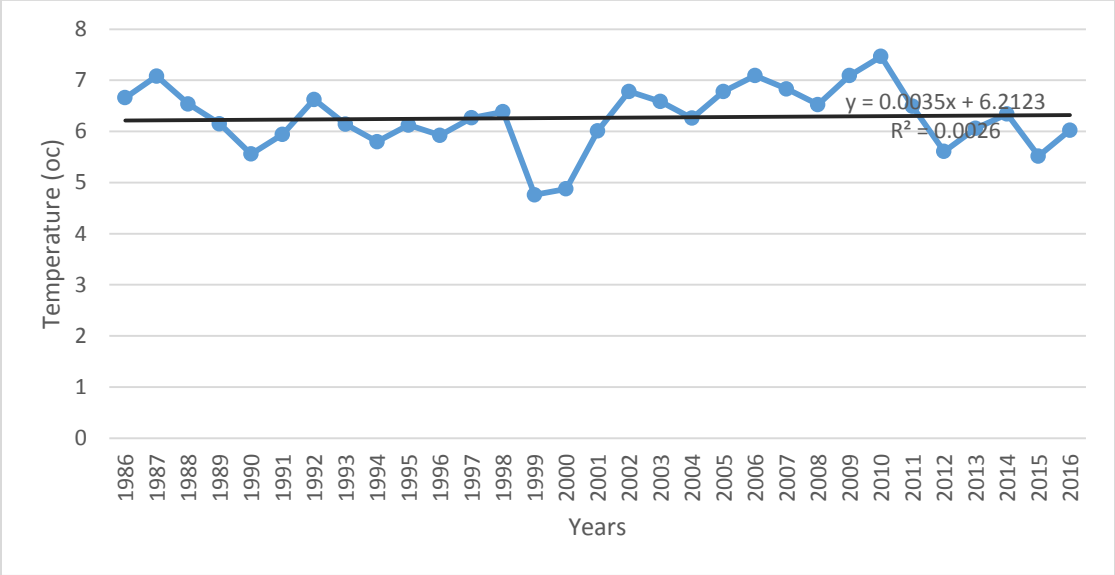
Source: NMA 2018

4.7.2.2 Mean Annual Minimum Temperature

It is also found that the mean annual minimum temperature of the *AnkoberWoreda*varies between 4.76^{0}C and 7.45^{0}C during the last 32 years, the lowest recorded being in the year 1999 and the highest in 2010. The figure below shows that the trend is not systematic in that it increases in some years and decreases in some others. The mean annual minimum temperature

was increased by 0.09^{0}C in the past three decades with an increment of 0.03 ^{0}C in every decade. This indicates as there is slight difference of temperature in mean annual minimum temperature.

Figure 7. Time series of annual average minimum temperature (1986-2016)

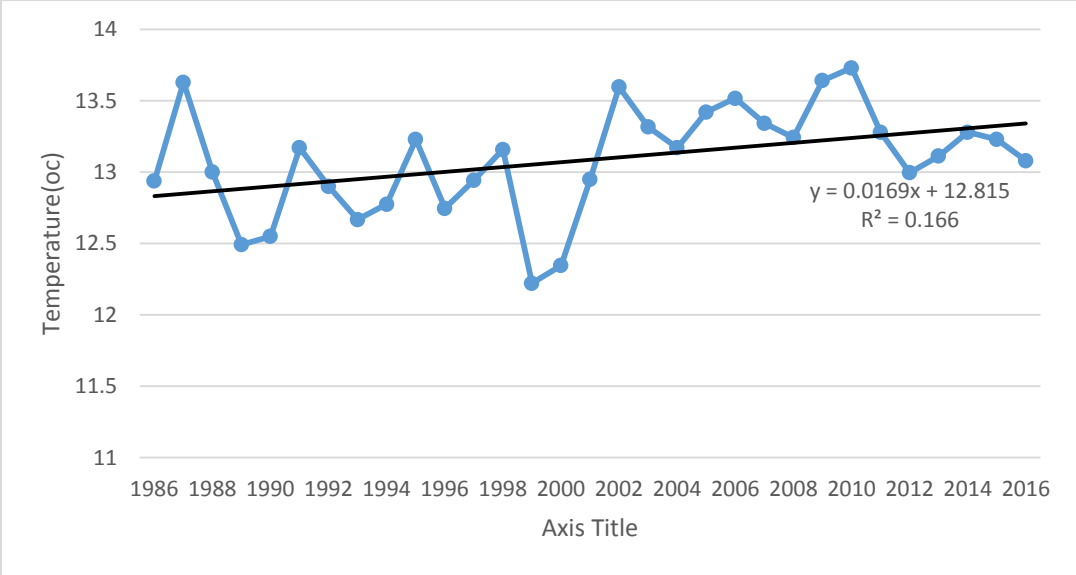


Source: NMA 2018

4.7.2.3Average Temperature of the woredas

Annual maximum, minimum and average temperatures are presented the warmest year was 2010(13.73^{0}C), while the coldest year was 1999(12.22^{0}C). Highest annual range was manifested in 1998, November (16.55^{0}C) while the lowest range was recorded in August, 2009(9.45^{0}C). Generally, the trend of temperature shows slight increment from year to year. The average temperature of the study area has increased by 0.48°C in the past 32 years with an increment of 0.16°C in every decade. On the other hand maximum and minimum temperature increased by 0.9°C and 0.09°C respectively in the past three decades.

Figure 8. Average temperature of the*woreda* Time series of annual average temperature (1986-2016)



Source: NMA 2018

4.7.2.4 Trends of Rainfall

Although models predicting precipitation give controversial results of both increasing and decreasing precipitation, all models agree that the temperature in Ethiopia will increase in the coming years. For instance, Strzepek and McCluskey (2006) showed that, based on different models, precipitation will either increase or decrease. They point out, however, that the temperature will increase under all models .Strzepek and McCluskey (2006) used three climate prediction models based on two scenarios from the IPCC Special Report on Emission Scenarios (SRES). These models are: the Coupled Global These models are: the Coupled Global Climate Model (CGCM2) (Flato and Boer 2001): the Hadley Centre Coupled Model (HadCM3) (Senior and Mitchell, 2000): and the Parallel Climate Model (PCM) (Washington et al. 2000).

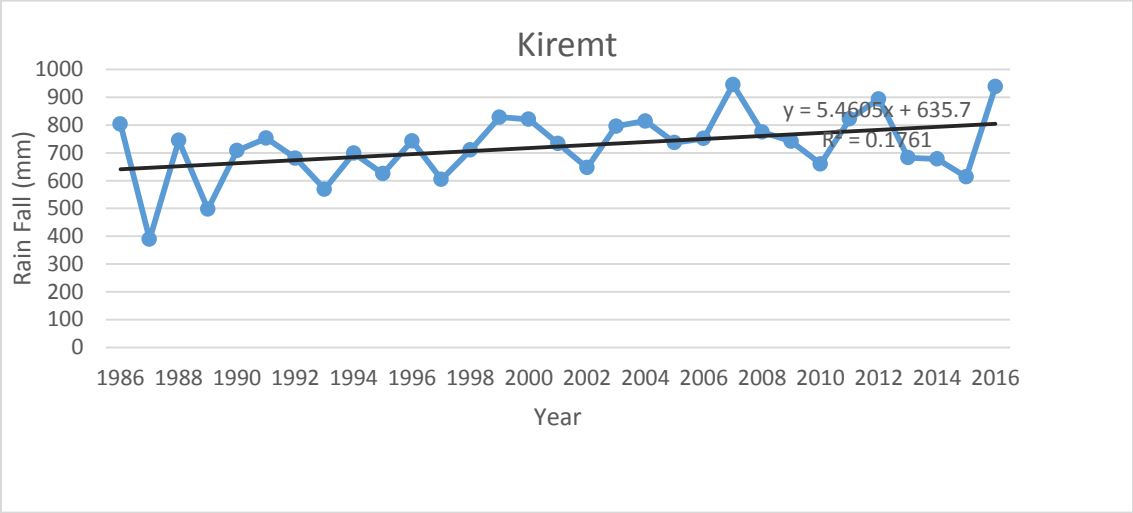
In the *AnkoberWoreda*, for the period of 1986-2016, annual rainfall ranging from 442.4 mm to 1083.5 mm with 2007 the moistest year and 1993 driest of all respectively.

4.7.3Results from Analysis of the Trends in the Climatic Variables and their Variability

4.7.3.1Results from Analysis of the Trends in Rainfall

Figure 9 shows the time series of June to September (Keremt) rain fall. It can be deduced from the figure that there is a positive trend in the rain fall of this season. The highest amount of rainfall recorded in 2007 (946.2mm) and the lowest amount recorded in 1989 (497.6mm). There is 448.6mm range between the two points. These indicate that highest rainfall amount variation at *kiremt* season was recorded through the last 31 years.

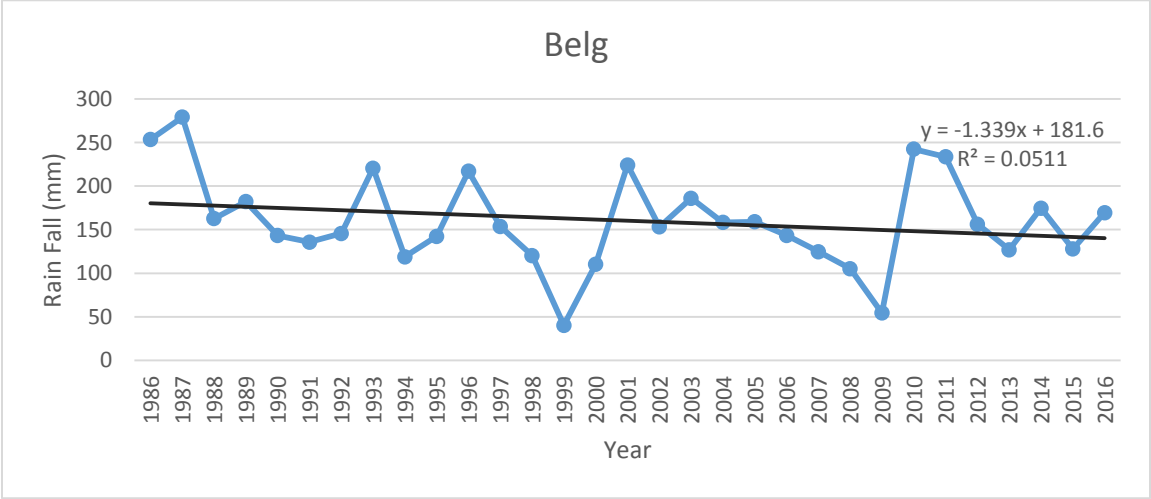
Figure 9. Time series of *Kiremt* Rain fall (1986-2016)



Source: NMA

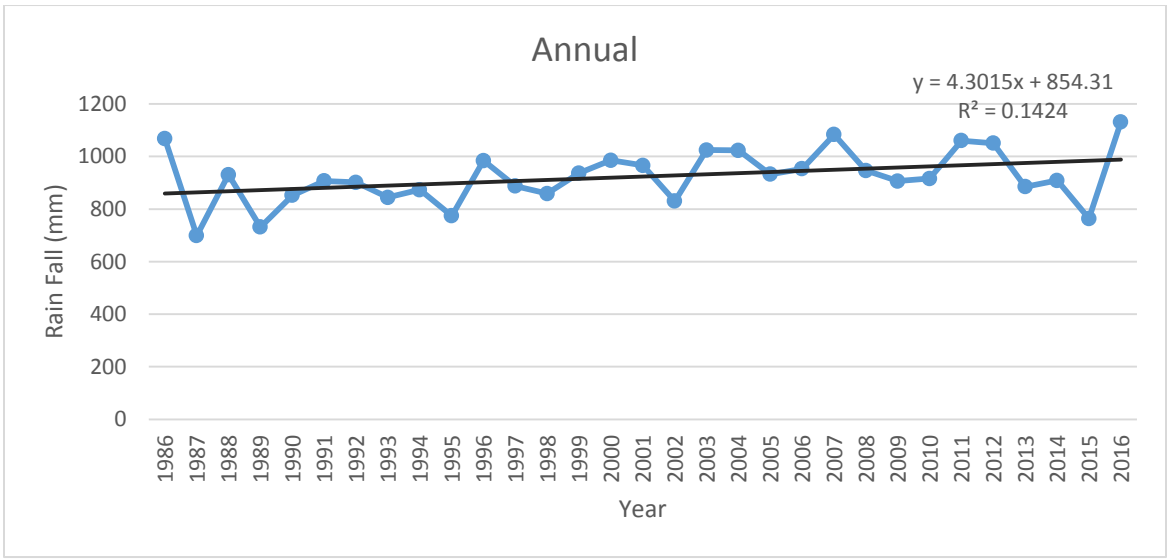
The time series of the second rain fall season "Belg" (February to May) is shown in Figure 7 below unlike "*keremt*" the rain fall during this season shows a negative trend. The amount of *Belg*rainfall in the study area has decreased by 40.7mm in the past 32 years with an annual decrement of 1.34mm.This indicate the amount of rainfall at *Belg*season it changes by dry rainfall season through the time 1986 toward.

Figure 10. Time series of annual Rain fall*Belg* (1986-2016)



Source: NMA 2018

Figure 11.Time series of annual Rain fall (1986-2016)



Source: NMA 2018

But the Overall, the time series of the annual rainfall amount which is indicated in Figure 8 have displayed an increment in it trend. In 2016 the highest amount of rainfall recorded (1131mm) and lowest amount recorded in 1987(698.5mm) in the study area. This implies the amount of annual rain fall in this *wereda* highest variation and range throughout 31 consquitive years.

4.8. Household Perception on the ClimateVariability /Change

Perception is the process of accomplishing awareness or understanding of sensory information (Maddison, 2007). They perceive there is an increase in temperature and decrease in precipitation but their perception about climate change not evidenced from weather monitoring stations (Maddison, 2006).

As indicated in the Table 4.9 below sample respondents/households were asked about their perception regarding the existing climate change that they are observing. Accordingly, the community living in the research areas clearly recognizes the climate change happening to their areas. The majority of the respondents confirm that people are expressing the adversely changing climate situation that is associated with increasing temperature, decreasing rainfall, loss of crops and animals, etc. this adversely changing climate and significantly impacted the life of many households. Out of the total sample respondents, 181(96.8%) of them (respondents) reported their vulnerability to the danger of the present climate change.

Table 9.Households Perceptions of Climate Changes

Climate change perceptions	**No.**	**percent**
Increase in day to day temperature	187	100
Decrease in amount of rainfall	182	97.3
Fluctuation of rain during *Kiremt*and*Belg*	187	100
Drying of ponds/springs in your area	161	86.1
Fluctuation of streams/river water volume	171	91.4
Drying of wet lands	166	88.8
Increased drought and flood frequency	174	93
Vulnerability of unfertile soil	174	93
Loss of crop variety and animal	174	93
Decline of agriculture yields	177	94.7
Prevalence of diseases	174	93

Source: Survey data 2019

The sample respondents were also asked to react about the major reasons that trigger the climate change in their *kebeles*. Accordingly, the sample households categorized the major factors that brought climate change in their area. One is the change(climate) occurred naturally and the second with human related factors. Besides, a significant number of respondents 24(13.1%) replied that communities living in the study area believe that the vulnerability occurred due to

climate changes is taken as acts of god. Whereas, the majority of the households (59.1 %) said that both natural and human factors are the cause of present climate changes.

However, household's educational level is one of the most difficult elements to cop up the impact of climate effects. One of selected farmer's developments of agriculture elders states that:

> *First of all one can easily understood that the educational level of farmers has a direct link with the perception to climate variability. Farmers with relatively higher education levels have opportunities to get information from schools, environmental clubs and other sources of information. Thus farmers with higher educational level have better perception than farmers with lower levels of education. Conversely, farmers who come from low level of education are losing all the above benefits.*

From human factors population pressure (51.4%) is the most factor of climate variability (change) on the study area; and then deforestation account to 25%, the rest over cultivation and over grazing are small amount on the effect of the changing climate condition according to selected respondents.

> *Interviewees and FGD participants were asked about the causes of climate change/ variability in their area? Accordingly, a significant proportion of the respondents replied that climate change is primary caused by deforestation, overgrazing, population pressure and are the key factors that causes the climate change.*
>
> *FGDs and interviewees were asked to identify the observed indicators of climate/variability. Accordingly, participants confirmed that some indigenous plant species like zigiba, wanza, and koso are highly decreased in number and some wild animals like midaqua, suse and dikula are totally disappeared from the study area and forced to migrate far from our wereda. And the impact of the climate change resulted in decreasing of water availability and loss of biodiversity and land degradation as indicators of increasing temperature in the study area and finally drought, rain shortage and livestock loss has become the dominant problem in our wereda.*

Figure 12 Land degradation because of human and natural factors

Table 10.Respondants Perceptions on the Causes of climate changes

		No	**Percent**
cause of climate change	Natural factors	21	11.5
	Human Factors	30	16.4
	Both	108	59.1
	Acts of God	24	13.1
	Total	183	100
type of human cause	over cultivation	14	7.6
	Population pressure	94	51.4
	Deforestation	25	13.7
	Over grazing	50	27.3
	Total	183	100

Source: Survey data 2019

However the households and other stockholders try to reduce the impact of climate variability/ changes and humans impacts on the study area, by using different coping mechanism.

The Table below shows this type of household's resistance to the impact of climate variability in terms of different methods.

Table 11.Households and other stockholders Coping Mechanisms

Coping Mechanisms		**No.**	**Percent**
Use different variety of crops	Yes	173	92.5
Drought resistant crops use	Yes	27	14.4
	No	99	52.9
Coping during long period drought	Selling cattle	25	13.4
	Borrowing money	162	86.6
Diversity adoption mechanisms	Crop diversification	98	52.4
	Growing short maturing crops	3	1.6
	Being selective in crop variety	58	31.0
	Shift in cropping pattern	23	12.3
The role of different organization	Giving early warning system	55	29.4
	Safety net program	26	13.9
	By providing credit	106	56.7

Source: Survey data 2019

As it can be observed from Table 4.10, respondents were asked to respond about the type of coping mechanisms that the community is performing. Accordingly the Table above, 173 (92.5%) of the sample respondents replied that different variety of crops are produced and in order to cope with the existing bad climate change. Again, 99 (52.95%) of the sample households did not use short season /drought resistant crops as coping mechanism.

Similarly, 162 (86.6%) of the sample respondents were replied that borrowing money as coping during long period drought diversity adoption mechanisms and selling cattle, growing short maturing crops, shift in cropping pattern and the like are widely practicing. Besides, respondents were asked to respond about the role of different organizations/institutions found in their respected *weredas*. Accordingly, organizations working around *AnkoberWereda* actively involved in giving early warning system, safety net program and providing credit to the community and the share of these activities are (29.4 %, 13.9% and 56.7%) respectively.

During FGD and interview session participants were asked about the responsibilities of the local peoples and the response of government organization. According to the response offered from the participants:

> *The local community need to look some strategies like replanting of trees, constricting terracing, diversifying the crops, developing and maintain spring water and rivers, re-applying the indigenous knowledge and so on. Regarding the government , periodic follow up and supervision has to be implemented, facilitate and organize training on environmental protection, introduce fast growing trees , drought resistant crops and budgeting good amount of money to replant trees and construct terracing and bridges.*

Figure 13 Reforestation

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Conclusion

The composition of household participating in the survey, regarding the gender of the households the majority were found male and the remaining households (40.6%) were female headed households. This figure clearly indicated that participation of female households in agricultural activities was relatively low in the study area. Therefore, an effort has to be exerted to promote and enhance the participation of females in all aspects of agricultural activities. In fact, female households, their participation at agricultural as well as community development activities were reasonably improved comparing to the previous trend. But, the proportion of female in the stunt areas was significantly less to that of male counterparts. Thus, attention must be given to female household as long as better natural resource prevention is concerned.

The composition of the population in AnkoberWoreda indicated that these households constitute 68.4 % of them were Orthodox Christians, 23.5% were belongs to Muslims and 8% of them were found as protestant. A significant proportion of the household were found nearly 47 years and a reasonable amount of the respondents were relatively energetic, matured and fit to take responsibilities and able work efficiently as well. Having reasonably matured age significantly impacts on the efficiency of the households because these people are ready and fit to take responsibilities as per needed.

Most of the households are able to read and write. From this result one can realize that significant number of the sample respondents has the ability to read and write and can understand and implement their activities as to their capacity. The education level of households was composed of 27.8% illiterate heads; and 40.1% of the households can only read and write. The rest of the households, constituting 20.3% are at primary education level, while only 11.8% of the households were found at high school education level.

The average family size in the household was six members; where the numbers of males were more than the number of females in the study area. The average land size holding of the

household in the study area was 0.59 hectares of land and for their rain-fed agricultural practice in the production of crops.

Regarding the perception on climate change, people leaving in the study area are expressing the adversely changing climate situation that is associated with increasing temperature, decreasing rainfall etc. This adversely changing climate has impacted the life of many households. As to the finding of the study, 96.8% of the respondents reported their vulnerability to climate change. Besides, the majority of the households believed that the causes of climate changes as acts of God (or natural), as well as human made; such as deforestation and over cultivation.

As a result households in the study area frequently experienced loss of crops and animals, due to draught and water shortage, that endangered their livelihood. The area experienced the loss of cattle per household during the last three years. Furthermore, households also experienced loss pack animals (donkeys) while the number of sheep's and goats declined by 55% and 18% respectively.

Climate variability affected all the households in Ankoberworeda in general and the sample kebeles in particular. The severity of the effect was found extremely high in case of 22.5% of the households. Besides, 48.7 % of the respondents had encountered high level impact while the climate change had resulted moderate level impact to the rest of the households in the study area.

The climate changes in the study area had caused different negative impacts and consequences. As to the finding of the study, the most significant impacts households identified includes were decrease of forage availability, as witnessed by 92% of the households' response. Other consequences of climate change were change in seeding period and change in harvesting time that 88.8% and 70% of the households witnessed respectively.

Considerable number of households had experienced decreased crop yield over the years while 12.9% of the households were experienced increased pests and weeds to their crops. This figure indicated that the study area have facing production lose. The households use different coping mechanisms to ease the impact of climate changes in their area. Accordingly, almost all of the villagers (households) were used different varieties of crops. Out of them, 52.4% of the sample households were used crop diversification for coping mechanisms. While 31.0% of the

households have involved in selective the crop variety; and the remaining households were adopting shift in cropping pattern.

Most of the farmers in the study area were accessing credit facilities. Accordingly, 86.6% of the households were borrowing the money for coping during long period of drought and the rest of the sample households were forced to sell their cattle in order to cope with their problem like food shortage, clothing and the so on. The role of government organizations were mainly on the provision of credit and this was reported by 56.7% of the households of the sample kebele's.

5.2. Recommendations

The findings of this study are believed to have some recommendations for practice. The implication might show areas of intervention to improve the existing dangers climate change. Accordingly, the following recommendations are made on the basis of the research findings and the conclusion.

- As to the finding of the study, in many cases most of the households were vulnerable to the climate change and this negatively impacts the livelihood of the farmers in the study area. Thus, extension services (in agriculture issues) need to address the farmersand priorities of the poor which attributes to the resilience of climate change and assuring food security.
- Again, the livelihood bases of theAnkoberworedamostly influenced by climate change and vulnerability. Thus, the concerned stakeholders and the local government should enhance the development intervention in order to encourage the farmers to tackle the existing climate.
- It is very mandatory and timely advice to supporting indigenous practices of the community in the study area because these peasants have wide and deep rooted practices in general agriculture, forestation and physical soil conservation measures like terracing and the so on. This is therefore, the community together with the local as well as the regional government need to encourage and reuse the forgotten indigenous practices by the community.
- Ankoberwereda administration together with the agriculture and woreda environmental protection office should establish early warning system in each of the rural community and help them to be aware of the danger of the climate change and its negative impacts as

well. Besides, associate the household with modern metrological measurements for reliable outcomes.

- The Ethiopian government already implementing the extension service on agronomic, livestock and natural resource management and these practices have attributed to the adaption of climate change. Thus, such practices should be addressed to the farmers (the households) because such measures will improved, intensified and expand for assuring food security and resource management in the study area.

  The last but not the least, Ministry of Agriculture, Metrological Agency, Environmental protection agency and all concerned bodies of Ankobereworeda should facilitate and offer continues training opportunities, allocation of adequate budget and resource, capacitate the ability of extension workers as long as friendly climatic zone is concerned.

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Appendix 1

ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES COLLEGE OF SOCIAL SCIENCE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

QUESTIONNAIRE FOR HOUSEHOLD HEADS (Farming Peasants in the Community)

Dear Respondents: My name is Mrs. Abinet W/Aregay, a graduate student of Addis Ababa University. I am conducting a research for the partial fulfillment of master degree in geography and environmental studies. The main objective of this questionnaire is to understand AnkoberWoreda's Farmers' perception and toward climate change, its impact and their adaptation strategies. This type of study is important for planners as well as decision makers at different level. Therefore, the information that you provide is believed to help the concerned bodies in understanding farmers' knowledge on climate change, its impacts and their adaptive strategies. Hence, taking the above objectives into consideration, you are kindly asked to provide the appropriate answer for the following questions.

Note to respondents

1. The response you give will not have any negative impact on you.
2. No need of writing your name on the questionnaire.
3. Please respond for in feeling free warty on think is correct.

Part I Background information

Kebele----------

1. Sex of household head: _____
2. Age of household head _____
3. Religions of household head _____
4. Marital Status A. Married B. Single C. Divorced D. Widowed
5. Educational Status A. Illiterate B. Read and write C. Primary education completed

D. High school complete E. Higher education complete

6. Family size Male……. Female……Total ……
7. Ethnic group

2. Socio economic conditions of households

8. Which income generating activities have been used as a source of livelihood for the households?

S.NO	Livelihood activities	yes	No
1	Crop production		
2	Sales of fire wood		
3	wood products such as stool and other		
4	Charcoal production		
5	Wage laborer		
6	Trading livestock		
7	Hand craft		
8	Traditional Healer		
9	Pensioned		
10	Remittance		
11	Ox renting		
12	Land renting		
13	Cattle fattening		
14	Milk and yoghurt selling		
15	Hides and skins production		
16	Livestock forage selling		
17	Animal breeding		
16	off farm activity		
17	Other activities (speciy)		

9. Do you have your own farm land? A. yes B. No

10.If your answer is yes, how many hectares of land do you have? _____

11. For what purpose your farm lands are used for? A. For pasture B. Crop production only C. Use for both D. If other specify

12. Type of agriculture practiced A. Rain fed only B. Irrigation only C. Both

13. If you used irrigated agriculture estimate the size of cultivated land _____ hectare.

14. For how long have you been farming? _____

15/ what are the main types and number of livestock that you are breeding?

S.NO	Livestock type	Number of livestock (before five years)	Number of livestock at present)
1	Cattle		
2	Camel		
3	Donkey		
4	Goat		
5	Sheep		
6	Other specify		

16.what are the most prevailing problem of livestock production in your locality?

A. Degrading of pasture (drought) D. shortage of water

B. Livestock disease (epidemic) E. increase in temperature

C. Absence of animal health treatment F. --------, --------, ------, ------can be possible answer

G. If others specify

17.was there any livestock death observed due to climate variability induced effect for the last three successive years? A. yes B. No

18. What are the main types and amount of crop production that you are the household produces?

19. Do you have access to financial credit? A. Yes B. No

20. If your answer is yes where do you get the credit? ……

3. **Farmers' perception of climate change and variability based on the last 10 years**

21.Have you heard about climate change before? A. Yes B. No

No	Indicators of climate variability	change Please put the (x)
1	Increase in temperature	
2	Decrease in temperature	
3	Increase in rainfall amount	
4	Decrease in rainfall amount	
5	Fluctuation of rainy season	
6	Drying of local ponds and springs	
7	Fluctuation in the volume of rivers and streams water	
8	Drying of wet lands	
9	High Frequency of drought	
10	Flood frequency	
11	Decline of soil fertility	
12	Loss of some crop variety	
13	Loss of some animal types	
14	Decline of agriculture yields	
15	Prevalence of human and animal diseases those are not familiar to the area	
17	Decline of forest resources	
18	If any specify	

22. Do you believe that there is climate change /variability in the area? A. Yes B. No

If yes what are the indicators of climate variability and change? (Multiple answers is possible)

23. From which source did you heard about climate change?

A. Radio B. School C. Television D. Government Organization

E. Non-government Organization F. Local people

24. What do you think about the main cause of climate change? A. Natural factors

B. Human factors C. Human and natural factors D. Acts of God E. If other (specify) ----------

25. If your answer to question number 21 is "Human factors" which of the following is the major causes of climate change?

A. over Cultivation B. Population pressure C. Deforestation D. Air pollution E. Over grazing

26. What are the patterns of seasonal variation of rain fall in your locality?

A. Normal, B. Late coming and early cessation, C. Late coming and late cessation,

D. Early coming and late cession E. If others specify

27. If your answer to question number' 26 'is' late coming and early cessation of rain fall, what would often happen in your locality? **A**. Decrease crop production **B.** Decrease in pasture land **C.** Drought **D.** Mobility due to scarcity of natural resource **E.** Increase livestock loss **F.** Distortion of production during harvesting time **G.**___, ___, ___, can be possible answers **H.** If others specify

28. What is your general perception on the characteristics of water cycle of the area in terms of its temperature and precipitation condition?
A. Erratic rain fall with slightly decreasing trend and increasing in temperature
B. Complete absence of rain fall and decreasing in temperature
C. uniformity in temperature and rain fall
D. if other specify

29. Do you feel that temperature of the area is changing?
A. Yes, very much B. Yes, I do C. No, I do not D. I do not know
30. Is diversity of crops changing?
A. Yes B. No C. I do not
31. Did you encounter complete crop failure?
A. Yes, very much B. Yes C. No, there is no D. I do not know
32. Is there an increase of livestock health problem due to climate change?
A. Yes, very much B. Yes C. No, there is no D. I do not know
33. If yes, what kind of Animal diseases more frequently affect your animal?----------
34. How many livestock died in your house because of drought or climate change caused problem?
35. Is there an increase of human health problem due to climate change? **A.** Yes **B.** No **C.** I do not know, If yes, what kind of health problem did you encountered?_____

Part III. Impact of climate change induced hazards on local farmers

36. what impacts do the temperature and rainfall trends have brought on agricultural production?
A. Decrease in crop yield production B. Decreased forage availability C. Increased incident of crop pest and weeds D. Change in seeding period E. Changing harvesting time F. Other (specify)

37. How would the NGO's ,regional government institutions, and private sector intervene and respond to reduce the impacts of climate variability condition in your particular local level?
A. Through giving early warning systems on climate variability and impacts and providing agricultural input
B. Safety net program
C. by providing credit
D. No one attempted to see these problems in our locality so far
E. ___,___,___, can be possible answers

F. If others specify----------

Part IV. Farmers' level of adaptation strategies

38. Do you use different varieties of crops?

A1. Yes B. No C. I do not know

39. If yes please explain crop varieties that you are using.

40. Did you apply short season growing crop and drought tolerant varieties?

A. Yes B. No C. I do not know

41. If yes, what are they?

42. What is your copping mechanism when you encountered long period drought?

A. Selling cattle B. Migration C. No copping mechanism D. Eating seeds

E. Borrowing money from relative or credit association

43. What are your diversity adaptation mechanisms?

A. Crop diversification

B. Growing short maturing crops

C. Being selective in crop variety

D. Shift in cropping pattern

E. Using small scale irrigation

F. Others ------if others please specify

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Appendix 2
Addis Ababa University
College of Social Science
Department of Geography & Environmental Studies

Interview Questions to be answered by key informants (Agricultural Development Officers, Community Officials, Elders and model farmers.

Dear respondent:

The purpose of the interview is to assess the community perception regarding the climate change and variability and also their understanding about the coping strategy that they are employing: In the case of Ankober Woreda North Shewa Zone, Amhara regional state. Your valuable information is essential for the completion of the research and is used for research purpose only. Therefore you are kindly requested to give your genuine response for the interview.

Questions for Key Informant Interview (KII)

1. Is there any variability of temperature and rain fall in AnkoberWoreda in the past 10 years?

A. Yes B. No

2. What do you think to be the causes of climate change/ variability?
3. What are the observed indicators of climate change/ variability?
4. How do you understand the impacts of climate change/ variability on your livelihood?
5. What are the main impacts of climate change/ variability on the community, on the livestock and the environment? List down
6. Who are the most vulnerable livelihood sectors to climate change/ variability?
7. Who is responsible to give response to the variability of climate?
8. What are the impacts of climate change/ variability on people's health?
9. What are the responsibilities of the local peoples?
10. What is the response of government organization?
11. What are the local peoples coping mechanisms used to reduce the impacts?
12. What are the main challenges and how do you think that they can be improved?

Appendix 3
Addis Ababa University
College of Social Science
Department of Geography & Environmental Studies

In-depth interviews of certain groups (Kebele representative and woredasectoral representative as indicated in methodology section)

1. What does climate change mean?_____

2. What are manifestations of climate change?

3. What is climate variability, climate change impact and adaptation and the main differences?

4. What are the main causes of climate change?

5. How can you adapt to climate change?

6. What is your opinion about the current climate change status in your local area?

What are the main impacts caused by climate change?

_____

_____

Who are more concerned about the impacts of climate change?

1. Social status: male or female

Old or young

2. Economic status: Poor or rich

7. What are the major factors associated with the perception of farmers about the impacts of climate change on socioeconomic conditions?_____

_____

_____

_____

8. Who is the most important to provide information about the impacts of climate change to the community?

_____

_____

_____

_____

_____

9. Were you affected by the past drought? If the answer is yes mention the impact of drought on your wealth (crop production, livestock, food security, health and drinking water)

_____

_____

10. What coping strategies do the peoples apply when drought break out?

_____

_____

_____

_____

Annex 1 Metrological data 1986-2017(precipitation)

Name	Elevation	Geogr1	Geogr2	Element	Year	Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ankober	2750	39.5	9.633333	PRECIP	2016	09:00	**12.7**	**3.4**			**66.1**	**104.3**	**496.5**	**267.1**	**70.5**	**3.9**	**7.2**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2014	09:00	**0.0**	**16.0**	**67.7**	**44.1**	**46.9**	**16.8**	**260.3**	**291.0**	**110.0**	**55.9**	**0.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2015	09:00	**0.0**	**0.0**	**24.9**	**0.0**	**102.9**	**95.8**	**117.6**	**248.5**	**151.8**	**6.1**	**8.8**	**7.3**
Ankober	2750	39.5	9.633333	PRECIP	1986	09:00	**0.0**	**74.7**	**99.2**	**52.5**	**27.0**	**141.9**	**271.3**	**274.7**	**115.7**	**11.3**	**0.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	1987	09:00	**5.0**	**19.2**	**108.1**	**51.7**	**100.2**	**0.0**	**32.3**	**309.5**	**47.5**	**18.7**	**0.0**	**6.3**
Ankober	2750	39.5	9.633333	PRECIP	1988	09:00	**10.6**			**83.1**	**16.2**	**16.0**	**286.2**	**290.0**	**153.1**	**12.1**	**0.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	1989	09:00	**2.3**	**40.5**	**97.6**	**42.7**	**1.4**	**41.1**	**211.4**	**177.4**	**67.7**	**18.6**	**0.0**	**30.7**
Ankober	2750	39.5	9.633333	PRECIP	1990	09:00	**0.0**	**62.2**	**20.7**	**59.5**	**0.9**	**1.6**	**321.0**	**217.2**	**168.7**	**0.6**	**0.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	1991	09:00	**4.8**	**8.3**	**64.6**	**21.0**		**63.7**	**215.6**	**387.5**	**86.6**	**6.4**	**0.0**	**6.4**
Ankober	2750	39.5	9.633333	PRECIP	1992	09:00	**30.3**	**26.7**	**19.4**	**80.2**	**19.3**	**13.3**	**307.6**	**267.6**	**92.9**	**41.9**	**0.5**	**1.8**
Ankober	2750	39.5	9.633333	PRECIP	1993	09:00		**43.2**	**0.0**	**116.9**	**60.5**	**9.1**		**168.4**		**43.2**	**0.0**	**1.1**
Ankober	2750	39.5	9.633333	PRECIP	1994	09:00	**0.0**	**0.0**	**95.6**	**0.0**	**23.2**	**92.7**	**281.7**	**222.9**	**101.7**		**36.5**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	1995	09:00	**0.0**	**28.5**	**19.1**	**68.4**	**26.3**	**23.3**		**233.8**	**60.4**	**5.1**	**0.0**	**1.7**
Ankober	2750	39.5	9.633333	PRECIP	1996	09:00	**20.7**	**2.8**	**75.4**	**9.7**	**129.2**	**138.0**	**328.4**	**252.5**	**24.3**	**0.0**	**3.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	1997	09:00	**29.5**	**4.0**	**41.2**	**82.4**	**25.9**	**96.9**	**272.1**	**200.6**	**34.8**	**89.7**		
Ankober	2750	39.5	9.633333	PRECIP	1998	09:00	**23.1**	**13.2**	**14.9**	**49.3**	**43.0**	**13.5**	**337.3**	**289.0**	**70.6**	**5.2**	**0.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	1999	09:00	**6.9**	**0.0**	**26.5**	**2.8**	**11.0**	**48.9**	**362.4**	**365.1**	**52.4**	**59.6**	**1.4**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2000	09:00	**0.0**	**0.0**	**25.9**	**47.3**	**37.1**	**45.8**	**352.4**	**317.5**	**105.2**	**28.5**	**18.8**	**6.8**
Ankober	2750	39.5	9.633333	PRECIP	2001	09:00	**0.0**	**33.8**	**71.2**		**64.6**	**34.9**	**406.7**	**260.4**	**32.2**	**4.1**	**0.0**	**3.4**
Ankober	2750	39.5	9.633333	PRECIP	2002	09:00	**18.1**	**28.0**	**60.6**	**46.1**	**18.4**	**29.1**	**214.4**	**294.8**	**109.1**	**3.1**	**0.0**	**8.4**
Ankober	2750	39.5	9.633333	PRECIP	2003	09:00	**15.6**	**36.3**	**60.2**	**85.7**	**3.8**	**99.5**	**334.1**	**288.7**	**74.2**		**0.0**	**7.4**
Ankober	2750	39.5	9.633333	PRECIP	2004	09:00	**24.4**	**9.7**	**29.7**	**113.3**	**5.6**	**99.7**	**334.7**	**301.3**	**78.9**	**14.1**	**11.8**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2005	09:00	**34.3**	**4.5**	**28.6**	**49.5**	**76.4**	**91.1**	**310.7**	**228.3**	**106.8**	**0.7**	**1.5**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2006	09:00	**17.3**	**24.4**	**61.0**	**38.3**	**19.8**	**35.2**	**432.6**	**224.2**	**59.8**	**8.6**		**26.3**

Ankober	2750	39.5	9.633333	PRECIP	2007	09:00	**2.0**	**30.4**	**8.9**	**71.8**	**13.6**	**93.2**	**309.9**	**414.6**	**128.5**	**4.9**	**5.7**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2008	09:00	**0.3**	**1.7**	**0.0**	**34.6**	**68.9**	**66.4**	**397.7**	**234.8**	**76.6**	**9.9**	**54.6**	**1.2**
Ankober	2750	39.5	9.633333	PRECIP	2009	09:00	**47.2**	**0.0**	**8.1**	**31.4**	**14.9**	**13.7**	**423.4**	**273.1**	**31.3**	**36.6**	**1.2**	**25.3**
Ankober	2750	39.5	9.633333	PRECIP	2010	09:00	**0.0**	**25.2**	**55.7**	**119.3**	**42.2**	**35.4**	**242.3**	**329.2**	**53.8**	**0.3**	**8.5**	**3.9**
Ankober	2750	39.5	9.633333	PRECIP	2011	09:00	**0.3**	**7.0**	**76.8**	**38.6**	**111.2**	**73.4**	**357.4**	**312.3**	**79.0**	**0.0**	**4.3**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2012	09:00	**0.0**	**0.0**	**5.2**	**93.3**	**57.9**	**56.0**	**351.6**	**394.5**	**92.4**	**0.0**	**0.0**	**0.0**
Ankober	2750	39.5	9.633333	PRECIP	2013	09:00	**0.8**	**0.0**	**48.8**	**54.2**	**23.9**	**40.1**	**358.5**	**204.4**	**79.6**	**63.1**	**11.5**	**0.0**

Annex 2 Metrological Data 1986-2017(maximum temperature)

Ankober	2750	39.5	9.633333	TMPMAX	2014	18:00	**19.7**	**20.9**	**21.3**	**20.9**	**21.3**	**22.8**	**20**	**18.4**	**18.7**	**19**	**20**	**19.6**
Ankober	2750	39.5	9.633333	TMPMAX	2015	18:00	**20.6**	**21.9**	**21.9**	**22.5**	**21.6**	**22.2**	**21.2**	**18.9**	**19.6**	**20.9**	**20.2**	**19.8**
Ankober	2750	39.5	9.633333	TMPMAX	2016	18:00	**20.4**	**22**			**21.1**	**21.6**	**18.3**	**18.4**	**19.5**	**20**	**19.7**	**18.8**
Ankober	2750	39.5	9.633333	TMPMAX	1986	18:00	**20.4**	**19.9**	**19.1**	**19**	**20.9**	**19.3**	**18.6**	**18.1**	**18.3**	**18.5**	**19**	**19.5**
Ankober	2750	39.5	9.633333	TMPMAX	1987	18:00	**19.5**	**20.9**	**19.5**	**19.7**	**19.5**	**21.9**	**22.4**	**19.5**	**19.8**	**19.5**	**19.8**	**20.1**
Ankober	2750	39.5	9.633333	TMPMAX	1988	18:00	**20.3**		**21.5**	**20.6**	**22.1**	**22.1**	**17**	**17.6**	**18**	**17.4**	**17.9**	**18.3**
Ankober	2750	39.5	9.633333	TMPMAX	1989	18:00	**19**	**18.5**	**19.7**	**18.1**	**20.4**	**21.4**	**18.8**	**17.2**	**18.2**	**18**	**18.7**	**18**
Ankober	2750	39.5	9.633333	TMPMAX	1990	18:00	**19**	**18.5**	**19.9**	**20.1**	**22.6**	**23**	**18.6**	**18.9**	**18.4**	**18.2**	**18.5**	**18.8**
Ankober	2750	39.5	9.633333	TMPMAX	1991	18:00	**23.3**	**22.7**	**22.7**	**22.1**		**22.5**	**18**	**17.8**	**19**	**18.2**	**18.6**	**18.3**
Ankober	2750	39.5	9.633333	TMPMAX	1992	18:00	**18.1**	**18.9**	**21.7**	**21.5**	**21.6**	**22.6**	**18.3**	**16.6**	**17.5**	**17.3**	**17.3**	**18.7**
Ankober	2750	39.5	9.633333	TMPMAX	1993	18:00	**18.9**	**18.7**	**20.6**	**19.4**	**19.9**	**21.9**	**18.5**	**18.9**	**18.4**	**18**	**18.2**	**18.9**
Ankober	2750	39.5	9.633333	TMPMAX	1994	18:00	**19.7**	**20.9**	**20.4**	**21.5**	**22**	**21.4**	**17.4**	**17.6**	**18.1**		**19.3**	**19.8**
Ankober	2750	39.5	9.633333	TMPMAX	1995	18:00	**20.2**	**20.8**	**21.3**	**20.8**	**22.1**	**23.4**		**18.7**	**19.4**	**19.2**	**19.8**	**19.7**
Ankober	2750	39.5	9.633333	TMPMAX	1996	18:00	**19.1**	**21.8**	**20.7**	**21.2**	**20.1**	**19.2**	**18.5**	**18.6**	**19.6**	**18.9**	**18.7**	**18.4**
Ankober	2750	39.5	9.633333	TMPMAX	1998	18:00	**19.8**	**21**	**20.9**	**22.2**	**22.4**	**23.3**	**17.8**	**17.7**	**18.7**	**18.6**	**18.4**	**18.4**
Ankober	2750	39.5	9.633333	TMPMAX	1999	18:00	**19.3**	**21.5**	**20.5**	**21.8**	**22.6**	**22.4**	**17.1**	**18.1**	**18.6**	**17.9**	**17.8**	**18.6**
Ankober	2750	39.5	9.633333	TMPMAX	2000	18:00	**19.7**	**20.5**	**21.5**	**20.8**	**21.8**	**22.7**	**18.3**	**17.7**	**18.5**	**18.4**	**18.5**	**19.4**
Ankober	2750	39.5	9.633333	TMPMAX	1997	18:00	**19.2**	**20.1**	**21.2**	**19.9**	**21.4**	**21.1**	**18**	**18.3**	**19.3**	**18.3**	**18.8**	**19.8**
Ankober	2750	39.5	9.633333	TMPMAX	2001	18:00	**19.9**	**20.8**	**19.2**	**21.2**	**22.2**	**21.5**	**17.9**	**17.6**	**19.6**	**19.9**	**19.6**	**19.3**
Ankober	2750	39.5	9.633333	TMPMAX	2002	18:00	**19.5**	**21.2**	**20.7**	**21.4**	**23**	**22.8**	**21.5**	**17.5**	**18.6**	**19.6**	**19.8**	**19.3**
Ankober	2750	39.5	9.633333	TMPMAX	2003	18:00	**20.3**	**21.4**	**21.2**	**20.8**	**21.8**	**22.5**	**18**	**18.3**	**19**	**19.4**	**18.5**	**19.4**
Ankober	2750	39.5	9.633333	TMPMAX	2004	18:00	**20.7**	**20.4**	**21**	**20.4**	**23.1**	**21.2**	**18.7**	**18.7**	**19.1**	**18.6**	**19.5**	**19.6**
Ankober	2750	39.5	9.633333	TMPMAX	2005	18:00	**20.1**	**22.1**	**22**	**21.3**	**20.4**	**21.6**	**18.3**	**18.9**	**19.3**	**19**	**18.8**	**18.9**
Ankober	2750	39.5	9.633333	TMPMAX	2006	18:00	**20**	**21**	**20.5**	**20**	**21.9**	**22.6**	**19**	**18**	**18.6**	**19.6**		**19.1**
Ankober	2750	39.5	9.633333	TMPMAX	2007	18:00	**19.9**	**20.6**	**21.8**	**20.8**	**22.7**	**21.2**	**18**	**18.2**	**18.7**	**19**	**18.6**	**18.7**
Ankober	2750	39.5	9.633333	TMPMAX	2008	18:00	**20**	**20.2**	**22**	**20.8**	**21.3**	**21.2**	**18.9**	**19**	**19.4**	**19.2**	**18.4**	**19.1**
Ankober	2750	39.5	9.633333	TMPMAX	2009	18:00	**19.3**	**20.3**	**21.5**	**21.7**	**22.4**	**23.6**	**17.9**	**18.7**	**19.9**	**18.8**	**19.7**	**18.5**
Ankober	2750	39.5	9.633333	TMPMAX	2010	18:00	**19.8**	**20.9**	**20.4**	**20.8**	**21.3**	**22.7**	**18.7**	**18.1**	**19**	**19.8**	**19.2**	**19.2**
Ankober	2750	39.5	9.633333	TMPMAX	2011	18:00	**19.5**	**21.6**	**20.1**	**21.9**	**21.2**	**22.2**	**19.1**	**18.2**	**18.8**	**19.4**	**19.4**	**19.4**
Ankober	2750	39.5	9.633333	TMPMAX	2012	18:00	**20.3**	**21.3**	**22.1**	**20.6**	**21.4**	**22.3**	**18.4**	**18.3**	**19.4**	**19.8**	**20.5**	**20.2**
Ankober	2750	39.5	9.633333	TMPMAX	2013	18:00	**20.8**	**21.9**	**22.1**	**22.2**	**22**	**22**	**17.6**	**17.4**	**19.1**	**18.8**	**19**	**19.1**

Annex 3 Metrological Data 1986-2017(minimum temperature)

Name	Elevation	Geogr1	Geogr2	Element	Year	Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ankober	2750	39.5	9.633333	TMPMIN	1986	09:00	3.8	7.4	7.6	8.6	7.7	8.6	8.3	8	6.1	4.5	4.3	5
Ankober	2750	39.5	9.633333	TMPMIN	1987	09:00	5	6.9	8.8	8	8.7	7.7	8.5	8.9	7.6	5.5	4.2	5.2
Ankober	2750	39.5	9.633333	TMPMIN	1988	09:00	6.8		13.5	8.2	7	6.6	9.7	9	7.9	3.9	-1.2	0.9
Ankober	2750	39.5	9.633333	TMPMIN	1989	09:00	0.3	6.2	7.4	8	5.5	6.3	8.7	9.2	9.4			6.7
Ankober	2750	39.5	9.633333	TMPMIN	1990	09:00	3.1	9.2	7.1	6.8	5.5	5.9	8.6	8.9	7.3	2	2.1	0.2
Ankober	2750	39.5	9.633333	TMPMIN	1991	09:00	5.3	6.1	8.4	7.7		7.4	9	8.8	7.1	1.6	1.7	0.8
Ankober	2750	39.5	9.633333	TMPMIN	1992	09:00	6.8	7.9	8.5	7.3	6.5	6.9	7.9	9	7	3.6	3.9	4.2
Ankober	2750	39.5	9.633333	TMPMIN	1993	09:00	5.8	6.9	5.8	8.2	6.8	6.5	8.8	8.6	7.8	4.5	1.5	2.5
Ankober	2750	39.5	9.633333	TMPMIN	1994	09:00	3.6	5.1	8.7	8	7.1	7.1	8.6	7.8	6.7		0.8	2.5
Ankober	2750	39.5	9.633333	TMPMIN	1995	09:00	2.8	7.5	6.7	8.7	6.4	6.7		9.2	7	2.7	1.2	5.8
Ankober	2750	39.5	9.633333	TMPMIN	1996	09:00	6.3	4.6	7.4	7.1	8	7.9	8.2	8.5	6.4	1.4	2.1	3.2
Ankober	2750	39.5	9.633333	TMPMIN	1997	09:00	6.1	2.2	8.2	7	6.7	8.5	8.6	8.1	7.1	6.1	4.3	2.3
Ankober	2750	39.5	9.633333	TMPMIN	1998	09:00	7.7	8.4	9.3	9.6	7.7	7.2	9.3	9.5	7.3	3.7	-1	-2.1
Ankober	2750	39.5	9.633333	TMPMIN	1999	09:00	2.2	3.1	5.9	5.2	5.8	6.3	8.6	8.6	6.2	4.6	-1.2	1.8
Ankober	2750	39.5	9.633333	TMPMIN	2000	09:00	1	3.4	4.8	7	7.1	5.7	8.6	8.1	6.8	3.3	1.7	1
Ankober	2750	39.5	9.633333	TMPMIN	2001	09:00	1.5	4.5	8.3	6	8.2	8	9.2	9.2	6.4	3.3	2.9	4.6
Ankober	2750	39.5	9.633333	TMPMIN	2002	09:00	5	6.3	8.4	7.6	7.7	7.6	9.1	9.1	7.5	3.1	2.8	7.2
Ankober	2750	39.5	9.633333	TMPMIN	2003	09:00	5.3	6.9	7.9	9.5	7	8	9.4	9.6	8.1	3	2.7	1.6
Ankober	2750	39.5	9.633333	TMPMIN	2004	09:00	5	4.4	5.6	8.9	6.7	8.1	9.2	9	7	3.3	2.7	5.2
Ankober	2750	39.5	9.633333	TMPMIN	2005	09:00	5.3	7.3	8.3	9.2	9.2	7.8	9.2	9.2	8.3	3.9	2	1.7
Ankober	2750	39.5	9.633333	TMPMIN	2006	09:00	5.9	8	7.5	8.5	7.4	8.2	9.8	9.8	7.4	5.4		4.7
Ankober	2750	39.5	9.633333	TMPMIN	2007	09:00	6.6	7.5	7.7	8.5	8.1	9	9.6	9.2	7.5	3.4	3.9	1
Ankober	2750	39.5	9.633333	TMPMIN	2008	09:00	5.4	5	5.5	7.7	8.6	8.5	8.6	9.2	7	4.2	4	4.6
Ankober	2750	39.5	9.633333	TMPMIN	2009	09:00	6.3	7.6	8.1	7.4	7	8.4	9.3	9.3	6.5	4.8	3.1	7.3
Ankober	2750	39.5	9.633333	TMPMIN	2010	09:00	6.4	9.3	9.2	9.2	9.2	8.1	9.1	9.3	7.2	3.7	4.1	4.8
Ankober	2750	39.5	9.633333	TMPMIN	2011	09:00	6.5	4.6	7.4	8.8	7.9	7.6	8.7	8.7	7.5	3.4	4.8	2
Ankober	2750	39.5	9.633333	TMPMIN	2012	09:00	3.8	3.5	6	8.4	7.5	7.6	8.7	7.9	6.5	1.8	1.9	3.7
Ankober	2750	39.5	9.633333	TMPMIN	2013	09:00	3.6	5.2	8.6	7.5	7.2	7.9	8.7	8.5	6.3	4.2	3.7	1.3
Ankober	2750	39.5	9.633333	TMPMIN	2014	09:00	5.6	7.1	8.3	8.3	8.3	7.1	8.5	7.5	6.3	3.9	2.8	2.4
Ankober	2750	39.5	9.633333	TMPMIN	2015	09:00	1.7	5.2	6.5	4.9	7.8	7.4	7.8	7.9	5.5	3.6	3.4	4.5
Ankober	2750	39.5	9.633333	TMPMIN	2016	09:00	7.1	6.9			7	6.8	8.1	7.6	6.9	2.8	2	1.5