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Households' Vulnerability to Climate Change and Adaptation Strategies: The Case of Choke Mountain Watershed, Eastern Gojjam Zone, Ethiopia

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Fenet Belay
Addis Ababa University,Addis Ababa, Ethiopia

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
RF	Rainfall
SPSS	Statistical Package for Social Science
SoVI	Social Vulnerability Index
TLU	Tropical Livestock Unit
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 areaAES5 (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.
Keywords: climate change, vulnerability, exposure, adaptive capacity and sensitivity

1. INTRODUCTION

1.1 Back Ground of the Study

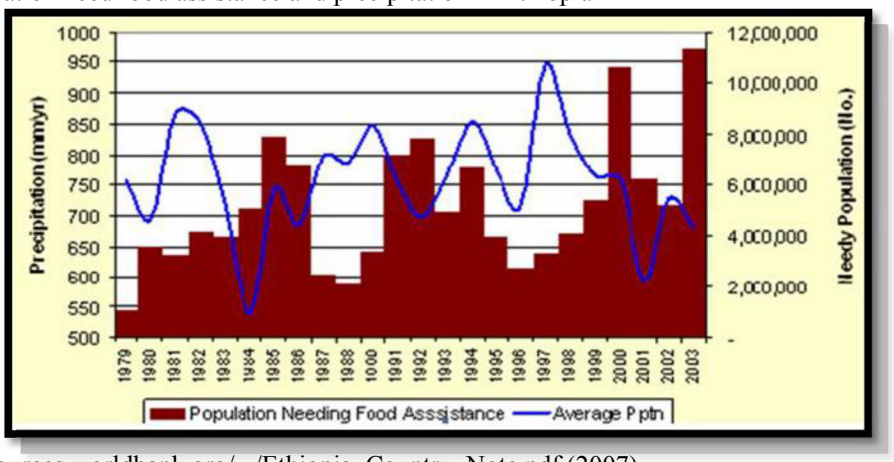
Currently, the issue of climate change has become one of the hottest and debatable agenda globally. It has been presented as a global issue resulting from an increase in green house gas emissions linked to human activities (Adger, W.N., 1999). It is also by now widely acknowledged that climate-change 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 a 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, 2009). Hence, development of planned adaptation strategies to deal with these risks is regarded as a necessary complement to mitigation actions (Burton, 1996; Smith *et al.*, 1996; Parry., 1986; Smit *et al*., 1999). Adaptation to climate change requires that farmers using traditional techniques of agricultural production first notice that the climate has altered. Farmers then need to identify potentially useful adaptations and implement them. This paper attempts to answer the following questions in particular: Do farmers perceive climate change to have occurred already and if so have they begun to adapt? From agro-ecologies of the choke mountain water shed, which is the most vulnerable? What kinds of adaptations have they under taken to climate change?

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 (Yosuf *et al.,* 2008). At present, agriculture dominates the Ethiopian economy, accounting for nearly half of GDP and for the vast majority of employment. While the country is highly dependent on the agricultural sector for income, foreign currency, and food security, the sector is dominated by small-scale farmers who employ largely rain-fed and traditional practices – a state which renders Ethiopia highly vulnerable to climate variability (as seen during past persistent drought), and thus to climate change. According to the World Bank (2007) Climate change is projected to reduce yields of the wheat crop by 33% in Ethiopia .This amounts to a serious threat to food security and to the achievement of major developmental goals.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 country's 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. Cycles of drought create poverty traps for many households, constantly thwarting efforts to build up assets and increase income. Survey data show that between 1999 and 2004 more than half of all households in the country experienced at least one major drought shock. These shocks are a major cause of transient poverty. Food shortage and famine associated with rainfall variability cause a situation of high dependency on international food aid (Fig. 1). And Ethiopia is one of the biggest food aid receipt countries in Africa that accounts to 20-30% of all food aid to sub-Saharan Africa (Bezu and Holden, 2008).

Figure 3: population need food assistance and precipitation in Ethiopia



Source: siteresources.worldbank.org/.../Ethiopia_Country_Note.pdf (2007)

Adverse effects of climate change are determined not only by the changing climate but also by the sensitivity of human and natural systems to these changes. In Sub-Saharan Africa countries, climate change is a major threat to sustainable development and the attainment of the MDGs (Temesgen,2009). The combined effects of climate change, increased global population and income growth, 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.

Consequently, harvest failure and incidents of food insecurity have become regular events occurring at least once or twice every decade and have been identified as a consisting of a convergence of social and political as well as natural factors (Erickson *et al*., 2007). Adger and Brooks (2003) have interpreted the human ability to respond to climate change as involving 'socially determined futures over which there is a degree of space for action'. Determining the degree to which systems are sensitive and capable of adapting is the topic of a growing literature on both national and international agendas, though finding good indicators for the capacity to adapt to climate change has proved difficult.

The recognition of the exposure of systems to multiple stresses implies that development frameworks will need to consider the links between sustainable development and climate change. Additionally, this will involve climate change being brought into development planning, which will be critical in acquiring an understanding of what policies will work where and when. For this purpose, estimates of the costs and benefits of various adaptation options are necessary.

Owing to the facts, 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.

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 nexus 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. However a little has been done regarding to the vulnerability status to climate changes and variability at lower scale assessment. This paper therefore will intend to assess the local households' vulnerability to climate change and the adaptation strategies in the choke water shed, 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 (Aklilu and Alebachew, 2009). Thus, climate change is reducing agricultural productivity, accelerated degradation of natural resources and intensifying climate related diseases. It has brought a worst effect of the agricultural sector of the country and thereby putting pressure on access and ownership of these capitals, they can effectively respond to the adverse effect of climate change and variability.

Historically, climate extremes, especially drought and flood, are not a new phenomenon in Ethiopia. Most part of the country is prone to drought (NMSA,1996). Recorded history of drought in Ethiopia dates back to 250 BC, and since then droughts have occurred in different parts of the country at different times (Webb *et al*.,

1992). Even though there has been a long history of drought, studies show that the frequency of drought has increased over the past few decades, especially in the lowland parts of the country (Lautze *et al*., 2003). Recurrent drought events in the past have resulted in huge loss of life and property as well as migration of people. For instance, the 1973-1974, 1983/1984, 2000/2003 drought -driven famines affected millions of people and claimed thousands of lives to death (Quinn and Neal, 1987; Degefu, 1987; Nicholls, 1993; Webb and Braun, 1994 cited in NMA, 2007). The deaths in all these years were due to chronic food insecurity resulted from massive crop failure, livestock deaths and water scarcity resulted from climate change. The other climate related hazards that affect Ethiopia from time to time are flash and seasonal river floods. Major floods which caused loss of life and property occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006(NMA,2006 cited in NMA,2007). For example, the 2006 floods of Dire Dawa and Omos brought many tolls including losses of human and livestock lives, crops, and biodiversity.

Despite the fact that Ethiopia has a long history of drought, studies have shown that the frequency and spatial coverage of droughts have increased over the past few decades (Lautze *et al*. 2003). Moreover, over the past 50 years, the average annual minimum and maximum temperatures across the country have increased by about 0.25^{o}C and about 0.1^{o}C, respectively, per decade, and precipitation has shown a decreasing trend throughout the country (NMSA 2001). This trend of increasing temperature, decreasing precipitation and increasingly frequent drought is predicted to continue in the tropics (which include Ethiopia (World Bank 2003).Thus, the country's agricultural sector should be considered vulnerable to future climate change.

Choke Mountain farming community in East Gojjam, like farmers in any other part of Ethiopia, are suffering from Climate upheavals which have become common natural disasters in the country (Bewket,2010) where, first, there has been more erratic rainfall in the June to September rainy seasons, bringing drought and reduction in crop yields and plant varieties; the rainfall especially in the later rains towards the end of the year has been reported as coming in more intense and destructive downpours, bringing floods, landslides and soil erosion. Second, there has been an increase in temperature which disturbs the physiology of crops, the micro-climate, and the soil system on which they grow. 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. Hence the study intended to assess the local household's vulnerability and adaptation strategies to climate change and variability.

1.3 Research Questions

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

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

1.4 Objectives of the Study

1.4.1 General Objective

The General objective of the study is to assess local vulnerability and adaptation strategies to climate change in the case of choke mountain water shed in the context of current climate change and variability's.

1.4.2 Specific Objectives

Based on the general objective some specific objectives drown as below:

1. To assess farmers' perception towards changes in temperature and rainfall pattern
2. To assess vulnerability status of the agro ecologies of choke mountain watershed
3. To identify the adaptation options undertaken by farmers in the study area.

1.5 Significance of the Study

As climate change is affecting in the whole world, different local studies are needed to assess how the problem is going on. Due to this reason, this study aimed to show the extent of vulnerability in choke mountain water shed of eastern Gojjam zone.

Even though climate change is affecting the whole world, the extent differs from region to region and from locality to locality. Similarly, the coping mechanism differs from community to community. These together indicate the fact that local studies are necessary to understand the extent of vulnerability at different levels and different coping mechanisms that may be replicated and used as remedial measures in other similar occasions.

Therefore, the researcher assumed conducting this study will have the following contributions. **Firstly,**

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 contribute in creating 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 of five agro ecologies with especial emphasis to the context assessing local vulnerability to climate change and adaptation strategies. The limitation of the study is that there is 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). The other limitation was that the respondents were not willing to give real information regarding some questions, like number their livestock, age, and their total asset.

1.7 Organization of the paper

This paper 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 and. Chapter two deals with the Literature Review and the Third Chapter describes about the Research Methodology and Study area. The Forth chapter deals with Result and discussion. Then, the last Chapter contains Conclusion and Recommendations. In addition, the data collation tools and some other information attached as appendices.

2. REVIEW OF LITERATURE

2.1 Definition of key terms and related issues

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 and political ecology literatures (Adger, 1996, Kelly and Adger, 2000, Brook, 2003).

Ben Preston and Mark Stafford-Smith (2009) define vulnerability as a reflection of the potential for a system to experience harm in response to some external influences, pressure or hazard. The relevant system or process may be an individual or population; a business enterprise or an entire regional economy; a single species or an entire ecosystem. The concept of vulnerability is broadly used across a range of disciplines, including finance, security, public health, economic development, natural hazard and of course, climate change. IPCC 2001,defines vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effect of climate change, including climate variability and extremes vulnerability is a function of the character , magnitude, and the rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Balaikie *et al*., (1994) define vulnerability as the characteristics of a person or a group in terms of their capacity to anticipate, cope up with, resist and recover from the impact of natural hazard. It involves the combination of factors that determine the degree to which sourer one's life and livelihood are put at risk by discrete and identifiable events in nature or societies.

Kelly and Adger (2000) define vulnerability as the capacity of individuals and social groups to respond to, cope with recover from and adapt to external stress on their livelihoods and well beings. IPCC (2000) also defined vulnerability as the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate.

Hence, a highly vulnerable system is one that is highly sensitive to modest changes in climate and one for which the ability to adapt is severely constrained. Then on IPCC (2001), defied 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'' (IPCC 2001).

Looking at vulnerability from food security point of view, FAO publication at The State of Food Insecurity in the World Bank (1999), defines vulnerability as "the presence of factors that place people at risk of becoming food insecure or malnourished." Clearly, this definition encompasses causes of food insecurity other than climate change (e.g., armed conflict, landlessness, etc.).Nevertheless, the concept of vulnerability includes hunger vulnerability, which refers to the vulnerability of individuals or households rather than that of regions or economic sectors.

(Watson *et al.,* 1998), argues that the vulnerability of a region depends largely on its wealth, and that

poverty limits and adaptive capabilities. According to IPCC (2001), vulnerability depends on the level of economic development and institutions. The report argues that socio-economic systems "typically are more vulnerable in developing countries where economic and institutional circumstances are less favorable" (Watson *et al.,* 1996). The report continues that vulnerability is highest where there is "the greatest sensitivity to climate change and the least adaptability." Though vulnerability differs substantially across regions, it is also recognized that even within, economic sectors and social group impacts, adaptive capacity and vulnerability will varies. This is due partly to the fact that changes in temperature and precipitation will occur unevenly, resources and wealth are distributed unevenly climate change impacts will be unevenly distributed around the globe. (IPCC, 2001)

Sensitivity: 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

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." According to the IPCC Third Assessment Report, adaptation "has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages." Furthermore, it is argued that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation[1].

However, "options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems" (IPCC 2001).

(UNFCCC, 2006) also defines Adaptation as processes through which societies make themselves better able to cope with an uncertain future. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes

Adaptive capacities: 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).

Climate variability: variation in the mean state and other statics (such as standard deviation, occurrences extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from variations in natural or anthropogenic external forcing (external variability) (IPCC, 2001).

Climate change (cc) 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).

Climate change perception- attitudes and awareness of societies to changing climate and related problems.

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, 2006).

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.

Perception: Krishna R. *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.

Vulnerability: The intergovernmental panel on climate change describes vulnerability as the degree to which a system is susceptible to, or the effects of climate change, including increased variability and down sides risk (IPCC, 2001).

[1] *Vulnerability- the degree to which a system is susceptible to, or the effects of climate change, including increased variability and down sides risk (IPCC, 2001).*

2.2 Overview of Global climate change and its impacts

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).Climate change has become a real phenomenon, as it is evident from an increased world temperature, which is known as global warming while many factors continue to influence global warming (Cowie, 2007).

Global average temperature has increased by about 0.6°C over the past 100 years, with a major warming upswing 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(T. Prato and D. Fagre,2006). As IPCC (2007) reports the concentration of green house gases in the atmosphere has increased mainly since 1980's. The global surface temperature has increased over the past 50 years from 1956 to 2005 at the rate of 0.13oc per decade. In addition to this, the average temperature of the ocean has increased to the depth of at least 3000m and that the ocean has been taking up over 80% of the heat being added to climate system since 1961.

Moreover other evidences showed that the atmospheric concentration of carbon dioxide and Troposphere ozone have each increased by 35% during the last 50 years, the concentration of methane raised by about 0.6 oc. (IPCC, 2007) Observed decreases in snow and ice extent are also consistent with warming. Satellite data since 1978 shows that, annual average arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3] % per decade, with larger decreases in summer of 7.4 [5.0 to 9.8] % per decade. Mountain glaciers and snow cover on average have declined in both hemispheres (IPCC, 2007).Those changes have an effect on different aspects in the whole world. Studies show that climate change adversely affects human and natural systems by reducing biodiversity, altering hydrological systems, impairing biological and chemical cycles, and making it more difficult to restore degraded ecosystems.

Agricultural and forestry management at northern hemisphere higher latitudes, such as earlier spring planting of crops, and alternatives in disturbance regions of forests due to fires and pests. Also on health wise, heat related mortality, infectious disease and allergenic pollen are seen in different parts of the world. (T. Prato and D. Fagre, 2006; IPCC, 2007). Variations and extremes of climate disrupt production of food and supplies of water, reduce incomes, damage homes and property, impact health and even take lives. Humans, in an unintended revenge, are getting back at the climate by adding to heat-trapping gases in the Earth's atmosphere that are changing the climate. However, the changes are amplifying the hazards.

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 (Burton, 2008). Developing countries have lesser capacity to adapt and are more vulnerable to climate change damages, just as they are to other stresses.

According to IPCC,(2001) this condition is extreme among the poorest people where there is climate sensitive natural resources that livelihoods, economic activities and national incomes of developing countries depended are in a degraded state from combined pressures caused by human use, climatic and environmental variation and change. Their degraded state makes these resources, and the people who are dependent on them, highly vulnerable to the damages from climate change. Many regions and countries will be capable of adapting to climate change but that the poorer countries regions will have difficulties responding to climate change. (Handmer *et al,* 1999) It is clear that climate change will in many parts of the world; adversely affect socioeconomic sectors, including water resources, agriculture, forestry, fisheries and human settlements, ecological systems, and human health, with developing countries being the most vulnerable (IPCC 2001).

2.3 Impacts of Climate change in Africa

According to the IPCC 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*., 1997)

Sufficient evidence shows that the average temperature rise in Africa is faster than the global average and is likely to persist in the future (Hulme *et al.,* 2000). The warming is definitely hazardous for agricultural activities in the continent as many of the crops are grown close to the thermal tolerance limits (*Collier et al.,*

2008). The warming of few degrees and increase in frequency of extreme weathers will consequently and strongly influences the agricultural production and make the society victim of the events and decreases the future adaptive capacities.

A recent study also shows that there was a dramatic decline in average rainfall conditions in all West African dry lands for the period 1960-1990 (Marcel Put *et al*., 2004 :). "Some of the regions in the northern zone with semi-arid conditions in 1930-60 had clearly become arid (on average) in the 1960-1990 period, with unsuitable conditions for millet or sorghum production in most years. A considerable part of the sub-humid zone in the period 1930-1960 had become semi-arid in 1960-1990 with considerable drought risks, certainly for crops which are less adaptable to drought stress (maize, cotton)" (Put *et al*., 2004).

As many scholars stated, climate change will lead to increased levels of drought in Africa. It can further lead to floods, starvation, landslides, drought and rising sea levels. According to the United Nations, climate change will affect Africa more than anywhere else will in the world due to extreme poverty levels, high rates of population and 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*., 1995).

2.4 Climate change in Ethiopia

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).

Over the years, repeated famines and chronic food crisis resulting from frequent droughts, environmental degradation and decline in food production havocked the country many times and still remain major challenges to the country. 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 seasoned floods and famine have become increasingly common occurrences (NMA, 2006).

Droughts and floods are very common phenomena in Ethiopia with significant events occurring every three to five years (World Bank, 2006). According to World Bank (2006), the country has experienced at least five major national droughts since the 1980s, along with dozens of local droughts. Over the years, the frequency of droughts and floods has increased in many areas resulting in loss of lives and livelihoods. Climate change is expected to exacerbate the problem of rainfall variability and associated drought and flood disasters in Ethiopia (NMA, 2006).

In recent years environment has become a key issue in Ethiopia. The main environmental problems in the country include land degradation, soil erosion, and deforestation, loss of biodiversity, desertification, recurrent drought, flood and water and air pollution. This is due to their low adaptive capacity and high sensitivity of their socio-economic systems to climate variability and change. Sensitivity and adaptive capacity also vary between sectors and geographic locations, time and social, economic and environmental conditions within a country.

Current climate variability is already imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters.

As pointed out on NAPA (2007) 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

2.4.1 Impact of climate change on Ethiopian agriculture

Climate change will bring with it-increased frequency of two types of natural disasters that affect agriculture and rural households: droughts and floods. It will also alter rainfall patterns, thereby changing farming practices, household behavior, and welfare (Futoshi Y. & Agnes Q., 2009). Like many other developing countries, agriculture (with the largest number of livestock in Africa) is the single largest livelihood of an overwhelming majority in Ethiopia, 85% of the population (CSA, 2008). As agriculture is the backbone of the country, it is believed to continue being the determinant sector to bring sustainable economic development to the country (CSA, 2008).

During drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality (engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood. Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures(Abate,2008).

Agriculture is one of the sectors most vulnerable to climate change impact. The impact is even stronger in Africa, where agriculture is truly important for the daily subsistence, and where adaptive capacity is low (Abate, 2008).

Ethiopian farmers are exposed to both gradual climate change (mainly temperature and precipitation) and extreme climate change (mainly drought and flood).(Temesgen *et.al.,* 2008) causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc.

Vulnerability assessment based on existing information and rapid assessments carried out under NAPA has indicated that the most vulnerable sectors to climate variability and change are agriculture, water and human health. In terms of livelihood approach, smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are affected most by drought (Abate, 2008). Therefore, reducing vulnerability involves reducing exposure through specific measures, or increasing adaptive capacity through activities that are closely aligned with development priorities.

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 (NMA, 2007).

Ethiopia being located in the tropics at latitude of 4^0 to 15^0 N to 33^0 to 48^0E, a large part of the country has arid and semiarid climatic and hence is highly prone to desertification and drought (NMSA, 2001). It has also fragile highland ecosystem that are currently under stress due to population pressure and associated socio-economic practices. The country's history is associated, more often, with major natural and manmade hazards that have been affecting the population from time to time (NMA, 2007). The hazards have been the main source of risk and vulnerability in most parts of the country.

Droughts, famine, epidemics and floods are also very common occurrences. In most instants, these disasters are associated with climatic variability and change (Aklilu and Alebachew, 2009). The outcome of these disasters has been loss of crops, destruction of built infrastructure, death of millions of people, and caused displacement of people. In general by weakening the productivity and functioning of livelihood resources, they aggravate the vulnerability of the people that are dependent on these resources for their living. According to the vulnerability assessment undertaken by national adaptation program of action (NAPA) team, in Ethiopia the most vulnerable sectors to climate variability and change are agriculture, water and human health. In terms of livelihood approach, smaller holder 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.

Climate is the key natural resource on which others depend. It influences food production, water and energy availability. It sets the stage for the establishment of habitats; affect the phase of primary productivity and influences species density and distribution. According to UNDP climate change profile for Ethiopia, the mean annual temperature has increased by 1.3^{oc}between 1960-2006 at an average rate of 0.28^{0c} per decade.

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 100^oc over the high table lands over North West, central and south east to about 35% over the northeastern edges (NMSA, 2001).Trend analysis of rainfall shows that rainfall remained more or less constant when averaged over the whole country. This due to high annual and inter decadal rainfall variability (NMA, 2007).

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 (Smit B. *et al.,* 2007).

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). Adaptation hence involves adjustments to decrease the vulnerability of communities, regions, and nations to climate variability and change and in promoting sustainable development. Adaptation needs vary across geographical scales (local, national, regional, global), temporal scales (coping with current impacts versus preparing for long-term change), and must be addressed within complex and uncertain conditions.

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.,* 1997). 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

2.5.1 Types of Adaptation

Depending on its timing, goal and motive of its implementation, adaptation can either be reactive or anticipatory (preventative), private or public, planned or autonomous. Adaptations can also be short/long term, localized or widespread (IPCC, 2001). In unmanaged natural systems, adaptation is autonomous and reactive and is the means by which species respond to changed conditions. In these situations, adaptation assessment is essentially equivalent to natural system impact assessment. Adaptations undertaken by individuals/communities can be classifies as: **Reactive or Anticipatory:** Reactive adaptation takes place after the initial impacts of climate change have occurred. Anticipatory adaptation takes place before impacts become apparent. In natural systems, there is no anticipatory adaptation

Private or Public: The distinction is based on whether adaptation is motivated by private (individual households and companies) or public interest (government).

Planned and Autonomous: Planned adaptation is consequence of deliberate policy decision, based on the awareness that conditions have changed or are expected to change and that some form of action is required to maintain a desired state. For example, deliberate crops selection and distribution strategies across different agri-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity (Easterling, 1996). Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that she/he changes crops or uses different harvest and planting/sowing dates.

Adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector. This complex mix of conditions determines the capacity of systems to adapt. Although scholarship on adaptive capacity is extremely limited in the climate change field, there is considerable understanding of the conditions that influence the adaptability of societies to climate stimuli in the fields of hazards, resource management, and sustainable development. From this literature, it is possible to identify the main features of communities or regions that seem to determine their adaptive capacity: economic wealth, technology, information and skills, infrastructure, institutions, and equity (IPCC, 2001).

2.6 Vulnerability to Climate Change and Its Components

The IPCC (2001) describes vulnerability as "The degree to which a system is susceptible 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 to Climate Change

Climate change exposure is defined by the magnitude, character and rate of climate change in a certain geographic area. 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 at more localized scales, scientific information (summarized and presented later in this section) it is often insufficient for analyzing local exposure to climate change. As a result, scientific information must build upon and be complemented by an analysis of local-level climate observations through consultations with communities and other local actors who are on the frontlines of climate change. Exposure relates to the degree of climate stress upon a particular unit analysis; it may be

represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events (IPCC, 2001).

B. Sensitivity to Climate Change

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. Sensitivity is the degree to which a system will be affected by, or responsive to climate stimuli, either positively or negatively.

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. 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). One of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over natural, human, social, physical, and financial resources. Because of the availability of these resources and services is limited in many developing countries, their adaptive capacity in the face of climate change is correspondingly low compared to developed countries.

Adaptive capacity is most commonly assumed to depend on a number of resources which constitute the asset base that lays the foundation for initiating adaptation. Vincent (2007) defines adaptive capacity as 'a vector of resources and assets that represent the asset base from which adaptation action can be made'. The main factors constituting adaptive capacity focus mainly on indicators such as economic wealth, technology, information and human capital, infrastructure, institutions and equity. But also other indicators, including life expectancy, insurance mechanisms, access to public health facilities, and other general development outcomes, have been included in analyses (Klein *et al.,* 2001).

In developing countries there is often inadequate infrastructure, a 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.

Due to its characteristics, adaptive capacity is not only different across developing and developed countries, but also within and across societies. Exploring national, regional and local contexts for adaptive capacity will provide policy makers with information on both the constraints and opportunities that social systems are facing in their efforts to cope with and adapt to changing conditions. Building adaptive capacity also seems to be closely associated with building a general capacity for sustainable development outcomes. The concept and indicators of adaptive capacity nevertheless remain useful when it comes to understanding the components and prerequisites for adaptation (Vincent 2007).

2.7 Approaches to Assess vulnerability

Due to complex nature of vulnerability different authors have developed several conceptual frame works 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 approaches (Temesgen *et.al.* 2008).

2.7.1 Socioeconomic 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 (Ford and smit, 2003). It is an approach which tries to analyze social vulnerability mainly focusing on economic and political condition of individual or social group is known as socio-economic approach (Adger, 1999; Fussel, 2007; Temesgen *et al.,* 2008).Social vulnerability is determined by factors such as poverty and in equality, marginalization, food entitlements, access to insurance, health, access to resources, and social status (Agder, 1999; Brooks, 2003).

Lack of access to resource (including information, knowledge and technology),limited access to political power and representation, social capital, including social network and connections, belief and customs are some of the factors that determine individual and social vulnerability in the society(Cutter,2003) and the variation of these factors among individuals and social groups also determine the variation in vulnerability. Adger and Kelly (2000) states that vulnerability is defined by the capacity of individuals and social groups to respond to, cope with recover Over from and adapt to external stress on their livelihoods and well beings.

Therefore socio-economic vulnerability approach focuses on identifying the adaptive capacity of individuals and communities based on their internal situation.

The limitation of this approach according to Temesgen *et al.,* (2008) is that it focuses only on variations within society (i.e. differences among individuals and social groups) ignoring the impact of hazard to vulnerability. In reality societies vary not only due to socio- economic factors but also environmental factors. Two social groups having similar socio-economic characteristics but different environmental attributes (Agro ecological, physical) can have different level of vulnerability and vice versa. The other limitation of this approach is that its ignorance of intensity and frequency of hazards. The increased frequency of extremes may lead to the deterioration of once strong social institutional and infrastructure.

2.7.2 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 (Fussel and Klein 2006). Kelly and Adger (2000) referred to the biophysical approach as an *end-point analysis* responding to research Questions such as, "*What is the extent of the climate change problem?"* and "*Do the costs of climate change exceed the costs of greenhouse gas mitigation*?"Although very informative, the biophysical approach has its limitations. The major limitation is that the approach focuses mainly on bio physical damages and sensitivity, such as change in yield, income, health and so on 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). For Example, a study on the impact of climate change on yield can show the reduction in yield due to simulated climatic variables, such as increased temperature or reduced precipitation (Temesgen *et.al*, 2008).

2.7.3 The 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 decisions (Ben Preston and Mark Stafford-Smith,2009). The integrated assessment approach combines both socioeconomic and biophysical approaches to determine vulnerability. Mapping vulnerability in south East Asia (Yusuf and Francisco; 2009) is good example of this approach, in which both biophysical and socio-economic factors are combined to determine vulnerability of the region.

IPCC (2001) defines vulnerability to climate as a function adaptive capacity, sensitivity, and exposure accommodates the integrated approach to analyze vulnerability. According to Fussel and Klein (2006), the risk hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity is mainly consistent with the socio- economic approach (Fussel, 2007).According to Temesgen, *et al.,(*2008), the 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). Despite the weakness, this approach has much to offer in terms of policy decision (Temesgen *et al.,*2008) and is the most amenable to empirical testing and the use of geo- spatial techniques(cutter *et al.,* 2009).Realizing these facts and objectives, the researcher adopts the approach to make the vulnerability assessment of agro-ecological zones of choke mountain watershed.

2.8 Methods for measuring vulnerability to climate change

Given that vulnerability can exist on different spatial levels and in reference to a wide variety of potential hazards, it is no surplus that there are many ways in which to measure vulnerability (Naude *et al.,* 2009). Various efforts are now underway to measure vulnerability at a level of household, countries and regional and local areas (Naude *et al.,* 2009). Despite their variety, these methods could be categorized in two basic groups. Econometric method, that roots in econometric literatures, and the indicator methods (Temesgen *et al.,*2008;Hoddinot and Quisumsing,2003;Naude *et al.,*2009).

2.8.1. Econometric Methods

Tracing back its roots in development economics literatures, the method use household level socio-economic survey data to analyze the level of vulnerability of different social groups (Temesgen *et al.,* 2008). In this method, there are three principal approaches to assessing vulnerability: vulnerability as expected poverty (VEP), vulnerability as low expected utility (VEU) and vulnerability as exposure to risk (VER)' Hoddinott and Quisumbing, 2003). To analyze the vulnerability, all the three approaches use to construct a model that predicts a measure of welfare loss attributed to shocks (Hoddinott and Quisumbing, 2003).

I. Vulnerability as expected poverty (VEP)

In the expected poverty frame work, vulnerability of a person is conceived as the prospect of that person becoming poor in the future, if currently not poor or the prospect of that person continuing to be poor, if

currently poor. Thus, vulnerability is seen as expected poverty, and consumption (income) is used as a proxy for well being. This method is based on estimating the probability that a given shocks, or set of shocks, moves consumption below a given minimum level(e.g. consumption poverty line) or forces the consumption level to stay below the given minimum requirement if it is already below that level (Temesgen *et al.,* 2008).

II. Vulnerability as expected low utility (VEU)

In this approach, vulnerability is defined as the difference between the utility derived from some level certainty equivalent consumption at and above which the household is not considered as vulnerable and expected utility of consumption. In other words, this certainly equivalent consumption is a kin to a poverty line (Gaiha and Imai, 2008).

III. Vulnerability as uninsured exposure to risk(VER)

In the absence of effective risk management tools, such shocks impose welfare less to the extent that they lead to a reduction in consumption (Hoddinott and Quisumbing, 2003). In this sense, it is a consequence of uninsured exposure to risk. VER is designed to assess expose welfare loss from a negative shock, as opposed to an ex-ante assessment of future poverty in VEP (Gaiha and Imai, 2008).

2.8.2 Indicator Method

This method of quantitative vulnerability analysis is based on selected some indicating from the whole set of potential indicators and then systematically combining the selected indicators to indicate the level of vulnerability (Temesgen *et al,* 2008). This level of vulnerability may be analyzed at local (Adger 1999), national (O'Brien *et al.,* 2004), regional (Leichen *et al.,* 2004) and global scale (Brooks, Adger and Kelly, 2005).

To calculate the level of vulnerability using this method at any scale there are two options: one assuming that all the indicators of vulnerability have equal importance and thus giving then equal weights (Cutter, Mitchell, and Scott, 2000) and the second one is assigning different weights to avoid the uncertainty of equal weighting given the diversity of indicators used in line weight the second method. Many methodological approaches have been suggested to make up the weight differences of indicator. Some of these approaches include use of expert opinion polling (Yusuf and Francisco, 2009; kaly *et al.,* (1999), principal component analysis (Rygel *et al.,* 2005; Cutter, Boruff, Shirley, 2003), correlation with past disaster events (Brooks,Adger and Kelly,2005).

2.9 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 (Eakin and Luers, 2006). Among these researches some of them are reviewed as follow.

To estimate the risks from climate variability and change Hahn *et al., (*2009) developed the livelihood vulnerability index (LVI) and used it to indicate the vulnerability levels of two districts found in Mozambique. The method uses multiple indicators, to assess exposure to natural disasters and climate variability, social and economic characteristics of households that affect their adaptive capacity, and current health, food and water resource characteristics that determine their sensitivity to climate change impact. Two approaches were presented: the first expresses the LVI as a composite index comprised of seven major components while the second aggregates the seven into IPCC's three contributing factors to vulnerability:- exposure, sensitivity and adaptive capacity. To construct the index they used primary data from household survey.

The LVI used seven major components that are also comprised of several indicators or sub components. To overcome the problem of differences in scale of measurement, they made standardization of indices and then followed the balanced weighted average approach to arrive at the final overall index level. The second method, LVI-IPCC, incorporates the IPCC's vulnerability definition. Exposure of the study population is measured by the number of natural disasters, and average standard deviation of the maximum and minimum monthly temperature and monthly precipitations over the past six years were considered. Sensitivity was measured by assessing the current state of districts food and water security and health status. Adaptive capacity was quantified by demographic profile of the districts and the strength of social networks.

The LVI values for the two districts shows 'Moma' to be more vulnerable in health and water structures than 'Mabote' by scoring 0.317 and 0.370 while the vulnerability level in 'manbote' is 0.241 and 0.099 respectively for the two indicators out of the seven. The overall calculation shows 'Mabote' had a higher LVI than 'Moma' (0.326 versus 0.316 respectively) indicating relatively greater vulnerability to climate change impacts. The socio-demographic profile and natural disaster and climate variability contribute a lot for vulnerability of Mabote. The LVI-IPCC analysis yields similar results i.e. 'Manbote' households to be more vulnerable than 'Momas' households(0.005 versus -0.074 respectively) the main explanation are 'Mabote's exposure(0.409) to climate change impacts compared with 'Moma'(0.312) is higher, and 'Mabotes'adaptive capacity (0.388)is weaker compared to 'Momma's(0.522).

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. Through further manipulation of data 11 factors which explained 76.4%of the variance among all countries identified. Then these factors scores were added to the original country as a composite SoVI score for each country. Here every factor was given equal weight assuming to have equal contribution to the country's overall vulnerability.

The finding shows that the vast majority of US countries exhibited moderate level of social vulnerability. The SoVI ranges from -9.6(low social vulnerability) to 49.51(high social vulnerability) with mean vulnerability score of 1.54(SD=3.38) for all US countries.393 countries (12.5% of the total) were classified in the most vulnerable category and are located in southern half of the nation stretching from South Florida to California. The explanations for these are greater ethnic and racial inequalities, rapid population growth and socially dependent populations (those in poverty and lacking in education).

Brooks *et al.,(*2005) present a set of indicators of vulnerability and adaptive capacity to adapt to climate variability and change using empirical analysis of data aggregate at the national level across 205 countries. Their purpose was to develop indicators of vulnerability to a range of climate hazard at a national level specifically by addressing vulnerability to mortality resulting from exposure to climate hazards for decadal periods. In the process they identified 11 key indicators that exhibit a strong relationship with decadal aggregated mortality associated with climate related hazards.

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).indicator method vulnerability was also employed by attaching different weight for different indicators and their proxies by using expert opinion polling method. They assessed exposure using information from historical records of climate related hazards. They also used population density as human sensitivity to climate –hazard exposure and ecological sensitivity of the region using biodiversity information as proxy variable. Index of adaptive capacity also assessed as a function of socio-economic, technological, and infrastructure factors. Based on these variables they constructed an index of overall climate change vulnerability of the region.

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. By identifying indicators from the socio-economic and biophysical they run a principal component analysis method to determine the factor scores or relative weight of the selected indicator of each region. The relative vulnerability revealed that the Afar, Somalia, Oromia, and Tigray regional states to be the most vulnerable regions. The vulnerability of Afar and Somalia was associated with the level of regional infrastructure development in the region. The vulnerability of Oromia region is attributed with high frequency of drought and flood, lower access to technology, institutional and infrastructure. Similarly the vulnerability of Tigray region is also attributed with the lower access to technology, health services, food, market and occurrence of drought and floods. Unlike Afar and Somalia the lower access to technology in Tigray and Oromia is due to their large size population in proportion to the available technology. The SNNP region is relatively the least vulnerable due to relative higher access to technology and food market, its highest irrigation potential and higher literacy rate.

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 intytegrated vulnerability approach and vulnerability indicator method to assess the level of vulnerability. To analyze the relative vulnerability of households and social groups, systematic combination of indicator variable using principal component analysis to determine the score value of each variable to construct an index. Then households' vulnerability index and social vulnerability index were calculated using the primary data.

The result revealed that half of sample households have VIHH value less than 0 which implies the net effect of households' adaptive capacity to be less than their sensitive and exposure and the groups of households were classified as highly vulnerable to impacts of climate change. The comparison of VI score of agro pastoralist (0.003) with that of pastoral social group. He argued that the reason lower economic status of members of the group, less experience of farming practice, and low application of modern inputs and new techniques of production are attributed to the vulnerability of agro-pastolasits.

2.10Conceptual frame work

The study adopts the IPCC (2001) definition of vulnerability to analyze the vulnerability of households of choke watershed 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 defition accommodates the concept of both bio physical and the socio-economic indicators in assessing the vulnerability(Temesgen *et al.,*2008).The study area is exposed to both gradual climate change (temperature and precipitation) and extreme climate conditions (drought).exposure affects sensitivity, which means that exposure to higher frequencies and intensities of climate risks highly affect the outcome. Exposure is linked to adaptive capacity in such a way that higher adaptive capacity reduces the potential damage from higher exposure. Sensitivity and adaptive capacity are also linked, given the fixed level of exposure; the adaptive capacity influences the level of sensitivity. In other words higher adaptive capacity (socio-economic vulnerability) results in lower sensitivity (biophysical vulnerability) and vice -versa.

3. RESEARCH METHODOLY

3.1. Description of the study area

The Choke Mountains is a large block of highland found in central Gojjam, 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 100 42' N and 370 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.

3.2. Research Design

The aim of this research is to investigate and assess vulnerability to climate change in the case of Choke Mountain. Thus, to conduct effective and practical study, the research design needed to have several features. First, the methodology should permit comparisons both at household and agro-ecology level. Second the design should not be costly to implement and should have a minimum turnaround time without unduly sacrificing the credibility of results. Third the design should not be costly to implement.

Considering of these parameters led to the adoption of the indicators- This method involves(i) identifying a range of indicators that reflect powerfully on farmer's level of adaptive capacity, sensitivity and exposure to climate change and variability and for which credible information can be quickly and inexpensively obtained;"(ii) designing a different methodology that facilitates the collection of information on these indicators from households living in the study area and (iii)formulating index that combines information from the range of indicators and facilitates vulnerability comparisons at different agro-ecological levels.

The development of this indicator- based vulnerability assessment research design or tool was accomplished following some methodological steps. 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 will be 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 which were gained from books, journals, articles and pertinent documents. 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 primary data was collected from the sample respondents, experts, and agricultural offices. This decision is made based on the strong belief that the above mentioned sources have great role in the project and that they are able to provide the necessary data. The secondary data were gathered from project publications, manuals, books, magazines, news papers and the internet sources will be used as a secondary source of data.

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

Household survey

This study was basically employed self-developed questionnaire as an instrument. In the design of this instrument the literature review will be 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.

Key informant interview

To supplement the quality and reliability of the data collected through questionnaire; interviews were conducted using an interview guide with those award and aged informants. In each kebeles, couple informants in light of their age and experience and religious leaders were selected. Accordingly, informants were asked about issues like the long term temperature and rainfall conditions, the overall productivity of their farm land to compare the past and the current climate change extremes had they faced with and how did they manage and cop up with. Thus the researcher, have taken a total of seven (7) individuals with various back ground and who have had deeper and better knowledge about the issue. The key informant interviewers were comprises of two community leaders, two elders, two agricultural experts and one religious leader that were select from each Kebele and interviewed to obtain relevant data.

Focus Group discussion (FGD)

Two Focus group discussions were carried out in five selected kebeles. Each of the focus group discussion composed of ten participants who are not part of selected sample and selected purposively. The first focus group carried out with elders and religious leaders, the second FDG, carried out with men women households to obtain relevant to obtain in-depth information on concepts perceptions and ideas of a group related to the concept of the study.

Field Observation

Field observation is also another primary method of data collection which the researcher conducted through directly observing the environment and capturing photographs and other methods on the related issues. During field surveys, transect walks were conducted in five the kebeles with the guidance of the kebele's chairman leading the team, including voluntary farmers, development workers and the researcher. In the meanwhile, the researcher tried to triangulate farmers' responses with actual physical observations.

3.4.2 Data collection instruments for secondary data sources

secondary data for this study gathered from, Books, policy documents, projects reports, magazines ,proceedings, news paper, annual reports, the internet and other relevant sources to obtain smart information. The secondary data also collected on the biophysical resources, socio demographic statics from the national statics offices. Finally data collected from the secondary sources substantiate with the first hand data collected from primary data sources mentioned above.

3.5 Sampling procedures

The study was conducted in Choke Mountain, which is located in East Gojjam of the Amhara Regional State. The strategy to identify the study area and sampling procedures are discussed as

Follows: from 6 agro-ecological zones according to traditional climatic zone classification system the researcher purposively five agro ecology, except the last one which is Afro Alfine (choke protected area) by selecting one Kebele from each agro ecological zones . Since the selected kebeles are homogeneous in term of their agro ecological zone, the household selection was through simple random sampling technique.

3.5.1 Sample size Determination

The researcher used Glenn's simplified formula to determine sample size which is retrieved from http:ifas.ufl.ed/pd006.The formula was used to calculate the sample size as follow. A 95% confidence level is assumed for the equation.

$$N = \frac{N}{1+N(e)^2}$$

where; n= sample size, N=population size

e= 95% (0.05)confidence level

When sample size was calculated using this formula it became 285 households which is difficult to manage in line with the budget and time. Due to time and budget constraint the researcher therefore the researcher decided to take 10% of the total population. Thus, the sample households of each agro ecology are as follow**.**

Table 1: Sample size of study area

No.	Agro ecological zones	Sample Kebele		
			Total population	Sample population (10%)
1	Low land and valley	Kurar	230	23
2	Mid land plain with black soil	Mehaberberhan	211	21
3	Midland plain with brown soil	Yemezegn	179	18
4	Midland slopping land	Enerata	170	17
5	Hilly and mountainous highland	Debre kelemo	210	21
Total			1000	100

Source: CSA (2007)

3.6 Method of Data Analysis

In order to attain the intended objective 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.

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 number 20 was the tool of analysis.

Livelihood vulnerability index- IPCC (LVI- IPCC)

Whereas, LVI-IPCC index was used to examine the vulnerability status of the study area

The researcher developed an alternative 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).The researcher assume that these components fully describe vulnerability in terms of exposure, sensitivity and adaptive capacity. These will developed based on a review of the literature on each major component.

The climate profile analyzes the changes in two important indicators of climate- temperature and rainfall. Sensitivity reflects the degree of biophysical response to a given change in climate. These include the changes in the natural ecosystems (soil, water and vegetation) as well as managed systems such as agriculture. 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. Assets, technologies, infrastructure, knowledge, skill, health, educational facilities and institutions are examples of indicators for adaptive capacity.

Once exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

$$LVI\text{-}IPCC = (E - Ac) * S$$

Where LVI–IPCC is the LVI for district d expressed using the IPCC Vulnerability framework, E is the calculated exposure score for district (equivalent to the Natural Disaster and Climate Variability major component), **Ac** is the calculated adaptive capacity score for district d (weighted average of the Socio-Demographic, Livelihood Strategies, and Social Networks major components), and is the calculated sensitivity score for district d (weighted average of the Heath, Food, and Water major components). We scaled the LVI–IPCC from _1 (least vulnerable) to 1 (most vulnerable) (Micah B, *et al.,* 2008).

The overall Steps to calculate the vulnerability index is broadly summarized as:

Step 1: Indicators

- Values for all the indicators are to be standardized for all the districts.
- Indicator Index (Ix) = $\frac{Id - I(min)}{I(max) - I(min)}$

Where, Ix = Standardized value for the indicator

Id = Value for the Indicator I for a particular district, d.

I (min) = Minimum Value for the indicator across all the districts

I (max) = Maximum Value for the indicator across all the districts

Step 2: Profiles

- Indicator Index Values are combined to get the values for the profiles
- Profile (P) = $\sum_{i=1}^{n} \frac{\text{Indicator Index}}{n}$

Where, n – no. of indicators in the profile
Indicator Index i – Index of the i ^{the} indicator.

Step 3: Components

●Values of the profiles under a component are to be combined to get the value for that component.

● Component (C) = $\sum^{n}_{i=1} \frac{W_{Pi} Pi}{\sum^{n}_{i=1} W_{Pi}}$

Where, WPi is the weightage of the Profile i

● Weightage of the profile will depend on the no. of indicators under it such that within a Profile each indicator has equal weightage.

Step 4: Vulnerability Index

● the combination of the values of the three components will give the vulnerability Index.

Vulnerability Index = (Exposure – Adaptive Capacity) x Sensitivity

Scaling is done from -1 to +1 indicating low to high vulnerability.

4. RESULTS AND DISCUSION

4.1 Socio-economic characteristics of Households

Table 2: Sex of respondents

	Kebele of HH											
Sex of HH	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo			
	No	%	No	%	no	%	no	%	No	%	Total	X^2
Male	12	52.2	11	52.4	11	61.1	9	52.9	11	52.4	54	*5.11**
Female	11	47.8	10	47.6	7	38.9	8	47.1	10	47.6	46	*p=0.065*
Total	23	100	21	100	18	100	17	100	21	100	100	

Significant at 5% level; Source: own survey (2012)

Sex is a major socio-economic characteristic of the study population. Based on this, sex distribution of the respondents shows that among the five kebeles, in Kurar the number and percentage of male and female respondents is 52.2% and 47.8% respectively. In Mehaberberhan the male and female respondents accounts for 52.4% and 47.6% respectively. Yemezegn account for 61.1% male and 38.9% of female respondents, Enerata constitutes 52.9% of male and 47.1.0% of female respondents; D/kelemo (AES5) constitute 52.4% of male and 47.6% of female respondents. Generally, the male respondents in all sample kebeles are 54% whereas the rest 46% are female respondents.

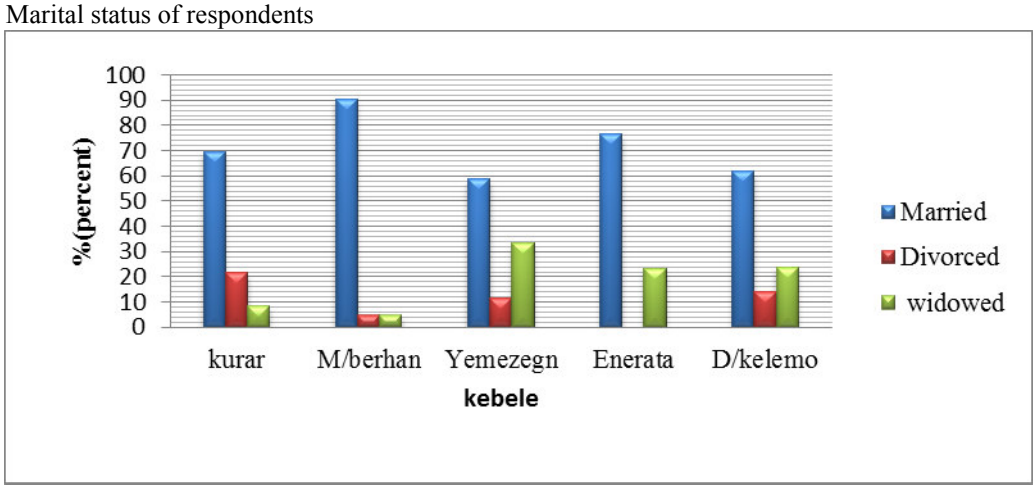
Table 3: Age profile of Households

	Kebele											
	Kurar		M/ Berhan		Yemezegn		Enerata		D/kelemo			
Age	no	%	No	%	no	%	no	%	no	%	Total	X^2
16-30	4	17.4	1	4.8	1	5.6	0	0	4	19	10	*1.33**
31-65	18	78.3	19	90.5	13	72.2	13	76.5	16	76.2	79	*P=0.11*
>65	1	4.3	1	4.8	4	22.2	4	23.5	1	4.8	11	
Total	23	100	21	100	18	100	17	100	21	100	100	

Significant at 5% level .Source own survey (2012)

Regarding the age profile of sample population, in Kurar 78.3% of population are aged 31-65years. 17.4% of sampled respondent's age fall between 16-30 years, and the rest 4.3% of them are above 65 years old. In Mehaberberhan, 90.5% of respondents age fall between31-65 years, 48% of them are aged 16-30 years, only 4.8%of the respondents aged above 65 years. Yemezegn (AES3) constitutes of 72.2% of population aged 31-65; 22.2% sample respondents aged above 65 years; the rest 5.6% of sampled population are between 16-30 years old. In Enerata (AES4) the majority of sampled respondents (76.5%) are aged between 31-65 years, 23.5% of respondents are aged above 65 years old. In D/kelemo the majority of respondents are active population. 76.2% respondents are aged 31-65 years, 19% of respondents' age ranges 16-30 and 4.8% of respondents are aged above 65 years. To sum up, concerning the age profile of in all kebeles 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.

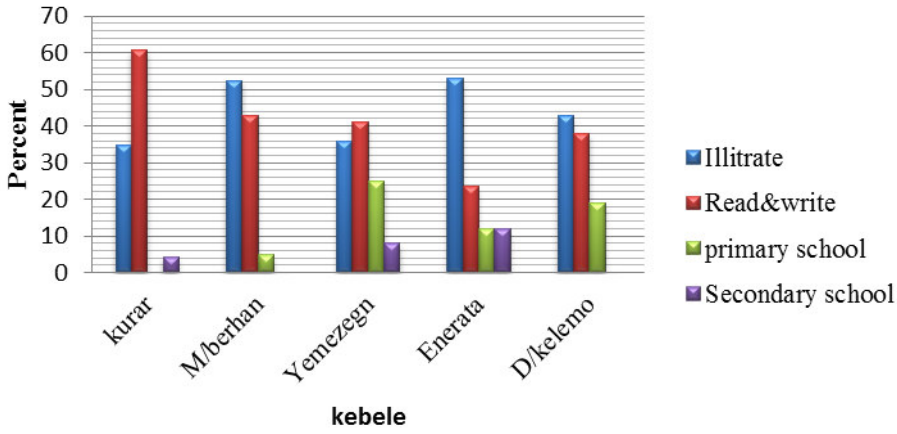
Figure 4: Marital status of respondents



Significant at 1% level. Source: own survey (2012)

Among all respondents over the five kebeles 71% are married, 18% widowed and 11% are divorced. When this is interpreted at Kebele levels, in Kurar, 69.6%of respondents are married, 21.7% divorced, 8.7% are widowed. In Mehaberberhan the majority of sample population is currently married and the number of divorced and widowed respondents is the same in this Kebele which is 4.8%. In the case of Yemezegn, 55.6% are married, 11.1% divorced and 33.3% are widowed. In Enerata Kebele 76.5% are married, 23.5% are widowed and no divorced sample respondents. D/kelemo, 61.9% are married, 14.3% divorced, 23.8% are widowed.

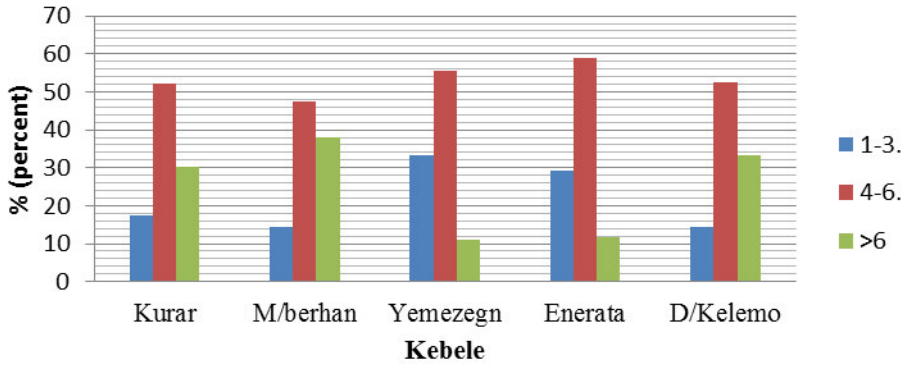
Figure 5: Educational status of sample kebeles



Significant at 5% level. Source: Researcher's own survey :(2012)

As shown on table 1, from the total respondents of 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). In the case of Kurar (AES1), 34.8% are illiterate, whereas, the majority of respondents able to read and write, and 4.3% of them had the chance of joining secondary school. In mahebereberhan, 52.4% are illiterate, 42.9% able to read and write, 4.8% joined primary school. In Yemezegn (AES3), 36% are illiterate, 41% able to read and 25% and 8% of them got chance of joining primary school and secondary school respectively. In Enerata, 52.9% are illiterate, 23.5% can read and write, 11.8% joined elementary school (primary school) and 11.8% of respondents are also got chance of learning secondary school. In debrekelemos(AES5) 42.9% of respondents are illiterate; 38%of respondents able to read and write,19%had opportunity to join elementary school(1-8), no one got chance to learn secondary school.

Figure 6: Total family size of respondent



Significant at 5 % level (p=0.11), Source: own survey: 2012

Family size is the important variable determining the adaptive capacity of the households to climate change, and which is considered as factor for the 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. When we proceed into Kebele level, the total family size in Kurar 52.2% of respondents, in M/berhan 47.6%, in Yemezegn 55.6 %, in Enerata 58.8% and in D/kelemo 52.4% of sample respondents have family size 4-6.

Table 4: Land ownership of respondents

Kebele	Yes		No		Total	
	No	%	No	%		X2
Kurar	12	52.2	11	47.8	23	
M/berhan	18	85.7	3	14.3	21	P=0.000
Yemezegn	15	83.3	3	16.7	18	
Enerata	4	23.5	13	76.5	17	
D/kelemo	14	66.7	7	33.3	21	

**Significant at 5% level, source: own survey (2012)

As shown on the above table, almost all samples of house hold are engaged in mixed farming, therefore land and livestock are the two most important basis of their economy. Based on this assumption, the sampled household respondents land holding is assessed in this section. As illustrated on the above table, in Debre kelemo, 66.7% of households reported that as they have owned cultivated land. In Yemezegn 83.3% of respondents reported as they have their own farm land; 23.5% and 52.2% respondents in Enerata and Kurar respectively reported as they have their own farm land. Whereas in Mehabere berhan the majority of the respondent households reported as they have their own cultivated land. Generally more than half 63% of the total kebeles households have their own cultivated land.

Table 5: Major means of livelihood of sampled households

	Kebele of HH											
	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo			
Means of livelihood	No	%age	No	%age	No	%age	no	%age	no	%age	Total	χ^2
Crop production	7	30.4	6	28.6	2	11.1	3	17.6	0	0	18	*15.6**
Livestock rearing	0	0	0	0	0	0	1	5.9	2	9.5	3	*p= 0.000*
Mixed farming	16	69.6	15	71.4	16	88.9	13	76.5	19	90.5	79	
Total	23	100	21	100	18	100	17	100	21	100	100	

Significant at 1% level. Source: own survey :(2012)

As shown on the above table, majority (79%) of sample kebeles population engaged on mixed farming, 18%, on crop production, and only 3% respondents' live depends on livestock rearing. When this is interpreted at each Kebele, 69.6% of Kurar's sample population engaged on mixed farming, 30.4% on crop production; like other kebeles in Mehaberberhan majority71.4% of sample population depends on mixed farming. In Yemezegn 88.9%, engaged on mixed farming, 11.1%, on crop production, in Enerata, 76.5% of respondents engaged on mixed farming, 17.6% on crop production, 5.9%, on livestock rearing; in d/ kelemo, 90.5% and 9.5% of debrekelemos' sample population engaged on mixed farming and livestock rearing respectively.

4.2 Household's Perception to climate change

Adaptation to climate change requires that farmers first notice that the climate has changed, and then that they identify useful adaptation options and implement them. 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. Farmers' perception of climate change is the condition for their initiation of adaptation practices. As many African studies indicate a large numbers of agriculturalists already perceive that the climate has become hotter and the rains 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.

Table 6: Households' perception on temperature change

Temperature difference observed within30 years	Kebele											
	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo		Total	
	No	%age	No	%age	No	%age	no	%age	No	%age		χ^2
Increased	22	95.7	18	85.7	18	100	15	88.2	21	100	21	6.32*
Decreased	0	0	2	9.5	0	0	2	11.8	0	0	0	P=0.297
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	

Significant at 1% level. Source: own survey :(2012)

Analysis of perception of farmers across the agro-ecological system of Choke Mountain 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 4% of respond claimed that temperature has decreased; the rest 2% said no change in temperature within 30 years.

Table 7: Perception difference on change in rainfall

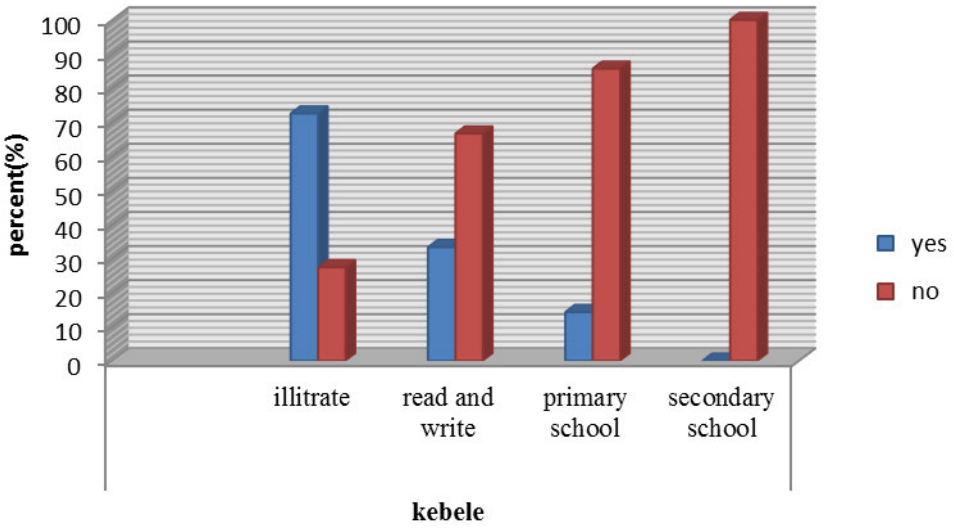
RF difference observed within the last 30 years	Kebele											
	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo		Total	
	No	%age	no	%age	no	%age	no	%age	No	%age		
Increased	13	56.5	2	9.5	4	22.2	1	5.9	5	23.8	25	χ^2
Decreased	6	26.1	13	61.9	14	77.8	16	94.1	15	71.4	64	*2.36**
No change	0	0	1	4.8	0	0	0	0	0	0	1	*P=0.002*
Change in rain season	4	17.4	4	19	0	0	0	0	1	4.8	9	
Drought	0	0	1	4.8	0	0	0	0	0	0	1	
Total	23	100	21	100	18	100	17	100	21	100	100	

Significant at 1% level. Source: own survey(2012)

Regarding the perception of households towards change in temperature and rainfall, the majority of the respondents (64%) perceived that rainfall has decreased throughout 20 years.25% claimed to increase,9%,change in rain season, and 1% observed increase in frequency of drought. Perceptions of rainfall change, however, differed across agro-ecological zones and kebeles, and this difference was significant at the 5% probability level. This is true when seen in each Kebele that means the majority of respondents have perceived as rainfall has decreased. Thus, households who perceive the climate change has undertaken the adaptation strategies and have better adaptive capacity in turn are less vulnerable. In this case, sample households in Yemezegn and M/ berhan have good perception on climate change, leading to have high adaptive capacity. According to the result obtained from FGD and KII, in D/ kelemo, Yemezegn and Enerata, perceived the long term temperatures were warming and precipitation is 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 years the rainy season was regular and the soil was also very fertile hence, there was high product and productivity.

Nevertheless, today respondents explained as they face shortage of rain fall during seeding and harvesting time, due to this the product decline from time to time. Discussants inAES1or Kurar added that they hitten more with drought (shortage of rain) and flood (due to their topography) so, during these extremes plants were dried, livestock were also died. Many people also migrated to the neighboring towns. According to FDG, 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) is different.

Figure 7: Perception of the households on climate change in terms of their educational status



Significant at 1% of level of level (p=0.002), source: own survey (2012

Perception is attitude of the households towards something .Thus 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. Perception of households towards climate change and variability determined by many factors including educational status, sex, age and etc. therefore in this section perception of households toward climate change in terms of educational status of sample households will be discussed. There is statistical difference (df=3, p=0.002) between educational status and perception of climate change and variability.37(72.5%) of illiterate sample HH, 13(33.3%) who able to read and write, and 1(14%) who got a chance of joining primary school perceived as the current climate condition is similar with that of 20 years ago. Whereas, all sample 3)100%) of sample HH who joined secondary school , 6(85.7%) who joined primary school, 26(66.7%) who able to read and write perceived as the current climatic condition is not similar with that of 20 years ago. Therefore from this result we conclude as educated households perceive as there is change in climate and undertake different adaptation strategies combat the impact.

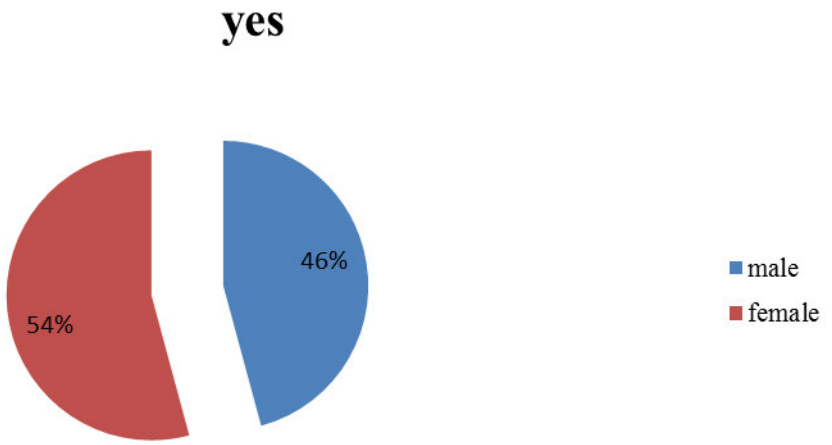
Table 8: Perception difference in terms of Age group

Significant at 5% level. Source: own survey :(2012)

	Temperature change							Rainfall change							
	Increase		Decrease		No change		Total	Increase		Decrease		No change			
Age group	no	%	no	%	no	%	no	no	%	no	%	no	%	Total	χ^2
16-30	9	90	0	0	1	10	10	2	20	7	55	1	7	10	*11.02**
31-65	74	94	4	5	1	1.3	79	17	21	55	69.6	7	8.9	79	*P=0.001*
>65	11	100	0	0		0	11	0	0	10	90.9	1	9.1	11	
Total														100	

Age also another determining factor that affect the perception of households to climate change. For this reason the sample households were asked how they perceive temperature and rainfall change. There is highly statistical difference among different age group concerning temperature and rainfall change. Thus, 90% of sample respondents who age 16-30, perceived as temperature increase and 55% of them claimed as rainfall decrease. 93.7% of sample households who aged 31-65, reported as temperature increases, whereas, 69.6% of them said that rainfall is decreasing. However all sample respondents who aged >65 reported as temperature increase and rainfall decreases within 30 years. From this we can conclude as the aged and experienced farmers perceived the change of temperature and rainfall easily and undertaken different adaptation measures to reduce the problem than those who are poor experienced and young one.

Figure 8: Perception on climate change in terms of sex



Not Significant at 5% of level of (p=0.21) level, source: own survey (2012)

Perception on the climate change, not only determined by age and educational status, but also by sex of household. Accordingly, both male headed and female headed households were asked whether current climate change is similar with that of 30 years ago. The result of the study shows no significant difference between female and male households. The result from this revealed that, 54% of female headed and 46 % of male headed households perceive as there is similarity between current climate condition and that of 20 and 30 years ago. The rest 54% of male and 54 % of female headed samples perceive as there is no similarity between current climate condition and that of 30 years ago. FGD result revealed, there is perception difference between male and female headed households. Discussants added as the perception difference in terms of sex comes due to the access of male headed to different trainings, information and actively involved in various socio-economic and political case of the country compared to female headed households.

Box 1. Decrease of Rain fall and increase of temperature

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 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 obeying 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 age agricultural expert in Kurar explained as there is climate change particularly increase of temperature and decrease of rainfall currently. He also elucidate 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. He also added, in the case of government, infrastructural development, giving different training to change the farmers' attitude and enhance their know how concerning environmental protection and natural resource rehabilitation are some of its responsibility

4.3 Major components of Vulnerability

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.

Wealth

Wealth is important indicator that determines adaptive capacity of farmers at local level. According to the sample population wealth accumulation mechanisms of farmers vary and diversified. Wealth accumulation and the expression of their socio economic status of the study area is determined by the number of livestock ownership, land owner ship, saving at house hold level off farm. Therefore wealth indicators will be explained as follow

Livestock owner ship

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.

Table 9: Respondents' livestock ownership

	Kebele											
TLU	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo			
	no	%	no	%	no	%	no	%	no	%	Total	χ^2
<2	3	39	0	0	0	0	7	41.2	3	14.3	13	
2-4	6	31	3	14.3	5	27.8	5	29.4	9	42.9	28	*P=0.001*
>4	14	30	18	58.7	13	72.2	5	29.4	9	42.9	59	
Total	23	100	21	100	18	100	17	100	21	100	100	

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

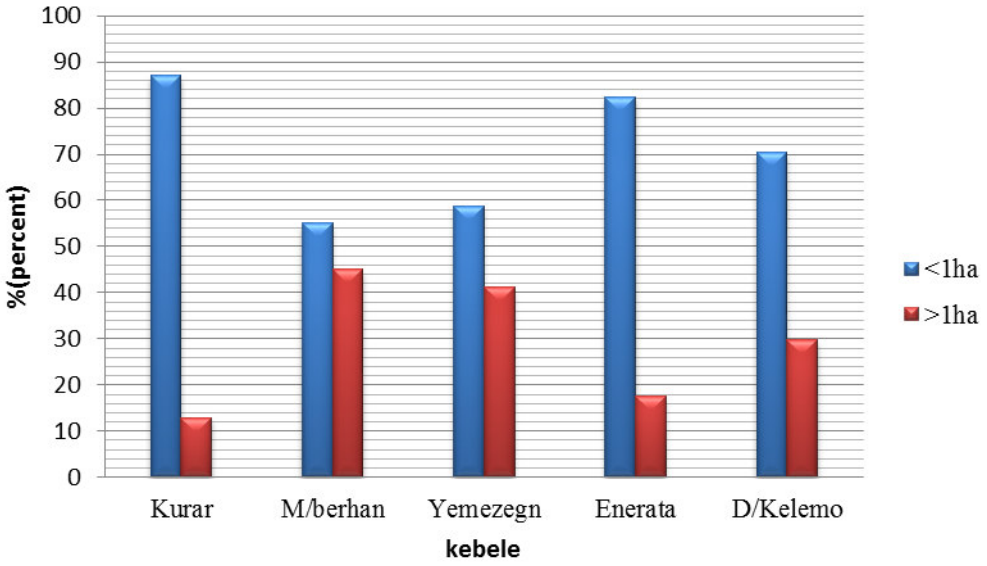
Livestock rearing forms the other important source of livelihood for the study area. It contribute to farmers' economy in different ways; i.e., as, source of cash income, source of supplementary food, and means of transport. Besides, livestock are considered a means of security and coping methods during crop failure and other calamities. Thus in this section households who possess high tropical livestock unit have relatively have high adaptive capacity and less vulnerable than who have less and no livestock at all.

AS depicted on the above table, the majority of the study areas respondents (59%) have TLU > 4, 28% of them have total tropical livestock unit 2-4, whereas, 13% of them have < 2 tropical livestock unit. when this is seen at Kebele level, in Kurar (AES1), 30% of respondents reported that they have TLU>4, 31% have TLU 2-4, and the rest 39% reported they have <2 TLU. In M/ berhan 14.3% of respondents are with TLU 2-4 and the rest 58.7% of sample hh are with TLU >4. In Yemezegn majority of the respondents 72.2% have >4 tropical livestock unit and the rest 27.8% have 2-4 tropical live stock units. From the total Enerata's respondents equal percentage 29.4% of them have TLU 2-4 and > 4; 41.2 of them have <2 tropical livestock unit. From the total sample population of D/ kelemo (AES5) households, 42.9% have >4 tropical livestock unit, 42.9 of them have 2-4 TLU, 14.3 of them have < 2 tropical livestock unit. There is significant statistical variation in livestock ownership of households in the watershed in the study Kebele. (P=0.001). 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 (Yemezegn) have lesser vulnerability with 58.7% and 72.2% of them have > 4 total tropical livestock vis-à-vis the 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).

Figure 9: Land holding size of households



Significant at 5% level (p=0.014), Source: own survey (2012)

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 Yemezegn 58.8%, in Enerata 82.4% and in D/kelemo 72% of sampled households possess land size less than 1ha.

Saving at Household level

Saving is the major strategy that the farmers used in order to come up with different challenges and unexpected situations related with climate change and related hazards. Thus, sample respondents in the study area were asked whether they save their product either in cash or in kind or not and this going to discussed in this section.

Table 10: Saving at household level

Significant at 1% level, source: own survey (2012)

	Kebele											
HH response	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo			
	no	%	no	%	no	%	no	%	no	%	Total	χ^2
Yes	4	17.6	12	57.1	10	55.6	3	17.6	4	19	33	*5.3**
No	19	82.4	9	42.9	8	44.4	14	82.4	17	81	67	*P=*
Total	23	100	21	100	18	100	17	100	21	100	100	*0.04*

As shown on the above table, the majority (67%) of sample respondents in the study area do not save their money, where as only 33% of them reported as they save their money. Nevertheless, there is variation among different agro-ecology. In Kurar, 82.6% and in Enerata 82.4% of sample households do not save their money either in cash or in kind. In M/berhan, 57.1% and in Yemezegn 55.6% of respondents save their products either in cash or in kind. D/kelemo 81%, Farmers who have saving habit level have better adaptive capacity and less vulnerable to climate change than those do not save. The focus group discussion result obtained from these kebeles depicts, because of low product and productivity resulted from climate change impacts such as: drought, seasonal variability, short growing season, their saving ability became limited. Besides, high population growth and subsistent farming system also aggravate the problem and in turn leads them to become hand to mouth consumers. They also claim as their products was not enough to even survive with and they forced to borrow crops locality relatively rich farmers and money from credit and saving institutions.

Access to modern technologies

Agricultural Inputs and Extension

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. Therefore, utilizations of modern farm inputs are expected to enhance farm households' food security and their adaptive capacity to climate change and variability. Access to modern technologies and the ability of farmers to use modern technologies determine the level of productivity; in turn it have impact on the adaptive capacity of farmers to climate and climate related factors in this section type of technology utilized by the sample respondents will be discussed.

Table 11: Access Agricultural technologies

The higher the percentage of total households who have access to agricultural technologies such as fertilizer supply, improved seeds, and others , the lesser the vulnerability and vice versa (Temesgen *et al.,*2008).

Kebele	Fertilizer utilization					Improved seed utilization					Irrigational utilization				
	Yes	%	No	%	Total	Yes	%	No	%	Total	Yes	%	No	%	Total
Kurar	22	95.7	1	4.3	23	1	4.3	22	95.7	23	1	4.3	22	95.7	23
M/berhan	21	100	0	0	21	11	52.4	10	47.6	21	5	23.8	16	76.2	21
Yemezegn	17	94.4	1	5.6	18	15	83.3	3	16.7	18	7	38.9	11	61.1	18
Enerata	16	94.1	1	5.9	17	16	94.1	1	5.9	17	16	94.1	1	5.9	17
D/kelemo	17	81	4	19	21	18	90	2	10	21	15	71.4	6	28.6	21
χ^2	P=0.159					P=0.000					P=0.001				

Significant at 5% level. Source: own survey: (2012)

As depicted on the above table utilization and access to technology in the sample kebeles vary from place to place. The use of irrigation, improved seeds and fertilizer is a good strategy for promoting the crop production sector in eastern Gojjam zone. The above table shows that farmers that use irrigation, fertilizer and improved seed had better adaptive capacity and less vulnerable to climate change than those who did not use it. The reason obviously seems that irrigation users do not lose crop through drought and also they obtain high productivity. There is statistically significant variation in utilization of improved seed and irrigation technology, but no statistical variation in the utilization of fertilizer in the study area.

Accordingly, In Kurar, 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 potential. In M/berhan all sampled 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.

Infrastructure and institutions

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 hhs who have access to infrastructure and have access have lesser vulnerability(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 centers, first cycle school, market access(see appendix 5)), access to electric, access to telephone service, veterinary services and etc.

Health service

In M/berhan 52.4% and in Yemezegn 50% of sample households reported as it takes $\leq$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 $\geq$5km to reach health center (see Appendix 5). The result from the FDG and KII also shows s there is no access to health service and they allowed going long distance to get the service, as such they have less adaptive capacity to the climatic and climatic related problems. In Yemezegn and M/berhan respondents have access and relatively go smaller distance $\leq$4km as compared with the rest kebeles. Generally, in the study area there is the problem of health provision and this have its own impact on the adaptive capacity of the farmers and in turn this affect the status of their vulnerability to climate and climatic related factors.

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**.** 94% of HH in Yemezegn, 94.1% of HH in Enerata, and 74.4% of HH in D/ kelemo have access to first cycle school and it takes $\leq$ 4 km from their residential home. In Kurar and M/berhan almost all of the respondents have the access and it takes $\leq$ 4km from their residential (see appendix 5). Thus from this we conclude as households who have access to school have less vulnerable to climate change vis-à-vis those who have no access.

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. Farmers with access to both input and output markets have more chances to implement adaptation measures. Input markets allow farmers to acquire the necessary inputs they might need for their farming operations such as different seed varieties, fertilizers, and irrigation technologies. On the other hand, access to output markets provide farmers with positive incentives to produce cash crops that can help improve their resource base and hence their ability to respond to changes in climatic conditions. Greater distance to the market where outputs are sold diminishes the probability of adaptation (Mano *et al*., 2003). >95% (all most all) of the sampled households in all kebeles; reported as there is no market center in their locality and takes≥ 5km to reach there (see appendix 5). Therefore, this is very challenging issue to the farmers to sell their agricultural products and use different farm inputs. In turn this leads to low adaptive capacity to climate change and shows their high vulnerability.

Veterinary service

The provision of veterinary service varies from place to place in the study area. When we see the provision of veterinary service in the study area the majority of them (68%) of them have access to veterinary service in their locality which takes them ≤4km from their residential house. When this is seen in Kebele level, in Kurar, 69.6%, in M/ berhan 76% of sample respondents in Yemezegn 77.8%, and in Enerata 42.9% and 57% of sample households in D/kelemo and Enerata have access to veterinary service in their locality respectively.

Electric provision

Electricity is important infrastructure that enables farmers to use different media service and other important benefits. Concerning electricity provision 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. In Kurar,3% of sample households, and in M/berhan 13% of sample households. In D/kelemo, Yemezegn and Enerata all sample households have no access of electricity.

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. 39% of the respondents reported as there are roads that connect their locality and the nearby city always. The rest 2% of the respondents claimed as there are no roads connecting to their locality and the nearby town.

When these result is seen at the Kebele level, in Kurar, 66.7% of sample households in m/berhan reported that as there are roads but sometimes break their service due to different factors. Especially during rainy season it is too difficult to get access of transportation. Besides the researcher's transact walk also approve the reality of unsuitability of roads in the study area.

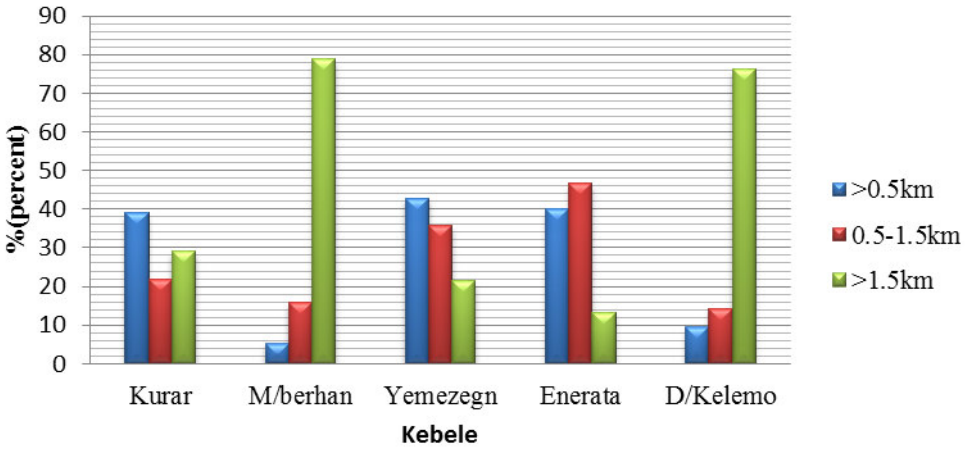
Table 12: Access to water sources

Kebele	Water source			
	River	Stream	Borehole	Pipe water
Kurar	100	0	4.3	0
m/ berhan	85.7	4.8	66.7	21
Yemezegn	61	55.6	16.7	16.7
Enerata	88.2	29.4	41.2	29.4
d/kelemo	95.2	20	9.5	19

Source: own survey (2012)

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 the most of sample respondents in the study area respond as they use river as a major source. For instance in Kurar 100% and in M/berhan 85.7%, in Yemezegn 61%, in Enerata 88.2%, in D/kelemo, 95.2% of households, of sample respondents' major source of water is river. For this reason, the researcher, tried to identify the distance of the river from household home and attempt to assess in the next section.

Figure 10: Distance of river water from HH's house in km



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

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, most 88% 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. In Kurar (AES1) 39.1 % of sample respondents, in M/berhan(AES2) 78.9%, in Yemezegn 21.4%, in Enerata (AES3) 13.3% and in D/kelemo 76.2% of sample 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 and access of water i.e. they fetch water from distant place. In addition to rivers 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 and have less adaptive capacity.

Table 13: Access to saving and credit service

	Kebeles											
HH response	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo		Total	
	No	%	No	%	no	%	no	%	no	%		χ^2
Yes	6	26.1	12	66.7	6	35.3	6	35.3	3	7.5	40	P=0.002
No	17	73.9	6	33.3	11	64.7	11	64.7	18	85.7	60	
Total	23	100	18	100	17	100	17	100	21	100	100	

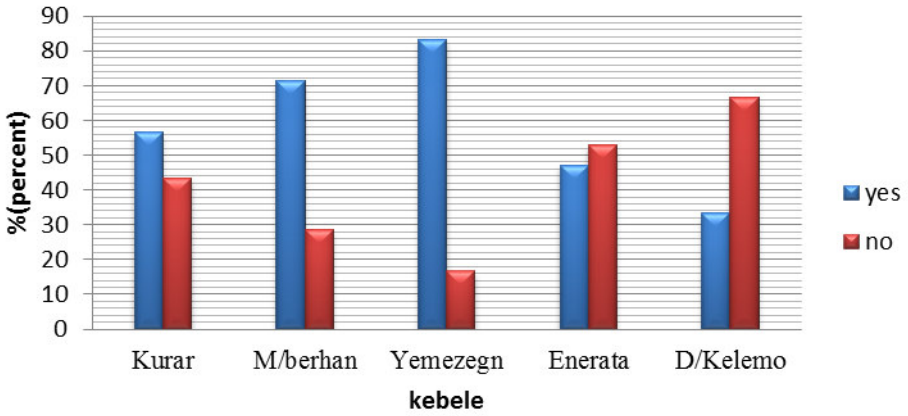
Significant at 5% level. Source: own survey (2012)

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 had benefited from credit. The statistical significance is found among the kebeles and the result. The result provided in the above table depicts that 60% of the studied households had not benefited credit association. Only 40% of households got credit. In d/kelemo, 85.7%, in Enerata 64.7%, in Kurar 73.9% of sample households do not have access to credit. In Yemezegn , 66.7% of households and in m/ berhan 61.9% of farmers reported as got credit and benefited. The focus group discussion result carried out in D/kelemo, Enerata and in Kurar revealed that in most kebeles the sample households they are not beneficiaries from saving and credit associations because they do not of afford to return the money.

VI. Access to Information

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).

Figure 11: Radio ownership of households



Significant (p=0.002) at 5%, Source: own survey (2012)

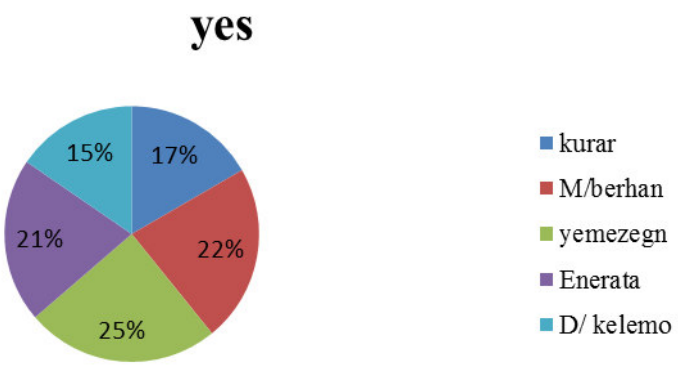
Information is the most essential resource for human beings. Information can obtained from different media sources such as radio, from agricultural extensions, Television, internet, news paper and so on. However in the rural Ethiopia including the study area, due to the inaccessibility of farmers to 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 access to radio and the rest 42% have no radio. 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. From this result, farmers in M/ berhan and Yemezegn are relatively better own radio. Therefore, this can be realized the hypothesis that say the more the farmers have access to information the more adaptive capacity they have.

VI. Social profile

Tradition of working together and non working days are the two important elements and have great role in social profile. 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.

Figure 12: Tradition of working together



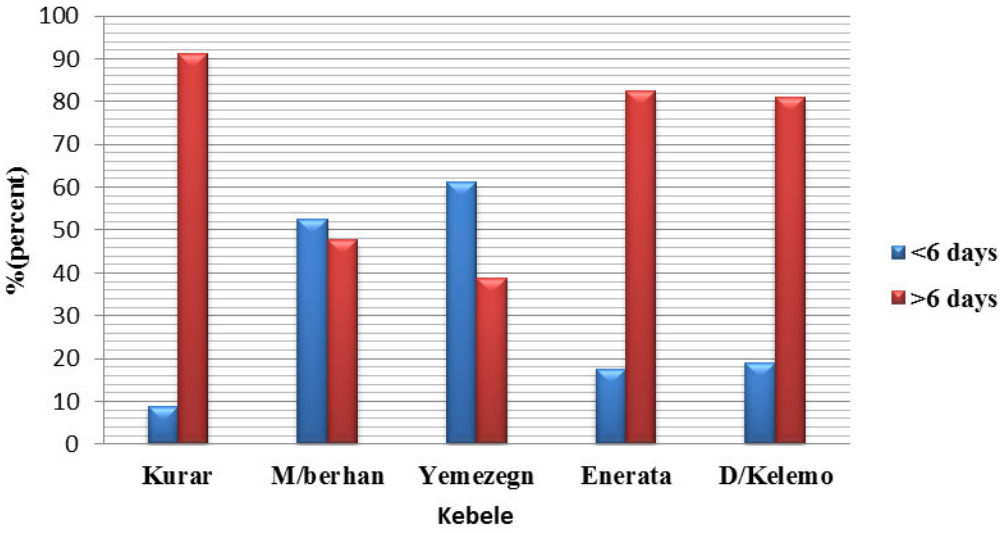
Significant at 1% level (p=0.110)Source: own survey (2012)

As illustrated on the above figure, 17% of sample households in Kurar; 22% of sample hhs, 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 work named as, Dabo (local name). 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 Equb, Eder,

and Mehabere also helped them to be socially bonded and be effective on their activities because they work cooperatively. 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, different information regarding their livelihood, climate change and so as to solve the challenges and problems they face through discussion. Thus from this result ewe understand, the more farmers have tradition of working together, the better adaptive capacity they have.

Figure 13: Number of non-working days.



Significant at 5% level. Source: own survey (2012)

Ethiopia is characterized by diversified ethnic, language, culture and religion. Similarly the study area also characterized by these and there are many religious days which the society believed as holiday which the farmers are celebrating and regarded to them as no-working days in month. Therefore, in the choke water shed the number of no- working days was ranged into 2 based on the mean average result ranging <6days and>6 days. 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 indifferent ways impact on (crop, health, environment)if they work on minor religious days on this dates (5, 12,19,21, 24,29 including the weekend) per month. Such like cultural and religious influence affect the productivity and low adaptive capacity they will be punished by God.

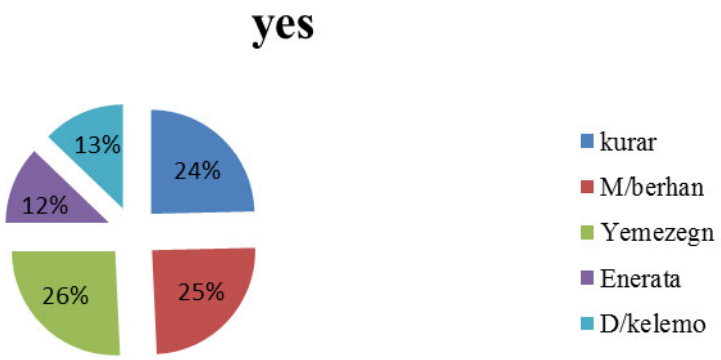
Generally, institution is a means for holding society together, giving it sense and purpose and enabling it to adapt." thus, countries with well-developed social institutions are considered to have greater adaptive capacity than those with less effective institutional arrangements commonly, developing nations and those in transition

4.3.1. 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

Figure 14: Use of crop rotation



Not Significant at 5% level of confidence, Source: own survey (2012)

As indicated on the above table 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. Fertility status of soil

Table 14: Fertility status of soil

Fertility status	Kebele											
	Kurar		M/berhan		Yemezegn		Enerata		D/kelemo		Total	
	no	%	no	%	no	%	no	%	no	%		χ^2
Fertile	1	4.3	10	47.6	3	16.7	3	17.6	1	4.8	18	P=0.0
somehow fertile	1	4.3	10	47.6	12	66.7	8	47.1	4	19	38.5	
Infertile	21	91.3	1	4.8	3	16.7	6	35.3	16	76.2	47	
Total	23	100	21	100	18	100	17	100	21	100	100	

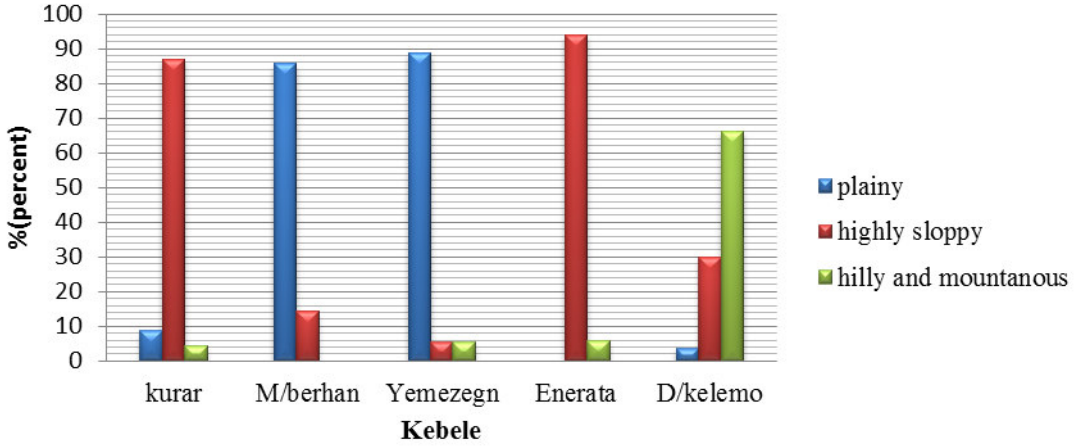
Significant at 5% level, Source: own survey (2012)

As depicted on the above table, the majority (47%) of the study areas' respondents reported as their soil is productive. in this Kebele in d/kelemo, 76.2% of the respondents reported as their soil fertility status are 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 fertility. 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).Accordinglywith 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, they are more vulnerable to negative impact of climate change as compared to the rest agro-ecologies.

Slope of farm land

Topography describes the shape and, relief feature of a given land. 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.

Figure 15: Slope of the farm land



Significant (p=0.000) at 5% of level, source: own survey (2012)

As depicted on the above figure, 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 Yemezegn 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 transact walk through Kurar Kebele it is highly sloppy and have lowland altitude, where the rain fall amount and temperature have inverse relation, thus due to its altitude it gets high temperature and low rain fall. As a result obtained from FGD, in Kurar and Enerata, due to the steepness of their topography their soil is highly eroded and this in turn responsible to low product and low productivity. They also claimed as their topography is high threat which is responsible for the farmer's displacement to the other places.

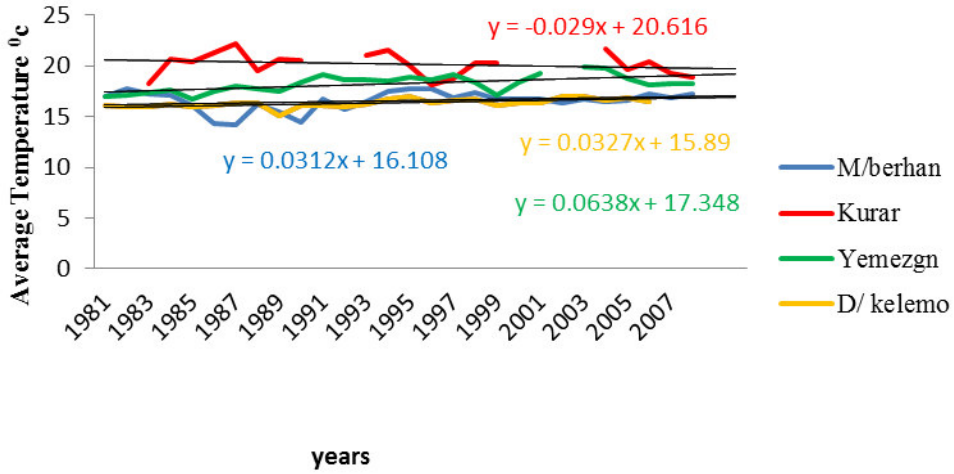
4.3.2. Indicator variables of Exposure

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.

4.3.3.1. Analysis of 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 for analyze the change. However, the researcher attempted to extrapolate the data from the nearest Kebele. Thus regarding due to the absence of meteorological data in D/kelemo and Enerata their temperature data was extrapolated from debremarkos which is the nearest station to this Kebele. Similarly, the temperature data of M/ berhan was taken from Debre work station. Likewise, rainfall data, of D/kelemo, Enerata and M/ berhan was extrapolated from D/ markos, Rob gebya, and D/ work respectively due to above mentioned reasons.

Figure 16 : Trend analysis of temperature change of the study area



Source: own calculation (2012)

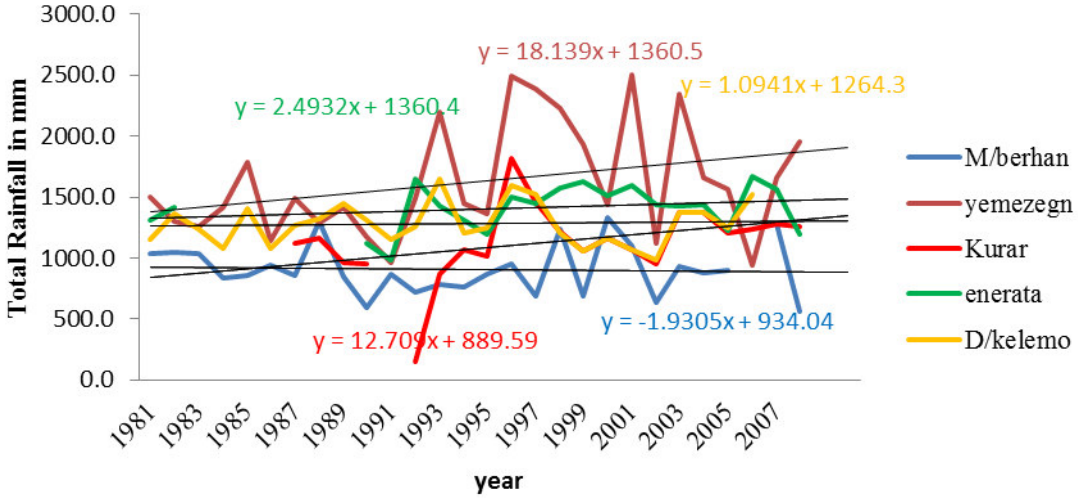
Climate change has become a real phenomenon, as it is evident from an increased world temperature, which is known as global warming. Global average temperature has increased by about 0.6°C over the past 100 years, with a major warming upswing in the 1970s (IPCC, 2001).

As the temperature data from (1981-2008) depicted in all kebeles the temperature trend shows an increment with the exception of Kurar, which shows decreasing trend by -0.7°c. In D/ kelemo the temperature shows an increment by 0.8°c, in Yemezegn -1.7°c, Enerata-0.8°c, M/berhan-0.84°c which is the important indicator of climate change.

Generally, due to climate change in the study area, the temperature has been increased within the (1981-2008), with a major warming upswing in the 2004 GC.

Analysis of rainfall change

Figure 17: Trend analysis of rainfall change of the study area



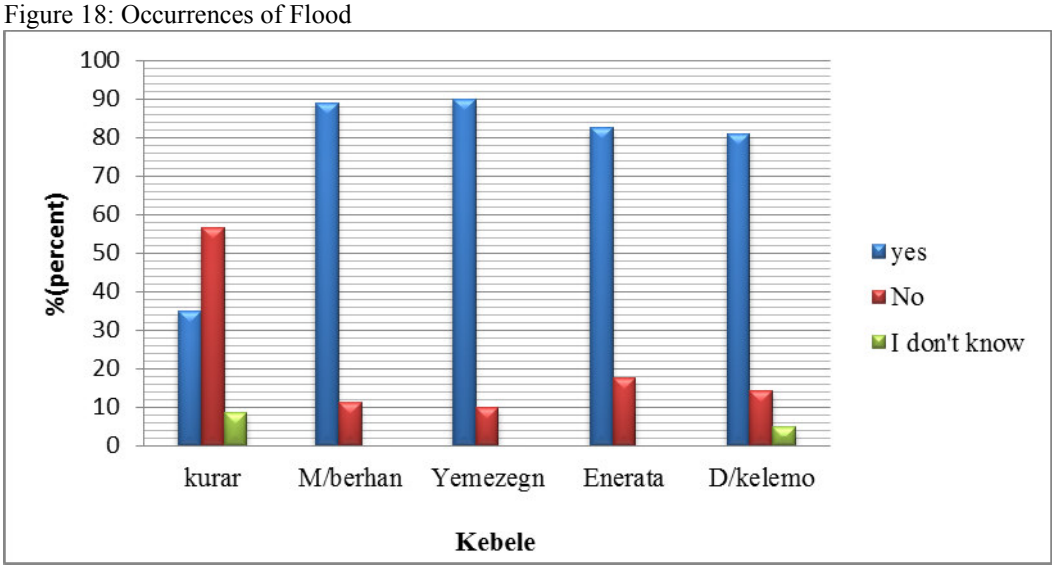
Source: own calculation (2012)

Concerning rain fall trend, in the study area above figure shows an increasing trend of rainfall with the highest trend in Yemezegn (i.e. 489mm) and with the minimum trend in D/ kelemo which shows 29.5mm of increase in rain fall. In the same fashion, in Enerata, Kurar and m/ berhan the rain fall trend shows an increment by 67mm, 343mm, and 52mm within. According to IPCC (2001) the major adverse impacts of climate change are seasonal variability of rain, drought and flood. Because of this, as the result from FGD and KII revealed the major impact of climate change relate to rain fall is seasonal variability, which is late or early coming of rainfall affecting their productivity and made them high vulnerable to climate change.

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**.**

Figure 18: Occurrences of Flood



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 years. Statistical significance is found in this result. in Kurar 34.8% and in m/ berhan71.4%; in Yemezegn,90%,in Enerata 82.4%; of sample respondents reported as the experienced extreme flood within the last 20 years. In d/ kelemo 81% of sample respondents reported as they experienced flood within 20 years.

Occurrence of drought

Table 15: Occurrence of drought

	Kebele											
	Kurar		**M/ berhan**		**Yemezegn**		**Enerata**		**D/kelemo**			
	no	**%**	**no**	**%**	**no**	**%**	**no**	**%**	**no**	**%**	**Total**	χ^2
Yes	23	100	19	90.5	17	94.4	16	94.1	21	100	96	*P=0.612*
No	0	0	1	4.8	1	5.6	1	5.9	0	0	3	
I 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	

Ns. Not statistically significant at 5% level of confidence. Source: own survey (2012)

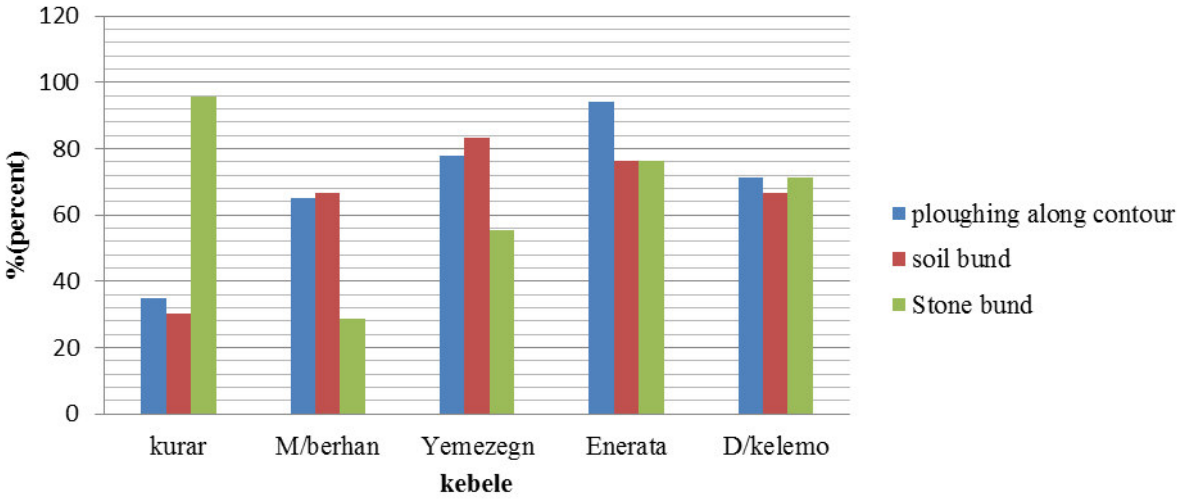
Regarding the occurrences of drought, the sample households were asked whether they experience drought occurrences within the last 20 years or not. According to Temesgen *et al.,* 2008, the higher the percentage of households, who experienced climate extremes, the higher the vulnerability and vice versa. Accordingly, in kurar100% and in m/ berhan 90.5% in Yemezegn 94.4%, in Enerata 94.1% and In d/ kelemo all respondents 100%,of sample respondents reported as they have experiences extreme drought season within the last 20 year. 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 moderately vulnerable.

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. Even if emissions are stabilized relatively soon, climate change and its effects will last many years, and adaptation will be necessary. Climate change adaptation is especially important in developing countries since those countries are predicted to bear the brunt of the effects of climate change. It is 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.

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 inputs.

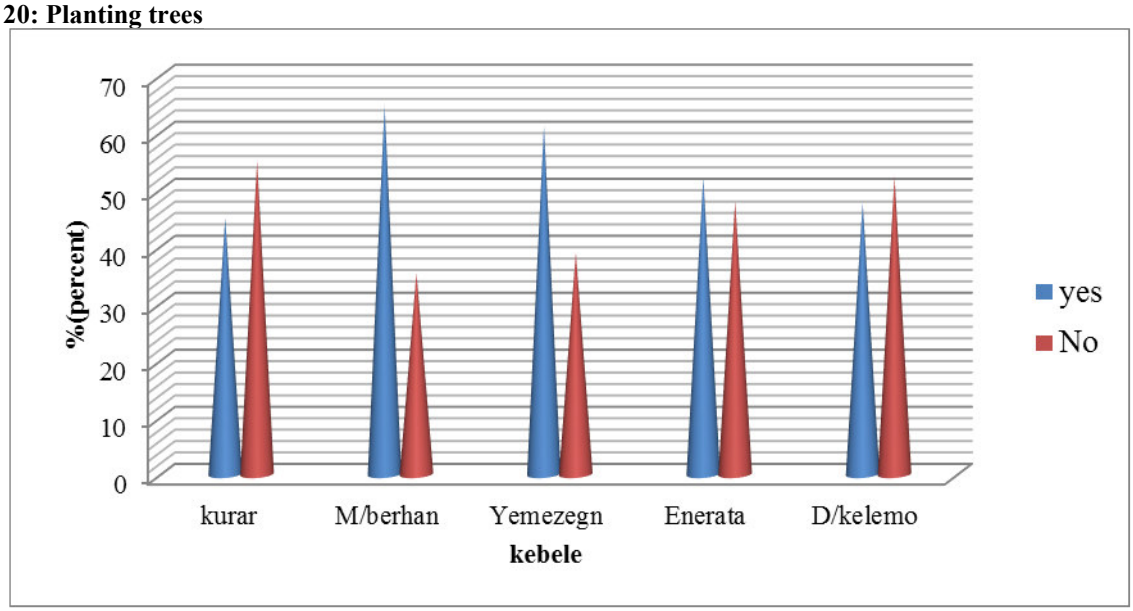
Figure 19: Soil conservation strategies



Significant at 5% leve(p=0.0041,0.021 and 0.0012)respectively. source: own survey (2012)

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 and 34.8% of sample hhs,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 this stone bund is the major and mostly used method so by applying this method they conserve their soil from erosion and other related problems.

Figure 20: Planting trees



Significant at 5% level. Source: own survey (2012)

Forest Conservation 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. As illustrated on the above table, 45% of sample respondents in Kurar, and 64.7% of sample households in M/berhan 57.1%, in Yemezegn 61.1%, in Enerata 52.1% and in D/ kelemo 47.7% reported as they plant trees, which are best method to protect forest resource and in turn protect their soil from erosion. According to Temesgen (2008), the more the percentage of households who plant trees the less vulnerable. Thus in this study, Enerata is moderately vulnerable to climate change while, Yemezegn and

M/berhan *kebeles* have relatively high adaptive capacity and less vulnerable.

Table 16**:** Managing Grazing land

Kebele	Rotational grazing method				Fodder preparation			
	Yes		**No**		**Yes**		**No**	
	no	**%**	**no**	**%**	**no**	**%**	**no**	**%**
Kurar	8	34.8	15	65.2	8	34.8	15	65.2
m/berhan	6	28.6	15	71.4	13	61.9	8	38.1
Yemezegn	7	38.9	11	61.1	4	22.2	14	77.8
Enerata	6	35.3	11	64.7	6	35.3	11	64.7
d/kelemo	9	42.9	12	57.1	7	33.3	14	66.7
Total	36%		64%		38%		62%	
X^2	df = 3, p= 0.025				df=4, p= 0.031			

As depicted on the above table, the majority (64%) and 62% of sample respondents in the study area reported as they do not use rotational grazing method and do not prepare fodder for their livestock. The same result is true when we come to Kebele level. In Kurar 65.2%; in m/ berhan 71.4% in Yemezegn 61.1%, Enerata 64.7%, in D/ kelemo, 57.1% of sample households, reported as they do not use rotational grazing system. FGD result with D/ kelemo, Kurar and Enerata, farmers also show as they do not have enough grazing land due to land fragmentation within family members to expand cultivation land.

Fodder preparation is also a method of managing and conserving grazing land in the study area. So that, in Kurar 65.2% of sample households reported as they do not prepare fodder for their livestock; in Yemezegn 77.8%; in Enerata 64.7%; Whereas in M/berhan 61.9% of households reported as they prepare fodder for their livestock. Farmers in AES5 (D/ kelemo) 66.7% of them reported as they did not prepare fodder for their livestock. Farmers do normally keep large numbers of livestock on a small grazing area when holding sizes shrink, which results in considerable overgrazing in the study area. Due to this, there is no satisfactory result regarding the grazing land management.

Table 17: Water harvesting strategy

	Water harvesting				
Kebele	**yes**		**No**		**Total**
	no	**%**	**no**	**%**	
Kurar	5	21.7	18	78.3	23
M/berhan	18	85.7	18	14.3	21
Yemezegn	15	83.3	3	83.3	18
Enerata	8	47.1	9	52.9	17
D/kelemo	2	9.5	19	90.5	21

Significant at 5% level of confidence (p=0.000). Source: own survey,(2012)

The above table illustrates the most important adaptation strategy to climate change and variability which is related with water in the study area and used there. Therefore, in this section water harvesting and irrigation potential of the study areas sample respondents going to be discussed. There statistical significance found in this section.

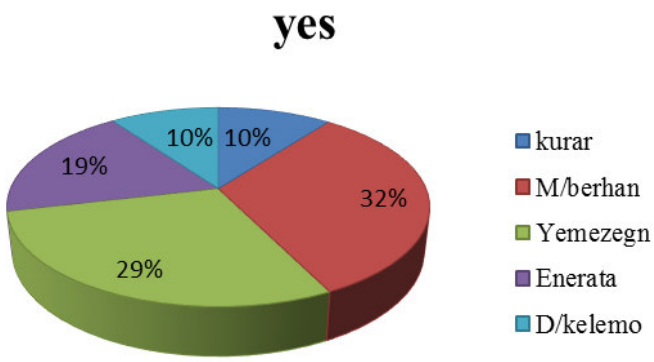
Accordingly, 55% of sample household in the study area do not use water harvesting, and 60% of them do not use irrigation technology. In Kurar, 78.3% of sample respondents do not use water harvesting strategy to adapt to climate change However, the relatively better water harvesting was undertaken in Yemezegn (83.3%) and in M/ berhan (85.7%). Regarding the irrigation system, in D/ kelemo, 38.1%of sample HH; in Yemezegn 27.8%; in Enerata, 52.9%; in Kurar 43.5% and in M/ berhan 38.1% of sample respondents reported as they use irrigation system. Generally, in the study area the adaptation strategy they have used to climate change and related problems were not enough and satisfactory, however their adaptation potential and strategies varies among different agro ecology and among different Kebele. 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. Due to these and other related factors, they used the indigenous and less effective adaptation strategies to come up with the difficulties of climate change.

Livelihood diversification

Rural livelihoods diversification has generally occurred as a result of an increased importance of off-farm wage labor in household livelihood portfolio or through the development of new forms of on-farm/on-site. In both cases, diversification ranges from a temporary change of household livelihood portfolio (*occasional diversification*) to a deliberate attempt to optimize household capacity to take advantage of ever-changing

opportunities and cope with unexpected constraints (*strategic diversification*).As agricultural specialization can start from an initial diversification move, also livelihoods diversification can eventually lead to some form of household specialization. For instance, in particular circumstance migratory wage labor may result so cost/effective to push the household away from conventional on-farm activities. Conversely, the identification of a particular niche commodity (e.g. mushrooms) may lead the household to invest all its labor and other assets in it, disregarding both conventional farming activities and wage labor. Livelihood diversification is diversification of own source of income by engaging in different off-farm activities. Thus, it is an important adaptation strategy to climate change and variability in the study area and will be discussed in as follow

Figure 21: Livelihood diversification as adaptive strategy to climate change and variability



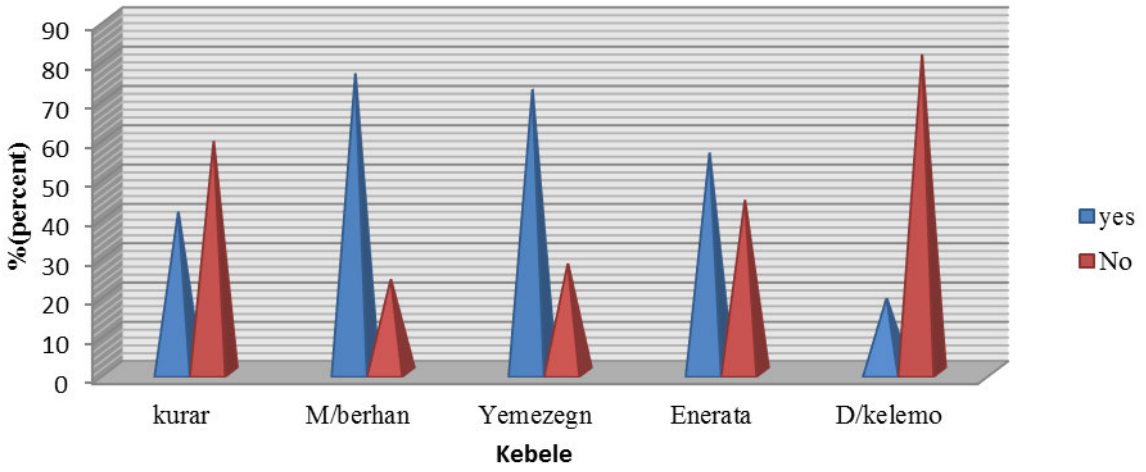
Statistically Significant (p=0.003) at 95% level of confidence. Source: own survey (2012)

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 and climate and related hazards. 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 has no additional source of income which help them during disaster.

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 used selling Kimba (local name), 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 names[1]), 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**.**

[1] *Kinba- is locally made, woody material used as agricultural material, household use and other domestic uses. Areke, tella and teg are local beer prepared from barley, malt and honey respectively. Iddir –local community based organization, Kebele- the smallest administrative unit*

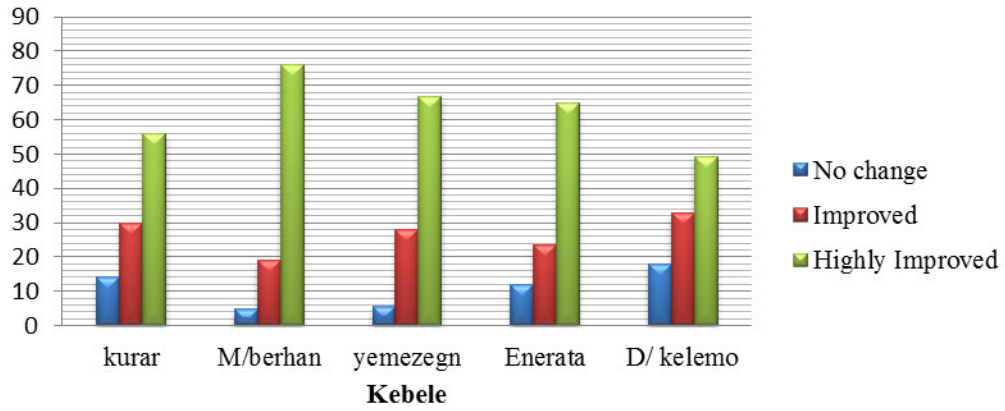
Figure 22: Using fast growing seeds



Significant at 5% level (p=0.003). Source: own survey (2012)

As illustrated in the following figure, 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. 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. Using this method as an adaptation strategy to climate change they explained as they were relatively better in food access.

Figure 23: The condition of households' livelihood after undertaking adaptation strategies to climate change



Significant at 1% level (p=0.121).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. 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 increase, income increase as a result afford sending their children to school, their soil moisture have been protected, due to the effective adaptation strategies they have used, they said "**WE FEEL BETTER**

NOW". In Kurar also the FGD result depicted as their soil was protected from erosion due to the Stone bund strategy they have been applied.

Result of the study

Adaptation to climate change requires that farmers notice that climate has changes and then they identify useful adaptation options. Thus perception of households to climate change varies in terms of educational status, sex, age and even within Kebele. Thus, regarding temperature and rainfall change, there is no statistical variation found within the Kebele. The majority of kebeles households perceive the increasing of temperature. For instance, in d/ kelemo, 71.4% of households perceive as rain fall has been decreasing, in Kurar, only 26.1% and in Enerata 94.1%, in Yemezegn 77.8%, households in M/berhan 61.9% of perceive as rain fall has been decreasing. 19% of households in M/ berhan, 17.4% in Kurar and 4.8% in D/ kelemo complain seasonal variation of rain fall (early or late coming of rain). Thus from this result, kebeles which perceive temperature and rainfall change better undertake different adaptation and coping mechanism to the challenges.

In terms of education, there is an assumption that the more educated households, the more perceive changes of climate change and variability and the better they undertake adaptation options to reduce the challenges. Accordingly, in the study area, 72.5% of illiterate sample households perceive as the current climate change is similar with that of before 20 or 30 years ago. However, 85.7%of respondents who join primary school and 100% of households who joined secondary school perceive as there is difference between current climatic condition and that of before 20 and 30 years ago. Therefore, the relatively educated farmers easily perceive the change of climate change than non- educated ones.

Age is also, another determinant factor of perception on climate change and variability. Thus, in terms of age there is an assumption that says, the aged and experienced households perceive change of climate change and undertake different adaptation options than younger ones. This is the fact that, the old aged are more experienced and passed through many challenges relate to their environment than the young one. Thus 90% of sample respondents aged 16-30, 93.7% aged 31- 65 perceive as temperature increase. However, 100% of sample households aged >65 perceived temperature increase and rain fall decrease and change seasonal variation currently.

Sex is also another determining factor of perception regarding climate change. Thus, sample households were asked whether there is similarity between current climate condition and that of before 20 and 30 years. Accordingly, 66.7% of male headed and 50% of male headed households perceived as there is difference between current climatic condition and of 20 years ago. Thus male headed households are better perceived climate change than female headed, because of different reasons. For instance, male headed, have better access to information, taking different training, and actively participate in various socio-economic and political cases of their locality in particular and country in general.

Adaptation to climate change is a response to climate change that seeks to reduce and cope with different climate change impacts. There are different adaptation options, like soil and water conservation, planting trees, livelihood diversification and natural resource rehabilitation, even though farmers in the study area undertake, some of them. Regarding soil conservation, in the study area, 62%of sample respondents with high percentage of Yemezegn (83.3%) used soil bund strategy, and 66% of sample kebeles households used stone bund strategy, with the leading Kebele Kurar (95.7%). Another strategy is what we call planting trees, where, d/ kelemo 57.1%, in Yemezegn 66.7%, in Enerata 64.7%, in Kurar 87% , in m/ berhan 52.4% of hh, has planting trees which is best option. Thus kebeles which plant trees have better adaptation to climate change and variability which in turn decrease their vulnerability. Concerning soil conservation, water harvesting strategy assessed. Thus, 90.5%, 52.9% and 78.3% of households in d/ kelemo, Enerata and Kurar do not harvest water respectively, whereas 83.3%of households in Yemezegn and 85.7% of households in M/ berhan apply this option as an adaptation option to climate change sand variability.

Diversifying livelihood (source of income) is also another adaptation strategy of climate change and variability. This is practicing through different off- farm activities so as to enhance their income. Thus households were asked whether they have additional source of income or not. As a result, in D/ kelemo 76.2% of sample households, in Yemezegn 66.7%, in Enerata 52.9%, in m/ berhan 57.1% and in Kurar all most all sample respondents claimed as they have no additional source of income or not engaging in off- farm activities. The rest percentage of these Kebele,(23.8% in d/ kelemo, 33.3% in Yemezegn, 47.1% in Enerata and 42.9%in M/ Berahan engaged in off- farm activities. Hence, this result realizing the hypothesis that says farmers who have diversified source of income have better adaptive capacity and less vulnerable to the climate shocks and variability than who do not have.

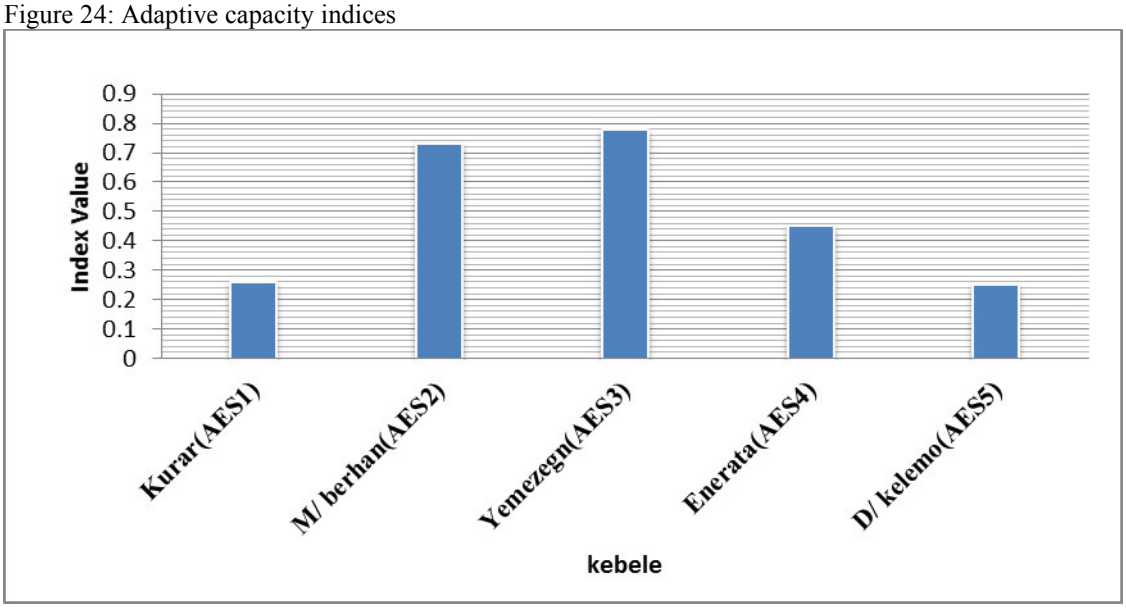
Results of vulnerability index

In the study area LVI- IPC*C* 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. After some steps the, ultimately the LVI-IPCC scaled from -1(least vulnerable) to 1(most vulnerable).

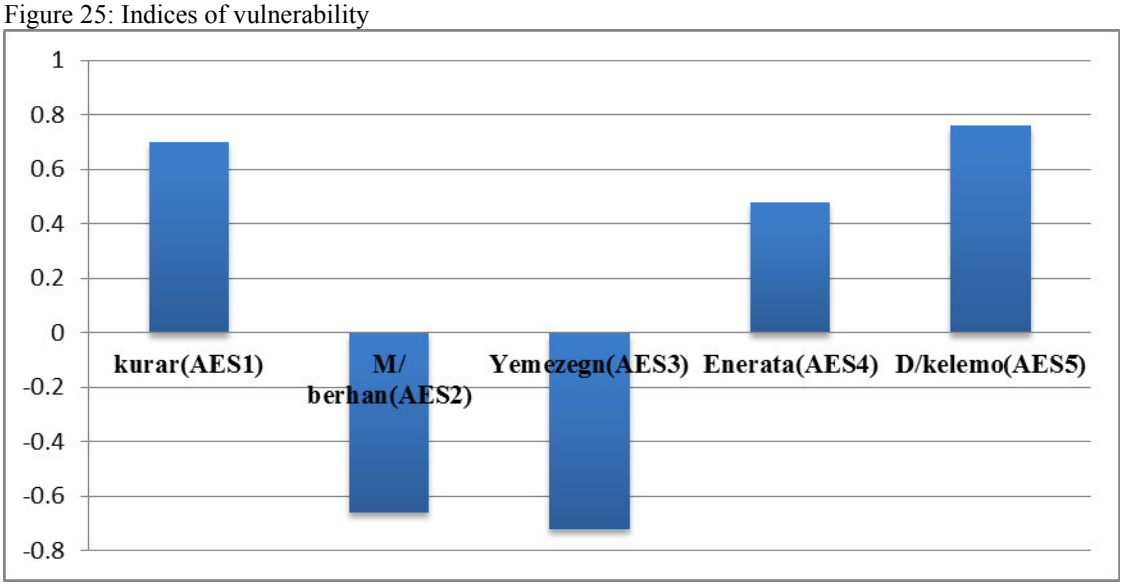
Once the factor score (weight of each indicator) was found and indicators of each determinants of vulnerability were normalized (see appendix3). The next step is calculating the vulnerability indices of each agro ecology by equation number four, assuming that people with high adaptive capacity are less sensitive to damage from climatic change and variability. The adaptive capacity ranges from (0 less adaptive capacity to 1 high adaptive capacity). The adaptive capacity indices of each Kebele was found using indicator variable of adaptive capacities , the sensitivity indices and expose indices also calculated using sensitivity indicator variables and exposure indicator variables respectively. Thus, M/ berhan (0.73) and Yemezegn (0.78) shows better adaptive capacity as compared to D/ kelemo (0.25), Kurar (0.26) and Enerata (0.45) which are referred to as highly vulnerable kebeles.

Figure 24: Adaptive capacity indices



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. Consequently, Kurar, D/ kelemo 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 0.48.

Figure 25: Indices of vulnerability



As depicted on the above figure, the vulnerability indices of each agro ecology 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, agro ecologies which are relatively less vulnerable are, mid land agro ecosystem (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. In addition to climatic factors, 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, particularly 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 HHs. Declining of productivity in the area, due to soil erosion and in accessibility of agricultural technologies and low provision of infrastructures(electricity, water, road, veterinary, health services).

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 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 watershed, 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 mostly tree in the high land agro ecology (Enerata). As KII in Enerata revealed, even though, there is seasonal variability of rain and reduction of agricultural production due to climate change, on the other hand, have an advantage in that, in the past the area was cold, but due to increasing temperature, they tried to get relatively warm season. The midland plain areas such as M/berhan and Yemezegn 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 higher adaptive capacity and lessen the areas' vulnerability.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Ethiopian farmers are exposed to both gradual climate change (mainly temperature and precipitation) and extreme climate change (mainly drought and flood) (Temesgen et.al, 2008) Causes for vulnerability of Ethiopia to climate variability and change include very high dependence on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc. This study attempts to analyze the vulnerability level of the households in choke mountain watershed in five agro ecologies using biophysical and socio-economic conditions.

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. Thus adaptive capacity was represented by wealth, technology, infrastructure and institutions, access to information and irrigation.

Using the LVI-IPCC equation, the vulnerability status of agro ecologies was calculated. Thus, the vulnerability indices of each agro ecology revealed high vulnerability of Kurar (low land agro ecology), D/ kelemo (mountainous high land) and moderately vulnerable Enerata (mid land with sloppy land).While, agro ecologies which are relatively less vulnerable are, mid land agro ecosystem (Yemezegn and M/ berhan).

This analysis underline the high sensitivity and vulnerability of farmers in choke mountain watershed 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 , slope of the farm land, low agricultural product, small land size (<1ha), low and unsatisfactory adaptation options of climate change, small number of livestock, lack of income diversification and others exacerbate the vulnerability of the area. By and large, the increase of exposure of study area to climate change and variability, high sensitivity of the environment coupled with low adaptive capacity which results the above mentioned are exacerbate the vulnerability of the choke mountain watershed.

5.2. Recommendation

Based on the finding of the study some 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 (NGO).To this end, some possible ideas are recommended in this section.

Awareness creation –creating and expanding the knowhow of the local communities about their environment including climate change, by providing them reliable and up -to- date information, through different trainings.

Emphasizing on adaptation strategies: focusing on preventative adaptation strategies can bring sustainable development in the area. Therefore policy makers should focus on modifying and support the indigenous adaptation practices to adopt effective strategies. The adaptation strategies undertaken in the study area, to combat effect of climate change were not sufficient, thus need to improved and strengthen.

Capacity building of the community: by Providing agricultural inputs with reasonable price, Promoting sustainable cropping practices, Providing effective trainings, Facilitating saving and credit association Creating employment opportunities, Enhancing and supporting current coping and adaptation strategies, Improving infrastructural provision.

The government should **encourage and support the indigenous knowledge** and experience of local communities in adaptation to climate change.

The policy intervention should **focus on strengthening both household and public level climate risk management**, through mitigation and coping practices aimed at reducing the impacts of climate change. The risk mitigation strategies that should be addressed at the household level include those that encourage crop and livestock diversification, use of drought tolerant crop varieties and livestock species, and mixed farming. Public level risk management strategies include, water harvesting, natural resource conservation and management, irrigation, agro ecological extension packages, inception of productive safety-net program.

Expansion of new varieties of crops and diversification from traditional crops to other types of crops which can with stand drought and higher temperature;

There should be a great need for the government through the meteorological department, research and extension, private sector and non-governmental organizations to provide **adequate extension information services** to ensure that farmers receive up-to-date information about rainfall and temperature patterns in the forthcoming season so that they can make well informed decisions about their planting dates. Financing of the rural area by setting up suitable financial systems that will allow small producers to have **access to credit.** These policies that improve household welfare as well as access to credit are also a priority for both short- and long-term adaptation measures;

Better management of natural resources: to improve the current natural capital of the study area, natural resource conservation and development activities such as planting trees, participatory forest management, and integrated water shed management, and etc. should be implemented.

Creating a unit for research into climate, development and societies and strengthening institutional set-ups working in research for large scale dissemination of adaptation technologies by boosting supervision and extension ;

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