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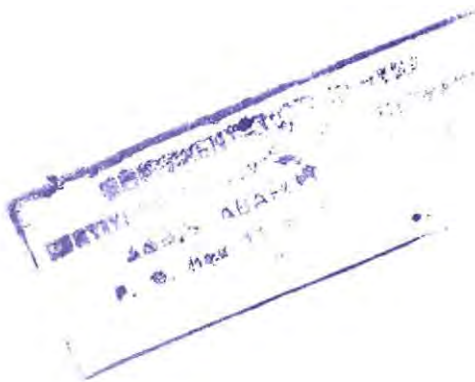
LOCAL LEVEL ASSESSMENT OF FARMERS VULNERABILITY TO CLIMATE CHANGE AND VARIABILITY: A CASE STUDY IN CHOKE MOUNTAIN EAST GOJJAM

A thesis submitted to the school of graduate studies of Addis Ababa University in partial fulfilment of the requirements for the degree of Master of Arts in Environment and Development

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Title

*Local Level Assessment of Farmers Vulnerability to
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Mountain East Gojjam*

By
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DEVELOPMENT STUDIES

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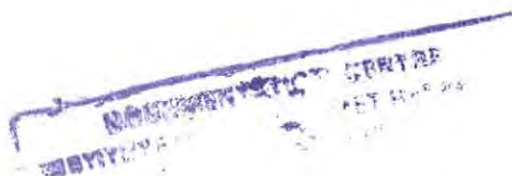
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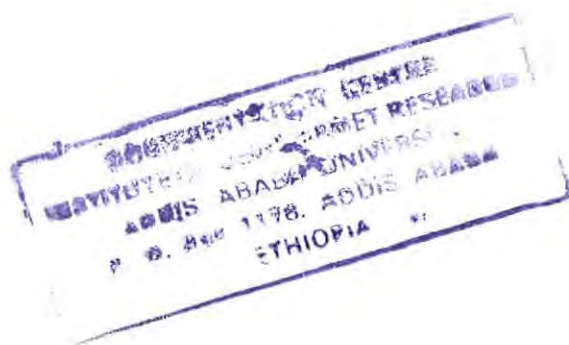
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Acronyms and Abbreviations

ACSI	Amhara Credit and saving institute
CBOs	Community based organisations
DFID	Department for International Development of the United Kingdom
DPPC	Disaster privation, preparedness, and Commission
FAO	Food and Agriculture Organization of the United Nation
GDP	Gross Domestic Product
GOs	Governmental Organization
HH	Household
HH _s	Households
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
KMO	Kaisar-Meyer-Olkin
M.a.s.l	Meter above Sea Level
MOA	Ministry of Agriculture
NMSA	National Meteorological Service Agency
NAP	National Action Programme to Combat Drought and Desertification
NAPA	National Adaptation Programme of Action
NGOs	Non-Governmental Organizations
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction

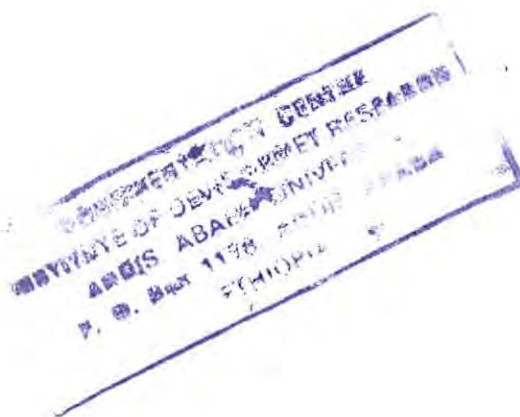


Table of Content

Content	Page
Acknowledgement.....	i
Acronyms and Abbreviations.....	ii
Table of contents.....	iii
List of Tables.....	iv
List of Figures.....	v
Abstract.....	vi

CHAPTER ONE

1. Introduction	1
1.1. Back ground.....	1
1.2. Statement of the problem.....	4
1.3. Objectives.....	6
1.4. Significance of the study.....	6
1.5. Scope and limitation of the study.....	7
1.6. Organization of the study.....	7

CHAPTER TWO

2. Review of Related Literature.....	8
2.1. Definition of Climate change.....	8
2.2. Causes and impacts of Climate change.....	8
2.3. Definition of Vulnerability	10
2.3.1. Adaptation.....	11
2.3.2. Adaptive Capacity	11
2.3.3. Sensitivity.....	12
2.3.4. Exposure.....	12
2.4. Conceptual Approaches.....	13
2.4.1. Socio economic approaches.....	14
2.4.2. Biophysical Approach.....	14
2.4.3. The integrated Approach.....	15
2.5. Methods for measuring Vulnerability to climate change.....	16

2.5.1. Econometric method.....	16
2.5.1.1. Vulnerability as expected poverty.....	16
2.5.1.2. Vulnerability as a low expected utility.....	17
2.5.1.3. Vulnerability as uninsured exposure to risk.....	17
2.5.2. Indicator method.....	18
2.6. Review of empirical studies.....	18
2.7. Conceptual Frame work.....	21

CHAPTER THREE

3. Description of the study area.....	25
3.1. Location of the study area.....	25

CHAPTER FOUR

4. Research Methodology.....	28
4.1. Design and methods of the study.....	28
4.2. Data type, Source and Method of collection.....	28
4.2.1. Primary Data Collection	28
4.2.2. Secondary Data Collection.....	30
4.3. Sampling size.....	30
4.4. Method of Data Analysis.....	30
4.5. Model variables and expected signs	31
4.6. Vulnerability Index Specification.....	35

CHAPTER FIVE

5. Descriptive Analysis of the sample population.....	39
5.1. Demographic, Social and Economic Characteristics.....	39
5.2. Economic condition of the sampled households.....	41
5.3. Determinants of vulnerability.....	43
5.3.1. Indicator variables of adaptive Capacity	49
5.3.1.1. Wealth	44
5.3.1.2. Access to modern technology	45
5.3.1.3. Infrastructure and institutions	46
5.3.1.4. Access to information	48
5.3.2. Indicator variables of sensitivity	49

5.3.2.1. Soil fertility	49
5.3.2.2. Slope of the farm land	50
5.3.3. Indicator variables of exposure	50
5.3.3.1. Analysis of temperature change	50
5.3.3.2. Analysis of rainfall change	52
5.4. Perception of farmers to climate change and variability	53

CHAPTER SIX

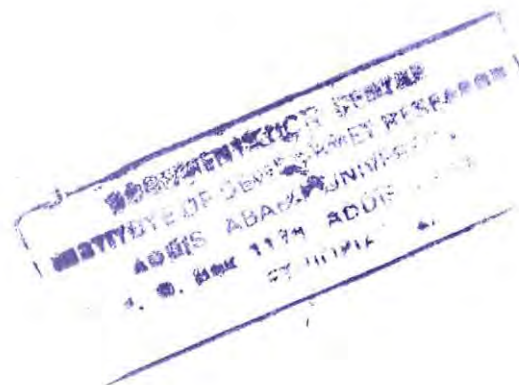
6. Result and Discussion	56
6.1. Results of vulnerability index	57
6.2. Results of KI and FGD	59
6.3. Discussion of the result	62

CHAPTER SEVEN

7. Conclusion and Recommendation	67
7.1 Conclusion	67
7.2. Recommendations	68
Reference.....	70
Appendices.....	74

List of tables

Table 1. Vulnerability indicators, units of measurement and expected direction with respect to Vulnerability.....	24
Table 2. Traditional climatic zone	28
Table 3. Marital status of the study area.....	40
Table 4. Educational status of the sample population.....	40
Table 5. Land ownership of the sampled population.....	41
Table 6. Source of income of the sampled households.....	42
Table 7. Livestock possession of the sample HHs.....	43
Table 8. Land size of the sampled HHs	45
Table 9. Agricultural input supply of the HHs.....	46
Table 10. Temperature analysis of <i>Dangulie, Dendegebe, & Kurar Kebel</i>	51
Table 11. Rainfall analysis of <i>Dangulie, Dendegeb, & Kurar Kebele</i>	52
Table 12. Perception about today's climate condition and before 20 years ago	54
Table 13. Perception about the trends of hot days over the last 20 years.....	55
Table 14. Perception about the trends of rainfall over the last 20 Years.....	55



List of figures

Figure 1. GDP and rain fall relationship in Ethiopia by World Bank	2
Figure 2. Conceptual frame work	22
Figure 3. Map of the study area.....	27
Figure 4. Trends of temperature in <i>Dangulie, Dendegeb, & Kurar</i>	52
Figure 5. Trends of rainfall and rainfall anomalies in <i>Dangulie, Dendegeb, & Kurar</i>	53
Figure 6. Adaptive capacity indices of Kebeles	57
Figure 7. Vulnerability indices of Kebeles	58
Figure 8. Strategy to reduce soil erosion in Kurar (Stone bund) kebele	61
Figure 9. Crop cultivation on the steep side of the mountain in <i>Dangulie</i>	63
Figure 10. Gully erosion in <i>Dendegeb</i> Kebele	65



Abstract

Ethiopia's economy is dominantly rain-fed agriculture accounting for 47% of GDP and 80% of jobs. However, this dominant sector has been challenged by climate change and variability. Besides, temperature and rain fall variation, the diverse economic, social, cultural and ecological condition made differences on the vulnerability level of farmers in the country. Taking this situation into account, the study was aimed at examining the vulnerability level of farmers in Choke Mountain ecosystem based on an integrated vulnerability assessment approach using its indicator variables. These indicator variables consist of various socio economic and biophysical attributes of local communities. To this end, four kebeles from the watershed were chosen based on their traditional agro-ecology, Dangulie (upper highland), Gedamawit (highland), Dendegeb (midland), and Kurar (lowland). The principal component statistical analysis (PCA) was employed to determine the weight of selected variables in constructing the vulnerability index. Vulnerability indices were constructed using the systematic combination of indicators of adaptive capacity, exposure and sensitivity. Data that collected from the KIs, FGD and Secondary source of data were triangulated with qualitative results. The vulnerability index of Kebeles' with different agro-ecology revealed an index ranges between -1.46 and 0.04; Based on the value of the index Dangulie representing the upper highland was found as the most vulnerable district (-1.46) and Dendegeb representing the midland was found less vulnerable kebele (0.55). Whereas, Gedamawit representing high land with VI(0.04) and Kurar representing lowland agro-ecology with VI (0.48) were found as vulnerable in relative terms. Based on the result, the vulnerability level of farmers in the watershed explained that greater exposure to climate extremes as well as low level of economic status, infrastructure development, and absence of institutions. Indicators that exacerbate the vulnerability level of farmers in the watershed were also identified farm land size, Slop of the farm land, the absence of institutions such as Veterinary Service, Credit and Saving Institution, low agricultural technology provision and non-farm income, access to market and poor transportation were the determinants. Hence, to enhance the adaptive capacity of farmers and to create a resilient ecosystem; the government should create job opportunity to absorb landless youngsters. Furthermore, all farmers should equally be accessed with credit provisions, good governance of natural resource, establishment of crop insurance together with Provision of relevant information about the change and variability thereby farmers would have the privilege to take the leading role in attesting the intended goal.

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



CHAPTER ONE

1. INTRODUCTION

1.1 Back Ground

There is scientific evidence of climatic change and it posse's important global risks. The IPCC has shown that an increase in human activities include the burning of fossil fuel, and changes in land use and land cover have increased the concentrations of green house gasses, particularly carbon dioxide, methane and nitrous oxide (IPCC, 1997, 2007a).

Despite the effects of climate change being evident on a global scale, its negative impacts is likely to be felt more severely in developing countries , particularly by those communities highly dependent on natural resources which have a limited capacity to cope with climate variability change and extremes . Climate change increases poor people vulnerability by adversely affecting their health and livelihood, thus under mining development opportunities (Dasgupta and Baschieri, 2010).

According to the IPCC report on the regional impacts of climate change, "Africa is the 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 quality of rain makes the region 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 locus of impacts of climate change" (Downing *et al.* 1997). Agricultural losses are shown to be possibly severe for several areas (e.g. the Sahel, East Africa and Southern Africa) accompanied by changes in length of growing periods impacting mixed rain fed, arid, semi arid systems (IPPC,2007).

Contribution of Ethiopia to the green house gas emission is insignificant. However, it is adversely affected by the impact of climate change induced by the developed countries following carbon intensive development.

The mean annual temperature increased by 1.3°C, at an average rate of 0.28°C per decades between 1960 and 2006. Comparing the last two decades average temperatures, for instance, the later decade has been substantially warmer by one standard deviation than the former. On the other side, an average country wide rainfall trends remained more or less constant between

1951 and 2006. During these times, however, both seasonal and annual rainfall has exhibited high coefficient of variation. Considerable declines in March- September and February-May (belg) rainfall were observed in many parts of Ethiopia. Future climate prediction showed increasing temperature (between 0.5 and 3.6 during 2070, a 3.8 up on the 1960-90 average) and decreasing rainfall (average daily rainfall will reduce by 3.5%) According to Ethiopia's First National Communications to UNFCC (NMSA, 2005).

According to World Bank report (2005) Ethiopia's GDP raises or fails about a year following changes in average rain fall with agricultural accounting for 47% of GDP and 80% of jobs; the Ethiopian economy is sensitive to climate variability, mainly variations in rain fall.

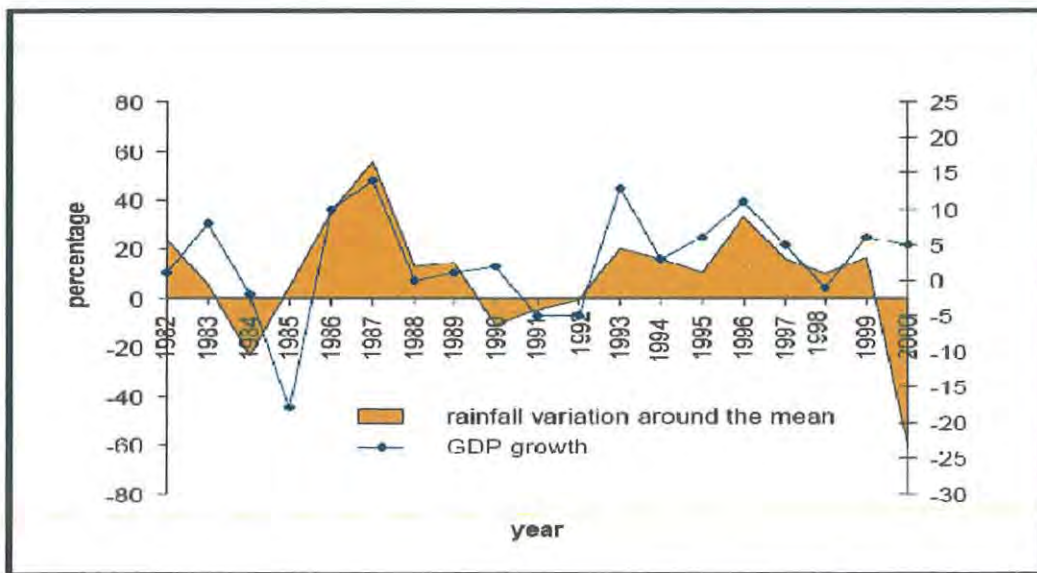


Figure 1: The relationship between GDP and rainfall in Ethiopia

(Source: World Bank, 2005)

The history of drought is as old as the country itself. Between 253 B.C. and first century A.D., drought occurred every seven years. From the first century A.D. up to 1500 A.D, there were 177 droughts (famines) which killed millions of people. Between 1500 A.D. and 1950, 69 drought events occurred. Rain fall variability and associated drought have been major causes of food shortage and famine in Ethiopia, (Mahmmud *et al*, 2008). Considering the above situations no doubt that Ethiopia is the most vulnerable country with less adaptive capacity.

Climate change vulnerability and impacts influence prospects for development, and inturn, development choices and decisions which influence a country or regions future capacity to

adapt (Bizikoya *et al.*, 2007) achieving development priorities and improving qualities of life remain key goals, with the adaptation to climate change a conditioning factor to be considered in the over all mix. It is the combination of development choices, adaptation actions and local capacities that allows for effective climate action in country. Successful adaptation reduces vulnerability to an extent that depends greatly on adaptive capacity.

According to working group II report for IPCC (2007) adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political and financial constraints. There are also significant barriers to implement adaptation. These are the inability of natural system to adapt to the rate and magnitude of climate change as well as formidable environmental, economic, informational, social, attitudinal and behavioural constraints.

Assessing vulnerability requires contributions from a variety of disciplines, institutions, local decision-makers, resources users and residents, the contribution of local and traditional knowledge to understanding climate change is well documented. This requires that research be grounded at the community level and involve local knowledge system (including traditional ecological knowledge) as well as cultural interpretations of the environment. This allows scientific views of changes to be framed in local context (Dolan and Walker, 2004).

Comparing vulnerability across countries can identify leverage points in reducing vulnerability to climate variability and by inference, to climate change, which is likely to be manifested through changes in the frequency and severity of existing hazards at least in the short to medium term (Eastering *et al.*,2000; Frich *et al.*,2002).

Identification of particularly vulnerable nations or regions (i.e. those that are least well equipped to cope with the impacts of climate change) can act as an entry point for both understanding and addressing the process that cause and exacerbate vulnerability. (Moss *et al.*, 1999; Yoha and Tol, 2002; Brooks and Adger 2003; Leichenock and O' Brien, 2002; O' Brien *et al.*, 2004 as cited in Brooks and *et al.*, 2005)

Local level assessment of vulnerability could enable to identify the level of vulnerability, the adaptive capacity of the local people, the adaptive strategies that have been implemented by the local people, the agro ecological condition that the locality has, and it is also important to consider the interest of the people with different attitude and perception about climate change and variability.

Studies have been made in Ethiopia to assess the impact of climate change and vulnerability; however researches that aimed to understand the vulnerability of the local people were not much in number.

Deressa *et al.*, (2008) in their study conducted to measure vulnerability of farmers in Ethiopia across regional state, they analyse farmers vulnerability based on an integrated approach using the definition of vulnerability coined by Intergovernmental panel on climate change (IPPC), vulnerability as a function of sensitivity, exposure, and adaptive capacity. They analysed the vulnerability indices by setting proxies for each indicator and associating positive for adaptive capacity and negative to exposure and sensitivity. Finally they found relatively less developed, semi arid, arid regions, Afar and Somali are highly vulnerable, the Oromia region characterised by good agricultural production in the high lands and midlands and by recurrent droughts in the low land is also vulnerable. Tigray and *Amhara* regions are also vulnerable to the negative impacts of climate change. SNNP and *Benishangul Gumuz* regions found relatively not vulnerable. Hence, Climatic shocks render an already vulnerable population susceptible to livelihood crises. However, since the study made at national level comparing the vulnerability of regions, it has failed to show the level of vulnerability at household level (considering differences in perception and agro-ecology at local level).

Abinet (2010) has also made a local level comparative assessment of vulnerability to climate change among pastoral and agro pastoral households in *Yabelo woreda* of *Oromia* regional state by using an integrated vulnerability approach and vulnerability indicator method to determine the level of vulnerability and he has come up with the result that agro-pastoralist's vulnerability is higher than pastoral social group. He argued 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-pastoralist.

1.2. Statement of the Problem

Farmers in Choke Mountain watershed are engaged in a mixed farming (crop production and livestock rearing) and used to known in surplus crop production. However, they have been challenged with the vulnerability to climatic and non climatic factors.

Climatic factors constitute extreme events and change in the mean temperature and rain fall.

Non climate factors are socio economic factors that affect vulnerability of a system or society to climate change by lowering the adaptive capacity. They include poor economic condition

with the variation in productivity, social, demographic, technological and political condition which determines the adaptive capacity of individuals or social groups. Adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political and financial constraints. There are also significant barriers to implement adaptation. These are the inability of natural system to adapt to the rate and magnitude of climate change as well as formidable environmental, economic, informational, social, attitudinal and behavioural constraints (IPCC, 2007).

Farm size, subsistence farming due to the population pressure, land degradation due to inappropriate use of land, inadequate use of Agricultural technologies such as improved seeds and fertilizer, absence of institutions (health, veterinary, credit and saving and crop insurance) and poor infrastructure provision (road, electric, telephone) are some of the socio economic factors that hamper the adaptive capacity of framers and the variation of these factors among individuals and social group also determine the variation in vulnerability by affecting the capacity to adapt.

Taking an integrated response required an in-depth research on climate change impacts, vulnerabilities and adaptation options of the agriculture sector across different agro-ecologies of the country and enhanced capacity building for the sustainable development of the country. A better understanding of the drivers and impacts of climate change, vulnerabilities and perceptions of stakeholders, assessing the existing institutional and policy environments is important to inform policy makers and sectoral institutions so as to promote successful adaptation strategies for the country (Belay,2010).

Given the above background, this study aimed at seeking the level of vulnerability and adaptive capacity among farmers in different agro-ecologies of Choke Mountain watershed by using biophysical and socioeconomic indicator variables.

In Choke Mountain watershed, no much research has been done on climate change impact and vulnerability assessment. Moreover, the available few literatures on climate change impact study in Ethiopia is not quite comprehensive particularly in terms of lack of vulnerability assessment at lower level (to mean at village or district level). A known study for Ethiopia is done by Deressa and *et al.*, (2008) is about measuring the vulnerability of farmers in Ethiopia across regional state, they analyse farmers vulnerability based on an integrated approach using the definition of vulnerability coined by Intergovernmental panel on climate change (IPPC), vulnerability as a function of sensitivity, exposure, and adaptive capacity. They analysed the

vulnerability indices by setting proxies for each indicator and associating positive for adaptive capacity and negative to exposure and sensitivity. Finally they found relatively less developed, semi arid, arid regions, Afar and Somali are highly vulnerable, the *Oromia* region characterised by good agricultural production in the high lands and midlands and by recurrent droughts in the low land is also vulnerable. *Tigray* and *Amhara* regions are also vulnerable to the negative impacts of climate change. *SNNP* and *Benishangul Gumuz* regions found relatively not vulnerable. However, since the study made at national level comparing the vulnerability of regions, it has failed to show the level of vulnerability at household level (considering differences in perception and agro-ecology at local level).

1.3. Objectives of the study

The overall objective of the study is to measure the vulnerability of farmers to climate change and variability in different agro ecologies of Choke Mountain watershed and identify indicators that exacerbate it.

The specific objectives of the study include:

- Assess the adaptive capacity of small hold farmer's in Choke Mountain watershed.
- Compare the relative vulnerability among the traditional agro-ecological zones of Choke Mountain watershed.
- Identify indicators that exacerbate the vulnerability of the farmers in each agro-ecological zone

1.4. Significance of the study

Scantiness of analytical studies on climate change and variability related issues at local level is amongst the most essential factors that deserves a prime attention to realize the development carrier of developing nations like Ethiopia. This study is therefore, beyond doubt important for the development endeavour of the country. Besides adding a brick to the body of knowledge on the subject, the output of the study could also be informative for donors and nongovernmental organizations operating and interested to operate in the country on strengthening the resilience and enhance the adaptive capacity of farmers in Choke Mountain watershed. The study will also help as a reference for future researchers who wanted to conduct a research in the area.

1.5. Scope and limitation of the study

The study was conducted only in four peasant *kebeles* of Choke Mountain watershed representing upper highlands (*Wurch*), highland (*dega*), midland (*weynedega* agroecology) and lowland (*kola*) agro-ecological zones. Therefore, the result obtained from the study could not be enough to give a broad conclusion about choke farmers' vulnerability. In understanding the drivers to vulnerability of an area in different agro-ecology there is a need to define specific local area of social and biophysical condition. Therefore the result in certain agro-ecology cannot be replicate to the other places with the same agro-ecology, unless they have the same socio economic condition.

The other limitation of the study the unavailability of full temperature and rain fall data that can enable to see the long term temperature and rain fall change in the study *kebeles*¹.

1.6. Organization of the Study

The research paper is organized into seven chapters. The first chapter is provided a general introduction, statement of the problem, the research objective, why the topic is worth to be conducted and scope and limitation of the study. The second chapter is dealt with review of literature pertinent to the research. The third chapter is covered descriptive of the study area; the fourth chapter covers the research methodology (research design, source of data, sample, sample size, sampling technique, and data collection instruments and data analysis). While the fifth chapter portray major findings of the research and the six chapters is summarized the result and discussion highlight the way forward and chapter seven is also highlighted about conclusion and recommendation.



¹ *Kebele* is the lowest political administration in Ethiopia

CHAPTER TWO

REVIEW OF LITERATURE

2.1. Definitions of Climate Change

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage is different from that in the framework convention on climate change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007).

2.2. Cause and Impacts of Climate Change

The climate of the earth in the past few decades has shown traceable changes both on global and regional scales manifested by increase in atmospheric temperatures. The Inter – Governmental Panel on Climate Change (IPCC), in its recently released report has reconfirmed that the global atmospheric concentrations of carbon dioxide, methane and nitrous oxide, greenhouse gases (GHGs), have increased markedly as a result of human activities since 1950, and now far exceed preindustrial values determined from ice cores spanning many thousands of years (IPCC, 2007).

According to IPCC(2007) the increasing concentration of green house gasses in the atmosphere has already resulted in warmer temperatures, changing precipitation patterns both temporally and spatially higher sea levels and storms retreating mountainous glaciers more frequent extreme weather events such as heat wave, droughts and floods . These are already causing sever damage to a range of unique and threatened ecosystem.

Evidences shows that temperature increase across the global is not uniform and there are significant regional variations in warming. The increase in extreme events may have the biggest impact and will add pressure on critical systems, such as agriculture, water availability and transport and energy infrastructure.

Even if from this moment, the emission of green house gasses could be drastically reduced, the world's climate would still continue to warm up for a long time. The development of climate change adaptation is based on the understanding that, for the foreseeable future, temperature will change; the frequency of extreme climate events will increase this condition. Further the impacts of climate change are likely to enhance the vulnerability of many of the

societies and communities, particularly those are already vulnerable to climate variability as well as lack of development.

According to a report of working grouping II of the IPCC (2007) for the future they are very high confident on the projected in Africa. Agricultural production in many African countries and regions will likely be severely compromised by climate change and variability. This would adversely affect food security and exacerbate malnutrition.

Agricultural losses are shown to be possibly severe for several areas (e.g. the Sahel, East Africa and Southern Africa) accompanied by changes in length of growing periods impacting mixed rain fed and semi arid systems under certain climate projections. In some countries, yields from rain fed agriculture could be reduced by up to 50% by 2020. At the local level, many people are likely to suffer additional losses to their livelihood when climate change and vulnerability occur together with other stresses (IPCC, 2007).

Attributing the contribution of climate change to changes in the risk of malaria remains problematic (high confidence). Human health, already compromised by a range of factors, could also be further negatively impacted by climatic change and climatic variability (e.g. in East Africa high lands). Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity. (IPCC, 2007)

Ethiopia is one of the developing countries, where agriculture is the most dominant sector in contributed 47% of the country's gross national product and more than 80% of its exports. However, the sector is highly vulnerable to climate change and variability. Ethiopia's low level of economic development combined with its heavy dependence on agriculture and high population growth rate make the country particularly susceptible to the adverse effects of climate change. Negative climatic impacts on crop and livestock production could result in a nationwide food shortage and greatly hinder the economy. If appropriate steps are not taken, food insecurity, deepened poverty, and increased incidence of disease, such as malaria and yellow fever, would be likely consequences.

A better understanding of the local dimensions of vulnerability is therefore essential to develop appropriate adaptation measures that will mitigate these adverse consequences.

2.3. Definitions of 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, Brooks, 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 influence, 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 hazards and, of course, climate change.

IPCC TAR, (2001) defines 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.

Cutter, (1993) argued vulnerability as the likelihood that an individual or group will be exposed and adversely affected by a hazard. It is an interaction of hazards of place (risk and mitigation) with the social profile of communities.

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

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, they advise a multi scale approach to understand regional and global systems with in which they are situated are important, their determinants of adapting capacity are sensitive to scale and defined as social entitlements (i.e. material sources at individual level).

2.3.1. Adaptation: Definitions

Smit *et al.*, 2000 point out that several definitions of adaptation are found in the climate change literature.

Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton 1992, cited in Smit *et al.*, 2000).

Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer-term climate change (Smit 1993, cited in Smit *et al.*, 2000).

The term adaptation means any adjustment, whether passive, reactive or anticipatory, that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change (Stakhiv, 1993, cited in Smit *et al.*, 2000).

2.3.2. Adaptive capacity

IPCC TAR, (2001) the ability 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 the consequences.

Ben Preston and Mark Stafford-Smith (2009) stated adaptive capacity as a fundamental component of vulnerability (to the extent that in some instances no distinction is made between the two), and they also argued how adaptive capacity is important in the vulnerability assessment as follows. The focus on adaptive capacity stems from a range of sources. These are:

- Awareness that understanding the biophysical component of vulnerability is not sufficient for reducing vulnerability.
- An understanding that it is a limiting step for adaptation.
- An awareness that it is the component of vulnerability that is perhaps most amenable to management.
- An interest in adaptation within the development community which is generally sensitive to the importance of capacity-building in achieving development goals.

- An understanding that adaptive capacity plays a dual role, in that constraints on adaptive capacity can constrain future adaptation policies and measures, yet adaptation measures may specifically target increasing adaptive capacity as an adaptation measure.

Adaptive capacity is the property of a system to adjust its characteristics or behaviour, in order to expand its coping range under existing climate variability, or future climate conditions. The expression of adaptive capacity as actions that lead to adaptation can serve to enhance a system's coping capacity and increase its coping range thereby reducing its vulnerability to climate hazards. The adaptive capacity inherent in a system represents the set of resources available for adaptation, as well as the ability or capacity of that system to use these resources effectively in the pursuit of adaptation. It is possible to differentiate between adaptive potential, a theoretical upper boundary of responses based on global expertise and anticipated developments within the planning horizon of the assessment, and adaptive capacity that is constrained by existing information, technology and resources of the system under consideration (UNDP, 2005).

2.3.3 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., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC TAR, 2001).

Sensitivity affects the magnitude and/or rate of a climate related perturbation or stress (while is the degree to which a system is susceptible to harm from that perturbation or stress) (UNDP, 2005).

2.3.4 Exposure

Exposure is defined as "the nature and degree to which a system is exposed to significant climatic variations" (IPCC 2001).

Exposure refers to the exposure of a system of interest to stimuli that act on that system. This can be readily conceptualized as climate variability and/or the various changes in the climate system that are often of concern to stakeholders: temperature increases, rainfall variability and change (including extremes), or changes in the frequency or intensity of tropical cyclones.

Communities or systems are often exposed to hazards through natural climate variability, independent of future changes in the climate system, yet climate change may alter the nature of those hazards, potentially increasing future exposure (Ben Preston and Mark Stafford-Smith 2009).

2.4. Conceptual Approaches

Due to the complex nature of vulnerability different authors have developed several conceptual frameworks to categorize vulnerability factors and to describe different concepts of vulnerability. Fussel (2010) reviewed conceptual approaches developed by different authors there are 'External' and 'internal' side of vulnerability to environmental hazards, biophysical (or natural) vulnerability and social (or Socio economic) vulnerability. Other classifications have been suggested by UN (2004) Physical, economic, social, and environmental factors and Moss *et al.*, (2001) physical-environmental dimension, socio economic dimension, and external assistance.

The most prominent interpretations of vulnerability in the climate change context are contextual vulnerability and outcome vulnerability. These interpretations of vulnerability are based on different conceptual frameworks, they produce different rankings, and they suggest different strategies for reducing vulnerability (Fussel, 2010). Contextual vulnerability (also known as starting-point interpretation or internal social vulnerability) is rooted in political economy. It is determined exclusively by internal characteristics of the vulnerable system or community that determine its propensity to harm for a wide range of hazards. Outcome vulnerability (also known as end-point interpretation or integrated cross-scale vulnerability) represents an integrated vulnerability concept that combines information on potential climate impacts and on the socio-economic capacity to cope and adapt (O'Brien *et al.*, 2004, O'Brien *et al.*, 2007, Fussel 2007).

Different interpretations of vulnerability do not only produce different rankings of vulnerable regions or systems; they also suggest different strategies for reducing vulnerability. 'Outcome studies' tend to focus on technological adaptation to minimize particular impacts of climate change whereas 'contextual studies' tend to focus on sustainable development strategies that increase the response capacity of human populations for dealing with a large variety of hazards (O'Brien *et al.*, 2007, Eriksen and Kelly, 2007 cited in Fussel, 2010).

To the knowledge of this study I shall better explain the three major conceptual approaches to analysing vulnerability to climate change. These are socioeconomic, the biophysical (impact assessment), and the integrated assessment approaches.

2.4.1. Socioeconomic Approach

Literatures on vulnerability argued that, social vulnerability focuses primarily on the human determinants of vulnerability, namely the social, political and economic conditions that makes exposure challenging (Ford and Smit; 2003). And an approach which tries to analyse social vulnerability mainly focussing on economic and political condition of individual or social group is known as socio economic approach (Adger, 1999; Fussel ,2007; Deressa *et al.*, 2008).

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 group also determine the variation in vulnerability. Kelly and Adger (2000) state that vulnerability is defined by 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. Therefore socio economic vulnerability approach focuses on identifying the adaptive capacity of individuals or communities based on their internal situations. A study by Adger and Kelly (2000) the environmental factor in a district to coastal low lands of Vietnam. And vulnerability was analysed based on only on variations in socio economic attributes.

The limitation of this approach according to Deressa *et al.*, (2008) is that it focuses only on variations within society (i.e., differences among individuals or social groups) ignoring the impact of hazard to the vulnerability. In reality societies vary not only due to socio-political factors but also to environmental factors. Two social groups having similar socioeconomic characteristics but different environmental attributes (Agro ecological, physical) can have different levels of vulnerability and vice versa.

2.4.2. Biophysical Approach

Biophysical vulnerability usually relates to the likelihood of impacts from natural hazard, focusing on the characteristics of the hazard, such as its magnitude, frequency, and areal extent (Burton *et al.*, 1993; Adger, 1996; Hewitt, 1997; Belliveau *et al.*, 2006).

The biophysical approach is concerned with the climatic hazards and the amount of damage that the human system is experienced. Vulnerability is measured by indicators such as monetary, cost, human mortality and morbidity (Brooks and Adger, 2003). Kelly and Adger (2000) referred to the biophysical approach as an end-point analysis responding to research question 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?’

The major limitation according to Deressa *et al.*, (2008) is that the approach focuses mainly on physical damages the biophysical approach focuses on sensitivity (change in yield, income, health) 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 the architecture of entitlements, as suggested by Adger (1999).

2.4.3. The integrated Assessment Approach

Integrated assessment may be one of the most informative assessment approach capturing diverse drivers (biophysical and socioeconomic) of outcomes, system interactions and feedbacks, 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 a good example of this approach, in which both biophysical and socioeconomic factors are combined to determine vulnerability of the region. The vulnerability mapping approach (Jan Ketil *et al.*, 2010) is another related example, in which both socioeconomic and biophysical factors are combined to indicate the level of vulnerability through mapping.

Fussler (2010) argued that the IPCC (2001) definition-which conceptualizes vulnerability to climate as a function of adaptive capacity, sensitivity, and exposure accommodates the integrated approach to vulnerability analysis. According to Fussler and Klein (2006), the risk-hazard framework (biophysical approach) corresponds most closely to sensitivity in the IPCC terminology. Adaptive capacity is largely consistent with the socioeconomic approach (Fussler, 2007). In the IPCC framework, exposure has an external dimension, whereas both sensitivity and adaptive capacity have internal dimension, which is implicitly assumed in the integrated vulnerability assessment framework (Fussler 2007, Deressa, *et al.*, 2008).

According to Deressa, *et al.*, (2008) the integrated assessment approach corrects the weaknesses of the other approaches, it has its limitations. The main limitation is that there is no standards method for combining the biophysical and socioeconomic 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 for earthquakes); these data sets certainly have different and yet unknown weights.

2.5. Methods for Measuring Vulnerability to Climate Change

Undertaking a vulnerability assessment can be complicated due to both, the multiple definitions of vulnerability and the scarcity of data usable for measuring vulnerability. Dasgupte *et al.*, (2010).

Deressa *et al.*, (2008) in their study of measuring Ethiopian farmers' vulnerability across regional states. They have stated the most common methods employed in vulnerability locations, namely, the econometrical and indicator methods.

2.5.1. Econometric Method

This method of vulnerability analysis employs household level of socioeconomic survey data to analyse the level of vulnerability of different social groups (Deressa *et al.*, 2008). This method is also classified in to three: vulnerability as expected poverty (VEP), vulnerability as low expected utility (VEU), and vulnerability as uninsured exposure to risk (VER) (Hoddinott and Quisumbing 2003 cited in Deressa *et al.*, 2008). All three share common characteristics in that they construct a measure of welfare loss attributed to shocks.

2.5.1.1. Vulnerability as Expected Poverty

In the expected poverty framework, vulnerability is the *ex ante* risk that households will be poor, if no so currently, and if they are currently poor, the risk they will remain poor. Poverty is therefore an *ex post* measure of wellbeing. (Chaudhuri *et al.*, 2000; cited in Dasgupta and Baschieri, 2010) In this frame work, the poor are considered to be active agents, and interventions can build on those strengths. 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 shock, or set of shocks, moves consumption by households below the given minimum level or forces the consumption level to stay below

the given minimum requirement if it is already below that level (Chaudhuri, Jalan, and Suryahadi 2002 Cited in Deressa *et al.*, 2008).

Dasgupta and Baschieri., (2010) in their study to measure vulnerability to climate change in rural Ghana and evaluating the method whether money metric poverty measurement is suitable to those communities most vulnerable to climate change, they pointed out that poverty and vulnerability are different concepts. Using the money metric measurement of poverty they identified poor households. Collecting socio economic and biophysical indicators and they describe the most vulnerable with bivariate analysis. They found that a large share of poor is vulnerable to climate related shocks. However the association between poverty and vulnerability was imperfect and some households that were not classed as living in extreme poverty were identified as vulnerable to climate change. They argued that poverty status alone is insufficient to identify those households which are vulnerable to climate change and money metric indicator poverty over look the welfare of communities highly vulnerable to climate change.

2.5.1.2. Vulnerability as a Low Expected Utility

In this approach vulnerability the difference between the utility derived from some level of certainty equivalent consumption at an above which the household would not be classed as vulnerable (Ligon and Schechter 2002, Cited Deressa *et al.*, 2008).

2.5.1.3. Vulnerability as Uninsured Exposure to Risk

The VER method is based on expose facto assessment of the extent to which a negative shock causes welfare loss (Houddinott and Quisumbing 2003, cited in Deressa *et al.*, 2008). In this method, the impact of shocks is assessed by using panel data to quantify the change in induced consumption. Brouwer *et al.*, (2007) employed this approach in their study socio economic vulnerability and adaptation to environmental risk carried out in south west Bangladesh. They collected and analysed data from 700 flood plain residents living without any flood protection along the river Maghna about their flood risk exposure, flood damage and coping mechanism. And their result confirmed that the presence of positive relationship between environmental risk exposure, poverty and vulnerability. Poor segment society live closer to the river, that face a higher risk of flooding are found more vulnerable and the environmental risk exposure also goes hand in hand with income inequality and access to natural resources.

2.5.2 Indicator Method

This method of quantitative vulnerability analysis is based on selecting some indicators from the whole set of potential indicators and then systematically combining the selected indicators to indicate the levels of vulnerability (Deressa *et al.*, 2008). These levels of vulnerability may be analysed at local (Adger 1999), national (O'Brien *et al.*, 2004), regional (Leichenko and O'Brien 2001), and global (Brooks, Adger, and Kelly 2005) scales.

To calculate the level of vulnerability using this method at any scale there are two options: one assuming that all indicators of vulnerability have equal importance and thus giving them 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 with the second method, many methodological approaches have been suggested to make up the weight differences of indicators. 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, and Shirley 2003), correlation with past disaster events (Brooks, Adger and Kelly 2005).

2.6. Review of Empirical Studies

Due to the complex nature of vulnerability different authors have conceptualized the word vulnerability differently in different times. To understand the drivers of vulnerability scholars have designed and employed different assessment techniques. They mapped and compare the relative vulnerability of regions, countries, and society with the objective of identifying the vulnerable society and to pinpoint those factors that threaten the livelihood and the lives of the community. In this section different empirical studies reviewed:

Yusuf and Francisco (2009) in their study mapping vulnerability in south Asia with the conceptual frame work of $\text{vulnerability} = f(\text{exposure, sensitivity, and adaptive capacity})$. 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 an indicator for human sensitivity to climate-hazard exposure and ecological sensitivity of the region using biodiversity information as proxy variable. Index of adaptive capacity is also assessed as a function of socio economic, technological, and infrastructure factors. Based on these variable they constructed an index of the overall climate

change vulnerability of the region. To make the climate hazard map they first find maps of five different climate hazards, frequency of droughts(1/5weight), floods(1/5weight), and cyclones(1/5weight) for about twenty years, then to make maps comparable they normalized each using the index formula. The overall sensitivity map encompassing both human and ecological factors was derived using the weighted averages of the standardized values of population density and protected area for each provinces they choose a higher weight of 0.70 for population density (with 0.30 for protected area) because of the higher importance they attached to human sensitivity to climate hazard exposure with the assumption the regions that are relatively less inhabited will be less vulnerable compared to regions with high population density. Adaptive capacity= f (socio economic, technology, infrastructure) socio economic having the weight (0.50) represented by human development Index(0.50), standard of living, longevity, education, poverty incidence ,Income inequality(0.22). Technology having the weight (0.25) was represented by Electricity coverage (0.53), extent of irrigation (0.47). Infrastructure having the weight (0.25) represented by road density (0.50) and communication 0.50) and normalized together. To obtain the overall vulnerability index of climate, they averaged each of normalized indicators of exposure (multiple hazard risk exposure)(1/3) sensitivity (human and ecological)(1/3) and adaptive capacity(1/3). To identify the vulnerable areas, they ranked the regions according to the index. The index is also divided in to four equal parts, the provinces in the fourth quartile were considered the vulnerable and further classified as mildly vulnerable, moderately vulnerable or high vulnerable. Mild vulnerability (with an index interval of 0.33-0.46) moderate vulnerability with an index (0.47-0.67) and high vulnerable with an index (0.68-1.00) and Thailand, Vietnam, Laos, Cambodia, Indonesia, Malaysia, and the Philippe were found as the most vulnerable to climate change.

To demonstrate a method of aggregating vulnerability indicators that results in composite index of vulnerability indicators without assigning weights for each index, Raygle *et al.*,(2005) conducted a social vulnerability to hurricane storm surges in USA, Hampton roads, Virginia using a vulnerability of place approach (an integrated) of vulnerability assessment. They also use poverty, gender, race, and ethnicity, and age and disabilities as an indicator of vulnerability. Fifty-seven variables were also chosen as a proxy of each indicator to include in a principal components analysis. When the variables were processed in to correlation matrix and a varimax orthogonal rotation with kaiser normalization, thirteen components with eigen values greater than 1.0 and these components accounted for 81.01% of the variance in the dataset. With a large number of components it was difficult to describe and screeplot

examined and three components were extracted for analysis. 1027 block groups in the study area were sorted in to five equal interval classes. Three component scores for each block group were averaged. But they explained that averaging components create two significant problems. "The first is construction of weighted average; simple average can be used if all components contribute equally to vulnerability. But if the researcher decides that certain components contributes to over all social vulnerability. He or she must make subjective decisions to create a weighting scheme. The second problem with using averages is that they may obscure high scores on one component. However, extreme values on even one component may indicate areas particularly in need of attention". To avoid the above problems they use absolute measurement and pareto ranking method to organise the block groups in to a series of rank and block groups were sorted in to 19 ranks. The block group that had a score of 19 were taken as the most vulnerable and block group that had score 1 were the least vulnerable. To increase the interpretability, the results were rearranged from 0 to 1 and over all vulnerability zones were established by sorting the scores in to four equal interval classes. Authors argued that the paper confirmed that the possibility to determine the relative vulnerability of places without the difficult practices of weighting the various indicators. As the same time the paper illustrated a technique based on pareto ranking that avoid the need to weight the vulnerability indicators.

Deressa *et al.*, (2008) in their study analysis of Ethiopian farmers vulnerability to climate change across seven regional state they analysed by using an integrated assessment approach. To analyse 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 in a principal component analysis method to determine the factor scores or relative weight of the selected indicators and subsequently the vulnerability indicators of each regions. The relative vulnerability result 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 high frequency of drought and flood. Unlike Afar and Somalia the lower access to technology and infrastructure in Tigray and Oromia is due to their large size population in proportion to what is available. The southern nation and nationalities region relatively the

least vulnerable and the reasons are; its relative higher access to technology and food market, its highest irrigation potential and higher literacy rate.

Abinet (2010) has also made a local level comparative assessment of vulnerability to climate change among pastoral and agro pastoral households in *Yabelo woreda* of *Oromia* regional state by using an integrated vulnerability approach and vulnerability indicator method to determine the level of vulnerability. To analyse the relative vulnerability of households and social groups, systematic combination of indicator variable by using principal component analysis to determine the score value of each variable to construct an index. Then household vulnerability index (VI_{HH}) and Social vulnerability index (VI_{sg}) were calculated using the primary data. The result revealed that half of the samples of households have VI_{HH} value less than 0 which implies the net effect of households' adaptive capacity to be less than their sensitive and exposure and the group of households were classified as highly vulnerable to impacts of climate change. The comparison of VI_{sg} score of agro pastoralists (0.003) with that of pastoralists (0.035) indicate the relatively lesser vulnerability of the pastoral social group. He argued 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-pastoralist.

2.7. Conceptual framework

For the analysis of vulnerability of this study the definition of the IPCC (2001) is adapted.

“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” (IPCC, 2001).

Exposure is defined in the same report as “The nature and degree to which a system is exposed to significant climatic variations.” *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., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).” *Adaptive capacity* is “The ability 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 the consequences.”

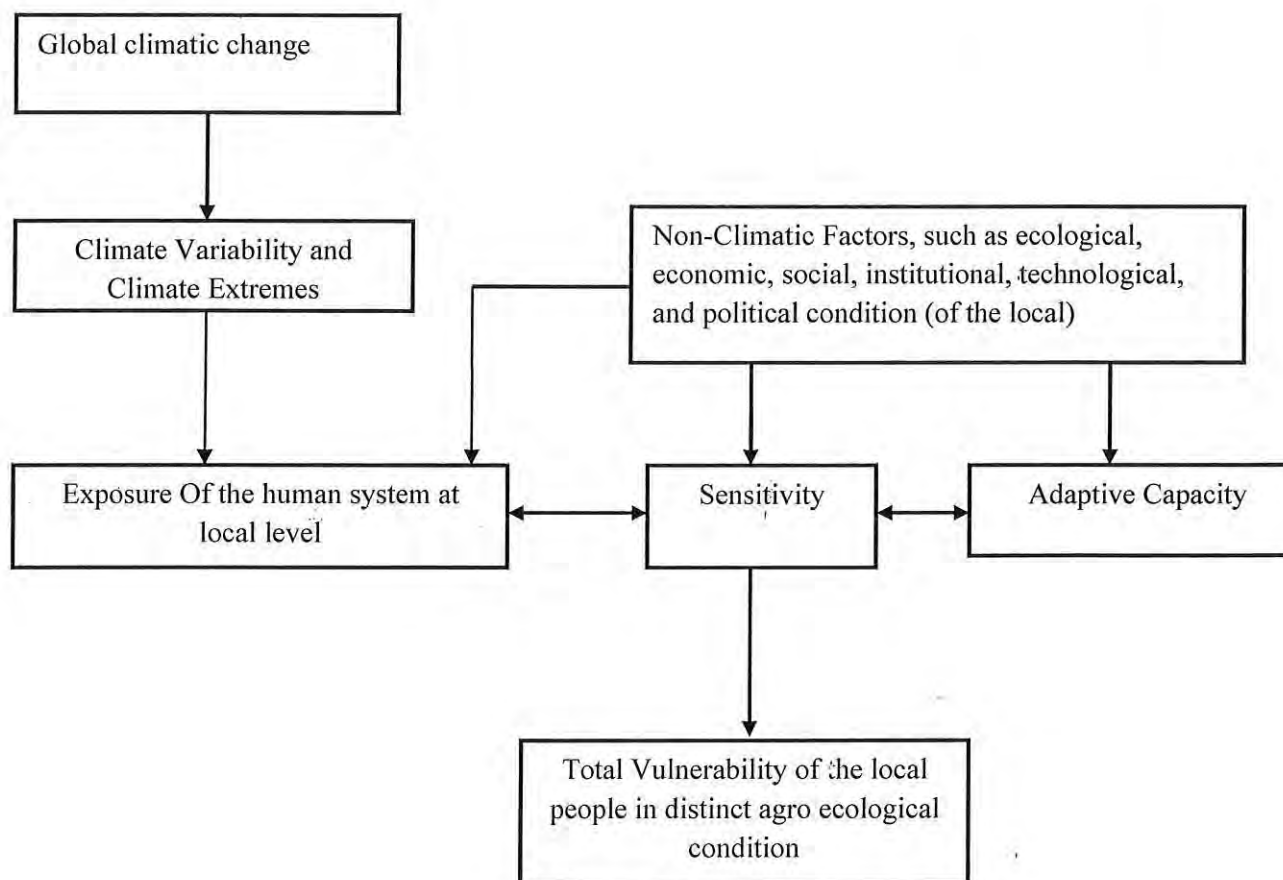


Figure 2: Conceptual framework.

(Adopted and modified from Fussel, 2004)

As it depicted in the conceptual frame work diagram, the vulnerability assessment approach accommodates climatic and non climatic factors. Farmers at local level are not only exposed to climate change and variability, their exposure to climate change is also determined by non climatic factors. Climatic factors constitute an important component of a system's exposure, and it is generally accepted that climate change: as changes in the mean climate on global scale will affect the local climate variability including the frequency, intensity and location of extreme events and change in the mean temperature and rain fall.

Non climate factors refer to a wide range of factors that affect vulnerability of a system or society to climate change and /or variability; they include ecological, economic, social, demographic, technological and political condition. In the conceptual frame work non climate factors can affect the sensitivity as well as the exposure of a system to climate stimuli (*Fussel, 2004*).

And exposure is linked with sensitivity that means the exposure of the local system to higher frequencies and intensities of climate risks highly affects the livelihood of the local system when the system is highly sensitive to climatic shock and vice verse.

Sensitivity and adaptive capacity are also linked together that means higher adaptive capacity of the local system will influence the sensitivity of the system and vice verse.

This study will use a bottom-up, approach to assess farmer's vulnerability to climate change and vulnerability in *Senan*, *Basoliben* and *Dejen Weredas* of East Gojjam Zone Choke Mountain watershed. It also seeks to compile some of the perceptions and experiences of local communities and individuals in these areas.

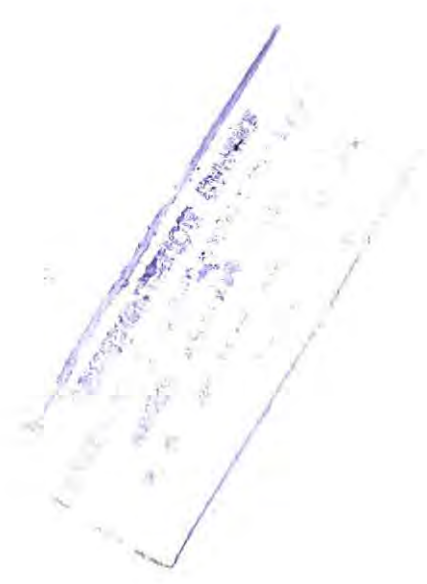


Table 1: Vulnerability indicators, units of measurement, and expected direction with respect to vulnerability

Determinants of vulnerability	Vulnerability Indicators	Description of Each Indicator Selected for Analysis	Unit of Measurement	Hypothesized Functional relationship Between Indicator and Vulnerability
Adaptive capacity	Wealth	Saving at HH level Quality of residential home Non-agricultural income Farm size of the HHs Number of Oxen at HHs	Percentage of total HHs Who own or have access to	The higher the percentage of total HHs with asset ownership and Access to these income sources the lesser the vulnerability
	Technology	Improved Agricultural Technology Fertilizer supply Improved seeds supply	Percentage of total HHs who access to these technologies	The higher the percentage of total HHs the lesser vulnerability.
	Infrastructures and institutions	All- weather roads Health services full cycle schools Veterinary services Food market Saving and Credit Institutions Electricity Provision Telephone Provision	Percentage of total HHs who are using these Infrastructures and institutions	The higher the percentage of total HHs the lesser the vulnerability
	Access to Information	Sex Radio owner ship	The percentage of total HHs who are categorised under the variable and who own.	The higher the percentage of the total HHs the lesser the vulnerability
	Irrigation potential	Irrigation potential at household level	Percentage of HHs with potential irrigable land.	The higher the irrigation potential the lesser the vulnerability
Sensitivity	Biophysical condition of plot land in the HH	Soil fertility Slop of the farm land-	Percentage of total HHs with infertile soil	The higher the frequency the more the vulnerability
Exposure	Change in climate	Change in temperature Change in precipitation	Changes in degrees from base value Percentage change from base value	Increasing temperature and decreasing precipitation increase vulnerability.

Source; Deressa et al. (2008)

CHAPTER THREE

DESCRIPTION OF THE STUDY AREA

3.1 Location

The study was conducted in Choke Mountain watershed, East *Gojjam* Zone of *Amhara* Regional state which is around 300 Kms away from Addis Ababa. The watershed is approximately between coordination $10^{\circ}33'06''$ to $10^{\circ}50'24''$ North latitude and $37^{\circ}42'36''$ to $37^{\circ}58'24''$ East longitude while its altitude ranges from 1500 to 4413 m.a.s.l.

According to the objectives set, this study was conducted in four *kebeles* of four *woreda* considering their agro-ecological condition to measure vulnerability and adaptive capacity there by make comparisons amongst. Based on the assumption, *Dangulie and Gedamawit kebeles* from *Senan wereda* were selected representing upper highland and highland agro-ecology respectively. Whereas, *Dendegeb kebele* from *Basoliben wereda*, on the other hand, representing midland agro-ecology and *Kurar kebele* from *Dejen wereda* representing lowland agro-ecology.

Dangulie kebele is located at 4kms and 340kms far from *Debre Markos* and Addis Ababa respectively. The altitude ranges from 3200m-3800m.a.s.l. and its topography is dominantly mountainous and dissected terrain with steep slop characteristics.

According to the household survey, in *Dangulie* there were 7,762 populations out of which, females were 3,577 while males were 4,185. With this figure mentioned, 1,148 of the total male population headed households while only 104 female of the total population headed households. Nearly all populations were seemingly engaged in mixed farming activities where non farming activities are hardly wide spread.

With regard to land size at HH level, the average plot size per household is 0.5ha while the maximum plot size per household is 1.5ha and the minimum holding size of 0.25ha. Of the total area of the *kebele*, 1,089ha was cultivated, 1,210ha was grazed land; and 80ha was covered with forest. The most common crop grown in this area includes Barely, Bean, Potato, and *Ingido*. Mean while, the Cattles, Sheep, Horses, Mules, Donkeys are the most popular livestock in the *kebele* mentioned.

Gedamawit kebele is located about 18kms from *Debre Markos* town and 318 kms from Addis Ababa. The altitude ranges from 2300m-3000m.a.s.l the topography is mostly hill accounting for 50%, mountainous 35% and plain land form with (15%) coverage. According to the household survey held in *Gedamawit kebele*, there were 9,193 population and 1,792 households.

Gedamawit kebele, which is one of the 17 *kebeles* in *Senan* district, has the average, maximum and minimum plot size of 0.5ha, 1.5ha and 0.25ha per household, respectively. It covers a total land area of 4,614ha. Out of this cultivate land covers 1,822ha, grazing land 725ha, forest and shrub 356ha; building 10ha, and barren land 15ha.

The dominant agro-ecology is *Dega* (95%) followed by *W/dega*(5%) thereby receiving an average rain fall ranging from 1200-1500mm. Clay (20%), grey (5%), and red (75%) are dominant soil types in the area.

Dendegeb Kebele is located about 37kms far from *Debre Markos* and 337kms far from Addis Ababa. The altitude ranges from 2300-2600m.a.s.l. having a topography of mostly plain.

According to the household survey, there were 1,086 male headed households 193 female headed households. The average plot size per household is 0.5ha while the maximum and minimum plot size per household is found to be 1ha and 0.25ha, respectively. From the area coverage 1,919ha is cultivable land, 196ha of it is forested by man made, 12 ha natural forest 401 ha grazing land. The soil types are red soil accounts 85%, Black soil accounts 15%.

As per the household survey the most dominant crops grown in *Dendegeb* were wheat and *teef*. In 2002/2003 cropping seasons out of 1919 ha cultivated land 1094ha was covered with wheat crop. The most popular livestock are cattle, sheep, goat, donkey, horse.

Kurar (Abay shelko) is located in the Abay gorge about 220 kms from Addis Ababa along the high way to *Debre Markos*. The altitude ranges from 1,080-1,860m.a.s.l. The topography is mostly rugged terrain, characterized by steep slope. The type of the soil, red soil accounts 3%, grey brown accounts 40%, black accounts 10% and lime accounts 47%.

According to the HH survey, there were 5,175 populations within which males are 2,595 while females are 2,580. With this figure discussed, there were 858 male headed households and 303 female headed households. The population consists of farmers that are engaged in a mixed farming, crop production and livestock raising who are supposed to be the most

size per household is 0.5ha and 2ha, respectively. While, 0.25ha of it represents the minimum holding size of the HHs. The area coverage of the *kebele* is 2,537ha. Of which, 1,611ha is cultivation land, 77ha is for grazing land, 200ha is for construction, 271.6ha is covered with forest, 25.5 ha was covered road construction, 204.4 ha covered with short trees 30 ha was under investment. Climate of the *kebele* is 97% is *kola* and 3% is *woynadega* agro-ecology.

The most dominant crops grown in the area include Sorghum, Millet, Sesame, *Teff*, *Nuge*, and Sunflower. The most popular livestock are Cattle, Goat, Sheep, and Donkey.

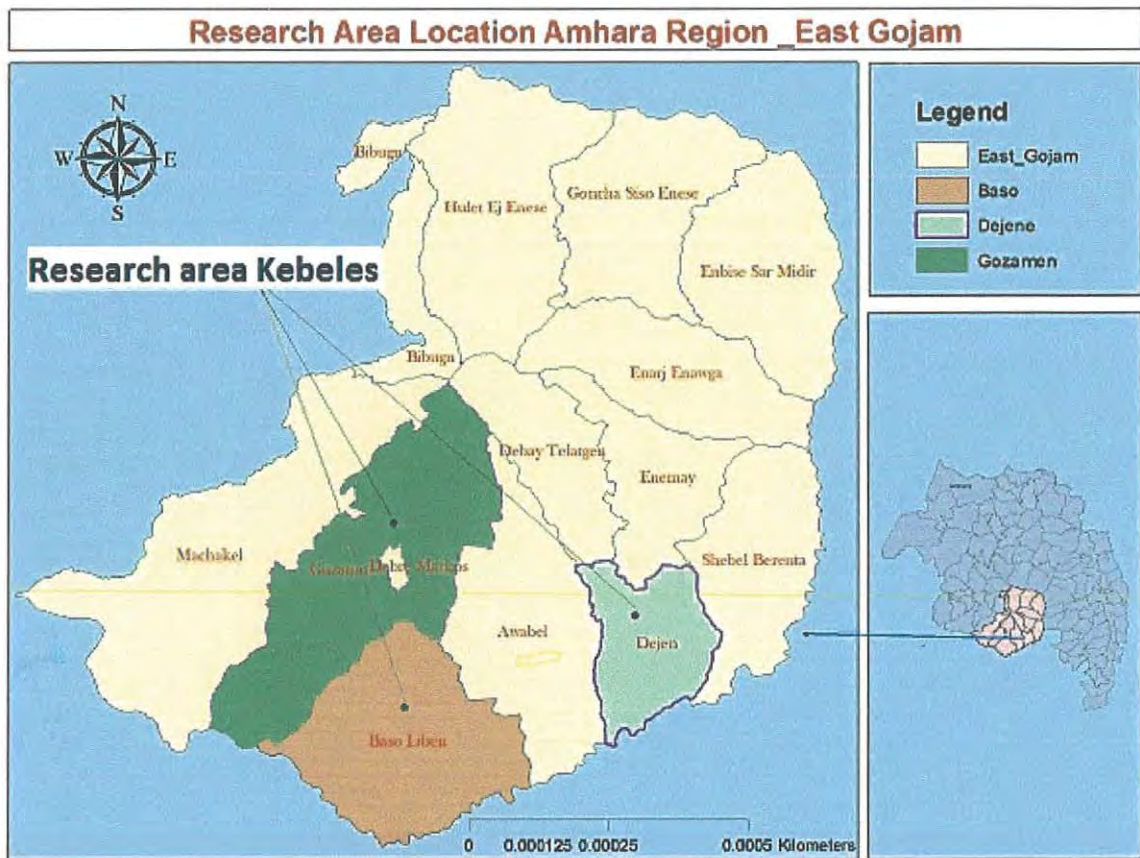


Figure 3: Map of the study area.

Source: Developed from arch Geographical Information System (GIS), 2011.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1. Design and Methods of the Study

To this research, cross sectional design was employed using an integrated assessment approach to assess the level of vulnerability of small hold farmers. The research used both socio-economic and biophysical attributes in vulnerability analysis. Socio-economic and biophysical indicators were also collected and analysed to get the vulnerability index.

Multistage sampling techniques were employed to select the study area. By referring the traditional climatic zones from Ministry of Agriculture; *woredas* in East *Gojjam* were categorized with their respective traditional agro ecological zone; however, no single *wereda* was represented by one agro-ecology.

Table 1: Traditional Climatic Zones

Zones	Altitude (meters)	Rainfall (mm)	Average temp. Annual(OC)
<i>Wurch</i> (upper high lands)	3200+	900-2,200	< 11.5
<i>Dega</i> (high lands)	2,300-3,200	900-1,200	17.5/16.0-11.5
<i>Weyna Dega</i> (midlands)	1,500-2,300	800-1,200	20.0-17.5/16.0
<i>Kola</i> (low lands)	500-1,500	200-800	27.5-20.0
<i>Berha</i> (desert)	Under 500	Under 200	>27.5

Source: MoA, 2000.

4.2. Data Types, sources and Method of data Collection

Qualitative and quantitative data types were collected using primary and secondary data sources, primary data sources were household survey, key informant, focus group discussion and informal survey through transact walk. Secondary sources were internet sources, Archives, documentary research journals articles, books and other pertinent sources.

4.2.1. Primary data collection

Primary data collection was made using the following tools such as household survey, key informant interview, focus group discussion and observation through transact walk.

A. Household survey questionnaire

This method of data collection was employed to assess and find out both biophysical and socio-economic indicators to measure the level of vulnerability indices and adaptive capacity of households. Consequently, the household survey was employed using questionnaire which was administered to 150 sample households.

B. Key Informant Interview

To supplement the quality and reliability of the data collected through the questionnaire; interviews were conducted using an interview guide with those award and aged informants. In four *kebeles*, couple of informants were selected from each *kebele* in the light of their age and experience. Accordingly, informants were asked about issues like the long term temperature and rainfall condition, the overall productivity of their farm land to compare the past and the current, what climatic extremes had they faced with and how did they manage and cop up with. For that matter, checklists were used to guide the interview.

C. Focus Group Discussions

These data gathering techniques were employed with the purpose of gathering households having different economic status, educational back ground and thereby discuss how rich and poor, vis-vis few literates and illiterates have perceived climate change and variability so that they respond to climate extremes. By doing so, it was enabled to look for equal beneficiaries and participation of the informants in decision making of every social and development activities of the *kebele*. Discussants were nominated following the profile information gained from the officials and Developmental agents of each *kebele*. By doing so, six discussants have been dealt with issues already mentioned.

D. Informal Assessment (Observation)

Using this technique, data about the *kebeles'* social, environmental, and economic condition were collected during survey through transect walk in the study areas.

4.2.2. Secondary data Collection

The study was made to be triangulated the primary qualitative and quantitative data with secondary data. Secondary data was collected from Internet, Archives from the study *wereda* Agricultural and rural development bureau of three *weredas*.

4.3. Sampling Size

With the objective of analysing vulnerability of small hold farmers in four agro ecological zones; *kebeles* from three *wereda* were defined using multistage sampling techniques.

Consequently, the sample size was calculated using the following formula $n = \frac{z^2 pq}{e^2}$

Despite, the result of the statistics was 342, due to constraints in time; cost and available resources the researcher attempted to take 150 household units taken out of 5,484 to conduct a household survey using questionnaires. Households were again identified based on their respective agro-ecology. Mean while, 40 households from upper highland and highland agro-ecology of each *kebele* were selected. Whereas, the midland and lowland agro-ecology of each *kebele* had 35 households drawn as a sample population

4.4. Method of data analysis

In order to attain the intended objective of the study, both qualitative and quantitative methods of data analysis were used. An indicator method of vulnerability measurement was employed to calculate the level of vulnerability of farmers. The indicator method of quantifying vulnerability is based on selecting some indicators from the whole set of potential indicators and then systematically combining the selected indicators to indicate the levels of vulnerability. The principal component statistical analysis (PCA) was employed to determine the weight of selected variables in constructing the vulnerability index. PCA is an example of factor analysis, a class of statistical methods that attempt to reduce the complexity of multivariate datasets by producing a set of new factors or components that are orthogonal, thereby avoiding the problem of correlation among indicators.

To analyse the quantitative data of vulnerability index calculation was made besides the descriptive statistics. To this end, SPSS version soft ware package and Microsoft Excel were used to organize and analyse the data collected through the aforementioned methods and instruments.

4.5. Model Variables and Expected Signs

To determine the vulnerability of households, the indicator variables for this study were categorized according to the study's conceptual framework. *Adaptive capacity* is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with the consequences (IPCC TAR, 2001).

1. **Adaptive capacity:** was represented by wealth, technology, availability of infrastructure and institutions, potential for irrigation.
 - A. **Wealth:-** Considering the study area wealth ownership (accumulation) is explained with the following indicators, Saving in cash, and quality of residential home, non agriculture income, Farm size and number of oxen at HH level.
 - i. **Saving in cash:-** The assumption is that households who have cash reserves are expected to with stand climatic shock. In this model, it is defined as a dummy variable with a value of one (1) representing households that save cash and zero (0) otherwise. Households with cash saving are expected to have higher adaptive capacity in comparison with households that don't save in cash.
 - ii. **Quality of residential home:** - Quality of home is taken as an indicator of wealth in the study area. Households with corrugated iron roof houses considered as wealthy. In the model it is defined as a dummy variable with value of one (1) representing households with corrugated roof houses and zero (0) otherwise.
 - iii. **Non-Agricultural Income:** - Since Agriculture is the main livelihood of farmers in the study area and is highly sensitive to any climate shock; households that earn income from Non-Agricultural activities are believed to be less vulnerable and have better adaptive capacity. In this study, access to non-Agricultural income is defined as a dummy variable one (1) representing those households that have Non-Agricultural income and zero (0) otherwise.
 - iv. **Land size of the HHs:** Since the livelihood of the farmers in the watershed is mixed farming, land is an important asset that determines the socio-economic status of

the farmers in the area. Farmers with large plot of land will have high adaptive capacity and farmers with low farm size will have relatively low adaptive capacity. Despite there is a significant variation in land holding among farmers, by taking the average possession of land holding, the researcher tried to classify sample HHs in to two. To mention, those who posses greater than the average and less than the average, and is defined as a dummy variable representing those who possesses greater than the average was represented in one (1) and zero (0) otherwise.

- v. **Number of Oxen at house hold:** - Oxen are the primary draft power source in rural area of Ethiopia particularly in Choke Mountain watershed. Ownership of more oxen guarantees the timely execution of agricultural activities thereby improving the level of productivity at household level. Households with high productivity will have capacity to withstand from any climate shocks. Households, who have four and above oxen were, represented in the dummy variable as one (1) and zero (0) otherwise.

B. Access to modern technology

Agricultural inputs play a great role in increasing the production of crop yields and enhance farmer's income. The types of technology, fertilizer, HYVS utilization of HH in the study are determined by the accessibility of these technology and inability of HH to purchase. In the dummy it is defined as those households utilize any kind modern technology are represented as one (1) and zero (0) otherwise.

C. Access to information

Access to information is represented by sex of the household leader, and radio ownership.

- i. **Sex of the household Head:-** Male headed households are more likely to get information about new technologies and undertake businesses than female headed households (Asfaw and Admassie, 2004). A study by Nhemachena and Hassean,(2007) argued to the contrary that female headed households are more likely to take up climate change adaptation methods. Deressa *et al.*,(2008) also argued that women are likely to adapt because they are responsible for much of agricultural works. As a result, they have greater experience and access to information on various management. However, to this study it was assumed that

male headed households are more likely to get information and use new technology. In the dummy it is represented as households led by male represented as one (1) and zero (0) otherwise.

- ii. **Radio ownership:-** Households that own radio are assumed to have access to information about climate change and variability and also they will have access to information about technology usage which could be broadcasted through radio. Therefore, radio owner ships included in the dummy households that possess radio are represented as one (1) and zero (0) otherwise.

D. Infrastructures and Institutions

The availability of institutions and infrastructure play an important role in enhancing the adaptive capacity of farmers in the rural area from any climatic shock by facilitating access to resources, infrastructures and institutions are, weather roads, health services, first cycle and second cycle, veterinary services, food market, Micro finance institution, Access to Electric and Telephone service .

- i. **Weather road: -** roads allow from the distribution of necessary input of farmers and to bring their products to the market, it also facilitates economic activity in general. In the model it is represented as those who have access to weather road represented in one (1) and zero (0) otherwise.
- ii. **Health Services:-** can assist on the provision of preventive treatments for diseases associated with climatic change, such as malaria, Evidence exists that an increase in infectious diseases including malaria and diarrheal diseases is likely in the face of climate change. Assuming that households without access to decent health facilities would be more likely to be affected by climate change shocks. In the model it is represented as those who have access to health services represented in one (1) and zero (0) otherwise.
- iii. **Full cycle school:-** households that are led by educated leader and who have educated members of the family are likely to survive climate shocks better, as they are more likely to find alternatives avenues of employment and using any adaptive strategies. In the model was represented as those who have access to school access were represented in one (1) and zero (0) otherwise.

- iv. Veterinary services:-** To maintain the health condition of livestock's provision of veterinary services need to be given due attention. Those who are getting the services are likely to survive (remain) with their line stocks, if any climatic shock appear in the area. It is defined as a dummy variable. The model it is represented as those who have access to health services represented in one (1) and zero (0) otherwise.
- v. Access to Market:-** Access to market will enable farmers to access input in their locality and also they will have job opportunity It is defined as a dummy variable. The model it is represented as those who have access to Access to market represented in one (1) and zero (0) otherwise.
- vi. Saving and Credit Institutions-** In the study area there is one micro finance institution that enable households to get access for credit with collateral. The institution also encourages households to save. To this study access to such institutions is represented by household membership to saving and credit associations. In the model, it is defined as a dummy variable HHs with access to the service representing one (1) and zero (0) otherwise.
- vii. Electricity provision:** Access to *electricity* was found to be an important factor explaining crop choice (Kurukulasuriya & Mendelsohn, 2006b) and livestock choice (Seo & Mendelsohn, 2006a) Farmers with better access to higher levels of technology and market access are expected to be able to take up adaptation measures that require high levels of technology use such as irrigation systems. In the model it is represented one (1) who gets the provision and zero (0) otherwise.
- viii. Irrigation potential:-** Irrigation potential was selected because of the assumption that places with more potentially irrigable land are more adaptable to adverse climatic condition (O'Brian et al 2004, Deressa, *et al.*, 2008). In the model it is represented as those who have access represented in one (1) and zero (0) otherwise.
- 2. Sensitivity:-** is the degree to which a system is affected by or responsive to the stimuli and is related to characteristics of the system and to broader non climatic factors (e.g. land use, livelihood, infrastructure, government policy), therefore to capture the sensitivity of the study area biophysical vulnerability index will be run.

The physical condition of each *kebele* was taken as a biophysical indicator used in the profile consisted of soil conditions (quality and depth), soil chemical status and slope of the topography.

It is assumed that area with more productive soil and farm land in plain/slightly gentle of farm land for agriculture will be more adaptable to adverse climatic conditions and better able to compete and utilize the opportunities of trade.

- A. Soil Fertility** farmer's perceptions that their lands are infertile may be a first step in the adaptation process to reduce any climatic shock. They may be more likely to adapt any adaptation techniques that will help improve their productivity. In the model the variable will run as a dummy variable those who do not perceive as Infertile represented as one (1) and zero (0) otherwise.
 - B. Slope of the farm land:** the location and slope of the farm land of individual HHs in the watershed also a determinant to the productivity and sensitivity of their farm land to erosion, therefore to capture farmer's perception of their farm land position this indicator was run as dummy variable representing farmers with farm land in steep slope one (1) and zero (0) otherwise.
- 3. Exposure:** is defined by the magnitude; character and rate of climate change in a given geographical area (i.e. change in temperature and rain fall and the perception of the farmers) in the study area exposure is defined as:
- A. Change in temperature:** Change in temperature is taken from the analysis of the temperature using the data obtained from NMSA. However due to the variation of the Base value the researcher used the available data.
 - B. Change in rainfall:** Change in rain fall is taken from the calculated analysis of the data obtained from metrological agency, however due to the variation in base value the researcher has influenced to use the available data.

4.6. Vulnerability Index Specification

To determine the level of vulnerability the study attempts to analyse vulnerability based on the integrated approach by making the use of vulnerability index. The use of indices is challenged by many ambiguities, some of which are the choices of the right indicators, directions of relationships with vulnerability weights attached and the optimal scale Deressa

et al. (2008). The choice of indices was undertaken based on a review of the literature and adjusting to the context of the study population. The direction of relationship in vulnerability indicators (i.e. their sign) was adopted from the procedure followed by (Deressa *et al.*, 2008, Abenet, 2010) who assigned a negative value to sensitivity and exposure and a positive value to adaptive capacity.

In this research, it is assumed that households with higher Adaptive Capacity are less sensitive to impacts of climate change keeping the level of exposure constant. Hence, vulnerability is the net effect of adaptive capacity, sensitivity and exposure.

$$Vulnerability = Adaptive\ Capacity - (Sensitivity + Exposure)..... (1)$$

For this, higher net value indicates a relatively lesser vulnerability of household or social group and vice versa. In this case the values of the indices are only relative values and have no further meaning.

Instead of simply assigning equal or average weight across the variables, a statistical technique, principle component analysis (PCA), was used to determining the weights in the index. PCA is an essential tool for summarizing variability among a set of variable, specially it seeks to describe the variation of a set of variables as a set of linear combinations of the original variables, in which each consecutive linear combination is derived so as to explain as much as possible of the variation in the original data, while being uncorrelated with other linear combinations. PCA as a technique extracts from a set of variables those few orthogonal linear combinations of the variables that capture the common information most successfully. Intuitively the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all the variables (Filmer and Pritchett, 2001; Longyintuo *et al.*, 2005; Deressa *et al.*, 2008).

Generating Vulnerability Index of each Agro-ecology (VI)

Suppose we have a set of K variables (a^*_{1j} to a^*_{zj}) that represents the K- variables (attributes) of each household. PCA starts by specifying each variable normalized by its mean and standard deviation. For instance, $a_{1j} = (a^*_{1j} - a^*_{i1})/s^*_{11}$, where a^*_{i1} is the mean of a^*_{1j} across districts and s^*_{11} is its standard deviation. The selected variables are expressed as linear combinations of a set of underlying components for each *Kebele j*:

$$\begin{aligned}
 a_{1h} &= V_{11}A_{1j} + V_{12}A_{2j} + \dots + V_{1k}A_{kj} \\
 &\dots\dots\dots j = 1, \dots, j. \dots (2) \\
 a_{k1j} &= V_{k1}A_{1j} + V_{k2}A_{2j} + \dots + V_{kk}A_{kj}
 \end{aligned}$$

Where a A's are the components and the V's are the coefficients on each component for each variable (and don't vary across Agro-ecology). Because only the left hand side of each line is observed, the solution to the problem is indeterminate. Principal component analysis overcomes this indeterminacy by finding the linear combination of the variables with maximum variance, usually the first principal component A_{1j} , and then finding a second linear combination of variable orthogonal to the first, with maximal remaining variance and so on. Technically the procedure solves the equations $(R - \lambda_n)v_n = 0$ for λ_n and v_n where R is the matrix of correlations between the n^{th} component for each variables. Solving the equation yields the characteristic roots of R, λ_n (also known as eigenvalue) and their associated eigenvectors, V_n . The final set of estimates is produced by scaling the v_n s so that the sum of their squares sums to the total variance, another restriction imposed to achieve determinacy of the problem.

The scoring factors from the model are recovered by inverting the system implied by equation (2). This yields a set of estimates for each of K principal components.

$$\begin{aligned}
 A_{1j} &= f_{11}a_{1j} + f_{12}a_{2j} + \dots + f_{1k}a_{kj} \\
 &\dots\dots\dots j = 1, \dots, j \dots\dots(3) \\
 A_{k1j} &= f_{j1}a_{1j} = f_{k2}a_{2j} + \dots + f_{kk}a_{kj}
 \end{aligned}$$

The first principal component, expressed in terms of the original (unnormalized) Variables which is used as a weight of each variable, is therefore an index for each Agro-ecology based on the following expression.

$$VI_{1j} = f_1(a^*_{1j} - a_1^*)/(s_1^*) + \dots + f_{1k}(a^*_{kj} - a_k^*)/(s_k^*) \dots\dots (4)$$

- VI_{1j} = the vulnerability index of each *Kebele*,
- f_j = the weight for the 1st variable (factor score)
- $(a^*_{1j} - a_1^*)/(s_1^*)$ = normalized value of the original variable data

CHAPTER FIVE

SOCIO ECONOMIC CHARACTERISTICS OF THE SAMPLE POPULATION

5.1. Demographic characteristics of the sample population

I Sex of the sample Population

To describe the demographic condition of the study population, Sex of the household led is best feature to explain the demographic characteristics. Based on this, from the total 150 households, 94% (140) of them were male household respondents while 6% (10) were female household respondents. When we see the distribution with respect to the agro-ecological variation, in *Dangule* out of 40 households 87.5% (35) were males and 12.5% (5) of them were females household led. In *Gedamawit* 92.5 % (37) were males and 3 females. In *Dendegéb kebele* out of 35 households 97% (34) were males and 1(3%) female households. Whereas, in *Kurar* out of 35 respondents, 97% (34) were males and 2.5% (1) female households.

II Age of the HHs

The age of household respondents ranges between 20 years with minimum and 68 years as maximum and the mean age of 41.66. From 150 households, there were 8% (12) HH head's between 20 -30years, 36% (55) HH head's between 31 - 40 years, 36% (54) HH head's between 41-50 years, 15% (23)HH head's between 51-60 years and 4% (6)HH head's whose age is ≥ 61 years.

III Marital Status of HHs

Marital status of the sampled households in the study area is found statistical insignificant variation among the sample households in the watershed at $P = 0.059$.

Table 2: Marital status of the study area.

<i>Marital status of the householder/respondent</i>							
Kebeles		<i>Married</i>	<i>Single</i>	<i>Divorced</i>	<i>Widow</i>	<i>Total</i>	X^2
<i>Dangulie</i>	Count	39	1	0	0	40	16.4NS df=9 p=0.059
	%	97.5					
<i>Gedamawit</i>	Count	32	3	3	2	40	
	%	80	8.7	8.7	5		
<i>Dendegeb</i>	Count	32	3	0	0	35	
	%	91.4					
<i>Kurar</i>	Count	34	0	0	1	35	
	%	97					
Total		137	7	3	3	150	

NS not significant less than at 5% level, source own survey (2011)

Out of 150 sample population, 91% (37) were married, 4.6% (7) single, 2% (3) divorced while 3(4.6%) were widowed. When we see the distribution of marital status across the *kebeles*, in *Dangule*, 97.5% (39) were married and 2.5% (1) single household, whereas, in *Gedamawit* 32(80%) were married, 8.7% (3) single, 8.7% (3) divorced and 5% (2) were widowed. In *Dendegeb kebele*; however, 91.4% (32) HHs were married while the rest 3HHs were found out single. *Kurar kebele* inturn was composed of having 97% (34) households being married and widowed with the remaining 3 % (1).

VI Educational level

Education level of the household led is important variable that determines the adaptive capacity of households. There is a statistically significant difference among household head educational level.

Table 3: Educational status of the household heads

Kebeles		<i>Illiterate</i>	<i>Able to read and write</i>	<i>Elementary school</i>	<i>Secondary school</i>	<i>Total</i>	X^2
<i>Dangulie</i>	Count	16	17	7	0	40	27.9** df=9 p=0.001
	%	40	42.5	17.5			
<i>Gedamawit</i>	Count	11	18	9	2	40	
	%	27.5	45	22.5			
<i>Dendegeb</i>	Count	7	27	1	0	35	
	%	20	77.1	2.8			
<i>Kurar</i>	Count	2	19	12	2	35	
	%	5.7	54.2	34.2			
Total		36	81	29	4	150	

** Significant at 1% level, source: own survey (2011)

In *Dangule*, from 40 HHs, there were about 40% (16) household heads who were found out being illiterate, whereas, 42.5 % (17) HH heads rather seemed to be literate once who were able to read and write where 17.5% (7) HHs were confirmed completing their elementary school. In *Gedamawit*, 27.5% (11) households were illiterate, 45% (18) HH heads were able to read and write while 22.5% (9) and 2 HHs were checked out completing their elementary and secondary school, respectively. In *Dendegeb* 20% (7) illiterate and 77.1% (27) HH heads that can read and write and 2.8% (1) elementary school completed and in *Kurar wereda* 5.7% (2) HHs were illiterate 54.2% (19) HHs were who can read and write and 34.2% (12) HHs were who completed elementary school, 5.7% (2) HHs were who completed secondary school.

5.2. Economic condition of the sampled households

Almost all samples HHs are engaged in mixed farming, therefore land and livestock are the two most important basis of their economy. Based on this assumption, the sampled HH respondents land holding is assessed in this section.

Table 4: Land ownership of the sampled population

<i>Land ownership of the householder/respondent</i>					X^2
		<i>Yes</i>	<i>No</i>	<i>Total</i>	
<i>Dangulie</i>	Count	30	10	40	12.419** df = 3 p=0.006
	%	75	25		
<i>Gedamawit</i>	Count	40	0	40	
	%	100	0		
<i>Dendegeb</i>	Count	32	3	35	
	%	91	9		
<i>Kurar</i>	Count	30	5	35	
	%	87	13		
	Total	132	18	150	

** Significant at 1% level, source: Own survey (2011)

From the above table in *Dangulie Kebele* 75% (30) HHs reported that as they are owned cultivable land. In *Gedamawit*, however, all sampled HHs possesses cultivable land. In *Dendegeb kebele* 91% (32) HHs respondents reported that as they are owned cultivable land for themselves and in *Kurar kebele* 87 % (30) HHs respondents reported as they own cultivable land.

Wealth accumulation of the sampled HHs in the study area

To accumulate their wealth and to diversify their means of income, farmers have been engaged in many activities. In this section activities that are practiced in each *Kebele*.

Table 5: Sources of income of the sampled HHs

<i>Kebele</i>	<i>Income from selling of fruit and vegetable</i>		<i>Income from labour wage</i>		<i>Income from selling of grass</i>		<i>Income from selling of fire wood</i>		<i>Engaging in grain and livestock trading</i>	
	<i>Frequenc y</i>	<i>%</i>	<i>Frequenc y</i>	<i>%</i>	<i>Frequenc y</i>	<i>%</i>	<i>Frequenc y</i>	<i>%</i>	<i>Frequenc y</i>	<i>%</i>
<i>Dangulie</i>	1	5	1	2.5	1	5	16	37.5	1	2.5
<i>Gedamawit</i>	25		3		2		17			
<i>Dendegeb</i>	6	20	2	5.7	0	0	0	0	0	0
<i>Kurar</i>	21	52.5	14	35	0	0	2	2.5	3	7.5

Source: Household survey (2011)

As depicted in the table, farmers, none farming and off farming activities vary from place to place. From HHs respondents in *Dangulie* in addition to their farming activities 37.5% (15) of HHs are engaged in selling of fire wood to increase their income. In *Gedamawit* Whereas, HH respondents in *Dendegeb* reported only 20% of respondents were engaged in selling of fruit and vegetable. In differ from other *kebeles* in *Kurar kebele* due to the presence of industry in and around the *kebele* 35% of HH respondents reported that they earn income from labour.

Livestock Ownership

Livestock rearing is also an important economic activity that farmers are depend on to raise their in all study are practicing as a means of livelihood. As it is depicted in the table below livestock holding of HH respondents in four *kebeles* vary in type and quantity consistent with the variation in agro-ecology.

Table 6: Livestock Possession of sampled HHs

Kebele	Qt	Types of livestock							
		Ox	Cow	Sheep	Goat	Horse	Mule	Donkey	Hen
Dangulie	0	-	-	-	-	-	-	-	-
	1-10	21	28	35	-	38	10	1	16
	>11	2			-				1
	%	52.5	72.5	87.5	-	90	25	7.5	40
Gedamawit	0	-	-	-	-	-	-	-	-
	1-10	36	32	34	2	31	6	-	20
	>11	-	-	1	-	-	-	-	1
	%	90	80	87.5	5	77.5	15	-	52.5
Dendegeb	0	-	-	-	-	-	35	-	-
	1-10	35	33	25	2	9	-	32	18
	>11	-	1	6	-	-	-	-	5
	%	100	94.2	88.5	5.7	22.8	-	91.4	65.7
Kurur	0	-	-	-	-	-	-	-	-
	1-10	33	22	6	19	1	-	26	10
	>11				2	-	-		3
	%	100	80	22.5	60	2.8	-	82.5	37.5

Source: House hold survey (2011)

When we see the trends of livestock possession of the respondent's, majority HHs reported that the number of livestock's at household level are declining trend.

5.3. Determinants of Vulnerability

Vulnerability of the people to climate change and variability is explained as a susceptibility of the system to climate change and other non climatic factors. Besides, the ability of this people to cop adapt or recover from those conditions (IPCC, 2001) as well as selection of vulnerability indicator variables was made based on review of literature and context of the area.

Farmer's ability to cop up with the climate extremes also determined on the type of crop grown and livestock rear which one of the most dominant type of economic activity of the farmers, the existence of infrastructure and the introduction of new technologies are also important determinants. At local level where cultivation of crop is the only economic activity land is an important asset is also determines their adaptive capacity agro ecological condition soil type physical condition of their farm plot and other socioeconomic factors are determinants of the adaptive capacity with low adaptive capacity farmers are believed to say vulnerable to climate change and variability.

5.3.1. Indicator variables of Adaptive capacity

Adaptive capacity is defined as the ability to deal with the exposed climate change and climate variability. Indicator variable of adaptive capacity were identified using literatures and the existing condition of the study area and their ability to measure the adaptive capacity.

5.3.1.1. Wealth

Wealth is important indicator that determines the adaptive capacity of farmers at local level. It enables farmers to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs (Cutter *et al.*, 2000). According to the sample population wealth accumulation mechanisms of farmers vary and diversify. Wealth accumulation and the expression of their socio economic status of the study area is determined by the number of livestock ownership, quality of residential home, their non agricultural income, saving at household level and number of oxen at HH level which are some of the indicators that are used to capture wealth condition of the sampled HHs. To this study wealth of HH will be explained by the following indicators.

I. Quality of Residential Home.

Quality of residential home in the study area is an expression of wealth and hence there are two types of holdings of houses, corrugated houses covered with iron roof, non corrugated houses covered with grass. When we see the types of houses of the HHs of the sampled population, in *Dangulie* 70% (28) in *Gedamawit* 90% (36) in *Dendegeb* 97%(34) and in *Kurar* 94%(33) respondents reported as they own corrugated iron sheet roof houses and non-corrugated houses.

II. Farm Land size of the HHs

Farm size of the household is an important variable that determine the production ability of farmers. However, the types of crop and the amount of revenue earned from one hectare in the study *kebeles* vary due to different reasons therefore one hectare possession of the HHs in four *kebeles* is not equally worthy. Land holding of farmer's classified in to two based on the average possession of land 1.h. There is significant statistical variation in farm land size of HHs in the watershed among study *kebeles* ($P=0.000$).

Table 7: Land sizes of sample households

Kebeles	Who posses land \geq 1hectar	%	Who posses land $<$ 1hectar	%	Total	X^2
<i>Dangulie</i>	12	30	28	70	40	49.357** df = 3 P = 0.000
<i>Gedamawit</i>	9	22.5	31	77.5	40	
<i>Dendegeb</i>	31	88.5	4	11.5	35	
<i>Kurar</i>	27	77	8	23	35	

** Significant at 1% level, source: own survey (2010)

When we look the land holding of the sampled households, in *Dangulie*, 70% of HHs possess less than the average land holding of the total HH respondents. In *Gedamawit*, 77.5% of HH respondents reported and 88.5% of HHs in *Dendegeb kebele* possesses greater than the average of the total possession of the sampled HHs and 34% of HHs possess less than the average possession the sampled HHs were as the remaining are land less HHs. In *Kurar*, 57.5% of HHs possesses a land greater than the average of the possession of the total HHs and 37.5% of HHs reported that as they possess less than the average.

III. Non-Agricultural income

Households that earn income from Non-Agricultural activities are believed to be less vulnerable and have better adaptive capacity. With this assumption households were asked whether they have income from non agricultural activities or not. 72.5% (29) of HH in *Dangule*, 97.5% (39) of HH in *Gedamawit*, 31.4% (11) of HH in *Dendegeb* and 88.5% (31) of HH in *Kurar* reported as they have income from no-agricultural activities.

5.3.1.2. Access to Modern Technology

Access to modern technology and the ability of farmers to use these modern technologies determine the level of productivity; in turn it will have an impact on the adaptive capacity of farmers. At this section the types of technology utilized by the sample population will be discussed.

Table 8: Agricultural input supply of the sampled Population

Kebeles	Agricultural technology					Fertilizer utilization					Improved seed utilization				
	Ye s	%	N o	%	Tota l	Yes	%	N o	%	Tota l	ye s	%	n o	%	Tota l
<i>Dangule</i>	8	20	32	80	40	1	2.5	39	10	40	8	20	32	80	40
<i>Gedamawit</i>	3	7.5	37	92.5	40	2	5	38	95	40	38	95	2	5	40
<i>Dendegeb</i>	35	100	-	-	35	35	100	0	-	35	34	97	1	3	35
<i>Kurar</i>	35	100	-	-	35	32	95	3	5	35	26	65	14	35	35
	$X^2=42.231$ $df=3$ $p=0.000$					$X^2=118.662$ $df=3$ $P=0.000$					$X^2=22.947^{**}$ $df=3$ $P=0.000$				

** Significant at less than 1% level, source: own survey (2011)

As depicted from the tables above, utilization and access to technology in the sample *kebeles* vary from place to place. There is also statistically significant variation of agricultural input supply among study *Kebeles* in the watershed. According to KI and FGD discussants, in *Dangulie kebele* argued that Inorganic fertilizer was not applicable in their *kebele* and in their farm because of the biological condition of the soil it was tested in their farm and it was found that a crop without fertilizer is productive than with fertilizer. In *Dangulie* only 20% households respond as they used improved technology. For this they attribute due to the inaccessibility of technology and inability to use. Whereas almost all households in *Dendegeb* and *Kurar* respond as they are utilizing improved technology to crop production.

5.3.1.3. Infrastructure and Institutions

Infrastructure provision and the existence of institution to the lower level of administration such as at *kebele* level will enable to build the capacity of farmers by introducing technologies and providing financial and technical support so that farmers can produce more and with stand from any climatic shock. In doing this, the adaptive capacity of farmers will be enhanced. Therefore, at this section, infrastructure and institution provision of the sampled HHs will be discussed.

I. Veterinary Service

The provision of veterinary service varies from place to place in the sampled *weredas*. Majority of HH respondents, in *Dangulie kebele* reported, they haven't access the services

and are subjected to travel along trip to the nearest town *Rebugebeya* with their livestock. In *Gedamawit* 80% (32) sample of HHs reported that as they have access to the service. 97% (34) sampled HHs in *Dendegeb* reported as they have accessed the service and in *Kurar kebele* 68.5% (24) sampled HHs reported that they are getting the service in their locality.

II. Health Centre

When we see the access to health services in the sampled *kebeles*, 95% (39) of sampled HHs in *Dangulie* and 90% (36) of HHs in *Gedamawit* stated as they have access to health service, 45.7% (16) of respondents in *Dendegeb* and 82.5%(33) of HHs in *Kurar kebele* reported have access to health service in their *kebele*.

III. Market Centre

Despite FGD and KI discussants in all *kebele* claimed the absence of market in their *kebele*; sampled 95% of HHs in *Dangule*, 85% of HHs in *Gedamawit*, 91% HHs in *Dendegeb* and 74% of HHs in *Kurar* reported the existence of market in their *kebele* and 49.5 % of the total HHs reported that they went once a week to market and 31% of the total sampled HHs reported that they went once within two weeks to the market.

IV. Saving and Credit Institution

To look the access to saving and credit institution, sample HHs were asked whether they have accessed the service or not in their locality. In *Dangulie*, only 15 %(6) HH respondents, in *Gedamawit* 87.5% (35) HHs reported the existence of these institutions and have accessed to the service were as in *Dendegeb* 97% (34)HH respondents reported they in their *kebele* and 80% (28) HH respondents in *Kurar kebele* reported that have access to the service in their *kebele*.

V. Full Cycle School

The existence of full cycle schools and alternative schools in local areas will give opportunity to farmers to send their children by near schools. However, all HHs don't equally access the service du to the distance from their home send their children to school equally. 97.5% (39) HHs in *Dangulie*, 90% (36) in *Gedamawit*, 45% (16) in *Dendegeb* and 94% (33) in *Kurar* 10% of the total HHs reported that they don't send their children to school and lack of interest

and the absence of labourer who can look after the livestock's and help the family are attributed as a main factor for not to send to school.

VI. Electric provision

Electric provision is important infrastructures that enable farmers to use radio to access information and to use technologies that reduce farmers from extra expense which in turn enhance the adaptive capacity of farmers. The introduction of flour mills in their locality following the provision of electricity at local level can reduce the long journey of farmers with their packed animal. Considering this idea, sampled households were asked whether they have access to electric or not. Except *Dangule kebele* households in all *kebeles* were provided with electricity however due to different cases all households in these are not equal beneficiaries from the electric power. In *Gedamawit* 25 % (6) HHs, in *Dendegeb kebele* 20 % (7) of HHs and in *Kurar* 75% (29) of HHs responded as they were access to this service.

VII. Telephone Provision

Like other services telephone service is important infrastructure to enhance communication of farmers. This could enable farmers to know the price of crops, livestock's or other goods which enable them not to incur in their transaction, so that they can enhance their adaptive capacity to any climatic shock. However, the provision of the service varies from place to place. In *Dangule* only 12.5% (5)of HH respondents claim that they are using the service, 80% (32) of HHs *Gedamawit* respond as they are accessing the service, 94% (22)of HHs in *Dendegeb* reported that as they are using the service and 74% (26)of HH respondents in *Kurar* claim that as they have access the service. From the total sampled Households 47% of HHs reported that they are using wireless telephone service and 18% of the total sampled HHs claim as they using mobile phone.

5.3.1.4. Access to Information

Access to information about social, economical and technological condition has important rôle to enhance household adaptive capacity at local level. HHs with information about climate change and variability are better to use different strategies early the hazard or the shock is happened than HHs with out in formation. Access to information was represented by sex of the household head and radio ownership. 52.5% of HHs in *Dangulie*, 72% of HHs in *Gedamawit*, 88.5% of HHs in *Dendegeb* and 57.1% of HHs in *Kurar* reported as they

possessed radio. To this study, it was assumed that male headed households are more likely to get information and use new technology. From the sampled HH respondents 85% of HHs in *Dangule*, 97% of HH respondents in *Dendegeb* and 77% HH respondents in *Kurar*, responded that they have access to information about agricultural technology, inputs and climate related information's.

5.3.2. Indicator variables of Sensitivity

Sensitivity was defined as the degree to which a system is affected either adversely or beneficially by climate related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise) (IPCC TAR, 2001)

Different factors could be attributed to farmer's livelihood sensitive to climate change and variability, some of the observed problems observed through transect walk were, acidity of soil, erosion and deforestation in *Dangulie* and *Gedamawit* soil erosion with water and deforestation in *Dendegeb* and soil erosion and land slide in *Kurar* are some of the observed problems related to climate change these observed problems in general environmental degradation is a series problem which intern affect productivity in Choke Mountain watershed. Therefore, to see the sensitivity of the area soil fertility and slop of their farm land are chosen assuming that these variables sensitivity of Farmers livelihood.

5.3.2.1. Soil fertility

Perception of farmers about the fertility of their farm land also taken as an indicator of sensitivity with the assumption of farmers who perceive their farm land is less fertile will take adaptive measures and use technologies to maximize the fertility and productivity of their farm land. From the sampled HHs, in *Dangulie* 45% (18), in *Gedamawit* 25% (10) in *Dendegeb* 94% (33) and in *Kurar* 97% responded as their land is Fertile. FGD and KI discussants in *Dangulie* argued that as their farm land is acidic and less fertile and in response to this they mentioned that as they are using deferent strategies to enhance the fertility of the soil. Whereas in *Dendegeb* unlike to the survey result discussants were argued that their farm land is infertile and in response farmers are using fertilizer more than what the science allows using per hectare. In *Kurar*, discussants argued that the fertility of the soil is declining that had known before thirty and forty years ago and due to the change in fertility they are

enforced to change the types of the crop that they had grown on the same farm land. In response to the change, farmers argued that they are practicing different strategies.

5.3.2.2. Slope of the farm land

When we see the slope of the farm land of HH respondents, in *Dangulie* 70 %(28), in *Gedamawit* 77.5%(31), in *Dendegeb* 17% (6) and in *Kurar* 97 % of HH respondents reported that their farm land was in Steep slop respectively. As it was observed through transact walk in the study area *Dangulie* and *Kurar kebele* most of their topography is rugged and mountainous and most of their farm land was in slightly steep slop and sensitive to erosion by water. According to FGD discussants, in *Kurar* due to steepens of their farm land their seedling and fertilizer washed during cropping time, land slide was also another threat that displace farmers from their residence.

5.3.3. Indicator variables of Exposure

Exposure is defined as the nature and the degree to which the local people are exposed to a significant climatic change and variability and the occurrences of climate extremes (drought and erratic rain fall)

To assess the exposure of the sample *Kebele* change in temperature and change in rain fall condition of each *Kebele* was collected from NMSA and HHs were also asked about their perception about temperature and rain fall variability using the questioner which administered at HH level.

5.3.3.1. Analysis of Temperature change

To see the long term temperature change data were collected from National Metrological Service Agency (NMSA) for each *kebele*, however a problem in Ethiopia the Meteorological data were not full and enough as much as the study wants. Nevertheless, the researcher has tried to extrapolate from data that are in a near distance of the study area. The temperature data of *Dangulie* and *Gedamawit Kebeles* were extrapolated using the temperature data from *Debre Markos* with an altitudinal variation of 1000m with *Dangulie* and 500m with *Gedamawit* from *Debre Markos* weather station at 2400m.a.s.l. Extrapolation was made by using adiabatic lap's rate (assuming that if a parcel of air climb 100 m.a.s.l it would lose 1°C) using temperature data of with a variation of 1000m difference between *Debre Markos* with altitude 2400m.a.s.l and *Dangulie* with altitude 3400m.a.s.l. whereas to *Dendegeb kebele*

temperature data of *Debre Markos* was taken as it was because no significance altitudinal variation between the two, but at *Kurar kebele* due to the availability of Metrological station it was possible to get temperature data from NMSA. Therefore, at this section the temperature analysis of each *kebele* will be discussed.

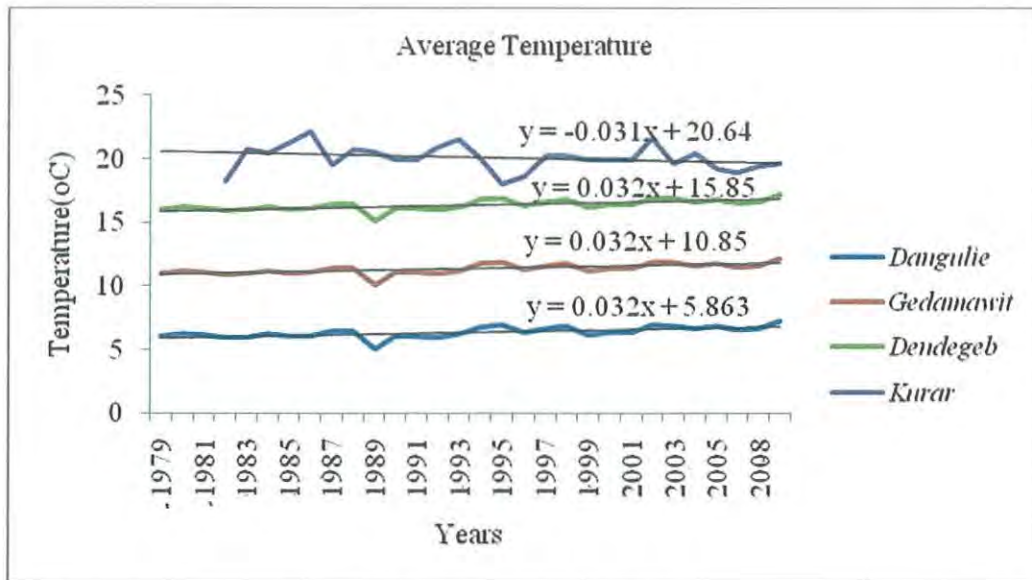
Table 9: Temperature analysis of *Dangulie, Gedamawit, Dendegeb* and *Kurar*

Temperature	Yearly				Summer(Kiremt)				Winter(Bega)			
	Dangule	Gedamawit	Dendegeb	Kurar	Dangule	Gedamawit	Dendegeb	Kurar	Dangule	Gedamawit	Dendegeb	Kurar
Mean(°C)	6.4	11.4	16.4	20.1	5.2	10.2	15.2	19.5	6.4	11.4	16.4	20.3
St. Deviation	0.4	0.7	0.4	1.1	0.4	0.5	0.4	1.3	0.5	0.4	0.5	1.2
Coff. Variation	6.8	5.8	2.7	5.4	7.8	6.5	2.6	6.8	7.9	6.1	3.1	5.7
Trend (°C)	0.87	0.96	0.96	-1.3	0.84	0.84	0.84	-0.756	0.9	0.9	0.9	-1.242

Source: Own Calculation (2011)

As it depicted in the above table, the statistical analysis of temperature in *Dangule, Gedamawit* and *Dendegeb* shows an increasing trend. Where, in *Kurar* the statistical result showed that the average temperature of *Kurar* is in declining trend (1.3°C 1983-2010) with maximum temperature increasing and minimum temperature declining. However, FGD discussants reported as they perceive that long term temperature is warming, Farmers' perception might be a result of simply viewing the maximum solar radiation of the day time. Perhaps, this decline is probably connected with the impact of local determinants since *Kurar* is located in the *Abay* gorge the temperature condition of the area could be determined by the local determinants such as valley breeze and mountain breeze.





Source: Own calculation(2011)

Figure 4: Trends of Temperature in *Dangulie, Gedamawit, Dendegeb* and *Kurar*

5.3.3.2. Analysis of Rainfall Change

The rainfall pattern in Choke Mountain watershed is uni-modal with a peak in *kiremt* season from June to September. To see the long term rainfall trend in the watershed rainfall data of *kebeles* were collected from NMSA and the same procedure taken place. Due to the absence of rainfall data in *Dangulie* and *Gedamawit* to calculate the analysis the same data was employed.

Table 10: Rainfall Analysis of *Dangulie, Dendegeb, and Kurar.*

Rainfall	Yearly			Summer(Kiremt)			Winter(Bega)		
	Dangulie	Dendegeb	Kurar	Dangulie	Dendegeb	Kurar	Dangulie	Dendegeb	kurar
Mean(mm)	1399.8	1346.7	1128.8	972.9	1028.7	859.4	135.7	41.8	37.3
StD deviation	181.1	393.4	289.6	146.9	348.0	245.2	62.1	24.0	39.2
Coff. Variation	12.9	29.2	25.7	15.1	33.8	28.5	45.8	57.3	105.0
Trend (mm)	88.592	688.59	292.1	157.304	708.77	281.98	-76.3	8.439	47.734

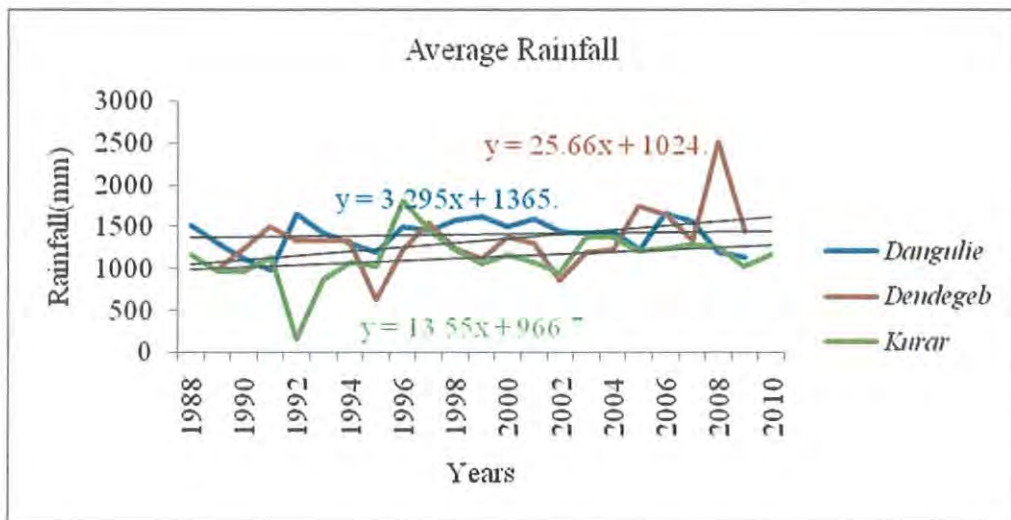
Source: Own Calculation (2011)

The rainfall analysis of *Dangulie*, (1981-2009) shows that 69.5% of the rainfall occurs during summer (*Kiremt*) season from June-September. The mean annual rainfall of the calculated years showed an increasing trend with a decreasing winter (*Bega*) season. From the total

sampled respondents 60%HH from *Dangulie* responded that they observed changes in rainfall at an increasing trend. Whereas, 20% HH from *Dangulie*, responded that they observed a change in rainfall at decreasing rate

The rainfall analysis of *Dendegeb*, from 1989-2009 shows that 88.4% of the rainfall occurs during summer (*kiremt*) season from June-September and the mean annual calculated rainfall shows increasing trend. The variability is also high in winter (*Bega*) season. 40%HH from *Dendegeb* responded that they observed changes in rainfall at an increasing trend. Whereas, 8% HH from *Dendegeb* responded that they observed a change in rainfall at decreasing rate.

The rainfall analysis of *Kurar*, (1987-2010) shows that, 74% of the rainfall occurs during summer (*kiremt*) season from June-September. The mean annual rainfall shows an increasing trend. 7.5% of HH from *Kurar kebele* responded that they observed changes in rainfall at an increasing trend.



Source: Own Calculation (2011)

Figure 5: Trends of rainfall in *Dangulie*, *Dendegeb* and *kurar*.

5.4. Perception of Farmers to Climate Change and Variability

To get information on their perception of climate change and variability, farmers were asked if they observed change and variability in climateic condition over the past 20 years. No statistical significant variation was found among household respondants in the watershed. 77.5% (31) household respondant in *Dangulie*,85%(34) household respondants *Gedamawit*,

97.1%(34) household respondents in *Dendegeb* and 88% of respondents in *Kurar* claimed that the present climatic condition was not the same as the condition that were 20 years ago.

Farmers were also asked whether the number of hot or rainy days had increased, decreased or stayed the same over the past 20 years. Statistically significant difference was found among the responses of households in different agroecologies ($p = 0.002$ and $p = 0.000$) of hot days and rainy days , this variation in perception of hot day and rainy days might be resulted from the variation in agroecologies. From sample household respondents 80% in *Dangulie*, 97.5% HHs from *Gedamait*, 100% in *Dendegeb* and 88% in *Kurar* reported as the trend of hot days over the last 20 years increasing and 10% of HHs in *Dangulie*, 2.5% of HHs in *Gedamawit* claimed the trend of hot days over the last 20 years decreasing.

From sample respondents, 60% of HHs in *Dangulie*, 40% of HHs in *Dendegeb* responded the trends of rainfall over the last 20 years is increasing, and 22.5% of HHs in *Dangulie*, 67.5 in *Gedamawit* , 85% of HHs in *Dendegeb* and 60% HHs in *Kurar* perceived the rainfall trend over the last 20 years is decreasing. whereas 7.5% HHs in *Dangulie*, 12.5% of HHs in *Gedamawit* , 51.4% of HHs in *Dendegeb*, 34.2% in *Kurar* responded the shift in raining time.

Is today's climate condition the same as the climate conditions that were 20 years ago?

Table 11: perception about today's climate condition and before 20 years ago.

<i>Kebeles</i>		<i>Yes</i>	<i>No</i>	<i>Total</i>			X^2
<i>Dangule</i>	Count	9	31	40			6.439NS df = 3 p = 0.092
	%	22.5	77.5	100			
<i>Gedamawit</i>	Count	6	34	40			
	%	15	85	100			
<i>Dendegeb</i>	Count	1	34	35			
	%	2.8	97.1	100			
<i>Kurar</i>	Count	4	31	35			
	%	11.4	88.57	100			

NS = not significant at less than 1% level, Source: own survey (2011)

What do you say about the trend of hot days over the last 20 years?

Table 12: perception about the trends of hot days over the last 20 years

Kebeles		Increasing	Decreasing	No change	I don't know	Total	X ²
Dangule	Count	32	4	4	0	40	26.510** df=9 P=0.002
	%	80	10	10		100	
Gedamawit	Count	39	1	0	0	40	
	%	97.5	2.5			100	
Dendegeb	Count	35	0	0	0	35	
	%	100				100	
Kurar	Count	31	0	1	3	35	
	%	88.5		2.85	8.57	100	

** , Significant at less than 5% level, Source: own survey (2011)

What do you say about the trend of precipitation over the last 20 years?

Table 13: perception about the trends of rainfall over the last 20 years

Kebeles		Increasing	Decreasing	Not changed	change in times of raining	Increase in frequency of drought	X ²
Dangule	Count	24	9	4	3	0	110.710** df=12 p = 0.000
	%	60	22.5	10	7.5		
Gedamawit	Count	0	27	0	5	8	
	%		67.5		12.5	20	
Dendegeb	Count	14	3	0	18	0	
	%	40	8.5		51.4		
Kurar	Count	0	21	2	12	0	
	%		60	5.7	34.2		

** , Significant at 1% level, Source: own survey (2011)



CHAPTER SIX

RESULTS AND DISCUSSIONS

As it is explained in the methodology, principal component analysis was run on the selected indicator variables. The number of principal components extracted can be defined by the user and common method used to select components where associated eigenvalue is greater than 1 (Vias and Kumaranayake, 2006).

To this research, 23 indicator variables were identified and processed into correlation matrix and a varimax orthogonal rotation with Kaiser normalization using principal component analysis. From the first iteration extraction three indicator variables were identified with extraction value less than 0.5 which is the minimum requirement of Kaiser and these three variables were rejected from further calculation. PCA was run again using 20 indicator variables and the communalities were found greater than 0.5 that suit with Kaiser Requirement. The KMO measure of overall sampling adequacy value is 0.7 which falls above the minimum requirement and Bartlett's test is highly significant ($p < 0.001$) therefore factor analysis is appropriate using the data (Field, 2005) (see annex II). The principal component analysis revealed six components with eigenvalue² of 1 or greater accounting for 62.147% of the total variance (Kaiser, 1960). Each observed variable contributes one unit of variance to the total variance in the data set. Any component that displays an eigenvalue greater than 1.00 is accounting for a greater amount of variance than had been contributed by one variable. Such a component is therefore accounting for a meaningful amount of variance, and is worthy of being retained. The first component has an eigenvalue of 4.553 and accounts for 22.765% of variance in the whole data followed by the second component with the eigenvalue of 3.276 and percentage of explanation of 16.378%. The analysis produced the component scores and the first component was used in weighting the variables for the construction of the vulnerability indices.

In the calculation of the indices, Indicators of adaptive capacity were positively attached with the PCA factor score those with negative factor score were rejected from further calculation. Whereas, indicators of exposure and sensitivity were also negatively attached with PCA, indicators with positive score were dropped from further calculation. Hence, for the construction of vulnerability indices indicators of adaptive capacity those are positively associated with the first PCA and indicators of exposure and sensitivity that are negatively

² An **eigenvalue** represents the amount of variance that is accounted for by a given component.

associated with the first PCA were selected. Higher vulnerability index show less vulnerability and vice versa.

6.1. Results of vulnerability Index

Once the factor score (weight of each indicator) was found and indicators of each determinants of vulnerability were normalized (see Appendix 1), the next step is calculating the vulnerability indices of each agro-ecology by using equation number four. Assuming that people with higher adaptive capacity are less sensitive to damages from climatic change and variability, keeping the level of exposure constant, indicators of adaptive capacity was attached positively where as sensitivity and exposure were attached negatively (equation one) (Deressa *et al.*, 2008).

The adaptive capacity indices of each *Kebele* was found using the indicator variable of adaptive capacity excluding the indicator variables of exposure and sensitivity as a result *Dangulie*, *Gedamawit* and *Kurar* were found with low adaptive capacity in relative terms. Whereas *Dendegeb* has better adaptive capacity with an index value of *Dangulie* -1.31, *Gedamawit* 0.25, *Dendegeb* 0.72, and *Kurar* -0.03.

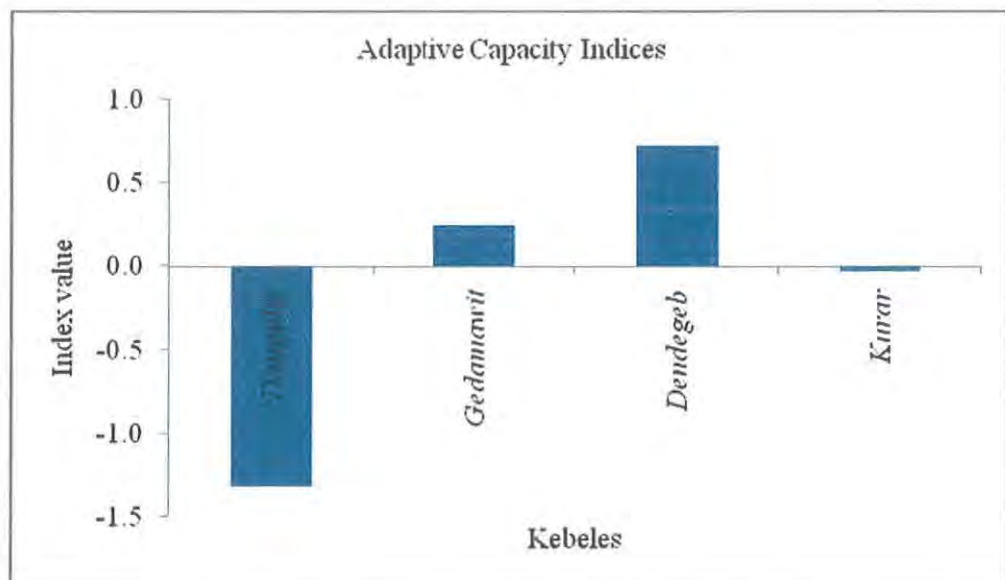


Figure 6: Indices of Adaptive capacity

Using equation Number 4, the vulnerability indices was made, with the assumption of *kebeles* with the highest vulnerability indices less vulnerable because the adaptive capacity that holds the largest indicator has attached with positive. As an example, the vulnerability index of

Dangulie (upper highland agro-ecology) calculated as follows and the same pattern was followed to calculate the vulnerability of other agro ecologies.

$$[(0.038*-0.019)+ (0.210*-1.473) + (0.123 *-1.063) + (0.076*-0.046) +(0.274*-1.191)+(0.288*-1.157)+(0.245*-1.073)+(0.129*0.483)]-[(0.024*-0.084)+(0.332*0.436)] = -1.46$$

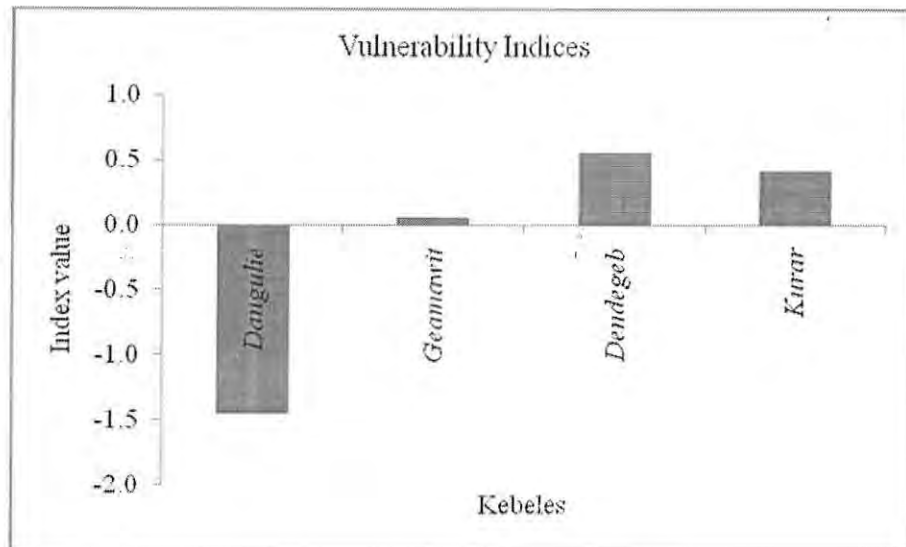


Figure 7: vulnerability Indices

Dangulie (upper high land) -1.46 *Gedamawit* (highland) 0.05, *Dendegeb* (midland) 0.56, and *Kurar* (lowland) 0.41.

To determine the vulnerability level of agroecologies the researcher has considered both the index value of vulnerability and adaptive capacity. The index value is simply to compare the vulnerability level of the area. According to the study, the vulnerability indices of each agro ecologically in Choke Mountain watershed revealed high vulnerability of *Dangulie* (upper high land agro-ecology) and *Gedamawit* (Highland agro-ecology) and *Kurar* (low land) vulnerable and *Dendegeb* (midland agro-ecology) less vulnerable in relative terms. Beside to the climatic factors the result revealed that, non-agricultural income, provision of agricultural technology (fertilizer, improved seed utilization), access to full cycle school, veterinary service, electric provision, telephone service, irrigation at household, slope of the farm land, socio-economic infrastructures and institutions particularly credit and saving institutions are linked with the vulnerability of farmers in Choke Mountain watershed.

6.2. Results of KI and FGD

Using FGD and KI checklists, farmers were asked questions about their perceptions of long term temperature and precipitation and what measures and practices they have typically opted for in order to cope with changes in climate and variability. According to the FGD, farmers argued that they are well aware of the information about climate change and variability using the information which has been broadcasted through radio and TV. In addition, agricultural extension workers and experts provided information about climate change.

Discussants perceived the long term temperatures are warming and precipitation is declining while, the raining time has been also shifting from they had known before 20 and 30 years ago. Farmers argued that, before 20 and 30 years the rainy season was regular and the soil was also fertile hence, there was no problem in productivity and fertility. But now they mentioned that they are facing shortage of rain fall in seeding time and heavy rain fall in harvesting time as a result productivity is declining from time to time.

Discussants in “*Dangulie*” added that as local indicator for the changing of temperature and rain fall before 10 and 15 years ago, the area was covered with fog and cloud. They were unable to see a clear sky and it was very cold. But now they can see a clear sky at all time and they feel warm. Moreover, in “*Dangulie*” eucalyptus tree and “*Gesho*” were not growing, these trees were grown in the lower part of the mountain now they are climbing to the “*ChoChe*” this is because the area feels warmer than before as the same time Potato was not growing in “*ChoChe*”³ now it is growing.

With respect to climate extremes, discussants in *Dangulie* (upper highland agro-ecology) reported as they hit more with drought (shortage of rain) and flood. During these extremes plants were dried, livestock’s were also died. Many people were migrated to the neighbouring towns. Due to low productivity there were farmers who had no grain in stock. Those who have resources which could be sold to buy food grain and those who had relatives were not severely affected by the extremes.

³ “*Choche*” means “very cold” in local language. The top of the mountain had been covered with ice and cloud and was very cold. The name of the mountain Choke is derived from the local naming very cold place “*ChoChe*”.

To diversify their income farmers have been using different strategies like introduction of different fruit that can be planted in the area, such as “*yedega* apple” “Barley for Brewery” “*Charplem*” were introduced. They have been also practicing different soil conservation practices like trench, drainage, stone bund, planting indigenous specious plants along steppe side of their farm.

Unlike to other *kebeles*, in *Dangulie*, there are two CBOs (Ambo watershed and *Chemoga* watershed) According to the discussants, these organizations were made with the aim of rehabilitating the watershed. To this end, they have been performing different activities such as, identifying the degraded areas and protecting from any livestock contact, preserving some indigenous plants and crop seeds by collecting from the olden people in the area. However, a great majority of farmers do not participate in the CBOs. The major reasons explained by the discussants for not participating in the CBOs were lack of awareness, and claim of the governance of the organizations.

According to the KI and FGD discussants, in *Gedamawit*, the climatic condition is not the same as they have known before. They perceived the temperature is increasing and the rainfall is shifting from its raining time. As local indicator farmers claim the change in fertility and these days have got warmer and the growing of crops that were not grown in their *Kebele*. For instance, maize hadn't been growing before but now it is growing. To reduce the soil acidity farmers have been using lime stone. Nevertheless, FGD discussants claimed the price of the lime is increasing and becoming unaffordable. They have been also practicing different strategies to reduce soil erosion like planting of trees along the farm, and stone bund.

Discussants in *Dendegeb kebele* perceived the long term temperature is increasing and the rainfall is declining. To diversify their means of income there were farmers who engaged in rearing of cattle, sheep and goat, poultry, and honey production by modern beehives by drawing credit from ACSI.

Discussants in *Dendegeb kebele* (midland agro-ecology) explained that they were hit with drought and erratic rainfall, during these extremes except some farmers, majority of farmers passed these times by themselves, they had grain at stock and selling their livestock and property. A KI in *Dendegeb kebele* told about the extreme which was happened in a near past.

“What was sever than the extreme, due to the crop failure resulted from erratic rainfall. We were unable to pay the money which we draw fertilizer in credit for the previous crop season before the extreme had happened, Despite we reported to the offices no one accepted and considered our problem because the extreme was only in our Kebele, other kebeles were not hit. Nevertheless, we were forced to pay selling our properties and livestock’s. Those who couldn’t pay selling their properties and livestock’s were confiscated their farm land and residential home. As a result, some household led migrated to other regions dissolving their family.”

This could justify that vulnerability assessment need to be grounded not only at *wereda* level but also at *Kebele and got* level considering the existence of differences in Agro-ecology.



Figure 8: Strategy to reduce erosion in Kurar kebele(stone bund)

In response to climate change farmers have been also employing different soil conservation strategies such as soil bund, check dam, trench at farm level. According to the discussants in *Kurar*, they have perceived the change in climate from their experience and using metrological information from agricultural experts. They perceived the long term temperatures are increasing and rain fall also shifting from its raining time that they had known before. As a local indicator they mentioned that they were producing *teff* (*Eragrostic teff*) without any problem now due to an increasing temperature *teff* (*Eragrostic teff*) productivity is declining to the lower part of the gorge and they have also shifted their seeding time of sorghum because of variability in raining time. To diversify their source of income farmers have been employing different strategies, they are producing fruit and vegetable in their homestead and by using irrigation near *Abay* River. They are also producing different cash crops like Sesame, sunflower, and nuge which were not produced extensively in the area.

Unlike to other *kebeles*, the existence of industries (cement and lime industries) in and around the *kebele*, enable farmers to engage in non-farm activities. The researcher has also observed different soil conservation practices through transact walk such as stone bund, cut of drain, and check dam in the area. With respect to climate extremes farmers argued that they were hit with land slide, erratic rain fall in different times and flooding was also the other extreme that washed their seedling several times. They mentioned that they were suffered a lot due to crop failure resulted from erratic rainfall in harvesting time. Due to land slide people were moved to other places and even it is a threat still now. There are also who are engaged in rearing of goat and sheep by drawing credit from ACSI.

According to FGD discussants in the Choke Mountain watershed drought, flood, erratic rainfall and land slide are some of the extremes that frequently appeared since in 1970s. However, the degree of severity and impacts in these agroecologies (*kebeles*) were explained differently from year to year and from place to place. Discussants argued that during these extreme times those who have resources which could be sold to buy grain and in a way to offset the problem and those who have relatives that had access to gift and remittance were less affected. Households without oxen and livestock, with large family size, those who did not have grain/cash reserves, elderly people, and female headed households were highly affected.

6.3. Discussion of the result

According to the study, the vulnerability indices of *Kebeles* in Choke Mountain watershed shows high vulnerability of *Dangulie* (upper high land agro-ecology) with low adaptive capacity and *Gedamawit* (Highland agro-ecology) and *Kurar* (lowland agro-ecology) vulnerable and *Dendegeb*(midland agro-ecology) less vulnerable in relative terms.

The higher vulnerability of *Dangulie* could be attributed to low economic status of the households resulted from multiple reasons, the reduction of land holding among HHs, declining of productivity in the area due to soil erosion and longevity of agriculture associated with the inaccessibility of agricultural technology and the absence of institutions and low provision of infrastructures in the area. In addition, in *Dangulie* due to the absence of non-farm job opportunities farmers are dependent on crop production and livestock rearing. The topography is also mountainous with rugged terrain that makes transportation and agriculture difficult in the area by making the area sensitivity to climate change. Frequency of drought and erratic rain fall also exacerbate the vulnerability of *Dangulie* in the watershed.

Land and livestock are the bases of the livelihood in the watershed, land on the other hand become scarce and land holdings per household have been declining because of the increasing population, and when we see the land holding of the sampled HHs in the watershed 30% of HHs in *Dangulie*, 22.5% HHs in *Gedamawit*, 88.5% of HHs in *Dendegeb* and 77% of HHs in *Kurar* possess land greater than the average (1hectar) with the a maximum possession of 3hectars. Which indicates large number of farmers in the watershed possesses less than the minimum requirement in contrary to the study made by the Ethiopian Economic Association (EEA) which showed “*if the existing level of productivity and price structure continue, the average grain producing farm household needs 2.8 hectares of land to satisfy the minimum food and non-food consumption requirement of its members and so lead a life above the poverty line, if reliant exclusively on farm related incomes*” (Senbeta, 2009).

Figure 9: Crop Cultivation on the steep side of the Mt.in Dangulie



Moreover, the productivity of crop lands has declined over time due to the conversion of crop land in to eucalyptus tree in the upper high land and high land agro-ecology. In addition drought, soil erosion, land slide, the variation inaccessibility and farmers inability to use agricultural technology in the watershed played a great role to the declining of productivity. The type of crops that are being produced also varies from place to place, determining the access to income of farmers.

Dendegeb (midland agro-ecology) is advantageous over other *kebeles* with the provision of fertilizer and other inputs to agriculture. The topography is almost plain, and it has also better access to institutions and infrastructure. However, to reduce the future impacts of climate related problems, there are no CBOs that are working on environmental protection activities, besides deforestation is still a problem.

Kurar (lowland agro-ecology) and *Gedamawit* (midland agro-ecologies) were found vulnerable. Relative to other *kebeles*, *Kurar* is also advantageous than others due the existence of lime and cement industries in the area provided non-farm job opportunity to farmers.

Provision of agricultural technology from the survey revealed that *Dangulie* with low utilization of chemical fertilizer whereas, in *Gedamawit* and *Dendegeb* all sampled population

and *Kurar* large number of HH respondents reported that they are accessing fertilizer and improved seeds.

Infrastructure and institutions also played a great role to the reduction of vulnerability by enhancing the adaptive capacity. The absence of permanent veterinary service in *Dangulie* can be taken as an attribute to the reduction of livestock, which in turn affect the adaptive capacity whereas in *Gedamawit*, *Dendegeb* and *Kurar* have access to veterinary service in their locality.

The existence of saving and credit institutions in local area played a great role in lowering the vulnerability level of farmers by enhancing the adaptive capacity providing finance. However, the accessibility of the service varies from place to place in the watershed. In *Dangulie* only 15% of HH respondents, 87.5% of HHs in *Gedamawit*, 85% of HHs in *Dendegeb* and 70% of HHs in *Kurar* reported as they have access to the service. FGD and KI discussants claimed the mechanism for accessing loans at present is not appropriate. It promotes land fragmentation through private tenure and the establishment structures, which required as collateral and they underlined that the mechanism access to credit need to be improved so that, poor farmers can access the service.

According to O'Brien *et al.*, (2004) districts with higher irrigation rates are expected to have higher capacity to adapt to climate challenges and other economic shocks. Despite the watershed is known as a source of many tributaries of Blue Nile, The HH survey revealed that irrigation potential is very low at HH level. HHs in *Gedamawit* and *Kurar* reported as they have irrigation potential. In *Dangulie* only 20 % and 5.7 % in *Dendegeb* of HH respondents reported with irrigation potential at HHs.

Fertility and slope of the farm land in the watershed also vary from place to place determining the sensitivity of farm households to climate change and variability by increasing or decreasing the level of productivity which in turn affect the adaptive capacity. HHs perception with fertile soil was considered as sensitive to climate change and slope of the farm land also assumed as a determinant of sensitivity. In addition, HHs whose farmland is in a steep slope was considered as sensitive because they are exposed to high erosion and landslide. From the sampled *Kebeles Dangulie* and *Gedamawit* were found highly sensitive to climate change and variability with low fertility, soil acidity and the farm land of most HHs is in steep slope in upper highland and highland agro-ecology. Landslide and low fertility were also problems in lowland agro-ecology. Despite *Dendegeb* was found as less vulnerable to climate change and variability, the agricultural expert explained that deforestation and gully erosion were some of the problems in the area and the researcher has also confirmed through transect walk.



Figure 10: Gully erosion in *Dendegeb*

According to FGD discussants, they perceived the long term temperatures are warming and precipitation is declining and shift in raining time from they had known before 20 and 30 years ago. From the sampled households in the watershed 77.5% of HHs in *Dangulie*, 85% of HHs in *Gedamawit*, 97% of HHs in *Dendegeb* and 88.5% of HHs in *Kurar* respondents claimed that today's climatic condition is not the same as the climatic condition before 20 years ago.

The statistical analysis of temperature in *Dangule*, *Gedamawit* and *Dendegeb* shows an increasing trend. It also goes in line with the perception of FGD discussants. Whereas, in *Kurar* the statistical result showed that the average temperature in declining trend (1.3°C 1983-2010) with maximum temperature is increasing and minimum temperature declining. However, FGD discussants perceived that long term temperature warming and this perception might be a result of simply viewing the maximum solar radiation of the day time. The decline trend could be connected with the impact of local determinants since *Kurar* is located in the *Abay* gorge and the temperature condition of the area could be determined by the local determinants such as valley breeze and mountain breeze.

In contrary, the gradual increasing in temperature from the low land to the upper high land will have a positive impact for the introduction of new crops that were not growing in the

area. According to the FGD discussants, in *Gedamawit* argued that due to an increasing temperature they are able to produce Maize in their locality which had not been growing before and this is consistent with the study by Kenney and Harrison (1992) that showed that temperature as the major constraint for the expansion of 'grain maize into higher altitude in Europe.

The rainfall pattern in Choke Mountain watershed is uni-modal with a peak in *kiremt* season from June to September. The rainfall analysis of (*Dangulie*) showed that 69.5% of the rainfall occurs during summer (*Kiremt*) season from June-September. The mean annual rainfall showed an increasing trend with a decreasing winter (*Bega*) season. From the total sampled respondents 60% HHs in *Dangulie* responded that they observed changes in rainfall at an increasing trend. The rain fall analysis of *Dendegeb* showed that 88.4% of the rainfall occurs during summer (*kiremt*) season from June-September and the mean annual rainfall shows increasing trend. The variability is also high in winter (*Bega*) season. 40% HH from *Dendegeb* responded that they observed changes in rainfall at an increasing trend. The rain fall analysis of *Kurar* depicted that 74% of the rainfall occurs during summer (*kiremt*) season. The mean annual rainfall showed an increasing trend, in line to this, 7.5% of HH respondents from *Kurar kebele* responded that as they observed changes in rainfall at an increasing trend. Whereas, 45%HH from *Kurar kebele* responded that they observed a change in rainfall at decreasing rate. FGD and KI discussants reported as they observed the amount of rain fall is in declining and seasonally shift from the trend before 15 and 20 years ago and they also added that as they faced with shortage of rain in seeding time and erratic/heavy rain during flowering time.

Comparing the variability of rainfall from the analysis, *Dendegeb* (midland agro-ecology) is found with high variability of rainfall followed by *Kurar* (low land agro-ecology). Hence, high variability rainfall associated with increasing temperature will have an implication of increased incidences of crop pests and malaria in the area. In consistent to this, agricultural expert in *Dendegeb* reported that in 2002/2003E.C cropping season the dominant crop "wheat" was hit with a fungus known as "*Chiklet spot*" this causes the reduction of productivity by half from the previous cropping season and this could be connected with high variability of rainfall.

CHAPTER SEVEN

CONCLUSION AND RECOMENDATION

Ethiopia is highly vulnerable to climate change because of its greater reliance on climate sensitive economic sectors like subsistence crop cultivation and livestock production. Moreover, the geographic location of large part of the country is in arid and semi arid climatic conditions making the country highly exposed to effects of desertification and drought (Aklilu and Alebachew, 2009).

This study attempted to analyse the vulnerability level of farmers in Choke Mountain watershed in four agro ecologies using an integrated vulnerability assessment approach (the biophysical and socio economic conditions).

In this study the IPCC definition of vulnerability is adopted. Vulnerability as a net result of exposure, sensitivity and adaptive capacity and indicators are also identified for each determinant. Adaptive capacity was represented by wealth, technology, infrastructure and institutions, access to information and irrigation potential. Sensitivity is represented by soil fertility and slop of the farmland while exposure is represented by changes in temperature and rainfall.

Vulnerability index is made by using the PCA. In calculating the vulnerability indices adaptive capacity was loaded positively, sensitivity and exposure are negatively loaded. Therefore, the higher net value implies the lesser vulnerability of the *kebeles*.

7.1. Conclusion

The analysis of vulnerability of farmers in Choke Mountain watershed has shown *Dangulie* (Upper high land agro-ecology) more vulnerable, *Gedamawit* (highland) and *Kurar* (lowland) vulnerable and *Dendegeb* (midland) less vulnerable to climate change. This is explained by the greater exposure to climate extremes such as drought, erratic rainfall and flood and change in the mean condition of temperature and the sensitivity of the biophysical condition such as slop and fertility of the soil as well as low level of economic status, low level of infrastructure development and absence of institutions.

The far reaching stressors that are enhancing the vulnerability of farmers in *Dangulie* (Upper highland agro-ecology) are land scarcity and unemployment, unaffordability and unavailability of agricultural inputs, the absence of infrastructures and institutions.

This analysis emphasizes that vulnerability of farmers in Choke Mountain watershed is not only a result of climate stressors (Climate change, variability and climate extremes). Non climatic factors also determine the vulnerability levels of farmers in Choke Mountain watershed. The study revealed that non-agricultural income, provision of agricultural technology (fertilizer, improved seed utilization), access to full cycle school, veterinary service, electric provision, telephone service, irrigation at household level, slope of the farm land, socio economic infrastructures and institutions (particularly credit and saving institutions) and land ownership are linked with the vulnerability of farmers in Choke Mountain watershed.

In conclusion, the increase in the exposure to climatic change and variability, high sensitivity of the environment coupled with low adaptive capacity which is a result of lack of financial institutions and poor agricultural practices could exacerbate the vulnerability of the watershed in the future.

7.2. Recommendations

- ❖ Though, all agro-ecologies are vulnerable to climate change and variability, the upper highland agro-ecology was found to be the most vulnerable agro-ecology in comparison to the other agro-ecologies. Therefore, there is a need for immediate intervention in the upper high land areas.
- ❖ Due to population pressure land fragmentation is becoming a serious problem in the watershed. Large numbers of the working group (in the upper highland) still remain land less earning their income from the sale of fire woods which in turn increases deforestation in the area. Therefore, to avert the pressure on the land and to absorb these who are in working age there is a need to create job opportunities in the watershed.
- ❖ To enhance the adaptive capacity of farmers and prepare them to future climate change impact they should have equal access to saving and credit services in their locality. The present mechanisms to get credit need to be revised to suit the needs of the farmers as it promotes land fragmentation which is often required as collateral.

- ❖ To reduce the impacts of future climate change and variability there should be good governance of natural resources in a sustainable manner preserving the indigenous flora and fauna and rehabilitating the degraded area. Farmers should also take the leading role in the management.
- ❖ To reduce climate related risks that affect farmers, crop insurance should be established so that farmers can withstand these risks.
- ❖ To provide farmers with relevant information about the change in climate and variability at the local level there is a need to establish metrological stations so that farmers could get the information in their locality and they can design relevant strategies.
- ❖ To increase the adaptive capacity of farmers there is a need to produce an opportunity for non-farm job opportunities in the local areas. Taking an intervention action aiming to promote investment and development of infrastructure and services.
- ❖ Addressing vulnerable households through development of better proxy indicators of vulnerability at household level is an important need for further research.

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Appendices

Appendix 1: Normalized value of the indicator variables

Table 1: Normalized value of Wealth Indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Quality of House</i>	-0.521	0.080	0.295	0.209
<i>Non Agri. Income</i>	-0.019	0.546	-0.948	0.345
<i>Saving of HHs</i>	-0.350	0.216	0.018	0.135
<i>Land size of the HHs</i>	-0.454	-0.604	0.719	0.490
<i>Number of Oxen</i>	0.222	0.287	-0.841	0.259

Source: own survey (2011)

Table 2: Normalized value of Technology Indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Agricultural Technology</i>	0.246	0.246	-0.089	-0.885
<i>Fertilizer</i>	-1.473	0.546	0.592	0.468
<i>Improved Seed Supply</i>	-1.063	0.345	0.784	0.036
<i>Irrigation</i>	0.483	-0.776	0.771	-0.074

Source: own survey (2011)

Table 3: Normalized value of Infrastructure and Institution Indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Weather road</i>	-0.228	-0.733	0.549	0.549
<i>Health Centres</i>	-0.532	-0.263	1.324	-0.416
<i>Full cycle school</i>	-0.046	0.093	-0.027	-0.027
<i>Veterinary</i>	-1.191	0.396	0.747	0.162
<i>Market Access</i>	-0.004	0.062	0.156	-0.221
<i>Credit and Saving</i>	-1.157	0.406	0.614	0.244

<i>Access to Electric</i>	0.624	0.290	0.178	-1.222
<i>Access to Telephone</i>	-1.073	0.333	0.631	0.214

Source: own survey (2011)

Table 4: Normalized value of Access to Information indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Sex of the HH led</i>	-0.234	-0.033	0.153	0.153
<i>Radio Ownership</i>	-0.316	0.110	0.453	-0.27

Source: own survey (2011)

Table 5: Normalized value of Sensitivity and Exposure indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Fertility of the farm land</i>	-0.074	0.332	-1.075	0.781
<i>Slop of the farm land</i>	-0.084	-0.243	1.031	-0.657
<i>Rainfall</i>	-0.375	-0.375	5.724	-0.375
<i>Temperature</i>	0.436	0.526	0.536	-1.733

Source: own survey (2011)

Appendix 2 Principal Component Analysis result

2.1. 1stCommunalities

	Initial	Extraction
Number of Ox	1.000	.515
Quality of House	1.000	.620
Non Agricultural income	1.000	.503
Saving in HHs	1.000	.651
Improved Agricultural Technology	1.000	.532
Fertilizer Utilization	1.000	.711
Improved seed utilization	1.000	.702
Weather road availability	1.000	.591
Accessibility Of Health station	1.000	.644
Accessibility Of Schools	1.000	.714
Accessibility Veterinary	1.000	.763
Accessibility of Credit and saving Institution	1.000	.777
Accessibility of Electric	1.000	.675
Accessibility of Telephone	1.000	.704
Sex of the HH	1.000	.504
Irrigation Availability	1.000	.594
Fertility of the HH land	1.000	.618
Slop of the HH land	1.000	.582
Temperature of KK	1.000	.792
Rainfall of the KK	1.000	.878
Farm Size	1.000	.475
Accessibility of Market	1.000	.488
Radio ownership	1.000	.466

Extraction Method: Principal Component Analysis.

<i>Access to Electric</i>	0.624	0.290	0.178	-1.222
<i>Access to Telephone</i>	-1.073	0.333	0.631	0.214

Source: own survey (2011)

Table 4: Normalized value of Access to Information indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Sex of the HH led</i>	-0.234	-0.033	0.153	0.153
<i>Radio Ownership</i>	-0.316	0.110	0.453	-0.27

Source: own survey (2011)

Table 5: Normalized value of Sensitivity and Exposure indicators

<i>Indicators</i>	<i>Dangulie</i>	<i>Gedamawit</i>	<i>Dendegeb</i>	<i>Kurar</i>
<i>Fertility of the farm land</i>	-0.074	0.332	-1.075	0.781
<i>Slop of the farm land</i>	-0.084	-0.243	1.031	-0.657
<i>Rainfall</i>	-0.375	-0.375	5.724	-0.375
<i>Temperature</i>	0.436	0.526	0.536	-1.733

Source: own survey (2011)

Appendix 2 Principal Component Analysis result

2.1. 1st Communalities

	Initial	Extraction
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Weather road availability	1.000	.591
Accessibility Of Health station	1.000	.644
Accessibility Of Schools	1.000	.714
Accessibility Veterinary	1.000	.763
Accessibility of Credit and saving Institution	1.000	.777
Accessibility of Electric	1.000	.675
Accessibility of Telephone	1.000	.704
Sex of the HH	1.000	.504
Irrigation Availability	1.000	.594
Fertility of the HH land	1.000	.618
Slop of the HH land	1.000	.582
Temperature of KK	1.000	.792
Rainfall of the KK	1.000	.878
Farm Size	1.000	.475
Accessibility of Market	1.000	.488
Radio ownership	1.000	.466

Extraction Method: Principal Component Analysis.

2.2. 2nd Communalities

	Initial	Extraction
Number of Ox	1.000	.514
Quality of House	1.000	.651
Non Agricultural income	1.000	.509
Saving in HHs	1.000	.666
Improved Agricultural Technology	1.000	.650
Fertilizer Utilization	1.000	.728
Improved seed utilization	1.000	.678
Weather road availability	1.000	.573
Accessibility Of Health station	1.000	.667
Accessibility Of Schools	1.000	.821
Accessibility Veterinary	1.000	.785
Accessibility of Credit and saving Institution	1.000	.787
Accessibility of Electric	1.000	.686
Accessibility of Telephone	1.000	.675
Sex of the HH	1.000	.632
Irrigation Availability	1.000	.600
Fertility of the HH land	1.000	.621
Slop of the HH land	1.000	.616
Temperature of KK	1.000	.783
Rainfall of the KK	1.000	.861

Extraction Method: Principal Component Analysis.

2.3. KMO and Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.734
Bartlett's Test of Sphericity	Approx. Chi-Square	1242.376
	Df	190
	Sig.	.000

2.4.Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.553	22.765	22.765	4.553	22.765	22.765	3.728	18.638	18.638
2	3.276	16.378	39.144	3.276	16.378	39.144	3.122	15.609	34.248
3	1.866	9.330	48.474	1.866	9.330	48.474	2.418	12.091	46.338
4	1.487	7.435	55.909	1.487	7.435	55.909	1.501	7.504	53.843
5	1.248	6.238	62.147	1.248	6.238	62.147	1.482	7.412	61.254
6	1.073	5.367	67.514	1.073	5.367	67.514	1.252	6.260	67.514
7	.867	4.337	71.851						
8	.777	3.887	75.738						
9	.729	3.647	79.384						
10	.691	3.453	82.838						
11	.592	2.961	85.799						
12	.508	2.542	88.341						
13	.472	2.358	90.699						
14	.433	2.167	92.866						
15	.355	1.776	94.643						
16	.283	1.416	96.059						
17	.248	1.241	97.299						
18	.227	1.135	98.434						
19	.190	.948	99.383						
20	.123	.617	100.000						

Extraction Method: Principal Component Analysis.

2.5. Component Matrix (a)

	Component					
	1	2	3	4	5	6
Number of Oxen	.334	-.465	-.136	-.289	.222	-.187
Quality of House	.366	.157		-.254	.651	
Non Agricultural income	-.299	.569	.297			
Saving in HHs	.194	.260	.106	.206	-.340	.626
Improved Agricultural Technology	.330	.360	-.499	.223		.324
Fertilizer Utilization	.784	.261	.181			-.109
Improved seed utilization	.649		.387	-.290	.113	.102
Weather road availability	.346		-.642	-.130	-.141	
Accessibility Of Health station	-.415	.397		.497	.271	.125
Accessibility Of Schools				.677	.545	-.223
Accessibility Veterinary	.790		.304	.199		-.109
Accessibility of Credit and saving Institution	.747	.174	.178	.326	-.162	-.186
Accessibility of Electric	.395	.589	-.380		-.110	-.134
Accessibility of Telephone	.743	.175	.187	.185	-.114	
Sex of the HH	.181	.150	.178	-.273	.426	.538
Irrigation Availability		.559	.492	-.181		
Fertility of the HH land	.224	-.702		.237		.136
Slop of the HH land	-.344	.622		-.252		-.216
Temperature of KK	-.163	-.716	.478	.108		
Rainfall of the KK	.787	-.372	-.290			.104

Extraction Method: Principal Component Analysis.
a. 6 components extracted.

2.6. Rotated Component Matrix(a)

	Component					
	1	2	3	4	5	6
Number of Oxen	.101	.478		.197	-.175	-.454
Quality of House	.205		.139	.696	.136	-.293
Non Agricultural income		-.666				.227
Saving in HHs	.189					.781
Improved Agricultural Technology	.104	.113	.652	.163	.259	.328
Fertilizer Utilization	.794		.210	.215		
Improved seed utilization	.592		-.100	.477	-.287	
Weather road availability		.296	.674		-.151	
Accessibility Of Health station	-.247	-.368			.637	.254
Accessibility Of Schools	.145	.130			.869	-.167
Accessibility Veterinary	.875	.102				
Accessibility of Credit and saving Institution	.860		.127		.112	
Accessibility of Electric	.319	-.239	.724			
Accessibility of Telephone	.803		.133			
Sex of the HH				.761		.221
Irrigation Availability	.263	-.693	-.117	.138	-.126	
Fertility of the HH land		.708	-.311			
Slop of the HH land	-.193	-.701	.253			-.142
Temperature of KK		.373	-.794			
Rainfall of the KK	.439	.705	.299	.201	-.194	

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

2.7. Component Score Coefficient Matrix

	Component					
	1	2	3	4	5	6
Number of Oxen	-.014	.111	.025	.113	-.059	-.318
Quality of House	-.028	-.025	.019	.481	.149	-.236
Non Agricultural income	.038	-.211	-.068	.009	.021	.118
Saving in HHs	-.002	.060	.006	.056	-.098	.654
Improved Agricultural Technology	-.075	.122	.276	.118	.164	.266
Fertilizer Utilization	.216	-.062	.011	.026	-.025	-.063
Improved seed utilization	.123	-.031	-.110	.261	-.150	-.008
Weather road availability	-.068	.126	.327	-.081	-.106	-.013
Accessibility Of Health station	-.046	-.052	-.014	.064	.404	.153
Accessibility Of Schools	.076	.062	-.025	.024	.632	-.186
Accessibility Veterinary	.274	-.024	-.080	-.073	.050	.011
Accessibility of Credit and saving Institution	.288	-.025	-.024	-.199	.099	.007
Accessibility of Electric	.057	-.077	.288	-.092	-.050	-.073
Accessibility of Telephone	.245	-.024	-.019	-.094	.036	.026
Sex of the HH	-.129	.027	-.035	.586	-.010	.228
Irrigation Availability	.129	-.276	-.120	.046	-.108	-.044
Fertility of the HH land	.016	.237	-.112	-.047	.052	.135
Slop of the HH land	-.024	-.241	.101	-.026	-.077	-.188
Temperature of KK	-.332	.090	.036	-.009	-.009	.054
Rainfall of the KK	.029	.223	.131	.080	-.078	.014

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
 Component Scores.

Appendix 3: Questionnaires

Household Survey for Climate Change Vulnerability

PART I. General information

1. Woreda _____ Potential status of the Woreda _____
 Kebele _____ Village _____ Household ID _____

2. Household characteristics

2.1 Household head's Age _____

2.2 Household head's Gender a) Female b) Male

2.3 Marital status 1 = married 2= never married 3 = divorced 4= widowed 5= separated

2.4 Household head's education level (refer to the alternatives in question number 2.5) _____

2.5 No. of household members

Age category	Sex (in number)		Level of education ^a	Occupation(see code) ^b	
	Male	Female		Main	Secondary
≤ 14 years					
Between 14 and 65 year					
≥ 65 years					

a-Educational status 1. Illiterate 2=Read and write 3= Primary level 4=Secondary level 5= Tertiary

b-Major occupation 1=crop production 2=livestock rearing 3= Mixed farming 4= government employee 5.other, specify _____

2.6 In what type of house do you live?

1. Corrugated 2. Non-corrugated 3. Other(specify) _____

III. Wealth, Economic Activities, and Household Income

1. In what type of house do you live?

2. Corrugated 2. Non-corrugated 3. Other(specify) _____

2. Do you own land? 1. Yes 2. No

3. If your answer to the above question is yes, how much in ha is

1. the cultivated area: _____.

2. grass and woodland: _____.

3. parcels/homestead: _____.

4. What type of agriculture do you practice? 1. Rain-fed 2. Irrigated 3. Mixed

5. If you have the seed and food stocks, indicate the type, amount and use of seed and food stock you accumulated in the following table(2009/2010 production season)

6. How do you see the trend of seed or food supply stock in your household for last 10 years?
 1. Increasing 2. Decreasing. 3. No change 4. I don't know

7. Do you rare animals? 1. Yes 2. No

8. If your answer is yes to question no 7 , indicate the type, number/ size/ and use of the animal you owned in the following table

No	Type	Number(Size)	Use
1	Oxen		
2	Cow		
3	Heifer		
4	Bull		
5	Calves		
6	Goat		
7	Sheep		
8	Donkey		
9	Mule		
10	Horse		
11	Bee colony		
12	Poultry		
	Other		

9. How do you see the trend of livestock ownership in your household for last 10 years?

1. Increasing 2. Decreasing 3. No change 4. I don't know

10. Would you tell your household source of cash income and its amount (in Birr)?

Major Area	Source and Amount of Cash		
	Types of Activities	Yes	No
<i>Farm Activity</i>	Selling of crop productions		
	Selling of livestock and their products		
	Selling of fruits, roots and vegetables		
<i>Off-farm Activity</i>	Labour wage		
	Engaging in fetching water		
	Selling of fuel woods		
	Selling of grasses		
	Selling of timbers and wooden poles		
<i>Non-farm activity</i>	Mat, basket and spinning		
	Bamboo work		
	Weaving		
	Tannery		
	Blacksmithing		
	<i>Tela and Areki</i>		
	Cooking egg, <i>kolo</i> and <i>kita</i>		
	Food aid		
	Food-for-work		
	Grain and livestock		
	Consumer goods (salt, soap, kerosene, etc)		
	Remittance		
	Other(specify)		
Total / year			

11. How do you see the trend of average income level in your household for last 10 years?

1. Increasing 2. Decreasing. 3. No change 4. I don't know

12. Do you save money? 1. Yes 2. No. If yes,

13. How much do you save? _____ birr/year

14. If you save money, where do you save it? 1. Home 2. Bank 3. Friends or families 4. Other (specify)?

15. With this total capital, in which socio-economic group do you put yourself? 1. Rich 2. Medium 3. Poor
16. What mechanism do you follow to accumulate your wealth?
 1. Purchase of livestock
 2. Petty trade
 3. Save in money
 4. Built rental houses in urban areas
 5. Other (specify)? _____

IV. Technology

17. What power do you use for farming? 1. Family labor 2. Shared labor 3. Animal traction 4. Tractor 5. other(specify)---
18. Do you have access to farm machineries and tools? 1. Yes 2. No.
19. If yes, where do you access them?
20. Do you have access to improved seed supply? 1. Yes 2. No
21. Do you use improved seeds? 1. Yes 2. No
22. If no, why?
 1. It is expensive
 2. Lack of regular supply
 3. Lack of awareness
 4. Other (specify)? _____
23. Do you have access to agrichemicals? 1. Yes 2. No. How far do travel to access them? _____ kms/hrs
24. Do you use fertilizer? 1. Yes 2. No.
25. If yes, on average how much kg/ha per year do you use _____
26. If no, why? 1. Lack of access 2. Expensive 3. Lack of awareness 4. Other (specify)? _____
27. Do you use insecticide and pesticides whenever necessary? 1. Yes 2. No.
28. If you say yes how much ml/ha per year do you use _____
29. If you say no, why? 1. No supply 2. Expensive 3. Lack of awareness 4. Other (specify)? _____
30. Do you have access to irrigation schemes? 1. Yes 2. No
31. If yes, how much lands do you irrigated?
 - (1) ½ timade
 - (2) 1 timade
 - (3) 1.5 timade
 - (4) 2 timade
 - (5) above 2 timade
32. For what purpose do you use it?
 1. To grow cash crops
 2. To water livestock
 3. To grow forage
 4. To supplement water scarcity
 5. Other (specify)
33. If your answer to question 38 is yes, on average how much litter of water do you use per annum? _____

II. Institution and Infrastructure

34. Do you have agricultural extension services in your area? 1. Yes 2. No
35. Do you think the agricultural extension service help you to improve your productivity? 1. Yes 2. No.
36. Do you have access to information? 1. Yes 2. No. If your answer is yes, identify your source(S)?
 1. Radio
 2. TV
 3. journal/newspaper
 4. extension agents
 5. Neighborhood
 6. Other (specify)----
37. Do you possess radio? 1. Yes 2. No
38. Have you ever heard climate related information in any one of the above source(s) listed in Q-3?
 1. Yes
 2. No
39. Have you ever used important climate information for production decisions? 1. Yes 2. No
40. Do you have access to credit Service? 1. Yes 2. No?
41. Do you use the credit? 1. Yes 2. No.
42. If your answer to question no 10 is yes, for what purpose do you draw money?
 1. Consumption
 2. Medication
 3. Petty trading
 4. Fattening of animals
 5. Education expense
 6. To buy agricultural inputs
 7. Other(specify)___
43. If your answer to question no 10 is no, why don't use the service?
 1. Difficult criteria
 2. I don't want
 3. Other(specify)_____
44. Do you have market access nearby? 1. Yes 2. No
45. If your answer is yes, how far is it? _____ KM (Hrs)(approximately) 1. 1-4kms. 2. 4 and above
46. How frequently do you go to market?
 1. At least once in a week
 2. Once in 15 days
 3. Once in a month
 4. Once in 3 months
 5. Occasionally.
47. Do you have weathered-roads of vehicle that connect you with nearby neighbors' towns or cities? 1. Yes, always usable 2. Yes, sometimes usable 3. No road.
48. Are the roads ok to use in rainy seasons? 1. Yes 2. No.
49. Do you have health posts at your village? 1. Yes 2. No.
50. How far from your residence? _____ km (hrs). 1. 1-4kms. 2. 4 and above
51. Do you have veterinary service in your kebeles? 1. Yes 2. No.
52. How far from your kebele? _____ kms(hrs). 1. 1-4kms. 2. 4 and above

53. Do you take your animals to veterinary service when you feel they are sick? 1. Yes 2. No.
54. Do you have education centers at your village? 1. Yes 2. No.
55. how far from your residence?----KM (Hrs). 1. 1-4kms. 2. 4 and above
56. Do you send your children to school? 1. Yes 2. No.
57. If no, why? _____
58. Do you have access to telephone service? 1. Yes 2. No
59. If yes, what kind of service? 1. Fixed line (home) 2. Fixed line (tele centers) 3. Wireless services
4. Other(specify) _____
60. Is there electric services in your village? 1.yes 2.No
61. If your answer to the above question is yes, what is the source of the power?
1.water 2.sun 3.bio fuel 4.wind 5.other(specify)-----
62. Do you have saving institutes nearby? 1. Yes, 2. No.
63. How far do you travel to get to the nearest saving institution? _____KM (Hrs). 1. 1-4kms. 2. 4 and above
64. Do you own land holding certificate? 1.Yes 2.No
65. If yes, do you feel secure in your land holding?

VII. Assessment of climate change and variability and Corresponding Impacts

66. Is today's weather the same as the weather conditions that were 20 years from now?
1. Yes 2. No
67. What do you say about the trend of hot days over the last 20 years?
1. Increase 2. No change 3. Decreased 4.the same, but with altered climatic range
5. I don't know 6. Other (specify) -----
68. Which local indicators do you use to evaluate the temperature trend in the area? (Please support your choice with example)
1. Prevalence of human and animal diseases that are not familiar to the area(malaria etc)
2. Introduction of plant and animal species that were not popular in the area(goat in highland not common)
3. Observation of physical structures and societal clothing styles (disappearance of ice cover in mountain peaks, frost damage become uncommon, dry up of rivers , streams, lakes, dressing light cloths etc)
4. Habitat shift towards higher locations
5. Other(specify)
69. What do you say about the trend of precipitation over the last 20 years?
1. Increased 2. Not changed 3. Decreased 4.change in times of raining
5. Increase in frequency of drought 6. I don't know 7.Other(specify)
70. Which local indicator do you use to evaluate today's rainfall pattern?
1. Loss of some plant and animal species
2. Increased drought and flood frequency
3. Growing period shortened
4. Rainfall come early or lately
5. Decline of soil productivity/fertility
6. Decline of agriculture yields
7. Decreased available water
8. Other(specify)
71. Have you encountered any climate related disasters after 1970 E.C?* 1. Yes 2. N

Checklists to Guide Key Informant Interviews:

Address (location) of the village: _____

I. Elderly Groups from the Community

1. How long have you been here?
2. How do you characterize the weather of this area in terms of its temperature and precipitation? Have you observed any change in temperature or rain fall?
2. If you perceived the change in climate, what is your local indicator?
3. Do you farm on the same farm where your father or fort father was farming?
4. If your question to the above question is no, where is your farming land now? And why you shift to the area you are farming now?

5. Do the crops you cultivate now the same with the crops your father or fort father was growing? If no, why you change the crops?
6. In your life, What climate hazards have you seen or have you heard from your family?(erratic rain, drought, flood)
7. If you say yes what climate related impact did you observe (heard)? Crop/livestock
8. How did you or your father pass the time? What coping mechanisms did you use?
Selling of property or livestock?
9. Do you observe any shift in crop season? If you say yes explain how?
10. What was the role of informal institution? Edir , maheber
11. What change do you observe in forest coverage?
12. What change do you observe river, aquifers
13. Who do you think is most harmed by the event? Why?
14. How did the government, GOs and NGO's respond to reduce the impact?
15. What the government or the community should do to avert the impact of climate change in the area?

II. Agriculture and Rural Development Office Officials, Development Agents and Other Experts

1. Name _____ Position _____
2. What is the agro-ecology of your district/kebele(s)? altitude _____ latitude _____ mean annual rainfall _____ mean annual temperature _____
3. Is there any form of Climate change in your district or Kebele(s)?
4. Is there any Change rainfall pattern from what had known in the wereda?
5. What change have you observed in temperature?
6. How these changes affect the productivity of farmers?
7. Do you think that there is a shift in cropping calendar? How?
9. What changes have you observed in crop type? Do you observe crops and livestock's that were not familiar in the area?
9. If your answer to question 6 is yes, would you explain the measures taken so far to minimize the risks?
10. Which group do you think is more affected? Why

III. Focus Group Discussion

Guiding question

1. Have you heard about climate change and variability?
2. Who did tell you? Have you heard from Radio? Or from extension workers or development agents?
3. Do you think the weather condition is changing? If you say yes how? Explain
4. With out having instrument to measure the change how do you explain by local indicators?
5. Do you observe a change in the rain fall pattern and temperature condition? Which one is increasing?
or Decreasing
5. Have you observed any climate extremes (floods and drought) in your locality? How many times occurred since 10 years ago?
7. How these climate extremes affect your productivity? Your livelihood? Your livestock's? Explain
8. How climate changes affect the soil fertility?
9. Do you observe any shift in cropping calendar?

10. Have you started planting new plants or crops that you hadn't cultivate before?
11. How did you adapt the when the rain varies from its raining season?
12. Do you access fertilizer? Do all of you have equal right to purchase regardless of you purchasing ability? If you say no why
13. Do you access Varsity seeds? Do all of you have equal access?
14. What adaptive mechanisms did you use?
15. Who are the most affected in the society? Male headed households? Female headed households? How they affected by the change? Any other _____
18. Are there micro finances that you can draw money to purchase agricultural technology?
19. Do you get extension service in your kebele?
20. What services do you get from extension workers? Explain...
21. What measures have been taken by GOs or NGOs so far?



Declaration

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

Declared by:



Daniel Desalegn

Candidate

Confirmed by



Advisor

