



Local Vulnerability to Climate Change and Farmers' Adaptation Strategies: The case of Choke Mountain watershed, Eastern Gojjam zone

A Thesis Presented to the School of Graduate Studies of Addis Ababa University
In partial Fulfillment of the Requirement for the Degree of Master of Arts (MA) in
Environment and Development

By

Fenet Belay

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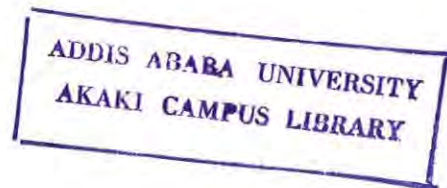
Addis Ababa University
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Center for Environment and Development

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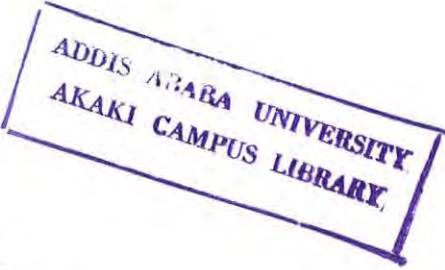
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Addis Ababa University
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Acronyms

AES	Agro Ecosystem
ARDO	Agriculture and Rural Development Office
CSA	Central Statics Agency
DFID	Department for International Development of the United Kingdom
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHG	Green House Gasses
HH	Household
Hhs	Households
IPCC	Intergovernmental Panel for Climate Change
KII	Key Informant Interview
M.a.s.l	Meter above Sea Level
NMA	National Meteorology Agency
NMSA	National Meteorological Service Agency
NAPA	National Adaptation Program of Action
SPSS	Statistical Package for Social Science
SoVI	Social Vulnerability Index
IPCC	Intergovernmental Panel for Climate Change
LVI	Livelihood Vulnerability Index
NGO	Non Governmental Organization
UNFCCC	United Nation Framework Convention on Climate Change
USAID	United States Agency for International Developments

Abstract

Rural poor in developing countries including Ethiopia are the most vulnerable community to climate change impacts because they depend mainly on climate sensitive economy. Hence this research attempted to assess the local vulnerability to climate change and farmers' adaptation strategies in five dominant agro ecologies of Choke Mountain watershed of Eastern Gojjam zone. The study attempted to examine farmers' perception towards climate change, their vulnerability (exposure, adaptive capacity and sensitivity) status and the adaptation strategies undertaken to cope with and reduce the impact of climate change and related hazards. To achieve the objects set, necessary data were collected from sample kebeles through different techniques. Due to time and budget constraint, the researcher selected only 10% of total kebele's household. Thus, the total sample respondents of the study area were, 100 in number. The study used integrated assessment approach capturing diverse drivers (biophysical and socio-economic) of outcomes to assess vulnerability of the study to climate change. Descriptive statistics was used to investigate farmers' perception and the adaptation strategies undertaking in the study area. Whereas, LVI-IPCC index was used to examine the vulnerability status. The result confirmed that the majority of sample households perceived climate change and as the impact of climate change was affecting their livelihood in many different directions. Even though farmers who perceive climate change, have been undertaking various adaptation strategies, such as irrigation, livelihood diversification, planting trees, soil and water conservation, the result shows as it was not satisfactory and insufficient, and needs to be enhanced. The LVI-IPCC, index showed as the relatively most vulnerable ecosystems were, the hilly and mountainous area AES5 (D/ kelemo) and the lowland area AES1 (Kurar) whereas, the midland plainly kebeles (Yemezegn and M/ berhan) relatively less vulnerable area, and the slopping land (Enerata) as moderately vulnerable to climate change. Generally, from the result of the study it can be concluded that the area is exposed to climate change and extremes due to low adaptive capacity of the area, thus high emphasis should be taken either by government or by the communities to reduce the impact.

Key words: *climate change, vulnerability, exposure, adaptive capacity and sensitivity*

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Currently, the issue of climate change has become one of the hottest agenda globally. It has been presented as a global issue resulting from an increase in greenhouse gas emissions linked to human activities (Adger,1999). It is also widely acknowledged that climate-change impacts amplify existing unfavorable conditions for developing countries. Recent studies point to less developed countries are the most ecologically, socially, and politically lagging behind on most economic and health indices and that climate change will be yet another stress factor in a vulnerable system because of their geographic exposure, low incomes, greater reliance on climate sensitive sectors, and weaker capacity to adapt(McCarthy, 2001).

It is also acknowledged that poor populations are more vulnerable and have less adaptive capacity to such changes. Countries with lack of resources, poor infrastructure, and unstable institutions have little capacity to adapt and are highly vulnerable. These factors are intrinsically linked with those promoting sustainable development that aims to improve living conditions and access to resources. Therefore, development planning and strategies have an important role in strengthening the adaptive capacities of societies at various levels (Temesgen et al., 2009).

Ethiopia is one of the least developed countries in the world, with a gross domestic product (GDP) of slightly more than US\$10 billion and a population of more than 70 million (Yusuf et al., 2008). At present, agriculture dominates the Ethiopian economy, accounting for nearly half of GDP and for the vast majority of employment. According to the World Bank

(2006), climate change is projected to reduce yields of the wheat crop by 33% in Ethiopia. Rainfall and temperature are important determinants of crop harvests, and unfavorable realizations of either the amount or the temporal distribution of rainfall triggers food shortages and famine. A recent mapping on vulnerability and poverty in Africa Yusuf et al., (2008) put Ethiopia as one of the countries most vulnerable to climate change with the least capacity to respond.

Indeed, Ethiopia has experienced at least five major national droughts since 1980, along with literally dozens of local droughts. Survey data show that between 1999 and 2004 more than half of all households in the country experienced at least one major drought shock. Food shortage and famine associated with rainfall variability cause a situation of high dependency on international food aid (World bank, 2006). The combined effects of climate change, increased global population and, among others, threaten to affect food and water resources that are critical for livelihoods in sub-Saharan Africa. This is especially true for those communities who live in the dry lands of Africa and who rely wholly on rain-fed agriculture for their livelihoods (world Bank, 2006).

High sensitivity of Ethiopian agricultural system and low adaptive capacity of the country, even a slight change in climate will have a huge impact on the farming community and the socio-economic activities of the country. As such the issue of climate change is therefore a major concern in Ethiopia. Hence, this paper intended to assess the local vulnerability to climate change and farmers' adaptation strategies in the Choke Mountain watershed, of Eastern Gojjam Zone.

1.2 Statement of the Problem

Available scientific evidences indicate that the national climate of Ethiopia which remained relatively static for years has now become very dynamic and unpredictable. This has brought worst effect on agricultural sector. The national program on how Ethiopia can adapt to climate change states that repeated droughts, hunger and recent floods are the most serious problems affecting millions of Ethiopians almost every year. Thus, climate change has been reducing agricultural productivity, accelerated degradation of natural resources and intensifying climate related diseases. It has brought a worst effect on the agricultural sector of the country and thereby putting pressure on access and ownership of these capitals (Aklilu and Alebachew, 2009).

Historically, climate extremes, especially drought and flood, are not a new phenomenon in Ethiopia. Where, most part of the country is prone to drought. Recurrent drought events in the past have resulted in huge loss of life and property as well as migration of people. The other climate related hazards that affect Ethiopia from time to time is seasonal river floods (Temesgen et al., 2008). Moreover, over the past 50 years, the average annual minimum and maximum temperatures across the country have increased by about 0.25°C and about 0.1°C, respectively, per decade, and precipitation has shown a decreasing trend throughout the country (NMSA, 2001).

Choke Mountain farming community in East Gojjam, is suffering from Climate upheavals which have become common natural disasters in the country. Where, primarily there has been more erratic rainfall. Second, and there has been an increase in temperature. Third, the crop and livestock production has been recurrently hit by droughts, and flood. Low educational

level, poor nutrition and poor health status, low level of infrastructural development, (access to safe drinking water, electricity, roads, health post etc., are also aggravated the vulnerability and lessen the adaptive capacity of the area. All these indicates the existence of problem in access and possession of key livelihood assets coupled with low level of awareness farmers to the adverse effect of climate change undermines the adaptive capacity of farmers to climate change and variability. Central to the above facts, empirical studies are essential to guide the policy intervention in the adaptation process of the country's agricultural sector. Some studies have been carried out in the areas of climate change and agricultural adaptation in different times by different scholars. Most of the studies focused on agriculture and impacts of climate change of Ethiopian farmers to the impact of climate change and variability often at higher level of analysis.

For instance, Temesgen et al.,(2008) made study on analysis of Ethiopian farmers' vulnerability across seven regional states using integrated assessment approach. The relative vulnerability revealed that the Afar, Somalia, Oromia, and Tigray regional states to be the most vulnerable regions. However a little has been done regarding to the vulnerability status to climate changes and variability at lower scale assessment. This paper therefore, intended to assess the local vulnerability to climate change and farmers' adaptation strategies in the case of Choke Mountain watershed, of Eastern Gojjam zone.

1.3. Objectives of the Study

The General objective of the study is to assess local vulnerability and farmers' adaptation strategies to climate change in the case of Choke Mountain watershed.

Based on the general objective, the following specific objectives were drawn.

- ❖ To assess farmers' perception towards changes in temperature and rainfall pattern
- ❖ To assess vulnerability status of the agroecosystems of Choke Mountain watershed
- ❖ To identify the adaptation options undertaken by farmers in the study area.

1.4 Research Questions

To achieve the objectives of the study, the researcher raised the following key questions.

1. How do farmers perceive to changing climate and variability?
2. Which agroecosystem is more vulnerable to climate change and extremes?
3. What are households' adaptation strategies towards climate change and climate related problems?

1.5. Significance of the Study

The researcher assumed conducting this study may have the following contributions. Primarily, the local administration may use the findings of this study to help the community to better face extreme weather conditions and associated climate variations, and to promote agricultural development. Secondly, it will create awareness in local communities and enable communities actively participate in combating the impact of climate changes. Thirdly, it will pave the way for further investigations and can be stepping-stone for those who are interested

to extend it for further study. Fourthly, it will guide policy makers to design agricultural adaptation policies that promote effective adaptation, and to develop viable adaptation menu.

1.6. Scope and Limitation of the Study

The study was conducted in Choke Mountain watershed of Eastern Gojjam zone with especial emphasis to the context assessing local vulnerability to climate change and households' adaptation strategies. The limitation of the study is that there was not sufficient meteorological data about the historical trends of climate change and variability of the study area. Due to time and budget constraint the researcher unable to take the sample size obtained by the formula (see under sample size determination) and simply take 10% of the total population

1.7. Organization of the Paper

This paper is organized in five chapters. The First chapter deals with the introductory part that contains background of the study, statement of the problem, objectives, research questions, significance and limitations. Chapter two deals with the literature review and the third chapter describes about the research methodology and study area. The forth chapter deals with results and discussion. Then, the last chapter consists conclusion and recommendations. In addition, the data collection tools and other appendixes were attached at the end.

CHAPTER TWO

2. REVIEW OF RELATED LITERATURE

2.1. Concepts and Definitions

Vulnerability: different scholars conceptualize and use the term vulnerability in different ways. The concept of vulnerability is not unique to the climate change scholarship; it has roots in the natural hazards, food security literatures (Brook and Adger, 2005). IPCC (2001), define vulnerability as “the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes.”

Sensitivity: is the degree to which a system is affected, either adversely or beneficially, by climate related stimuli. The effect may be direct (e.g. Change in crop yield in response to a change in the mean, range, or variability of (IPCC, 2001).

Exposure: the other central concept related to vulnerability to climate change is exposure, meaning the degree, duration, and/or extent in which the system is in contact with, or subject to, the perturbation (Adger and Nick Brook, 2003).

IPCC (2001) defined Exposure as the, “degree of climate stress upon a particular unit of analysis; it may be represented as either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events.”

Adaptive Capacity: adaptive capacity is defined as “the potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences” (Smit and Pilifosova, 2001).

Adaptation: IPCC (2007) defines adaptation as “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effect, which moderates harm or exploits beneficial opportunities.

Climate variability: variation, of the climate on all temporal and spatial scales beyond that of individual weather events (occurrences of extreme events such as drought and flood).

Climate change:refers to the change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that persist 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).

Perception: Krishna et al., (2010) define perception, as the process by which we receive information or stimuli from our environment and transform it into psychological awareness. It is interesting to see that people infer about a certain situation or phenomenon differently using the same or different sets of information. But, in this case perception is the attitudes of households towards climate change and variability, how they perceive the prevalence and sense the climate change impacts.

Mitigation:The IPCC (2001) defines mitigation as an anthropogenic intervention to reduce the sources or enhance the sinks of green house gases (GHG).

Resilience:Turner et al., (2003) define resilience as the degree to which an impacted system rebounds or recovers from a perturbation. Climate change impact necessitates responses and adjustments to the biophysical and social condition which together determine exposure to climate hazards.

2.2. Overview of Global Climate change

Climate change refers to the change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that persist 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. Global average temperature has increased by about 0.6°C over the past 100 years, with a major warming in the 1970s. Warming is the result, in part, of rapid increases in emissions of greenhouse gases (GHG), particularly carbon dioxide (CO₂), which is a byproduct of the combustion of fossil fuels, such as coal, oil, and natural gas, used for power generation and transportation (IPCC, 2007).

The effects of climate change are substantial, particularly in developing world. These countries are highly dependent on climate sensitive natural resource. Sectors for livelihoods and incomes, and the challenges in climate that are projected for tropics and subtropics, where most developing countries are found, are generally adverse for agriculture (IPCC, 2001). Furthermore, the means and capacity in developing countries to adapt to changes in climate are scarce due to low levels of human and economic development and high rates of poverty. These conditions combine to create a state of high vulnerability to climate change in most of the developing world. Thus, developing countries have lesser capacity to adapt and are more vulnerable to climate change damages, (Burton, 2008).

According to the IPCC (2001), report on the regional impacts of climate change, Africa is the continent most vulnerable to the impacts of projected changes because widespread poverty limits adaptation capabilities. The importance of agricultural activities for the economies of most African countries, combined with the farming sector's reliance on the amount of rain

during the rainy season, make countries in the region particularly vulnerable to climate change. Thus, from the point of view of food security, the increasing incidence of drought represents a very serious threat. It has been argued that, in Africa, drought hazard and vulnerability are likely to be the most damaging impacts of climate change (Downing et al., 2005)

Sufficient evidence shows that the average temperature rise in Africa is faster than the global average and is likely to persist in the future. The warming is definitely hazardous for agricultural activities. According to IPCC,(2001), climate change will affect Africa more than anywhere else will in the world due to extreme poverty levels, high rates of population growth, over-reliance on rain-fed agriculture and over-dependence on natural resource-based livelihoods. Furthermore, Africa suffers from climate or water-related diseases, such as yellow fever, cholera, river blindness, bilharzias, malaria and tuberculosis. In particular, climate change will create favorable conditions for malaria risk in Africa in the years to come (Hulmes et al., 1998)

Ethiopia has historically suffered from climatic variability and extremes. Rain failures have contributed to crop failures, deaths of livestock, hunger and famines in the past. Even relatively small events during the growing season, like too much or too little rain at the wrong times, can spell disasters. The farmers who are already struggling to cope with the impacts of current climate variability and poverty will face daunting tasks to adapt to future climate change (Aklilu and Alebachew, 2009).

Most of the regions and people throughout the country are living through a period of rapid and dramatic changes in ecological conditions, land use patterns, and socio-economic

conditions. The pace of change in the pattern of climate and different forms of environmental hazards in the country often exceeds the capacity of national and local institutions to cope with or mitigate the effects of such changes. This is especially true in drier, more fragile rural areas where catastrophic seasonal floods and famine have become increasingly common occurrences (NMA, 2006).

The major adverse impacts of climate variability in Ethiopia include: Food insecurity arising from occurrences of droughts and floods; Outbreak of diseases such as malaria, yellow fever, water borne diseases; Land degradation due to heavy rainfall; damage to communication, road and other infrastructure by floods. Ethiopia is vulnerable to climate change because of its greater reliance on climate sensitive economic sectors: subsistence crop cultivation and livestock production. Low level of economic development, inadequate infrastructure, lack of institutional capacity and higher dependency on natural resources base make the country more vulnerable to climatic factors including climate variability and extreme climate events (NMSA, 2001).

In terms of livelihood approach, rain fed farmers are found to be the most vulnerable. The arid and semiarid and dry sub humid parts of the country are highly prone to drought. In Ethiopia, the mean annual temperature has increased by 1.3^oc between 1960-2006 at an average rate of 0.28 ^oc per decade (NMSA, 2001). Mean annual rainfall ranges from about 2000mm over some pocket areas in the south west to about less than 250mm over the Afar lowlands in the northeast and Ogden in the southeast. Mean annual temperature varies from about 10^oc over the high table lands over North West, central and south east to about 35^oc over the northeastern edges. Trend analysis of rainfall shows that rainfall remained more or less constant when averaged over the whole country (NMSA, 2001).

2.3. Vulnerability and Its Components

The IPCC (2001) describes vulnerability as “The degree to which a system is subject to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

A. Exposure

Exposure is defined by the magnitude, character and rate of climate change in a certain geographic area (IPCC, 2001). Due to the lack of long-term and/or continuous meteorological records in many parts of the developing world, as well as the lack of scientific projections, difficult to assess exposure at more localized scales.

B. Sensitivity

Communities’ sensitivity to climate change is the degree to which a community is adversely or beneficially affected by climate-related stimuli (IPCC, 2001). It largely depends on the main livelihood activities of the community (including its dependence on livestock and rain-fed agriculture), its key livelihood resources, and the impacts of climate hazards on these key resources.

C. Adaptive capacity

The adaptive capacity of a community is ability to adjust to climate change, to moderate or cope with the impacts, and to take advantage of the opportunities (IPCC, 2001). Adaptive capacity is often determined by a range of factors, processes and structures such as income, literacy, institutional capacity, social networks, as well as access to information, markets, technology and services (IPCC, 2007).

In developing countries there is often inadequate infrastructure, lack of well functioning institutions, little access to technology, inequalities and high poverty levels. These conditions generally give developing countries a low capacity to adapt to climate change. The concept of adaptive capacity therefore seems inversely correlated with that of vulnerability, where the conceptual link between adaptation and vulnerability is constituted by adaptive capacity. On these grounds, a system with high adaptive capacity could be adapting to changes and possess low vulnerability to the impacts from climate change (Temesgen,2010).

2.4. Approaches to Assess vulnerability

Due to complex nature of vulnerability different authors have developed several conceptual frameworks to categorize vulnerability factors and to describe different concepts of vulnerability. There are different conceptual approaches and methodologies in different literatures to assess vulnerability based on the objectives to be achieved and the methodologies employed. The major three conceptual approaches to analyzing vulnerability to climate change are the socio-economic, the biophysical (impact assessment), and the integrated assessment approach (Temesgen et al., 2008).

2.4.1. Socio-Economic Approach

Literatures on vulnerability argued that, social vulnerability focuses primarily on the human determinants of vulnerability namely the social, political and economic condition that makes exposure challenging. The limitation of this approach is that it focuses only on variations within society (i.e. differences among individuals and social groups) ignoring the impact of hazard to vulnerability. The other limitation of this approach is that its ignorance of intensity and frequency of hazards (Temesgen et al., 2008).

2.4.2. Biophysical Approach

The biophysical, or impact assessment, approach is mainly concerned with the physical impact of climate change on different attributes, such as yield and income (Fussler and Klein, 2006). The major limitation is that the approach focuses mainly on bio physical damages and sensitivity, such as change yield, income to climate change and disregards much of the adaptive capacity of individuals or social groups, which is more explained by their inherent or internal characteristics or by architecture of entitlements as suggested by (Adger, 1999).

2.4.3. Integrated Assessment Approach

Integrated assessment approach may be one of the most informative assessment approach capturing diverse drivers (biophysical and socio-economic) of outcomes, system interactions and feed backs, and the evaluation of different adaptation. The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. Mapping vulnerability in south East Asia is good example of this approach, in which both biophysical and socio-economic factors are combined to determine vulnerability of the region(Yusuf and Francisco; 2009).

Integrated assessment approach corrects the weakness of other approaches. However it has its own limitation. The main limitation of this approach is there is no standard method for combining the bio physical and socio-economic indicators. This approach uses different data sets, ranging from socioeconomic data sets (e.g., race and age structures of households) to biophysical factors (e.g., frequencies of earthquakes); these data sets certainly have different and yet unknown weights (Temesgen et.al., 2008).

2.5. Adaption to Climate Change

Climate change predictions are still too coarse to give highly specific guidance. Drought-affected areas are likely to expand, and the poor have the least capacity to adapt to the increasing severity of weather events that are expected (USAID, 2007). To adapt to increasing weather variability, buffering and diversification strategies such as cropping systems change, water harvesting and small-scale irrigation, soil and water conservation, livelihood diversification (income diversification), integrated crop management and diversification of higher-value crops, are important (Smith, 1991).

Government policies and longer-term development pathways to build the resilience of smallholder farmers are also urgently required. The definition used here is taken from IPCC 2001, wherein adaptation refers to, "adjustments in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. This term refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC, 2001).

For vulnerable groups such as developing countries, adaptation strategies are vital, as failure to adapt could lead to "significant deprivation, social disruption and population displacement, and even morbidity and mortality" (Downing et al., 2005). The problem is in identifying those adaptations that favor the most vulnerable groups. For example strategies such as large-scale agriculture, irrigation and hydroelectric development, may benefit large groups, or national interests, but may harm local, poor, indigenous populations. Hence what must be remembered is that adaptation does not yield the same benefits everywhere and win-win situations are unlikely in climate change, and there will also be winners and losers.

Bryan et al., (2010) studied the adaptation strategies used by farmers of Ethiopia and South Africa, and analyzed the factors influencing the decision of farmers to adapt. The study identified the following as common adaptation strategies in Ethiopia: use of different crops or crop varieties, planting trees, soil and water conservation, livelihood diversification, using fast growing crops, changing planting dates, and irrigation.

2.6. Livelihood Assets

The rural livelihoods framework developed by Ellis (2000) views adaptive capacity as comprised of activities that are continuously invented, adapted and adopted in response to changing access to five broadly defined types of capital including:

- Human capital(HC) – the skills, health and education of individuals that contribute to the productivity of labor and capacity to manage
- Social capital (SC) – reciprocal claims on others by virtue of social relationships, the close social bonds that facilitate cooperative action and the social bridging, and linking via which ideas and resources are accessed
- Natural capital (NC) – the productivity of land, and actions to sustain productivity, as well as the water and biological resources from which rural livelihoods are derived
- Physical capital (PC) – capital items produced by economic activity from other types of capital that can include infrastructure, equipment and improvements in genetic resources (crops, livestock)
- Financial capital (FC) – the level, variability and diversity of income sources, and access to other financial resources (credit and savings) that together contribute to wealth.

2.7. Review of Empirical Studies

Despite the complex concept of vulnerability and various methodological and conceptual approaches over the past decades, several authors have been comparing and ranking vulnerability across regions, countries and populations, with the objective of the aiding government bodies and other organization in allocation of resources for vulnerability reduction (Downing et al., 2005). Among these studies some of them are reviewed as follow.

To estimate the risks from climate variability and change (Hahn,etal.,2008), developed the livelihood vulnerability index(LVI) and used it to indicate the vulnerability levels of two districts found in Mozambique. The LVI values for the two districts shows ‘Moma’ to be more vulnerable in health and water structures than ‘Mabote’.

Cutter et al., (2003) construct an index of social vulnerability to environmental hazards, called the social vulnerability index (SoVI) for 3,141 United States (US) countries using country level socio-economic and demographic data. About 42 variables were identified to characterize the broader dimension of social vulnerability. The finding shows that the vast majority of US countries exhibited moderate level of social vulnerability.

Yusuf and Francisco (2009) in their study mapping vulnerability in south Asia with the conceptual frame work of vulnerability = f(exposure, sensitivity and adaptive capacity).

Temesgen et al., (2008) in their study analysis of Ethiopian farmers vulnerability change across seven regional states they analyzed using integrated assessment approach. To analyze the overall vulnerability of farmers they calculate vulnerability as a function of adaptive

capacity, sensitivity and exposure. The relative vulnerability revealed that the Afar, Somalia, Oromia, and Tigray regional states to be the most vulnerable regions.

Abenet (2010) has also made a local level comparative assessment of vulnerability to climate change among Pastoral and agro-pastoral households in Yabello woreda of Oromia regional state using integrated vulnerability approach and vulnerability indicator method to assess the level of vulnerability.

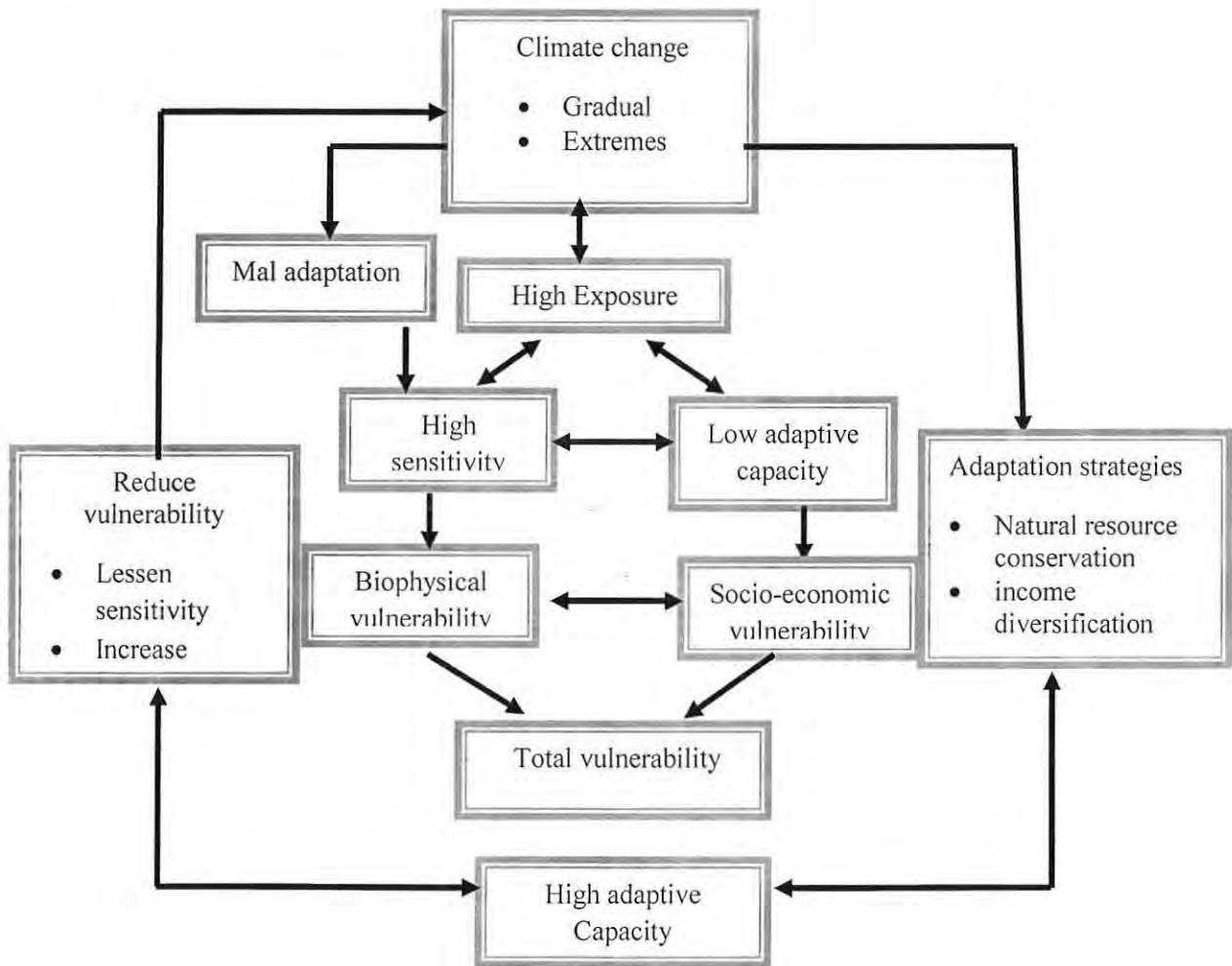
2.8. Conceptual Framework

The study adopts the IPCC (2001) definition of vulnerability to analyze the vulnerability of households of Choke Mountain watershed of eastern Gojjam zone. IPCC defines vulnerability as the degree to which a system is susceptible or unable to cope with the adverse effect of climate change including climate variability and extremes, and vulnerability is a function of the character, magnitude and the rate of climate variations to which a system is exposed, its sensitivity and its adaptive capacity(IPCC,2001).The study is based on the integrated vulnerability assessment approach since the IPCC definition accommodates the concept of both bio physical and the socio-economic indicators in assessing the vulnerability(Temesgen, 2010).

The study area is exposed to both gradual climate change (temperature and precipitation) and extreme climate conditions (drought and flood). If there is climate change either gradual or extreme, this means that the area has high exposure to the climate risks. There is direct relationship between exposure and sensitivity; the higher the exposure, the higher the sensitivity, and lower adaptive capacity to the impacts. Exposure is linked to adaptive capacity in such a way that higher adaptive capacity reduces the potential damage from higher

exposure. The other concept in this framework is that, if the households perceive the change in climate, they going to undertake various adaptation strategies to reduce the impacts, which moderates harm or exploits beneficial opportunities. However, in some cases if not properly implemented and fail, it might be leads to mal adaptation to climate change, which may contribute to increase the sensitivity of an area, and finally increase the vulnerability (Burton, 2008).

Figure 1: Conceptual Framework to Assess Vulnerability



Source: Adopted and modified from Temesgen, 2010

CHAPTER THREE

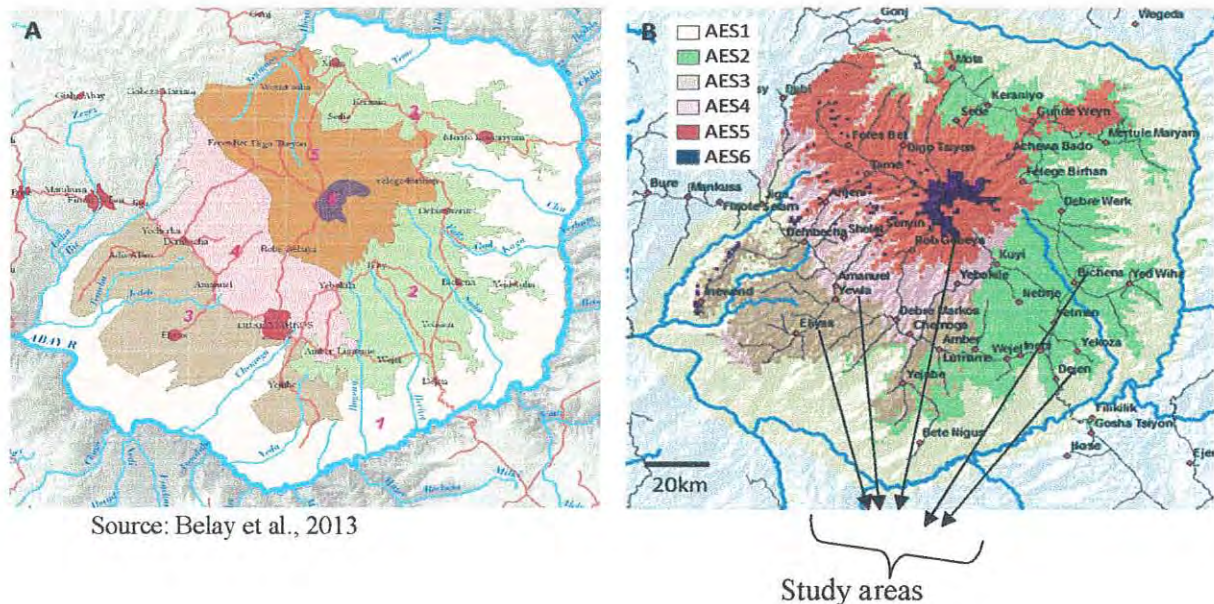
3. RESEARCH METHODOLOGY

3.1 Description of Study area

3.1.1. Location

The Choke Mountain watershed is a large block of highland found in Central Gojjam Zone, Amhara Regional State. It is located on plateaus that rises from a block of meadows and valleys and have elevation ranging from approximately 800 - 4200 meters above sea level. The central peak is located at $10^{\circ} 42' N$ and $37^{\circ} 50' E$. The mountains were formed by volcanic activity about 30 million years ago in the middle of late tertiary. While the central cone of the mountain chains of Choke occurs in six weredas of East Gojjam, namely Hulet Eju Enesie, Enarj Enawga, Sinan, Debay Telatgin, Bibugn and Machakel, the Mountain watershed includes all East Gojjam and part of West Gojjam.

Figure 2: Map of study area



Source: Belay et al., 2013

3.1.2. Climate

The prevailing climate can be described as “tropical highland monsoon”. Seasonal precipitation is tightly correlated with the movement of the Inter-tropical Convergence Zone (ITCZ), with most rain falling during the May-October kiremt rainy season. The distribution of precipitation within the Choke is far from uniform; average annual precipitation ranges from 600 to 2000 mm yr⁻¹, and exhibits strong local variability associated with topographic gradients. Precipitation events are convective in nature, and are characterized by short, sometimes intense erosive bursts with notably large raindrops. Interannual variability in precipitation has significant impacts on agricultural production and soil erosion rates. Variability on this timescale is strongly associated with the El Nino Southern Oscillation (ENSO) and, perhaps, with Indian Ocean SST (Belay, 2011).

3.1.3. Socio- Economic Condition

East Gojjam zone has considerable ecological and socioeconomic significance at the local, national, and regional levels in its contribution to food security in Ethiopia. This highland zone has the most favourable climate with land resources suitable to grow large variety of crop and livestock species, it stands as the most intensively cultivated and is considered as one of the bread basket areas of the country. However, the situation is changing due to anthropogenic and environment related constraints. The key problems, among others, are land degradation mainly through erosion and soil fertility loss; lack of access to technology and markets; and weak infrastructure (Belay, 2011).

3.1.4. Soil

The dominant soils are Leptosols (34%), Vertisols (26%) and Nitosols (23%). Soils include reddish Nitosols and Acrisols on deeply weathered bedrock, while Phaeozems and Andosols dominate at higher altitudes and to the northern portion of the region, (Belay, 2011).

3.1.5. Agro ecosystems

The following classification and definition of agroecosystems was based on the overlay of three inputs: an agro-climatic zoning based on precipitation and temperature, a soil and terrain analysis, and a map of the distribution of farming systems. In view of that, they classify agroecosystems of Choke Mountain watershed into six (Belay et al., 2013).

- I. Lowland and valley fragmented agro ecosystems (AES 1; 7200 km²):** This agro ecosystem includes the lowlands in the eastern part of the Choke Mountain watersheds and fragmented valleys along the Blue Nile gorge, with an altitude range of 800 to 1400 m. The annual temperature varies between 11 and 15°C. K̄urar is found in AES1 which is characterized by relatively unfavorable agro-ecologic conditions: rugged terrain, lower and more sporadic rainfall than the other AES, and extensive land degradation.
- II. Midland plains with black soil (AES 2; 3200 km²):** AES 2 is found on the eastern toe of Choke Mountain, extending from the town of Dejen to the town of Mota, where, M/berhan is one among many kebeles. This agro ecosystem represents midland plains with black soil with an elevation ranging from 1400 to 2300 m.
- III. Midland plains with brown soils (AES 3; 1600 km²):** AES 3 is found on the western and southern toe of Choke Mountain toe. Yemezegn kebele is found in this agroecosystem. It is a midland plains area dominated by Nitosols, a brown soil very suitable for agriculture, and

Alisols, with some Cambisols as well. The elevation of AES3 varies between 1400 and 2400 m. The annual temperature varies between 16 and 21 °C.

- IV. **Midland Sloping Lands (AES4; 1300 km²):** AES 4 is located at the foot-slope of Choke Mountain with elevation ranging from 2400 to 2800 m. The annual temperature varies between 11°C-15°C.. Enerata kebele is found in this agroecosystem, which is, constrained by low natural fertility due to leaching of base ions and high level of soil acidity.
- V. **Hilly and Mountainous highlands (AES5; 2400 km²):** These hilly and mountainous highlands are found on the back-slope of Choke Mountain. Debrekelemo is found in this agroecosystem where, soils are predominantly Leptosols and Luvisols, and altitude varies between 2800 and 3800 m.
- VI. **Afro Alpine (AES6; 250 km²):** The Afro Alpine is the Choke Mountain summit. Elevation ranges from 3800 to 4200m. Given the important functions of AES6 as a reservoir for biodiversity and a soil and water retention zone, combined with the area's relatively low agricultural potential due to low temperatures, the most appropriate use of AES6 is as a protected bioreserve. At present, ecological pressure due to grazing and fuel wood collection is reducing the proportion of AES6 that fulfills this role.

3.2. Research Design

The aim of this research is to investigate and assess local vulnerability to climate change and household's adaptation strategies in the case of Choke Mountain watershed. The researcher used LVI-IPCC index where different indicators were assessed to measure the vulnerability status of the study area. Initially expensive literature review and assessment on the general availability and use of vulnerability indicators were made which enabled the selection of indicators of analysis.

This study combined purposive sampling and simple random sampling techniques for selection of the agro ecology, woreda, Kebele and households. The researcher uses the combination of qualitative and quantitative research data which were collected from both primary and secondary sources. The primary data was collected from household survey, key informants and focus group discussion. Thus, this primary information is supplemented by secondary data sources. And finally the data obtained through different data sources was analyzed through descriptive statistics using Statistical Package for social science Version 20 and the vulnerability status of the kebeles was analyzed by LVI-IPCC. Lastly, conclusion and recommendations were suggested by the researcher.

3.3. Data Sources

The data source for the study was of two types: primary and secondary. The research used both primary and secondary data sources. The primary data was generated from interviews, Focus group discussions, and household survey whereas secondary data was obtained from internet sources , document files, research journals and articles, different reports, proceedings and books.

3.4. Data Collection Instruments

As it has been indicated, this study employed both qualitative and quantitative research design in order to achieve the objectives. Therefore, multiple data collection tools such as, house hold survey; interview, observation, as well as focus group discussions were employed to collect necessary data.

3.4.1. Data collection instruments for primary data sources

A. Household survey

This study was basically employed self-developed questionnaire as an instrument. In the design of this instrument the literature review was used as a base. Both close and open-ended types of questions were prepared in English language, then translated in Amharic for maximize comprehension. The collections of house hold survey data conducted by recruiting enumerator. With project beneficiaries being either illiterate or barely able to read and write, the enumerators read and explain questions to the respondents.

B. key Informant Interview(KII)

The use of key informants is another important technique to gain access to available information. To supplement the quality and reliability of the data collected through questionnaire; interviews were conducted. Thus the researcher, take a total of three (3) individuals in each kebeles with various back ground and who have deeper and better knowledge about the issue. The key informant interviewees were comprises of one elder, one expert with agricultural and environmental background and one religious leader.

C. Focus Group Discussion (FGD)

Focus Group Discussion can develop relevant research hypotheses by exploring the problem to be investigated and its possible causes in greater depth as well as helps to formulate appropriate questions for more structured, larger scale surveys. Thus, two Focus group discussions were carried out in five selected kebeles. Each of the focus group discussion composed of ten participants who are not involved in household survey selected purposively. The first focus group carried out with elders and religious leaders, the second FDG, carried

out with men and women households to obtain relevant and in-depth information. To guide the discussion, semi-structured checklists were designed specific to the research issues.

D. Field Observation

During field surveys, transect walks were conducted in the study areas with the guidance of the kebele's chairman, including voluntary farmers, and the researcher. In the meanwhile, the researcher tried to triangulate farmers' responses with actual physical observations and took pictures of important observations which are actually put as exhibits to support findings.

3.4.2. Data collection instruments for secondary data sources

Secondary data for this study were gathered from, books, policy documents, projects reports, journal articles, annual reports, internet and to obtain smart information. The primary qualitative data on farmer perceptions of climate change and variability collected through survey was triangulated with secondary data.

3.5. Sampling Procedures

The study was conducted in Choke Mountain watershed, which is located in East Gojjam of the Amhara Regional State. In order to select the study area, the researcher used multi stage sampling technique, where the five agroecosystem purposively selected from six agroecosystems, except AES6 which is bioreserved (Choke Protected area). Sample kebeles (kurar, M/berhan, D/Elias, Enerata and D/kelemo) from those 5 agroecosystems were selected through simple randomly sampling. Finally the Gotes (Sub-villages) from each kebele were selected purposively by considering their accessibility and proximity to the main road. Ultimately, the researcher selected sample households from each gote using simple random sampling method because the households living in each gotes are homogenous in terms of

their economic activity, topography, technological development and other socio-economic conditions.

3.5.1. Sample size Determination

The researcher decided to take 10% of the total population. Thus, the sample households of each Agroecosystems.

Table 1: Sample Study area and Proportion of Sample HHs

No	Agroecosytem	Sample kebele	Sample Gote	Total hh heads Within Gote	Sample populat ion (10%)
1	Low land and valley	Kurar	Mekni	230	23
2	Mid land plain with black soil	M/berhan	Dinda kutir 2	211	21
3	Midland plain with brown soil	Yemezegn	Yelowa	179	18
4	Midland slopping land	Enerata	Melit	170	17
5	Hilly and mountainous highland	D/kelemo	Addis Amba	210	21
Total				1000	100

Source: CSA,2007

3.6 Method of Data Analysis

In order to attain the intended objectives of the study, both qualitative and quantitative methods of data analysis were employed. An indicator method of vulnerability measurement was employed to calculate the level of vulnerability of households in the Choke Mountain watershed.

To achieve the objects set, necessary data were collected from sample kebeles through different techniques. The study used integrated assessment approach capturing diverse drivers

(biophysical and socio-economic) of outcomes to assess vulnerability of the study to climate change.

I. Descriptive statistic

Descriptive statistic (means, frequency, crosstabs, percentage, count, chi-square) was used to analyze farmer perceptions on changes in long-term temperature and precipitation changes as well as various adaptation measures undertaken to combat the effect of climate change. Here, SPSS version 20 was the tool of analysis.

II. Livelihood vulnerability index- IPCC (LVI- IPCC)

LVI-IPCC index was used to examine the vulnerability status of the study area. The researcher developed an Indicator method for calculating the LVI that incorporates the IPCC vulnerability definition. The LVI includes six major components: climate and the five livelihood capitals (natural, physical, financial, human and social capitals) (Hahnn, et al., 2008). The researcher assumes that these components fully describe vulnerability in terms of exposure, sensitivity and adaptive capacity. Sensitivity reflects the degree of biophysical response to a given change in climate. Adaptive capacity denotes the capacity to cope up with the changes and adapt to changing conditions. It is dependent on several socio-economic factors such as financial, physical, human and social capitals.

The vulnerability index for the different AESs has been calculated by combining the values of these components following the IPCC vulnerability framework using the following steps.

1. Because each of the sub-components is measured on a different scale, it was first necessary to standardize each *indicator* values as an index (Eq. 1).

$$I_v = \frac{I_a - I(\min)}{I(\max) - I(\min)} \dots\dots\dots (1)$$

Where, I_v = Standardized value for the variable, I_a = Value for the variable I for a particular AES a, $I(\min)$ = Minimum Value for the variable across all the AESs, and $I(\max)$ = Maximum Value for the variable across all the AESs

2. After each variable was standardized, the values for the *profiles* were averaged using Eq. 2.

$$P_a = \sum (I_v) / N \dots\dots\dots (2)$$

Where P_a = the value for one of the 8 profiles for AES a, I_v = represents the standardized value for variables under a profile, and N = number of variables in the profile.

3. Once values for each of the *eight profiles* for AES were calculated, they were averaged using Eq. 3 to obtain the AES level LVI.

$$LVI_a = \sum N_p P_a / \sum N_p \dots\dots\dots (3)$$

Where LVI_a , the Livelihood Vulnerability Index for AES a, equals the weighted average of the eight profiles (major components) ($W_p P_a$), W_p is the number of components

4. The eight profiles are combined according to the categorization scheme of IPCC (Exposure, Sensitivity and Adaptive capacity) using Eq. 4.

$$CF_a = \sum W_p M_a / \sum W_p \dots\dots\dots (4)$$

Where C_{Fa} is an IPCC-defined contributing factor (exposure, sensitivity and adaptive capacity) for AES a , M_a are the major component for AES a , W_a the weight of each major component (no of profiles)

5. Finally, the LVI-IPCC for AESa is calculated using Eq. 5.

$$\mathbf{LVI-IPCC}_a = (\mathbf{e}_a - \mathbf{a}_a) * \mathbf{s}_a \dots \dots \dots (5)$$

Where $LVI-IPCC_a$ is the LVI for AES a expressed using the IPCC vulnerability framework, e is the calculated exposure score for AES a , a is the calculated adaptive capacity score for AES a , and s is the calculated sensitivity score for AESa. The LVI is scaled from 0 (least vulnerable) to 1 (most vulnerable). Table I shows the indicators and the broad structure chosen for this study.

CHAPTER FOUR

4. RESULTS AND DISCUSION

4.1. Socio-economic Characteristics of Households

In this part the general profile (age, sex, marital status and educational status, Economic activities) of sample households is presented.

A. Sex of the respondents

Table2: Sex of Respondents

Sex	kebele										Total
	Kurur		M/berhan		Yemezeegn		Enerata		D/kelemo		
	No	%	No	%	No	%	No	%	No	%	
Male	12	52.2	11	54	11	52.9	9	52.9	11	52.4	54
Female	11	47.8	10	46	8	47.1	8	47.1	10	47.6	46
Total	23	100	21	100	18	100	17	100	21	100	100

Source: Own survey, 2012

Sex is a major socio-economic characteristic of the study population. As depicted on the above table, from overall kebeles sample households, the male respondents constitutes about 54% whereas, the rest 46% are female respondents.

I. Age profile of the respondents

Regarding the age profile of sample population throughout the study area, the majority (79%) of respondents are active population which aged between 31-65 years old, whereas the old aged (above 65 years old) and respondents who are between 16-30 are constitutes of 11% and 10% respectively.

II. Marital status of the respondents

The survey result shows, from the total sample respondents of the study area, 71% are married, 18% widowed and 11% are divorced. Similarly the majority of sample respondents in all kebeles are married. In Kurar, 69.6% of respondents are married, 21.7% divorced, 8.7% are widowed; in the case of Yemezegn, 55.6% are married, 11.1% divorced and 33.3% are widowed; in Enerata 76.5% are married, 23.5% are widowed and no divorced sample respondents; in D/kelemo, 61.9% are married, 14.3% divorced, 23.8% are widowed.

Table 3 : Marital status of respondents

Marital status	Kebele									
	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo	
	No	%	No	%	No	%	No	%	No	%
Single	-	-	-	-	-	-	-	-	-	-
Married	16	69.6	19	90.5	10	55.6	13	76.5	13	61.9
Divorced	5	21.7	1	4.8	2	11.1	-	-	3	14.3
Widowed	2	8.7	1	4.8	6	33.3	4	23.5	5	23.8
Total	23	100	21	100	18	100	17	100	21	100

Source: Own survey, 2012

Iv. Educational status of the respondents

As illustrated on below table, from the total respondents, the majority (51%) are illiterate, 39% can read and write, 7 % of them had opportunity to join elementary school (1-8), 3% are who joined secondary school (8-12).

Table 4: Educational status of sample kebeles

Educational status	Kebele										Total
	kurar		M/berhan		Yemezeegn		Enerata		D/kelemo		
	No	%	No	%	No	%	No	%	No	%	
Illiterate	8	34.8	11	52.4	14	77.8	9	52.9	9	42.9	51
Read& write	14	60.9	9	42.9	4	22.2	4	23.5	8	38.1	39
Primary school	0	0	1	4.8	0	0	2	11.8	4	19	7
Secondary school	1	4.3	0	0	0	0	2	11.8	0	0	3

Source: Own survey,2012

III. Total family size of the respondents

Family size is the important variable determining the adaptive capacity of the households to climate change. Throughout the Kebele, about 53% of the respondents have total family size 4-6. 26% of the respondents have family size >6, and only small percent (21%) of sample respondents have total family size 1-3.

Table 5 : Total Family size of respondent

Family size	Kebele									
	Kuror		M/berhan		Yemezeegn		Enerata		D/kelemo	
	No	%	No	%	No	%	No	%	No	%
1-3	-	-	1	4.8	1	5.6	1	5.9	-	-
4-6	2	8.7	5	23.8	5	27.8	4	23.5	5	23.5
>6	21	91.3	15	71.4	12	66.7	12	70.6	16	76.2
Total	23	100	21	100	18	100	17	100	21	100

Source: Own survey,2012

IV. Major means of livelihood of sampled households

From the total sample respondents the majority (79%) of sample kebeles population engaged on mixed farming, 18%, on crop production, and only 3% respondents' live depends on livestock rearing.

4.2. Household's Perception to Climate Change

Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify implement different adaptation strategies. People living in different agro-ecological systems are believed to perceive climate change differently, even when the systems are in close proximity to one another, due to contrasts in local climate impacts, as well as to differing socio-economic perspectives on these impacts. As many African studies indicate a large numbers of agriculturalists already perceive that the climate has become hotter and the rain less predictable and shorter in duration (Temesgen, 2009). Such understanding is the main derive for farmers and policy-makers to initiate adaptation strategies. Based on the household survey results, the following tables show how farmers perceive the change.

A. Perception towards Temperature Change

As illustrated on the below figure, analysis of perception of farmers across the study area showed no statistically significant variation in perception of temperature change: the majority of respondents or about 90% of the respondents perceived that the temperature has increased over the last 20 and 30 years. This is in agreement with scientifically observed temperature data of the area. About 8% respond claimed that temperature has decreased; the rest 2% said no change in temperature within 20 and 30 years.

Table 6: Households' Perception towards temperature change

Temperature change	Kebele										X ²	
	Kurur		M/berhan		Yemezegn		Enerata		D/kelemo			Total %
	No	%	No	%	No	%	No	%	No	%		
Increased	22	95.7	18	85.7	18	100	15	88.2	21	100	21	P=0.29 7
Decreased	0	0	2	9.5	0	0	2	11.8	0	0	0	
No change	1	4.3	1	4.8	0	0	0	0	0	0	0	
Total	23	100	21	100	18	100	17	100	21	100	21	

Not Significant at 5% level. Source: Own survey, 2012

B. Households Perception towards rainfall change

Regarding the perception of households towards change in rainfall, the majority of the respondents (47%) perceived as there is seasonal variability of rainfall throughout 30 years. 27% of them claimed to increase, 23%, reported as rainfall decrease. This result is inline with the meteorological data (1981-2008) which indicates as the rainfall trend increase.

Correspondingly, the result obtained from FGD and KII, in all kebeles depicted as the long term temperatures were warming and precipitation declining while, the raining time has been also shifting from they had known before 20 and 30 years ago. They argued that, before 20 and 30 there were regular rainy seasons. However, FDG, according to discussants in Choke Mountain watershed, drought, flood, erratic rainfall and land slide are some of the extremes that frequently appeared since 1970's. However, the degree of severity and impacts in these agro ecologies (kebeles) varies.

Table7: Households Perception on change in Rainfall

Rainfall change	Kebele										Total %	X ² P=0.002
	Kurar		M/Berahan		Yemezegn		Enerata		D/kelemo			
	No	%	No	%	No	%	No	%	No	%		
Increased	13	56.5	5	23.8	3	16.7	3	17.6	3	14.3	27	
Decreased	1	4.3	1	4.8	6	33.3	10	58.8	5	23.8	23	
No change	0	0	1	4.8	1	5.6	0	0	1	4.8	3	
Seasonal variability	9	39.1	14	66.7	8	44.4	4	23.5	12	57.1	47	
Total	23	100	21	100	18	100	17	100	21	100	100	

Significant at 5% level. Source: Own survey,2012

C. Perception to climate change and Educational status

In this section perception of households is the attitude of households to climate change and variability including change of temperature and rainfall and the like. In this section perception of households toward climate change in terms of educational status of sample households going to be discussed. There is statistical difference ($p=0.002$) between educational status and perception of climate change in terms of education.

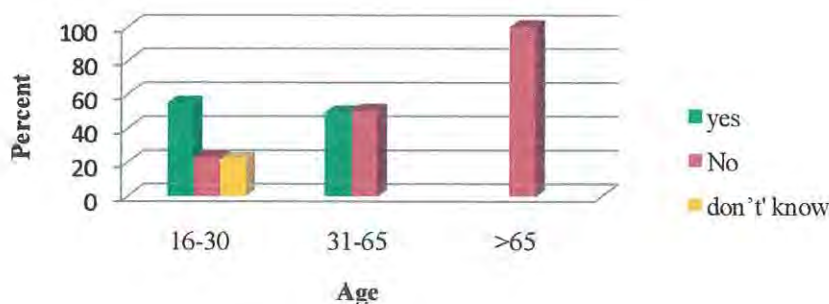
The survey result shows that, 72.5% of illiterate sample, perceived as the current climate condition is similar with that of 20/30 years ago. Whereas, all sample 100% of sample HH who joined secondary school perceived as the current climatic condition is not similar with that of 20/30 years ago. Therefore from this result we conclude as educated households perceive as there is change in climate and undertake different adaptation strategies to combat the impact. This result is in line with and approve the hypothesis said educated households are better perceive climate change and variability than non-educators.

D. Perception to climate change and Age

Age is also another determining factor that affect the perception of households to climate change. For this reason the sample households were asked whether there is similarity between current climate change and that of before 20 and 30 years ago. There is highly statistical difference among different age group concerning climate change. Thus, the survey result indicates 55% of sample respondents who aged 16-30, reported as there is similarity, 23% as there is difference in climatic condition today and before 20 and 30 years. whereas, all (100%) the sample respondents aged >65 perceive as there is difference between current and the past climate condition.

From this we can conclude as the aged and experienced farmers perceived the change of climate easily and undertaken different adaptation measures to reduce the problem than those who are poor experienced and young one. In this case the result approved the hypothesis said the aged and experienced households perceive the changing climate and variability than the younger.

Figure 3: Perception of households towards Climate Change interms of Age



Significant at 5% level. Source: Own survey,2012

Box 1. Perception of households on climate change-results from KII

The researcher conducted an interview with 80 years old age religious leader named as Abba Desse in D/ kelemo. The first question raised was whether the today's temperature and rainfall condition similar with that of 20 and 30 years ago? He respond as there is great variation between the current rainfall and temperature and that of before 30/20 years ago; today there is surprisingly high temperature and low and erratic rainfall which is different from 20 years ago in which there were moderate temperature and rainfall. He also said as the major impacts related with this problem are drought, late or early coming of rainfall, decreasing volume of rivers, shortening of growing period, low agricultural products and animal diseases.

This religious leader also asked the causes of the problem. Accordingly, he responded as the chief factor for increasing temperature and decreasing of rain fall in current generation is violating the rule of almighty God. Consequently, our sin and mistake forced the God to Judge as such and pay the cost on the earth and its creatures by these challenges.

Surprisingly, he strongly recommended to obey the rule of God by fasting and praying day and night to reduce the impact of climate change other related problems. Besides the government also responsible to full fill the infrastructure: road, electricity, health station, veterinary service. In turn the farmers also responsibilities to plant trees and conserve the natural resource that the God create for us. He also claimed as the price of fertilizer and tax increase from time to time, so they do not afford to pay it; therefore the government should have to reduce the prices he said.

Another 30 years old agricultural expert in Kurar explained as there is climate change particularly increase of temperature and decrease of rainfall currently. He also explain as, erratic rainfall, seasonal variability, drought, soil degradation, which leads to low agricultural products are the key indicators. He also gave detail on the adaptation strategies to reduce the impacts of climate change; planting trees, plough along contour livelihood diversification, migrating in search of employment; soil bund and stone bund are some of them.

4.3. Assessing Vulnerability to climate change

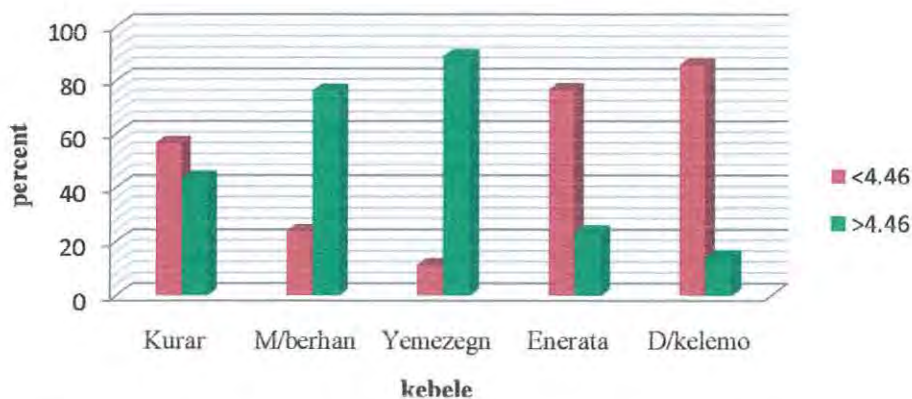
4.3.1 Indicator variables of Adaptive Capacity

Adaptive capacity is defined as the ability to deal with the exposed climate change and climate variability. Adaptive capacity comprises of different major components, like **financial capital**, in which wealth profile of the household assessed; **physical capital**, where technology and infrastructure profile assessed; **human capital** where, community profile measured; **social capital**, where social profile of the households measured, and natural capital where ecosystem profile and agricultural profile of the households addressed.

Financial capital

Livestock ownership: live stock rearing is also an important economic activity that the farmers in choke mountain watershed are engaged in and their by depend their life on it. Here, the total live stock of the farmers is converted to standardized form of the tropical life stock unit of the respondents in all agro ecological zones. According to Asfaw and Jabor (2008), the average TLU value in Ethiopia is 4.46. thus the researcher take the average and classify the total livestock of households in the study area. Thus in this section households who possess high tropical livestock unit have relatively high adaptive capacity and less vulnerable than who have less and no livestock at all. ss

Figure 4: Respondents' livestock ownership



Significant at 5% of level($p=0.000$), Source: Own survey, 2012

According to the survey data, the majority of the study areas respondents (51%) have TLU less than the national average (< 4.46) whereas, the rest, 49% have own TLU greater than national average TLU (>4.46). In M/berhan the majority of sample respondents reported as they possess TLU, >4.46 . Similarly the majority of sample respondents in Yemezegn 88.9% have TLU value >4.46 . According to Temesgen et al., (2008), the higher the percentage of total households with asset ownership (including livestock) and access to income source, the

lesser the vulnerability and have higher adaptive capacity. Thus, in this case AES2 (M/berhan) and AES3 (Yemezezn) own the highest TLU value as compared to the rest kebeles, and have lesser vulnerability vis-à-vis rest kebeles.

Land size of the house holds: farm size of the house hold is also an important variable that determine the production ability of farmers. Here the total land holding size of the respondents is summation of their cultivated land, forest and grass land, irrigation land holding size of farmers is classified into 2 based on the average land holding size in Amhara region (CSA, 1992).

One of our country's development challenges now is the rapid population growth rate that by far exceeds the pace of the economic growth. The other demographic constraints under Consideration here seem to be the direct outcome of this factor. Due to this and other factors mentioned, in the Choke Mountain water shed Land became scarce and land holding per household have been declining from time to time. Surprisingly, in the study area, the majority (72%) of the sample respondents possesses land size less than average (1ha), only 28% of them possess greater than average land size. In Kurar, 87% of households, in M/berhan 55%, in Yemezezn 58.8%, in Enerata 82.4% and in D/kelemo 72% of sampled households possess land size less than 1ha.

Physical capital

A. Access to modern Agricultural Technologies: numerous studies in our country have proved that appropriate application of modern farm inputs such as chemical fertilizers, improved seeds and the use of irrigation can increase crop yield and productivity. Because of this fact, farmers in Ethiopia have been for long encouraged to adopt modern farm inputs and utilization of modern farm inputs. The importance of these inputs becomes more significant in

highly eroded soils and fragile environments as in Eastern Gojjam Zone to improve land productivity and to boost overall production.

The higher the percentage of total households who have access to agricultural technologies such as fertilizer supply, improved seeds, the lesser the vulnerability and vice versa (Temesgen et al., 2008). In Kurar, about 95.7% of respondents used fertilizer, 95.7% of them reported as they do not use improved seed, 4.3% of them reported as they used irrigation. In M/berhan all sample households used fertilizer, 52.4% of them reported that as they used improved seeds, and the rest 23.8% of them used irrigation. In Yemezegn, 94.4% of respondents used fertilizer, 83.3% of them used improved seed, 38.9% of households used irrigation technologies. In Enerata, 94.1% of respondents utilized fertilizer, 94.1% of them have used improved seed, 94.1% of them have also used irrigation technology. In D/ kelemo, 81%, 90%, 71.4% of sampled respondents have access and utilization of fertilizer, improved seeds and irrigation respectively.

B. Infrastructural Provision: adaptive capacity is likely to vary with social infrastructure. 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. The higher the percentage of households who have access to infrastructure and have access are lesser vulnerable (Temesgen et al., 2008). Infrastructure provision and the existence of institution have an important role in enhancing the adaptive capacity of farmers in the rural area from any climatic shocks by facilitating access to resource, infrastructure, weathered roads, (health posts, schools, market access, access to electric, access to telephone service, access to veterinary services and etc.

Table 9: Access to health post, school and market

Kebele	Distance of Health service in Km				Distance of 1 st cycle school in km				Distance of Market in km			
	≤4		>4		≤4		>4		≤4		>4	
	No	%	No	%	No	%	No	%	No	%	No	%
Kurar	5	21.7	18	78.3	23	100	0	0	1	4.3	22	95.7
M/berhan	11	52.4	10	47.6	21	100	0	0	0	21	21	100
Yemezegn	9	50.0	9	50.0	17	94.4	1	5.6	0	0	18	100
Enerata	4	23.5	13	76.5	16	94.1	1	5.9	0	0	17	100
D/kelemo	7	33.3	14	66.7	15	71.4	6	28.6	0	0	21	100
χ^2	<i>P=0.025</i>				<i>P=0.003</i>				<i>P=0.044</i>			

Significant at 5% level. Source: Own survey, 2012

Health service

In M/berhan 52.4% and in Yemezegn 50% of sample households reported as it takes ≤4km to reach the nearby health center. However 66.7% of sampled households in D/kelemo, 78.3% in Kurar reported as it takes them ≥5km to reach health post. The result from the FDG in D/kelemo also shows that they allowed to go long distance to get the service. In Yemezegn and M/berhan respondents have access and relatively go smaller distance ≤4km as compared with the rest kebeles. The results of FGD in these kebeles also depicted as they got better service by specialized physicians when go to the health center.

First cycle school

The existence of full cycle school and alternative schools in local areas will give opportunity to farmers to send their children in nearby schools. Thus, the respondents were asked whether they send their children to school or not and the distances of school from their home. Accordingly, 100% of sample households responded as they send their children to school.

94% of sample households in Yemezegn, 94.1% in Enerata, and 74.4% in D/ kelemo have reported as it takes ≥ 4 km to reach the school. The focus group discussion conducted in all kebeles depicted as they send their children to school thus, their children able to be educated even discussants added educating their children contribute for their perception change towards their environment in large , create job opportunity for their children and as a result lessen the land fragmentation. In D/kelemo the discussants added as their childrens are lucky to get the school in shorter distances that compensate, the past time there were no such access to schools that is why they are being illiterate.

Access to Market

Access to market enables farmers to access input in their locality. Lack of market access can also limit the potential for farm-level adaptation. Greater distance to the market where outputs are sold diminishes the probability of adaptation (Mano et al., 2003). The majority (95%) of the sample households in all kebeles; reported as there is no market center in their locality and takes ≥ 5 km to reach there. The researcher conducted FGD, in the study area. Thus, in D/kelemo and yemezegn, the discussants replied as they face various difficulties to reach the market center found in the town. Surprisingly, they said as they walk by their barefoot to reach the nearest market center. Thus, this is very challenging issue to the farmers to sell their agricultural products and use different farm inputs.

Access to Veterinary service

Veterinary service one of the basic infrastructural provisions necessary for the local farmers who their live is rely on livestock rearing. The respondents were asked whether the veterinary service found in their locality or not and also whether they go to veterinary service stations while their animals are diseased. Accordingly, throughout all kebeles the

majority(87%) of sample respondents reported as there veterinary service stations in their locality. However, the respondents who got the service varies in all kebele. Thus, 45% of sample respondents in Kurar, 68% in Yemezegn,71% in M/berhan reported as they go to veterinary service while their animals got sick. The FGD results in Enerata kebele revealed that as the service they got from this station is very limited because this station only works for few days per week and no regular service provided. Due to this they replied as they loss their livestock, if possible they forced to go more than 8km to get the service.s

Access to Electric power

Electricity is important infrastructure that enables farmers to use different media service and other important benefits. Concerning access to electricity farmers were asked whether they have access to electricity or not. The majority of (84%) of sample kebeles' households reported as they have no access to electricity, reported as they use fuelwood and petroleum gass instead of electricity as power source.

Access to weather roads

Road allow the distribution of necessary input of farmers and to bring their products to the market. In all sample kebeles the majority of (59%) of the respondents reported that there are roads but sometimes break their service due to different reasons.About 39% of the respondents reported as there are roads that connect their locality and the nearby city always.

When we see at the Kebele level, in Kurar, 66.7% of sample households in m/berhan 79%, in Yemezegn, 82.4%, in Enerata, 91.3%, of sample respondents reported as there are roads but sometimes break their service due to different factors. Especially during rainy season it is to difficult to get access of transportation. Besides the researcher's transact walk also approve the reality of unsuitability and unaccessibility of roads in the study area.

Access to different water sources

The availability of clean drinking water is likely to decrease due to the increasing evaporation and the increasing variability of rainfall events. Households in the choke mountain watershed were asked which source of water they used for various purposes. As a result all of sample respondents in the study area respond as they use river as a major source. For this reason, the researcher, tried to identify the distance of the river from household home and attempt to assess in the next section.

Table 10: Access to water sources

Kebele	Water source			
	River (%)	Stream (%)	Borehole (%)	Pipe water(%)
Kurar	100	0	4.3	0
M/ berhan	100	4.8	66.7	21
Yemezegn	100	55.6	16.7	16.7
Enerata	100	29.4	41.2	29.4
D/kelemo	100	20	9.5	19

Source: Own survey,2012

Distance of river water from households home

Water is the most important natural resource which is used for the existence of human beings on the earth. Even though there are many sources of water in the study area, all of respondents in the study area used river as source of water. For this fact, the households were asked the distance of river from their home. The survey result depicted as majority (45%) of sample respondents go >1.5km to fetch river water. In d/ kelemo 76.2% of sample respondents reported as it takes them >1.5km to reach the river to fetch water. In Yemezegn 38.9% of

sample respondents reported as it takes them < 0.5km. In Kurar (AES1) 39.1 % of sample respondents, in M/berhan (AES2) 71.4%, respondents claimed as it takes them more than 1.5km to reach river source.

Results from FDG in the study area revealed as water is basic element for their livestock, for drinking, for household purpose and in general for their existence than other resource. However, in these kebeles, the discussants claimed as they severely suffered from shortage of water i.e. they fetch water from distant place. In addition to river sources there were also different streams used as water source before 20 and 30 years, nowadays due to climate change and variability many water sources were drying and degraded from time to time. Consequently, the absence and inaccessibility of water in the study area made them more vulnerable.

Table 11: Distance of river water from HH's house in km

Distance in km	Kebele									
	Kurar		M//berhan		Yemezegn		Enerata		D/kelemo	
	No	%	No	%	No	%	No	%	No	%
>0.5	9	39.1	2	9.5	7	38.9	7	41.1	2	9.5
0.5-1.5	5	21.8	4	19	8	44.4	8	47.1	3	14.3
>1.5	9	39.1	15	71.4	3	16.7	2	11.8	16	76.2
Total	23	100	21	100	18	100	17	100	21	100

Significant at 5% level (p= 0.04). Source: Own survey, 2012

Access to saving and Credit services

The accessibility of agricultural credit to the subsistence farmers who have modest or no wealth or savings to invest in farming is an important component in small farm improvement programs. In line with this view, an attempt was made to know the number of farmers who

have access and able to get credit from these institutions. From the total respondents 60% of the households had not got and benefited from credit association. Only 40% of households have the access and take credit services and able to benefited. In d/kelemo, 85.7%, in Enerata 64.7%, in Kurar 73.9% of sample households have not got credit. In Yemezegn 66.7% of households and in m/ berhan 61.9% of farmers reported as got credit. The focus group discussion result carried out in D/kelemo, Enerata and in Kurar revealed as they are not beneficiaries from saving and credit associations because they do not afford returning the money.

Human capital

Human capital consists of sex of hh heads, educational level, health services, which are already discussed under earlier sections and radio ownership.

Radio ownership:-Households that own radio are assumed to have access to information about climate change and variability and also have information about technology usage which could be broad casted through radio. On the other hand the more information households have the more the adaptive capacity (Temesgen et al., 2008). Information is the most essential resource for human beings. Information can obtained from different media sources such as radio, agricultural extensions, television, internet, news paper and so on.

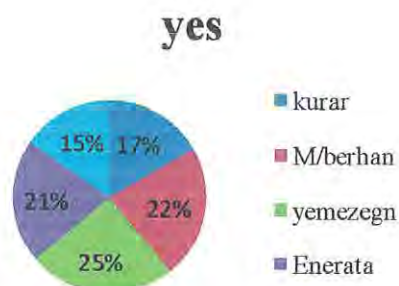
However, in the rural Ethiopia including the study area, due to the inaccessibility of farmers to these information sources, they were asked whether they have radio or not. Accordingly, from total kebeles' sample households 58% of them reported as they have radio and the rest 42% have not. When we come to kebele level, in Kurar, 56.5%, 71.4% in Yemezegn, 83.3% in Enerata 47.1% and 33.3% of sample respondents in D/ kelemo have possess radio and have access to information.

Social capital

Tradition of working together and non working days are the two important elements and with great role in social capital. The more farmers are members with less non working days and the more tradition of working together the better adaptive capacity (Temesgen et al., 2008).

Traditional of working together have an essential role in social capital by facilitating the work of the households. Thus, the sample respondent, were asked whether they have traditional working together or not, which is discussed as follow.

Figure5: Tradition of working together



Significant at 5% level ($p=0.010$)Source: Own survey, 2012

As illustrated on the above figure, 17% of sample households in Kurar; 22% of sample households, in m/ berhan, in Yemezegn 25%; 21% of samples in Enerata; 15% of sample respondents have tradition of working together. The result of FGD, in Yemezegn and M/berhan revealed that they cooperatively do together whenever necessary. For instance , on the farming activities, they have cooperatively work together with their neighbor by cooperative works.

The FGD result and KII in all kebeles revealed as they have tradition of working together they added without working together they did not be effective and neither accomplish nor effective in their activities, this is the fact that the majority of households in the study area

engaged on subsistent farming which is traditional way, consumes, time and energy, and need many labour. They also added, so as to be effective in their work they highly need extra human power and time.

The KII, in all kebeles also explained as the traditional cooperative organizations such as, Eder –local community based organization) also helped them to be socially bonded and be effective on their activities because they work cooperatively together. The FGD in Yemezegn also added as cooperative work has advantageous, better and effective than working alone. Furthermore, working together creates close social bond and good relationship, to share experience regarding their livelihood, climate change. Thus from this result we understand, the more farmers have tradition of working together, the better adaptive capacity they have.

Table 12: Number of non-working days.

Non-working days	Kebele									
	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo	
	No	%	No	%	No	%	No	%	No	%
<6 days	2	8.7	11	52.4	11	61.1	3	17.6	4	19
>6 days	21	91.3	10	47.6	7	38.9	14	82.4	17	81
Total	23	100	21	100	18	100	17	100	21	100

Significant at 5% level (P=0.002) . Source: Own survey, 2012

The author tried to range the number of non-working days in the study area into 2 based on the mean average result ranging <6days and>6 days. Accordingly, in Kurar 91.3%, in M/berhan (AES2),47.6%, in Yemezegn 38.9%, in Enerata 82.4% and in d/kelemo, 81%, of respondents reported as they have more than 6 non-working days per month. FGD conducted in all kebeles results depicted as they perceive, as God will punish them if they work.

4.3.2. Indicator variables of sensitivity

Sensitivity is the degree to which a community is adversely or beneficially affected by climate related stimuli (IPCC, 2001). Sensitivity constitute of natural capital where different major profile components are included. The two chief profiles under sensitivity are ecosystem and agricultural profile.

I. Agricultural profile: here, the respondents were asked whether they use crop rotation or not. Accordingly, the majority of (54.6%) sample households of the study area do not use crop rotation. When we see at Kebele level, 24% and 25% of households in Kurar and m/ Berahan respectively use crop rotation, In Yemezegn 26% reported as they use crop rotation. In Enerata, and D/kelemo 12% and 13% of respondents respectively, use crop rotation. From this result the kebeles which have relatively high percentage of households who use crop rotation are less vulnerable.

II. Ecosystem profile: in ecosystem profile, the respondents were asked two basic questions: soil fertility status and slope of thei land. Soil fertility determines the capacity of farm land to bear product of an area. The majority (47%) of the study areas' respondents reported as their soil is infertile. Whereas, when seen at kebele in d/kelemo, 76.2% of the respondents reported as their soil fertility status is infertile, in Kurar, Yemezegn and Enerata, 91.3%,16.7 and35.3% of respondents respectively reported as their soil fertility decrease. Whereas in M/ berhan 47.6% of respondents reported as their soil fertility is somehow fertile.

The higher the percentage, of households with infertile soil and unsuitable topography the more vulnerable they are and have less adaptive capacity (Temesgen et al.,2008).Accordingly,

with regard to this study AES1(Kurar) and AES5(D/kelemo) have highly vulnerable with 91.3% and 76.2% of respondents reported as their land is infertile respectively. Thus, these kebeles are more vulnerable to negative impact of climate change as compared to the rest agroecologies.

Land form : Choke Mountain watershed has six different agro ecologies which are endowed with enormous and amazing land features. Thus, the study kebeles have different topography which is referred as determining factor and responsible for sensitivity of an area for impacts of climate change. This is why the respondents were asked what their farm land' topography is.

Table 13: Land form

Land form	Kebele										X ²
	Kurar		M/berhan		Yemezezn		Enerata		D/kelemo		
	No	%	No	%	No	%	No	%	No	%	
Plainy	2	8.7	18	85.7	16	88.9	-	-	3	14.3	P=0.00
Highly sloppy	20	87	3	14.3	1	5.6	16	94.1	1	4.8	
Hilly and mountainous	1	4.3	-	-	1	5.6	1	5.9	17	81	
Total	23	100	21	100	18	100	17	100	21	100	

Significant at 5% of level, source: Own survey, 2012

As depicted on the above table , in Kurar 87% of sample respondents reported as most of their topography is highly steep slope which facilitate soil erosion and highly exposed to land slide in M/ berhan 85.7% respondents and in Yemezezn 88.9% reported as their land is plainly, in Enerata the majority 94.1% of households, and in d/kelemo 66.3% of household respondents reported as their land is hilly and mountainous. AES1 and AES5 are characterized by relatively unfavorable agroecological condition: fragmented and steep slopes, with the highest

degradation rate combined with shallow soil which is responsible for their high vulnerability to negative impact of climate change (Belay et al., 2013). Similarly, in this study Kurar (AES1) and AES5 (D/kelemo) which are characterized by rugged terrain and steep slopes were the most vulnerable kebeles.

As it was observed through transect walk through Kurar Kebele it is highly sloppy and subjected to soil erosion easily. As a result obtained from FGD, in Kurar and Enerata, due to the steepness of their topography the soil is highly eroded and this in turn responsible to low productivity. They also claimed as their topography is high threat which leads to for the farmer's displacement to the other places.

4.3.3. Indicator variables of Exposure

IPCC (2001) defined Exposure as the, "degree of climate stress upon a particular unit of analysis; it may be represented as either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events". Therefore, in this section, exposure is measured by the climate profiles, where, climate variability and natural disasters are major profiles. Regarding the climate variability the meteorological data of 30 years i.e. temperature and rainfall data were taken to assess the exposure of the study area. To assess the exposure of the sample kebeles change in temperature and rainfall condition of each Kebele was to be collected but due to absence of these metrological data the researcher allowed to analyze the exposure by changes in climate variability, including the magnitude and frequency of extreme events occurred in the study area.

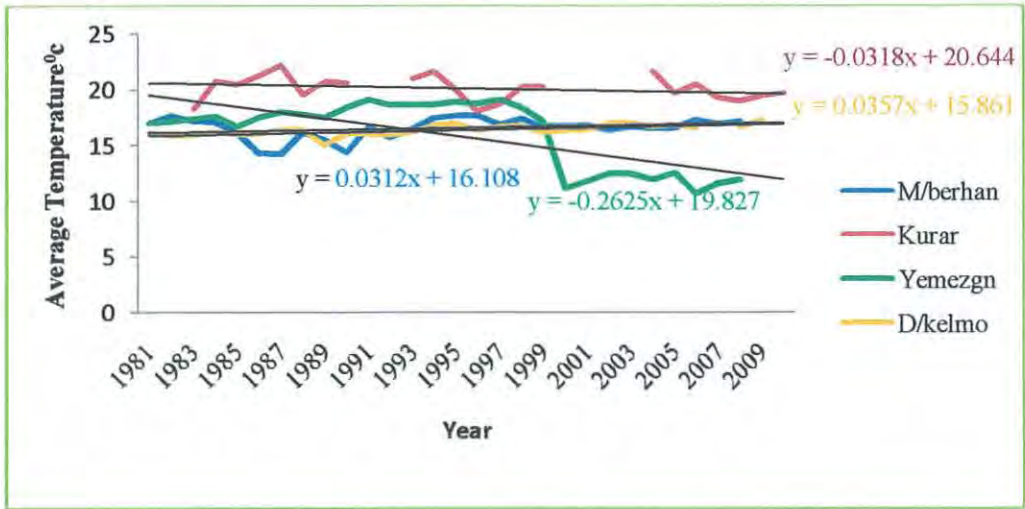
I. Analysis of local Temperature and Rainfall change

To analyze the temperature and rainfall data change of study area, meteorological data were obtained from National Meteorological service agency, despite the fact that there were incomplete and insufficient data at each kebele for analyze the change. For this reason the researcher decided to take the data from woreda level. Even some Woredas lack meteorological data. In this case the researcher tried to extrapolate rainfall and temperature data for for D/kelemo and Enerata kebeles from nearby stations of D/markos. Hence, the trend analysis is computed from the year 1981-2010 for each kebele on both temperature and rainfall.

A. Analysis of Temperature change

Climate change has become a real phenomenon, as it is evident from an increased world temperature, which is known as global warming. Global average temperature has increased by about 0.6°C over the past 100 years, with a major warming upswing in the 1970s (IPCC, 2001). as illustrated on figure below, the temperature trend of D/kelemo, Yemezegn, Enerata and m/Berhan for the given years shows an increasing trend. On the other hand, average annual temperature in Kurar shows a decreasing trend by 0.70°C.

Figure 6: Trend analysis of annual Temperature for sample kebeles (1981-2008)

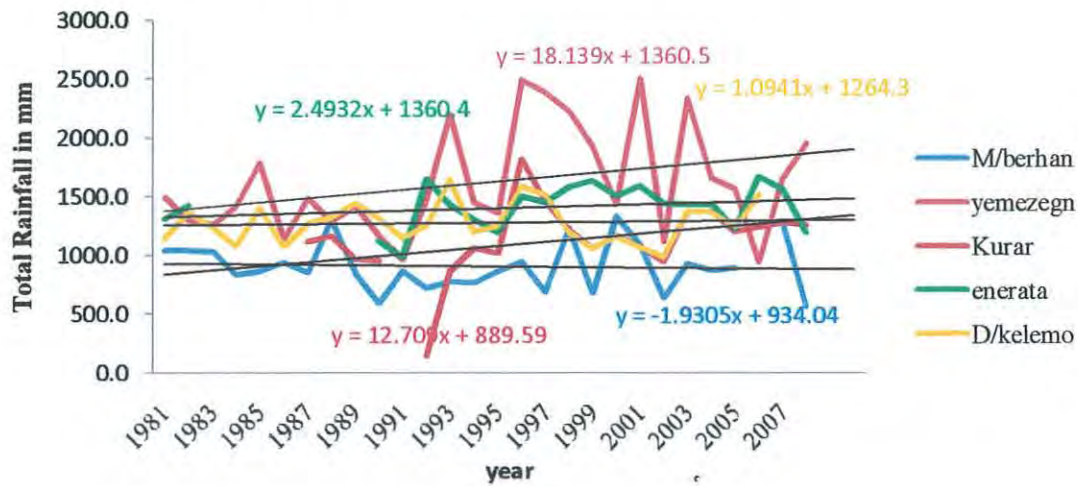


Source: Own calculation, 2013, from NMA,2007

B. Analysis of rainfall change

As illustrates on the below figure, the total rainfall pattern for the year 1981-2008 shows an increasing trend in most of the sample kebeles. However in Yemezegn and Kurar, kebele (AES3 and AES1) there exists a high increment of rainfall trend compared with the other kebeles, (agroecosystems) 489.7mm and 343.1mm respectively. Though there is also an increment in rainfall pattern in those kebeles, trend of rainfall is low in Enerata and D/kelemo (AES4 and AES5) with total annual variation of 67.3 for Enerata and 29.5mm for D/kelemo. However, there is a decrement of total annual rainfall trend in M/berhan kebele (-52mm) for similar year.

Figure 7: Trend analysis of annual Rainfall for sample kebeles (1981-2008)



Source: Own calculation, 2013 from, NMA,2007

I. Occurrences of Extreme events

Extreme events in climate change are the occurrence of extreme drought and extreme flood. Thus, they are the important variables used to assess the exposure of an area to climate change and variability.

Table 14: Occurrences of Flood

	Kebele										Total	X ²
	Kurar		M/berhan		Yemezeegn		Enerata		D/kelemo			
	No	%	No	%	No	%	No	%	No	%		
Yes	8	34.8	15	71.4	16	88.9	14	82.4	17	81	70	P=0.011
No	13	56.5	5	23.8	2	11.1	3	17.6	3	14.3	26	
I don't know	2	8.7	1	4.8	0	0	0	0	1	4.8	4	

Significant at 5% of level, source: own survey, 2012

AS depicted on the above table, the majority (70%) of sample households in the study area reported as they experienced flood within 20/30 years. In Kurar 34.8% and in m/

berhan 71.4%; in Yemezeegn, 90%, in Enerata 82.4%; of sample respondents reported as they experienced extreme flood within the last 20 and 30 years.

Table 15: Occurrence of Drought

Drought occurrence?	Kebele										Total
	Kurar		M/berhan		Yemezeegn		Enerata		D/kelemo		
	No	%	No	%	No	%	No	%	No	%	
Yes	23	100	19	90.5	17	94.4	16	94.1	21	100	96
No	0	0	1	4.8	1	5.6	1	5.9	0	0	3
don't know	0	0	1	1	0	0	0	0	0	0	1
Total	23	100	21	100	18	100	17	100	21	100	100

Not statistically significant at 5% level of confidence ($p=0.11$). Source: Own survey, 2012

Regarding the occurrences of drought, the sample households were asked whether they experience drought occurrences within the last 20 and 30 years or not. According to Temesgen et al., (2008), the higher the percentage of households, who experienced climate extremes, the higher the vulnerability and vice versa. In Kurar 100% and in M/berhan 90.5%, in Yemezeegn 94.4%, in Enerata 94.1% and in D/kelemo all respondents reported as they experienced extreme drought season within the last 20 years. Therefore, from this result one can understand that AES1 (Kurar) and AES5 (D/kelemo) have high vulnerability and lesser adaptive capacity in comparison with the rest kebeles, and AES4 (Enerata) seems relatively moderate.

4.4. Adaptation Strategies

Adaptation to climate change and variability is a response to climate change that seeks to reduce the vulnerability of biological systems to climate change effects. There fore in this section different adaptation options of the farmers in the study area going to be assessed

Soil conservation: Can be improved inexpensively by implementing management strategies for areas prone to soil erosion. By examining land-use along with soil characteristics and vegetative communities, improved land use planning and soil conservation strategies can be developed that not only improve environmental quality, but also reduce agriculture input.

Soil conservation strategies: the survey data showed as the majority of (58%), 62%, and 66% of sample households in the study area reported as they use strategies like plough along the contour, using soil and stone bund strategies to cope up with climatic and related impacts respectively. When we see, this result at Kebele level, in Kurar 34.8% of sample households 65% in M/berhan, in Yemezegn 77.8%, in Enerata, 94.1% and 71.4% in D/ kelemo plough their farm land along the contour. Regarding soil bund, 30.4% of sample respondents in Kurar, 66.7% in M/ berhan; 83.3% in Yemezegn; 76.5% in Enerata; 66.7% in D/ kelemo reported as they used soil bund strategy to protect their land from erosion.

Stone bund is another strategy used to conserve soil resource in the study area. Accordingly, in Kurar, 95.7% and in m/ berhan 28.6% of sample households, in Yemezegn 55.6%; in Enerata, 76.5%; in D/kelemo 71.4%, reported as they used stone bund strategy. As result from FDG and KII obtained shows, farmers in Kurar used different strategies to protect their soil from being eroded, among these, irrigation and stone bund is the major and mostly used

method so by applying this method they conserve their soil from erosion and other related problems.

Planting trees: is the practice of planting and maintaining forested areas for the benefit and sustainability of future generations. It is the upkeep of the natural resources within a forest that are beneficial to both humans and the ecosystem. The survey result indicates, 45% of sample respondents in Kurar, and 64.7% of sample households in M/berhan 57.1%, 47.7% in D/kelemo reported as they plant trees.

Water harvesting strategy: in the study area, about 83% of sample household do not use water harvesting strategy to adapt to climate change. However, the relatively better water harvesting was undertaken in Yemezegn (83.3%) and in M/berhan (85.7%).

Generally, in the study area the adaptation strategy undertaken to combat adverse effect of climate and related problems were not satisfactory. The FGD and KII results throughout these kebeles revealed, as the most hindrance factor to undertake effective adaptation strategies were, financial and technological constraints, lack of skill, lack of information. Besides, they also claimed as the lack of well- developed institutions hindered their adaptive capacity.

Income diversification:about (50.5%) of sample respondents in the study area reported as they do not have additional source of income other than agriculture, and their life rely on agriculture, which is referred as their back bone of economy. 49.5% of them reported as they have extra source of income; meaning that this small percentage of sample respondents engage in different off- farm activities to cope up with climate change. The same is true in Kebele level, in Kurar (AES1) and in D/kelemo (AES5) equal percentage of respondents reported as they have additional source of income. In M/berhan 32%, in Yemezegn 29.1% of

respondents and in Enerata 19% of sample respondents reported as they have additional source of income other than agriculture. The rest percentage of all kebele's sample respondents had no additional source of income.

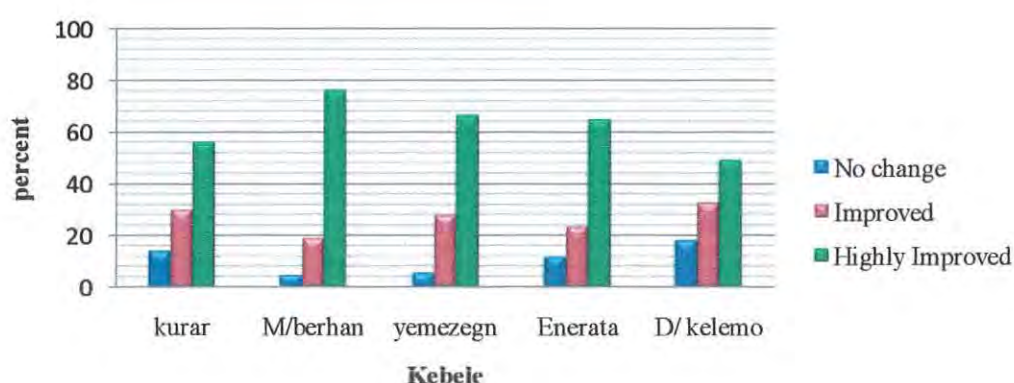
The FGD and KII results throughout the Kebele revealed as farmers adopted various response measures to counterattack the impact and shocks of climate change and related hazard. Those are referred to as coping mechanisms. For instance male headed respondents most of the time sell Kimba (locally prepared woody material), migrating to other places for search of employment, selling of livestock, bee keeping- (from which they earned better income because it is very expensive), selling of forest products and etc. Female headed respondents by and large, selling of forest products, Selling of Areke', 'Tej' and 'tella'(local names¹), selling of fuel wood, selling of tea and etc. besides, they also explained as reduction of consumption level at household level is also an important coping strategy.

Using fast growing seeds: the survey result depicts, about 74% of sample kebeles' households use fast growing crops to cope up with the changing change. 65%, 76.2%, 72.2% and 19% of sample respondents in Kurar, M/ berhan, Yemezegn and Enerata respectively used fast growing seeds as an adaptation to erratic rain fall and other related impacts of climate change. As the result of FGD and KII in Kurar and D/kelemo depicted, due to climate change and variability especially drought and seasonal variability of rain from time to time the farmers in these kebele were experienced frequent drought seasons which are responsible for their food insecurity.

¹ Areke, tella and teg are locally prepared beer.

To overcome the shortage of food they explained as they use fast growing crops. likewise, In Yemezegn, M/ berhan, and Enerata the result of FGD and KII revealed as households in these kebeles used fast growing crops as an adaptation option to the climate impact, which is related to shortage of rain and highly variable g season. They added the major fast growing crops which grow at least within three months are potato, Barley and maize.

Figure 8: Change in livelihood after undertaking of adaptation strategy



Significant at 5% level ($p=0.011$). Source: Own survey, 2012

Effective implementation of the adaptation options to climate change is essential for sustainable development of one country, if not properly implement it might be mal adaptation to climate change, even facilitate the impact (Belay, 2011). That is why the respondents were asked whether the above explained strategies were improving their livelihood or not. As such, in Kurar 56% of respondents, in M/berhan 76.2%, in Yemezegn 66.7%, in Enerata, 64.7% and in D/ kelemo 49.7% of sample respondents reported as their livelihood was highly improved due to adaptation strategies they have ever used.

As a result from FDG and KII revealed, in Yemezegn and M/ berhan the adaptation strategies they have used like planting trees, soil and water conservation strategies, changing crop

calendar and the like have various significances to their livelihood. They reported as their productivity and income increase as a result of this afford sending their children to school, their soil moisture protected, due to the effective adaptation strategies they have used, they added “**generally we feel better now.**”

4.5. Results of Vulnerability Index

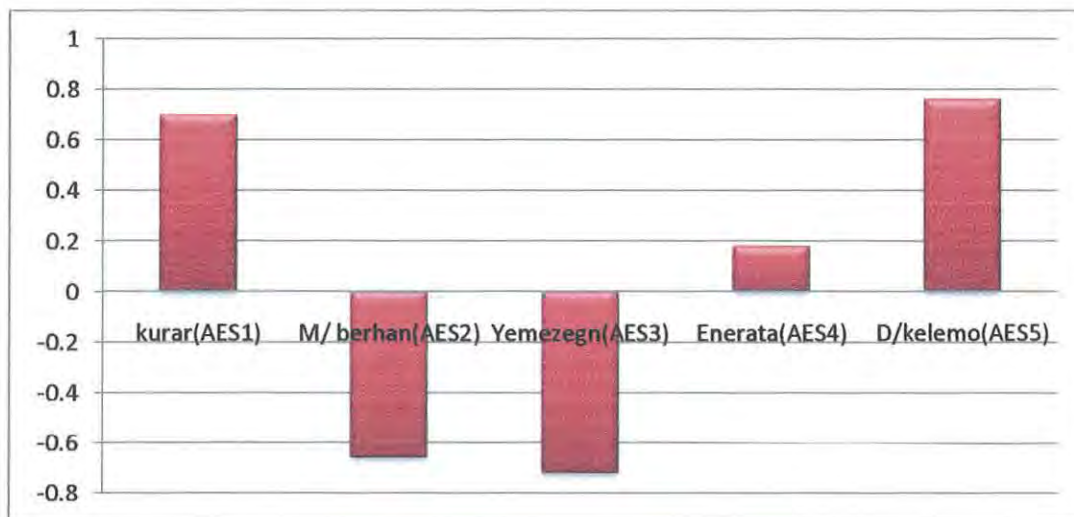
In this study LVI- IPCC was used to measure the vulnerability status. The methodology places multiple indicators under the broad umbrella of three factors which define vulnerability-exposure, adaptive capacity and sensitivity. The assessment of vulnerability involves four steps moving from indicators to profiles and ultimately to the final vulnerability index. The data for the indicators were normalized. Then, for each profile a value was obtained by combining the data for the indicator under it. Ultimately the LVI-IPCC scaled from -1(least vulnerable) to 1(most vulnerable).

Once the factor score (weight of each indicator) was found and indicators of each determinants of vulnerability were normalized. The next step is calculating the vulnerability indices of each agro ecology by equation number four, assuming that people with high adaptive capacity are less sensitive to damage from climatic change and variability.

The vulnerability index was calculated with assumption of kebeles with the highest vulnerability indices attached with positive is more vulnerable and have less adaptive capacity. Whereas, the vulnerability index attached with negative is likely to be less vulnerable and have high adaptive capacity. where an index value (-1 to -0.66) referred as less vulnerable,(-0.67to 0.22) as moderately vulnerable and(0.23-1) as more vulnerable (Hahhn et al.,2008).

Consequently, D/ kelemo and Kurar found to be high vulnerable kebeles and Enerata found with moderately vulnerable in relative terms. Whereas, Yemezegn and M/ berhan were the least vulnerable kebeles with an index value of Yemezegn -0.72 and M/berhans -0.66, Kurar, 0.70; D/kelemo,0.76 and Enerata 0.18.

Figure 9: Indices of vulnerability



Source: Own computation,2013

As depicted on the above figure, the vulnerability indices of kebeles revealed high vulnerability of D/ kelemo (AES5) which is characterized by shallow soil, overgrazing-due to overstocking, deforestation) and AES1 (Kurar) and moderately vulnerable kebele (Enerata (AES4). According to Belay et al., (2013), AES1 is characterized by relatively unfavorable agroecological condition: rugged terrain lower and more sporadic rainfall than other AES and extensive land degradation which are responsible for the negative impact of climate change and made the area more vulnerable.

While, agroecologies which are relatively less vulnerable are, mid land agroecosystem (Yemezegn(AES3) and M/ berhan(AES2) which are characterized by soils having considerable potentially suitable for mechanized agriculture and have potential irrigation capacity which leads to rapid increase in productivity and less vulnerability to negative impact of climate change. As it is discussed in this study there are a lot of factor that determine the vulnerability level.

The result depicts off- farm activities to diversify income, provision of agricultural inputs and technologies, access to credit and saving, access to school, veterinary service, utilization of irrigation system, topography, and socio-economic and institutions in general are the key determining factors of adaptive capacity and vulnerability of farmers in choke mountain watershed. According to the study, the higher vulnerability of D/ kelemo, Kurar and Enerata could be attributed to low economic status of households resulted from multiple reasons, reduction of land holding among households.

Besides, in Kurar, due to absence of off-farm activities and all most all households depend only on agriculture, and frequent drought and erratic rainfall also exacerbate its vulnerability. M/ berhan and Yemezegn have relatively better infrastructural and institutional provision and better economic capacity (relatively, fertile soil, high TLU value and better productive) as a result are less vulnerable and have high adaptive capacity to climate change and variability. Land and livestock are basis of household's livelihood in the study area, however, land on the other hand become scarce and land holding size of households have been declining due to increase of population.

When we see land holding size of house hold in the water shed, in d/ kelemo 66.7% of households, in Enerata 82.4%, in Yemezegn 77.8%, in Kurar 87% and in M/ berhan 75% of sampled households possess land size less than average (1ha).Furthermore, productivity of crop lands has been declining over time due to the conversion of crop lands in to eucalyptus tree in the high land agro ecology (Enerata).The midland plain areas such as M/berhan(AES2) and Yemezegn(AES3) have advantageous over the other Kebele, because of their plain and suitable topography, the degree of soil erosion and land slide are also relatively less and in turn this result leads to lesser vulnerability.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The farming community of Choke Mountain watershed noticed that their area is getting warmer and drier due to increased frequency of drought and changes in the timing of rains. Their perception of households were inline with the Observed trends of temperature. Hail storm, flooding, frequent droughts and changing precipitation patterns are among the major hazards related to climate change in the study area.

This study attempts to analyze the vulnerability level of the households in Choke Mountain watershed in five agroecologies using integrated assessment approach. In this study IPCC definition of vulnerability is adopted, which revealed vulnerability as a net result of exposure, sensitivity and adaptive capacity and indicators are also identified for each determinant. This analysis underline the high sensitivity and vulnerability of farmers in D/kelemo, Kurar and Enerata is mainly due to low adaptive capacity which is a result of lack of credit and saving institutions, in accessibilities of agricultural inputs, absence of infrastructure and institutions income diversification and others exacerbate the vulnerability of the area. AES 2(M/berhan) and AES3(Yemezegn) are less vulnerable kebeles with better adaptive and better infrastructural and institutional development in relative terms.

By and large, the increase of exposure of study area to climate change and high sensitivity of the environment coupled with low adaptive capacity exacerbate the vulnerability of AES1 and AES5.

5.2. Recommendation

Based on the finding of the study the following measures should be taken to counter attack the impacts of climate change and enhance the adaptive capacity of the local people. Furthermore, the coping and adaptation strategies need additional effort either from the local farmers or from the government. To this end, some possible ideas are recommended in this section.

- Creating awareness should be done for the local communities by providing them reliable, up -to- date information, and effective training so as to improve their perception towards their environment.
- Better management of natural resources & conservation practices such as planting trees, water and soil conservation strategies should be implemented in order to improve the adaptive capacity and lessen the exposure of the study area.
- The government should focus on capacity building of the community by providing, effective trainings, enhancing and supporting current coping and adaptation strategies,.
- Improving infrastructural provision need to be undertaken to increase the accessibility of local communities to various services.
- Better provision of agricultural input technologies should be provided to the farmers so us to enhance agricultural productivity.
- The government should establishing local meteorology stations, to better climate forecasting at grassroots level.
- Further investigations should be conducted which adequately address the issue of baseline of climate change in the study area.

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Appendix 1: Survey Questionnaires

Addis Ababa University

Institute of Development Studies

Department of environment and development

Dear respondents: You should be confident that the data/information which you give me works only for this study and the development of the target community.

Lastly, I thank you for your cooperation

Name of data collector _____ Date _____ Code _____

AES: _____ Kebele _____

General information:

I. Socioeconomic Characteristics:

1. House Code _____
2. Sex 1= Male 2= Female
3. Age 1= 15-30 2= 31-65 3=>65
4. Marital Status 1=married 2= not married 3= divorce 4=single
5. Educational Status 1= illiterate 2= Capable of reading and writing
3= primary school 4= Secondary school 5= Higher education
6. Livelihood source 1= crop production 2= livestock 3= Mixed agri. 3=
governmentcivilservant4=other,pleasespecify _____
7. Responsibility in the community 1= member of the community 2= religious
leader 3= coordinator of community development work 4= other, please
specify _____
8. Size of family

No	Age	Sex (in number)		
		Male	Female	Total
8.1	<14 year			
8.2	15-65 years			
8.3	> 65 year			

II. Perception regarding climate change

1. Is the current climate condition the same to that of before 30 years ago in your locality?
1. Yes 2. No
2. How is the condition of the temperature of the day in the past 30 years?

1. Increasing 2. Decreasing 3.No change/constant 4. I don't know 5. Other, please specify_____

3. What are the local indicators that show the variability/change in temperature through time in your surrounding?

1. Human and animals diseases that has not been seen before
2. The emergence of new species of animals and plant in your local area
3. Changes of clothing style of the communities and shrinking of snow coverage
4. Degradation/deterioration of rivers through time
5. Change of animal and plants/crop type (for instance cultivation of Teff and other crop types)
6. Other, please specify_____

4. How is the condition of rainfall for the last 30 years? And how do you comment?

1. Increasing 2.Decreasing 3. No change 4. Change in the seasons of rainfall 5. Increase the frequency of drought 6. I don't know 7. Other, please specify_____

5. What are the local indicators that show the variability/change in rainfall through time in your surrounding?

1. Distinction of some plant species
2. Increasing the frequency of drought and floods
3. Shorting crop growing time
4. Degradation of soil and decreasing its productivity
5. Rains come early and lately from normal
6. Decreasing agriculture production
7. Deterioration/decreasing of water amount
8. Other, please specify_____

III. Adaptive capacity

Wealth profile

1. Do you have your own farm land 1. Yes 2. No
2. If your answer for question 1 is yes, what is its size in hectare or (Timad)?
 - 1.1.Cultivated land _____
 - 1.2.Grass and woodland _____
 - 1.3.homestead _____
 - 1.4. Irrigated Land _____

3. Number of live stock

Type of animal	Size in number
Ox	
Cow	
Sheep	
Goat	
Horse	
Mule	
Donkey	
Others	

Infrastructures

1. What is your information source?
 1. Radio 2. Television 3. Newspaper and magazine 4. Agriculture experts
 5. Neighbors 6. Other, please specify _____
2. Is there any saving giving service institution/organization in your locality? 1. Yes 2. No
 2.1. If your answer is yes please specify the list of institutions/organizations _____
3. How far is the nearest saving service institutions from your home? _____
4. Is there any credit service in your locality? 1. Yes 2. No
5. Are you using credit service? 1. Yes 2. No
6. Is there any market access in your locality? 1. Yes 2. No
7. If your answer is yes how long it takes to reach there (KM or Hour)? _____
 8. Is there any road connection to your neighbor and the nearby towns? 1. Yes there are roads that connect always 2. Yes there are but sometimes they break their services 3. No
9. Is there any Veterinary Service station in your locality? 1. Yes 2. No
10. Do you go to the Veterinary Service station while your animals are diseased? 1. Yes 2. No
11. Are there schools in your surrounding? 1. Yes 2. No
 11.1. If your answer is yes how much far is it from your home? _____
12. I there any electric power service in your locality? 1. Yes 2. No
13. If your answer is yes, what is your source of the power? Please Specify _____
14. Is there any water source in your locality/surrounding? 1. Yes 2. No
15. If your answer is yes please fill the following table.

water source	Distance from home in Km	Purposes			
		For irrigation	For drinking	For animal	For house consumption

River

Spring

Borehole

Pipeline

Other

Modern agricultural technologies

16. Do you use modern fertilizer applications on your farm land? 1. Yes 2. No
 17. Do you use improved seeds? 1. Yes 2. No
 18. Do you use irrigation technologies? 1. Yes 2. No

Social Capital:

20. Is there a tradition of cooperation to carry out farming activities? 1. Yes 2. No
 21. Are there local (informal) institutions in your locality? 1. Yes 2. No
 21.1. If your answer is yes, please list the name of these organization _____.

22. How many days you become free of work per month and how many religious holydays per month?

IV. Sensitivity

23. Do you practice crop rotation? 1. Yes 2. No
 24. How is the status of your cultivated land fertility?
 1. Not fertile 2. Some-how fertile 3. Fertile 4. Highly fertile
 25. How is the slope of your cultivated land?
 1. Plain 2. Highly sloppy 4
 . Hilly and Mountainous 5. Other please specify _____.

VI. Exposure

26. Have you ever experienced extreme drought in your locality within 20 and 30 years ago?
 1. Yes 2. No
 27. Have you experienced flood in your locality within 20 and 30 years?
 1. Yes 2. No

VII. Adaptation Strategies

28. What are the response measures taken and barriers to adapt and protect the problems caused due to climate change/variability in your locality? To be mark on the following strategies.

Adaption strategies	Strategies you use make (x) if you use it	Hindrance to implement
1. Means to keep soil fertility and its moisture content		
• Plowing along the contour		
• Stone bund		
• Soil bund		
• Crop rotation		
• Use of chemical fertilizer		
• Preparing and use of compost		
2. Forest resource conservation		
• Forestations/plantation		
• Aforestation		
• Planting trees around the farm land		

3. Livestock and feed resource management		
• Cut and carry system		
• Rotational grazing methods		
• Expand the size of fodder growing land		
• Prepare and produce fodder		
4. Crop production management and conservation		
• Changing cropping calendar		
• Application of fertilizer		
• Conservation of water and protect soil erosion		
• Irrigation		
• Use of improved seeds		
• Fast growing crop species		
• Water harvesting		

29. Explain the problems that hinder the implementation of the above listed adaptation strategies and give you suggestion to protect the problems.

30. Do you feel that your livelihood is improved while you use the above listed adaptation strategies? 1. Yes 2. No

Appendix 2: Guiding Questions for Focus Group Discussion

Address _____

Date of discussion _____

Time _____

1. In what economic activities do you engaged?
2. What other opportunities do you have to support your livelihood?
3. Identify hazards that threaten your livelihood system?
4. Is current climate condition similar with that of 30 years ago?
5. If not what are the changes observed?
6. What kind of changes has observed your environment over the past 20 or 30years?
9. What are the impacts of these changes on your livelihood system?

A. Impacts on the factors of production

B. Impact on source of income

C. Impact on social system

C. Impact on human health

8. What are the adaptation strategies you undertaken to overcome these challenges?

9. Do you think the adaptation strategies you undertake improve your livelihood? If yes explain how it improved?

10. What are the constraints to adopt these new strategies?

11. Do you think your way of life and styles have made you more vulnerable to the effects of climate change? How?

12. What is your opinion about development interventions undertaken in your area by government bodies concerning climate change?

Appendix 3: Guideline Questions for key informants

1. How long have you been here?

2. How do you characterize the weather of this area in terms of its temperature and rainfall?

3. Have you observed any change in temperature and rainfall

4. If you perceive the changes what are the local indicators? What are the major impacts climate change in your locality? Explain

5. What climatic hazards have you experienced or have you heard from your father and grandparents?

6. Do you undertake any adaptation measures to come up with the climate hazards? Explain these adaptation options

4. How did government bodies and NGO's respond to reduce the impact of climate change in your locality?

5. What activities have been done in the following areas?

A) Infrastructural development

B) Institutional set up

C) Environmental protection activities

6. What are the options that the communities have to reduce the vulnerability to the effect of climate change?

Appendix 4: Vulnerability indicators and expected relation with respect to vulnerability

Determinants of vulnerability	Vulnerability indicator	Description of indicator selected for analysis	Unit of measurement	Hypothesized functional relationship b/n indicator and vulnerability
Adaptive capacity	Wealth	-Number of livestock -Land size -Non-agricultural income Saving at hh level	Percentage	The higher the percentage of total HH with asset ownership and access to the income source the lesser the vulnerability
	Technology	-Improved agricultural technology -Fertilizer supply -Improved seeds	Percentage	The higher the percentage of total hh, who have access agricultural technologies the lesser vulnerability
	Infrastructures and institutions	-All-weather roads -Health service -Full cycle school -Veterinary services -Access to market -Electricity provision -Saving and credit institutions -Radio owner ship -Access to Water	Percentage	The higher the percentage of hh, who are using these infrastructure and have access of the lesser the vulnerability
Sensitivity	Biophysical condition of plot of land	-soil fertility -Slope of their farm land	Percentage	The higher the percentage of hh, with infertile soil and unsuitable topography of land the more the vulnerability
Exposure	Change in climate	-Change in temperature -Change in rainfall -Occurrences of drought -Occurrences of flood	Percentage	The higher the percentage of hh, who experienced climate extremes the higher the vulnerability they have

Source: Temesgen et al., 2008

Appendix 6: Normalized values of vulnerability indicator variables

Table1. Normalized values of wealth indicators

Indicators	Kebele				
	Kurar	M/berhan	Yemezegn	Enerata	D/ kelemo
TLU	0.064	0.1293	0.129	0.097	0.012
Land size	0.016	0.172	0.057	0.016	0.036

Saving	0.14	0.08	0.15	0.1	0.12
Extra income source	0	0.32	0.2	0.043	0.13

Source: Own calculation, 2013

Table2. Normalized value of technology indicator

Indicators	Kebele				
	Kurar	M/berhan	Yemezeegn	Enerata	D/kelemo
Insecticides	0.1	0.23	0.12	0.045	0.15
fertilizer	0.12	0.45	0.2	0.1	0.16
improved seed	0.02	0.21	0.32	0.089	0.25
Irrigated land	-0.98	3	-0.8	0.9	0.65

Source: Own calculation, 2013

Table3. Normalized value of infrastructure and institution indicator

Indicators	Kebele				
	Kurar	M/berhan	Yemezeegn	Enerata	D/kelemo
Market access	0.111	0.388	0.33	0.222	0.33
Veterinary service	0.02	0.048	0.13	0.14	0.02
Access to school	0.029	0.046	0.144	0.096	0.244
Access to saving & credit	0.285	0.183	0.28	0.285	0.346
Health	0.163	0.132	0.132	0	0.183
Weather roads	0.14	0.04	0.22	0.2	0.23
Access to Electricity	0.09	0.1	0	0	0

Source: Own calculation, 2012

Table4: Normalized value of social profile

Indicators	Kebeles				
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	Kurar	M/berhan	Yemezegn	Enerata	D/kelemo
Tradition of working together	0.06	0.32	0.16	0.14	0.23
Non- working days	0.23	1.61	0.23	0.923	0.56
Member of equb and Edir	0.1	0.048	0.12	0.13	0.16

Source: Own calculation, 2013

Table5: Normalized value of community profile

Indicators	Kebeles				
	Kurar	M/berhan	Yemezegn	Enerata	D/kelemo
Access to health center	0.08	0.143	0.23	0.1	0.2
Access to agricultural extension	0.08	0.4	0.1	0.1	0.21
Radio ownership	0.1	0.12	0.12	0.06	0.16
Dependency ratio	0.6	0.88	1.2	0.5	0.31

Source: Own calculation, 2013

Table 6: Normalized value of ecosystem profile

Indicators	Kebele				
	Kurar	M/berhan	Yemezegn	Enerata	D/kelemo
Slope of the land	0.087	0.714	0.944	0.05	0.143
Fertilized land	0.12	0.1	0.167	0.05	0.06
Increased productivity	0.002	0.5	0.21	0.04	0.1
crop rotation	0.005	0.022	0.21	0.13	0.05

Source: Own calculation, 2013

Table7: Normalized values of climate profile

Indicator	Kebele				
	Kurar	M/berhan	Yemezeegn	Enerata	D/kelemo
Mean annual RF	0.2	0.6	0.43	0.77	0.45
Mean annual T ⁰	1.2	0.5	0.5	0.5	0.5
Frequent Drought	1	0.9	0.94	0.94	1
Frequent Flooding	0.08	0.42	0.6	0.64	0.619

Source: Own calculation, 2013

Appendix 7: Conversion factor used to estimate tropical livestock unit

Animal category	TLU	Animal category	TLU
Cow and Ox	1.00	Horse	1.10
Calf	0.25	Chicken	0.013
Heifers	0.75	Sheep/goat(old)	0.13
Donkey	0.7	Sheep/goat(young)	0.06

Source: Stork et al., 1991

Appendix 8: Sample Photos

KII with religious leader, in D/kelemo



KII with agricultural experts, and model farmers, in Yemezegn



Traditional bee keeping.- in M/ berhan

Selling 'Kinba'-. in D/kelemo



FGD with female headed, in Kurar




KII with Agri, office head in Dejen worda



Declaration


I declare that this thesis is my original work and has not been presented for a degree in any University, and that all the source of materials used for the thesis has been duly acknowledged.

Declared by

Name: Fenet Belay Signature:  Date: 03/7/13

The examiners' comments have been duly incorporated.

Confirmed by:

Name: Belay Smae Signature:  Date: _____

