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Vulnerability and Adaptation Strategies of Rural Communities to Climate Change: The Case of Kola Tembien *Woreda*, Tigray Region

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List of Acronyms

ADF	African development forum
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHG	Green House Gas
HH	House Holds
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
KMO	Kaiser-Meyer-Olkin
KTWARDB	Kola Tembien Woreda Agricultural and Rural Development Bureau
KTWFB	Kola Tembien Woreda finance bureau
PCA	Principal Component Analysis
PECCN	Poverty, Environment and Climate Change Network
SERA	Strengthening Emergency Response Abilities
SWC	Soil and Water Conservation
UNDP	United Nation Development program
UNFCCC	United Nations frame work convention on climate change
WFP	World Food Program

Abstract

Vulnerability and Adaptation Strategies of Rural Communities to Climate Change: The Case of Kola Tembien *Woreda*, Tigray Region

Esie Gebrewahd

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Ethiopia, like many other countries in Africa, is highly vulnerable to the harmful effects of climate change and the rural population, for whom agriculture is the primary source of food, direct and/or indirect employment and income, will be most affected due to agriculture's vulnerability to climate change. This study was conducted to assess local/agro ecology level vulnerabilities and adaptation strategies of rural communities to climate change in Kola Tembien Woreda, Tigray region. The specific objectives of the research are analyzing the level of vulnerability across different communities in different agro ecologies, identifying the major adaptation strategies employed against the changing climate and the major factors influencing their strategies to adapt to climate change impacts. A stratified sampling was employed to determine the sample villages. Accordingly, four kebeles, namely Begashka, Tabotegiorgis, Limat and Menji were selected from two agro ecological zones. Sample household respondents were then selected randomly from each development group found in their respective kebeles. Household survey, focus group discussions and key informant interviews were employed. An indicator based vulnerability index was used to assess and compare the level of vulnerability across the selected kebeles and agro ecological zones. Besides, descriptive statistics was used to identify the major adaptation strategies as well as major factors influencing the adaptation of rural communities. Results obtained from the vulnerability index revealed that there was a difference in the vulnerability levels of the selected kebeles. Accordingly, Menji (low land agro-ecology) and Begashka (Mid land agro-ecology) were found to be relatively more vulnerable than Limat (low land agro-ecology) and Tabotegiorgis (Mid land agro-ecology). The difference in vulnerability was highly associated with the variations in the combined effects of livestock ownership, saving, access to microfinance, farm land sizes, irrigation potential, and education levels across the surveyed households. Adaptation strategies were found to be similar across the surveyed kebeles (agro ecologies) and various crops, livestock and land related strategies has been used across varied periods. However, households' choice of adaptation strategies were found to be influenced by financial constraints, shortage of information, poor potential for irrigation, land shortages and even lack of labor. Therefore, efforts should be made by the local government and NGOs to promote the off-farm income-earning opportunities and local/farm-level adaptation strategies by giving due attention to the early warning systems and disaster risk management to reduce vulnerability and improve income levels.

Key words: vulnerability, principal component analysis, adaptation strategies

CHAPTER 1

1. Introduction

1.1. Back ground of the study

People all over the world are being confronted with the reality of climate change. For some, climate change is simply a matter of changes in weather patterns. For others, it is already a matter of survival. However, the real injustice of climate change is that those who have contributed least to its causes are suffering most from its effects (PECCN, 2011). The development and wellbeing of humans is threatening by climate change through bringing changes to hydrological cycles and rain regimes, temperature increase, and worsening severity of extreme climate events. Therefore, humans in general will be increasingly subject to ever greater risk and vulnerability as climate change damages humans' means of subsistence, health and security (UNDP, 2009). As per the reports of WFP and OXFAM America (2012), 1.3 billion people in the world are vulnerable to the impacts of climate change. Weather and other climate-related shocks become a constant threat to their food security and wellbeing due to the fact that they earn less than dollar a day and depend on agriculture as a means of their livelihoods.

Certain regions of the world are more severely affected by the effects of climate change than others. It is generally agreed, however, that economically developing countries and the poorest people in those countries are likely to be hit hardest by climate change, and their capacity to respond to climate change is low (Olmos, 2001; Charles *et al*, 2011). Hence, vulnerability to climate change seems closely related to poverty, as the poor are least able to respond to climatic stimuli.

Of all developing regions, Africa (and in particular sub-Saharan Africa) is likely to be the worst affected by present-day climate variability and future climate change because of their low resilience and limited adaptive capacity resulted from widespread poverty, an extensive disease burden and pockets of political instability across the continent (Charles *et al*, 2011). In its Fourth assessment report, IPCC also indicated that ''Africa is one of the most vulnerable continents to climate change and climate variability,'' (2007a, p. 435) and that by the 2050s, 350–600 million

Africans will be at risk for increased water stress, predominately in the northern and southern parts of the continent.

Ethiopia is highly vulnerable to the harmful effects of climate extremes primarily drought and flood. Drought occurs anywhere in the world but its damage is not as severe as in Africa in general and in Ethiopia in particular (NMA, 2007). The country has been highly vulnerable to climate variability and changes because large segments of its population are poor, have low adaptive capacity, dependent on income opportunities that are highly sensitive to the weather, and have low access to education, information, technology, and health services (Senait *et al.*, 2010).

The agricultural sector in Ethiopia is especially vulnerable to the adversities of weather and climate due to the sectors dependence on rain fed and done using relatively basic technologies on tiny plots of land (Senait *et al.*, 2010). Therefore, Ethiopian farmers are highly vulnerable to climate change impacts because of their dependence on rain-fed agriculture and high poverty (Temesgen, 2010). The economy of the nation depends on agriculture and the agricultural sector in turn depends on climatic condition, especially rainfall so that the macro economic performance of the country follows rain fall patterns. Hence, rainfall condition and economic performance of the nation are directly related.

In many developing countries, vulnerabilities and adaptations to the impacts of climate change are gaining due attention due to the fact that mankind cannot avoid some negative impacts of climate change, regardless of the next steps being taken to reduce global green house gas emissions (IPCC, 2001; Olmos, 2001; Makoka and Kaplan, 2005). In the last decade, adaptation to climate change has attracted wide attention and has been highlighted as an urgent priority among many developing countries (UNFCC, 2007). Effective and equitable adaptation requires an understanding of the dynamics of vulnerability (PECCN, 2011). Adaptation strategies for climate change on the other hand will be more effective if made with a participatory decision-making process which involves levels of vulnerability, resilience and autonomy of men and women when confronted with different threats (UNDP, 2009). Besides, different literatures further indicated that adaptation is place-based and requires place-specific strategies. Therefore, due to the contextual variations of climatic elements, effects of climate change along with its degree of vulnerability and adaptation strategies varies across different nations, regions, localities as well as communities and even households. Rural communities in Kola Tembien *Woreda* are being confronted with the reality of climate change impacts. Though, the effects are not equally pronounced, the study area is among the vulnerable areas of Tigray region due to a combination of biophysical and socio-economic factors. Hence, in the diversified situation of the real world it will be better to enhance adaptive capacity and adaptation if further vulnerability and adaptation strategy related assessments are carried out at a more particular scale.

1.2. Statement of the problem

Ethiopia, like many other countries in Africa, is highly vulnerable to the harmful effects of climate change as a result of a combination of widespread poverty, population pressure, fragile environment, dominance of climate-sensitive sectors in economic activity, and low adaptive capacity (Alemneh D, 1990; Calzadill,*et al.*, 2009; Senait *et al*, 2010; NMA, 2007). The rural population, for whom agriculture is the primary source of food, direct and/or indirect employment and income, will be most affected due to agriculture's vulnerability to climate change.

According to Temesgen *et al.,* (2008), the exposure, sensitivity and adaptive capacity of people vary from region to region in Ethiopia. The relatively least developed, semiarid, and arid regions of Afar and Somali are highly vulnerable to climate change. The Oromia region-a wide region characterized both by areas of good agricultural production in the highlands and midlands and by recurrent droughts, especially in the lowlands is also vulnerable. The Tigray region, which is characterized by recurrent drought, is also vulnerable to the impacts of climate change in comparison with the other regions. The same report further indicated Tigray as among the most vulnerable regions because of higher frequencies of drought and floods, lower access to technologies, fewer institutions dealing with climate related hazards, and lack of infrastructure. However, vulnerability to climate change differs within regions, within communities and even within households (PECCN, 2011). Hence, this study is limited in the sense that it is more of general and did not reveal variations in a particular basis such as *Woreda*, communities or even household level so that further study is needed at a more particular scale.

Another study made by Dejene (2011) in Adiha, *Kola* Tembien *Woreda* also identified and ranked vulnerable groups using simple descriptive statistics such that children, elderly, disabled and poor farmers as highly vulnerable groups of the society where as female headed households and non irrigators as medium vulnerable groups. He further classified wealthy farmers as less vulnerable to the changing climate. But, this study assesses individual's vulnerability in different socio-demographic groups within in a single kebele that have a relatively higher irrigation potential than others in the *Woreda*. Besides, this study is limited in the sense that it hardly represents the diverse agro ecological zones and socio economic systems of the *Woreda*. There are different households in the *Woreda* living across different agro ecological zones with a varied economic status and livelihood strategies (KTWFB, 2012) and such areas and households may exhibit different levels of vulnerability and adaptation mechanisms. Hence, further local/agro-ecology based assessments of vulnerability and adaptation strategies of rural communities in different parts of the *Woreda* will be significant.

Therefore, based on the aforementioned reasons and the fact that climate has been changing in the past and continues to change in the future, there is a need to assess how much rural community in specific localities and different agro ecological zones are vulnerable to the harmful effects of climate change. This could be important to find out an appropriate clue for adaptation. In addition, identifying their ongoing adaptation strategies and the factors that influence adaptation strategies used by the communities will be another crucial issue of the study.

1.3. Objective

1.3.1 General objective

The general objective of this study is to assess the vulnerability and adaptation strategies of rural communities to climate change in *Kola* Tembien *Woreda*, Tigray region.

1.3.2 Specific objective

The specific objectives include:

- ✓ To analyze the level of vulnerability of rural communities to climate change in *Kola* Tembien *Woreda.*
- ✓ To identify the adaptation strategies of rural communities to climate change in the study area.
- ✓ To assess the factors that influences the adaptation strategies of the rural communities to climate change in the study area.

1.4. Research questions

1. What is the extent or level of vulnerabilities of rural communities to climate change?
2. What are the existing adaptation strategies of rural communities to the changing climate?
3. What are the factors that influence the adaptation strategies of rural communities to climate change?
4. How do rural communities respond to climate change-related threats?

1.5. Significance of the study

In the context of climate change, assessing vulnerability is an important component of any attempt to define the magnitude of the threat. Analysis of vulnerability provides a starting point for the determination of effective means of promoting remedial action to limit impacts by supporting coping strategies and facilitating adaptation. Understanding the vulnerability level of a given geographic area, communities or households will become an important move for adaptation plans to identify needs and priorities in order to take in to account some relevant procedures. Therefore, this step will contribute a lot for designing appropriate adaptation strategies/practices at regional, *Woreda* or even at *kebele* level. The results obtained from this study can be also used as a spice in the preparation of an adaptation related policies and ultimately address the problems resulted as a result of climate change. Besides, this study can serve as a base line for further studies pertaining to the problem understudy in the *Woreda.*

1.6. Scope of the study

This study focuses mainly on the assessment of the vulnerability and adaptation strategies of rural communities to climate change in *Kola* Tembien *Woreda.* It was mainly focused on the comparative assessment of vulnerability across the selected kebeles from mid and low land agro-ecological zones in *Kola* Tembien *Woreda.* An assessment on adaptation strategies and on the factors influencing them was also made across the surveyed kebeles in the study area. Since vulnerability is a broad concept which involves a detailed analysis of different systems to climate change, it may not be possible to address all the issues so that this study was tend to give emphasis only to the rural households vulnerability to climate change in the above mentioned area. Besides, in understanding the drivers to vulnerability of an area in different agro ecological setting there is a need to define specific local area of social and bio-physical condition. Therefore, the result in certain kebele/agro-ecology cannot be replicated to the other places with the same agro-ecology, unless they have the same socio-economic and bio-physical condition.

1.7. Limitation of the study

The study area is characterized by *Kola*, *Dega* and *Woina dega* agro climatic zones which constitutes 58%, 1% and 41% respectively. Therefore, having considered the available time and financial means the study covered only the *Kola* and *Woina dega* agro climatic zones. Besides, due to the absence of available climatic data at kebele/agro-ecology level, the vulnerability analysis of the surveyed kebeles/agro ecologies was made based on their adaptive capacity and sensitivity assuming a relatively constant exposure.

1.8. Organization of the paper

The thesis is divided into five major chapters. It begins with the introductory part that deals with introduction, Statement of the problem, objectives of the study, research questions, significance of the study, scope of the study, and limitation of study. Second chapter addresses concepts and theories related to vulnerability and climate change, major empirical reviews on the assessments of vulnerability and adaptation strategies, and conceptual framework of the study. The third chapter talks about research methodology that had been followed. The fourth chapter deals with the analysis and presentation of the findings. The fifth chapter deals with the conclusions and recommendations made.

1.9. Operational definition of terms

Different scholars can define things differently but what matters is contextualization. Besides, literatures have indicated the existence of lots of definitions towards similar terms in the climate change context. However, to this study the following definition of terms was applied.

- ✓ **Climate change;** a definition given by UNDP (2009) and IPCC (2001) such that climate change refers to any change in the climate, whether due to its natural variability or as a result of human activity.
- ✓ **Vulnerability;** All the concepts and definitions given to vulnerability are relatively similar and more or less centered on the exposure, sensitivity and adaptive capacity of a given system to climate change. Hence, the definition of vulnerability as a function of exposure, sensitivity and adaptive capacity given by IPCC (2001) but with a due emphasis to rural communities living across different agro ecological zones was adopted for this study.
- ✓ **Adaptation;** in identifying the ongoing adaptation strategies employed by rural communities in the study area, the concept of adaptation given by IPCC (2001) and (Charles and Rashid, 2007) was adopted. Adaptation is then conceptualized as improved society's ability to cope with changes in climatic conditions across time scales, from short term (e.g. seasonal to annual) to the long term (e.g. decades to centuries).

CHAPTER TWO

2. Review of related literature

2.1.The concept of Climate and climate change

As recently as a decade ago, experts from environmental and atmospheric science were the main actors of discussions concerning climate change. Today, the attention over climate change is changed because every corner of the world is being faced by the harmful effects of climate change so that everybody is aware of that (UNDP, 2009). Because of the scientific work that has been done, more people now understand how human activities are hastening it and climate change seriously threatens sustainable human development. Besides, it is going to affect agriculture, energy, human health, food security, the economy, and physical infrastructure.

According to UNDP (2009), climate change is a scientifically proven phenomenon that includes *"any change in the climate, whether due to its natural variability or as a result of human activity"*.

Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs 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 the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007, P. 6).

According to Lobell and Burke (2010), climate change refers to the potential shifts in the longer-run mean and extremes of temperature, precipitation, and other meteorological variables in a given area. Year-to year changes in these variables ("climate variability") play a central role in affecting all human and biological systems as well as global and regional production systems. It can both illuminate and constrain possible longer run adaptation to climate change. Longer-run climate exerts significant influence on agricultural decision-making and makes production more risky, which might influence farmers' adaptation measures. Studies on the impact of climate change in Ethiopia should focus on the agricultural sector for it is undoubtedly the most important, and sensitive, sector to climate change.

The definitions and explanations given to the process of climate change (centered on green house gas concentrations) are practically difficult to perceive in isolation. Climate is part of a complex whole, which functions as a component of the climate system and the entire ecosystem (IPCC, 2001). According to Yamin and Depledge (2004), Climate change is linked to the presence of greenhouse gases (GHGs) in the atmosphere. The naturally existing green house effect which is essential to life on the land is being disrupted due to the dangerous anthropogenic intervention through rising emissions of GHGs from the consumption of fossil fuels along with, production of man-made chemicals, intensive agriculture, forest clearance and other land-use changes.

Climate change, and its impacts, can vary significantly at a regional level and an integrated assessment approach should be adopted in assessing adaptation needs and priorities. This provides for a more detailed picture of climate risks and opportunities, allows for interactions between systems and engages stakeholders in identifying omissions and weaknesses in higher level studies (Allen Consulting Group, 2005).

The impacts of climate change will be far-reaching. Intense droughts may exacerbate water shortages in arid and semi-arid regions; more frequent heavy rainfall events could threaten regions already prone to flooding. Many diseases such as malaria flourish in a warmer climate and could extend their geographical ranges. The agricultural sector which is the main stay to many developing countries is heavily dependent on climatic conditions could be disrupted. Sea level rise, in turn, threatens low-lying islands and coastal areas, not just through submergence by the sea or ocean, but also through greater coastal erosion, periodic storm surges and the encroachment of salt water into irrigation systems and drinking water. Society's vulnerability to any increase in the intensity or frequency of extreme weather events such as cyclones, storms, and drought-induced forest fires is already demonstrating (Yamin and Depledge, 2004).

Scientific communities are strongly agreed that climate change will have a disproportionately major effect on socio-economic development in Africa. The average cost of climate change to African economies could be equivalent to 1.5 to 3 per cent of GDP by 2030 and will continue to rise. Climate change not only threatens the achievement of sustainable development and poverty reduction in the continent but also it has the potential to undo the modest gains the continent has achieved towards attaining the Millennium Development Goals (ADF, 2010).

2.2. Vulnerability to climate change

The concept of vulnerability appears frequently in both scientific reports and policy documents. It has important communicative value: it captures notions of possible loss, damage and impact; of threat, risk and stress; of uncertainty and insecurity; of a lack of power and control; and of a number of other factors that contribute to a feeling or state of being vulnerable (Mike *et al.*, 2009).

According to the IPCC (2007), vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system. Therefore, vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change. Similarly, the IPCC (2001) report defined vulnerability as the extent to which a natural or social system is susceptible to sustaining damage from climate change.

Swanson, *et al.*, (2009), conceptualized vulnerability of a socio-economic and environmental system to climate change as a function of a system's exposure to climate change effects and its adaptive capacity to deal with those effects. They believed that the more exposed a system is to a particular climate stimulus, the greater the system vulnerability; conversely, the greater the adaptive capacity of the system to a given climate event, the lower its vulnerability.

Vulnerability is a broadest concept that is caused by multi and interrelated factors. Natural and manmade hazards causes vulnerability of a community, households or an individual when there is inability to with stand or cope up with the problem. It refers to the full ranges of factors that place people at risk of becoming affected by disaster. It is the propensity of people to experience substantial damages and disruption as the result of hazard (e.g. drought, epidemics) and difficulty (e.g. through lack of resources) to cope with and recover from them. In simple terms vulnerability has two factors external exposure to disaster (Shocks, stress and risks) and the lack of means to cope without suffering damaging lose (SERA Project, 2000). According to Shewmake (2008), vulnerability is the risk that Climate Change will cause a decline in the well being of poor people and poor countries. It is highly correlated with poverty and living status of especially farmers and determines their vulnerability to and adaptation with climatic changes. An increase in the frequency of climate related hazards could lead households to lower expected income which in turn can cause to fall below poverty threshold level.

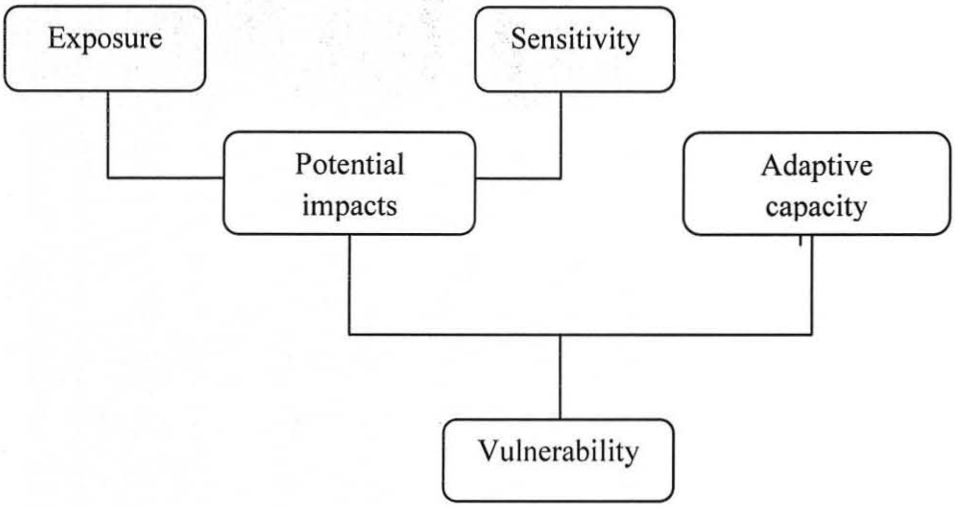
Not everyone is equally vulnerable. Vulnerability is highly dependent on context and scale. The methods and frameworks for assessing vulnerability must also address the determinants of adaptive capacity in order to examine the potential responses of a system to climate variability and change (Mike *et al.,* 2009). It is further indicated that vulnerability is not the same for different populations living under different environmental conditions and confronting different social, economic, political, and institutional challenges (Senait *et al*, 2010). It also differs substantially across regions, communities and even households, and the communities that are most vulnerable to climate change also face poverty, health disparities, and other social inequities (Texas Health Institute, 2012).

It is clear that all the concepts and definitions given to vulnerability, as stated above, are relatively similar and more or less centered on the exposure, sensitivity and adaptive capacity of a given system to climate change. Hence, the definition of vulnerability as a function of exposure, sensitivity and adaptive capacity given by IPCC (2001) but with a due emphasis to rural communities living across different agro ecological zones will be adopted for this study. A highly vulnerable system would be a system that is very sensitive to modest changes in climate, where the sensitivity includes the potential for substantial harmful effects, and for which the ability to adapt is severely constrained.

Components of Vulnerability

According to IPCC (2001) vulnerability to climate change is a function of exposure, sensitivity and adaptive capacity.

The detail description can be shown as follows.



Source: Adapted from IPCC (2001)

Exposure

Refers to the degree of climate variability and change that an entity (a country, community, individual or ecosystem) experiences. It relates to the influences or stimuli that impact on a system. In a climate change context it captures the important weather events and patterns that affect the system, but can also represent broader influences such as changes in related systems brought about by climate effects. Exposure represents the background climate conditions against which a system operates, and any changes in those conditions. It departs from hazard definitions, which have historically defined vulnerability as the probability of a hazard and the magnitude of the damage - ignoring the potential for adaptation options (IPCC, 2001).

Sensitivity

Refers to the assessment of the amount of impact climate factors have on the entity; and reflects the responsiveness of a system to climatic influences, and the degree to which changes in climate might affect it in its current form. Sensitive systems are highly responsive to climate and can be significantly affected by small climate changes. Understanding a system's sensitivity also requires an understanding of the thresholds at which it begins to exhibit changes in response to climatic influences, whether these system adjustments are likely to be 'step changes' or gradual, and the degree to which these changes are reversible (IPCC, 2001).

Adaptive capacity

The IPCC (2001) defined adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantages of opportunities or to cope with the consequences. This describes the ability of the entity to manage the negative impacts and take advantage of any opportunities that arise. Adaptation reflects the ability of a system to change in a way that makes it better equipped to deal with external influences. It is an inherently strategic and conscious effort to increase the capacity of a system to cope with (or avoid) the consequences of climate change.

According to the IPCC (2007), a region's vulnerability to climate change and variability depends on its adaptive capacity, sensitivity, and exposure to changing climatic patterns. Vulnerability is a complex issue because it is determined by a combination of various factors and events (erosion, demographic changes, macro polices, market changes). This means the consequence of climate change cannot be clearly separated from those of others events and remained complex but the extent which a natural or social system is susceptible to sustaining damage from climate change, determine by exposure, sensitivity and coping capacity as well as structural process.

2.3. Climate Variability and Change in Ethiopia

Climate variability is nothing new in Ethiopia. Climate patterns has shown variations across times and spaces. According to NMA (2007), the country has experienced 10 wet years and 11 dry years over the last 55 years showing strong inter-annual variability. Years such as 1952, 1959, 1965, 1972, 1973, 1978, 1984, 1991, 1994, 1999 and 2002 were dry while 1958, 1961, 1964, 1967, 1968, 1977, 1993, 1996, 1998 and 2006 were wet years. However, the trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country. The same report further indicated that the country has experienced both warm and cool years over the last 55 years. However, the recent years are the warmest compared to the early years. The annual minimum temperature has shown a warming trend by about 0.37 °C every ten years between 1951 and 2006.

The country has always suffered from great climatic variability, both yearly and over decades. Rain failures have contributed to crop failure, death of livestock, hunger and even famine in the past. Even relatively small events during the growing season, like too much or too little rain at the wrong times, can spell disaster. Small farmers and cattle herders, who are already struggling to cope effectively with the impacts of current variability and poverty, face daunting task in coping with weather variability and adapting to future climate change (Alebachew, 2011; Senait *et al*, 2010).

Climate change in Ethiopia is fundamentally a sustainable development issue. Key natural resources and natural systems such as land resource, wetlands and natural habitats, all of which are vital to sustainable development, are sensitive to changes in climate, including both the magnitude and rate of climate change as well as to changes in climate variability. Economic activities, such as crop farming, livestock herding, energy production and water supply, that depend on these natural resources are therefore, also sensitive to climate variations. Thus climate change represents an important additional stress on the natural resource base of the country. Climate change is going to have adverse impacts on human health, water resources, energy resources, and on rural livelihoods, economic growth and transformations (Alebachew, 2011).

The NMA (2007) report further elaborated the impact of climate variability and stated that;

- ✓ Food insecurity arising from occurrences of droughts and floods;
- ✓ Outbreak of diseases such as malaria, dengue fever, water borne diseases (such as cholera, dysentery) associated with floods and respiratory diseases associated with droughts;
- ✓ Land degradation due to heavy rainfall;
- ✓ Damage to communication, road and other infrastructure by floods are the major climate variability related adverse impact affecting the nation.

2.4.Ethiopia's Vulnerability to Climate Change

Ethiopia is highly vulnerable to the harmful effects of climate extremes primarily drought and flood. Drought occurs anywhere in the world but its damage is not as severe as in Africa in general and in Ethiopia in particular. Recurrent drought events in the past have resulted in huge loss of life and property as well as migration of people. Major floods which caused loss of life and property occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 (NMA, 2007).

The country has been highly vulnerable to climate variability and changes because large segments of its population are poor, have low adaptive capacity, dependent on income opportunities that are highly sensitive to the weather, and have low access to education, information, technology, and health services (Senait *et al.*, 2010). Moreover, poverty, lack of access to technology, subsistence agriculture, deforestation, soil erosion and over-population are some of the problems that increase the vulnerability of the people to climate-related disasters. Constant wars and political instability also contributed to the severity of the impact of disasters (Tsegay *et al*, 2000). To be specific, the agricultural sector in Ethiopia is especially vulnerable to the adversities of weather and climate due to the sectors dependence on rain fed and done using relatively basic technologies on tiny plots of land. Therefore, having selling off assets as a mean to cope will result for little to be left to plan for the future. Thus, communities are faced with simultaneously increasing climate variability, risk and vulnerability (Senait *et al.*, 2010). However, not all regions and households are equally vulnerable (Temesgen *et al*, 2008) and different factors are indicated for their vulnerability.

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

2.5.Methods to assess vulnerability to climate change

Vulnerability and adaptive capacity are integrative components of evaluating the potential effects of climate change but they are complex to be measured directly. As per the ideas of Hoddinot and Quisumbing (2008), the most common methods in the climate change literature are the econometric and indicator methods.

I. Econometric methods

The econometric methods, uses household-level socio-economic survey data to analyze the vulnerability levels of different social groups. Such methods involve assessments based on vulnerability as expected poverty (VEP), vulnerability as low expected utility (VEU) and vulnerability as uninsured exposure to risk (VER) (Hoddinott and Quisumbing, 2003). All of these methods construct measures of welfare loss attributed to shocks, but differ in that VEP and VEU measure the ex ante probability of a household's consumption or utility falling below a given minimum level in the future due to current or past shocks, while VER measures ex post welfare loss due to shocks. The most commonly cited shocks resulting in welfare loss include climatic, economic, political, social, legal, crime and health shocks (Hoddinott and Quisumbing, 2003).

Vulnerability as expected poverty

In the expected poverty framework, an individual's vulnerability is the prospect of that person becoming poor in the future if currently not poor, or the prospect of him/her continuing to be poor if currently poor (Christiaensen and Subbarao, 2004). It can be further defined as Vulnerability of household h at time t, Vht is the probability that the household's welfare (consumption) at time t + 1 (cht + 1) will be below the benchmark (consumption poverty line, z): Vht = Pr (ch, t + 1 = z) (Hoddinott and Quisumbing, 2003). It is useful to produce a "headline" vulnerability figure, identify households "at risk" who are not poor, relatively straightforward to calculate and it can be estimated with a single cross-section. However, this method is criticized for the use of estimations made across a single cross-section which requires the strong assumption that the cross-sectional variability captures temporal variability.

Vulnerability as uninsured exposure to risk

This method is an *ex post* assessment of the extent to which a negative shock caused a welfare loss (Hoddinott and Quisumbing, 2003). Here, the shock impact is assessed by using panel data to quantify shock-induced changes in consumption. It differs from VEP measures in that it is backward looking; it is an ex post assessment of the extent to which a negative shock caused a welfare loss rather than an ex ante assessment of future poverty. It differs from VEP and VEU measures in that there is no attempt to construct an aggregate measure of vulnerability. It is important in that it provides *prima facie* evidence that existing risk management mechanisms are doing a poor job in protecting households from income shocks. Moreover, it is useful to indicate whether covariate or idiosyncratic shocks are the principal cause of welfare losses, be adapted to determine whether shocks have different effects across different groups and is *ex post* rather than *ex ante.*

Vulnerability as low expected utility

Hoddinott and Quisumbing (2003) defined Vulnerability as the difference between the utility derived from some level of certainty-equivalent consumption, at and above which the household would not be considered vulnerable and the expected utility of consumption. It is useful in that it provides clean disaggregation between vulnerability due to poverty and vulnerability due to uninsured risk. It can also be used to calculate an aggregate measure of vulnerability. On the contrary, this method is criticized for being the hardest measure to calculate and the units of measurements are somewhat difficult to convey to individuals with little formal training in economics.

VEP and VEU approaches measure vulnerability at the individual level; summing over all individuals or households gives a measure of aggregate vulnerability. VER do not measure vulnerability because they do not construct probabilities; instead, they assess whether observed shocks generate welfare losses. They are ex post assessments of the extent to which a negative shock causes a household to deviate from expected welfare, measuring the length of the rule to the left of the expected level of welfare (Hoddinot and Quisumbing, 2008).

II. Indicator Methods

The indicator approaches are based on developing a wide range of indicators and selecting some of them through expert judgment (Kaly and Pratt, 2000), principal component analysis (Cutter et al, 2003), or correlation with past disaster events (Brooks *et al.,* 2005). Each of these selection procedures is used to choose the indicators that account for the largest proportion of vulnerability. According to Luers *et al.,* (2003), the indicator approaches are valuable for monitoring trends and exploring conceptual frameworks. However, these approaches are limited by: 1) considerable subjectivity in the selection of variables and their relative weights, 2) the availability of data at various scales, and 3) the difficulty of testing or validating the different metrics.

The indicator approach uses a specific set or combination of indicators (proxy indicators) and measures vulnerability by computing indices, averages or weighted averages for those selected variables or indicators. This approach can be applied at any scale (e.g., household, county/district, national, system). The major limitation of the indicator approach is its inability to capture the complex temporal and social dynamics of the various systems being measured. However, the indicator approach is valuable for monitoring trends and exploring conceptual frameworks (Glawadys and Claudia, 2009). Both Glawdys and Claudia (2009) base their definition of vulnerability on the Intergovernmental Panel on Climate Change's definition, where a region's vulnerability to climate change and variability is described by exposure, sensitivity, and adaptive capacity (IPCC, 2001). Their vulnerability indicator approach was integrated, in that the selected indicators represent both the biophysical conditions of the farming regions and the socio-economic conditions of the farmers. The indicators were selected through an extensive review of previous reports; guided by a list of indicators that were developed in a workshop setting, and then pragmatically assessed in relation to data availability.

Temesgen (2010), in his study on the assessment of the vulnerability of Ethiopian agriculture to climate change was used both the indicator and econometric methods to quantify vulnerability. The vulnerability as expected poverty was used to analyze vulnerability at the household level where as the integrated vulnerability assessment approach, one of the indicator based vulnerability methods was used to compare the level of vulnerability among the agriculture based administrative regions in Ethiopia. Another study made by Glawdys and Claudia (2009) on the mapping of south African farming sector vulnerability to climate change and variability used an integrated vulnerability assessment approach based on indicator method. However, only the indicator method of quantifying vulnerability was employed to determine as well as compare the vulnerability levels of rural communities in *Kola* Tembien *Woreda* across different Kebeles/ agro ecologies.

2.6. Meaning of Adaptation and Adaptation strategies

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). It also refers to planned and autonomous (or spontaneous) adjustments in natural or human systems in response to climatic stimuli. Adaptation can reduce harmful effects or exploit opportunities. Lobell and Burke (2010), similarly defined adaptation as changes made to a system impacted by climate and includes both changes that either reduce negative outcomes or enhance positive outcomes. It refers to adjustments in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. The concept of adaptation in climate change issue is important to the assessment of impacts and vulnerabilities and to the development and evaluation of response options.

Adaptation can be also defined as improved society's ability to cope with changes in climatic conditions across time scales, from short term (e.g. seasonal to annual) to the long term (e.g. decades to centuries) (Charles and Rashid, 2007). The goal of an adaptation measure is to increase the capacity of a system to survive external shocks or change. The assessment of farm-level adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture.

It is clear that pressure from climate change can be felt by all systems. A key focus of adaptation policy should be then to reduce the adverse consequences, and capitalize on any opportunities, arising from climate change. If adaptation processes are to be effective, understanding the needs, capacities and priorities of the most vulnerable groups must be the primary focus of vulnerability assessments, and these groups must represent the main targets for adaptation funding and support. This implies processes that examine sub-national differences, that are participatory and that seek to uncover the underlying causes of vulnerability to climate change in order to identify vulnerable groups and empower them to engage in decision-making on adaptation (PECCN, 2011). Hence, in order to reduce vulnerability to climate change, measures should be done to build adaptive capacity and in some cases to reduce exposure or sensitivity to climate impacts, particularly of the most vulnerable people (Daze *et al.*, 2009).

Adaptation will not necessarily occur automatically in response to observed and projected changes. Experience has shown that identified adaptation measures do not necessarily translate into changes because there are context-specific social, financial, cultural, psychological and physiological barriers to adaptation (IPCC, 2007). Barriers may include societal values and priorities, governmental regulations, lack of availability or access to technologies, or economic or political interests that may hinder new technological systems or knowledge systems.

Adaptation can be a specific action, such as a farmer switching from one crop variety to another that is better suited to anticipated conditions. It can be a systemic change such as diversifying rural livelihoods as a hedge against risks from variability and extremes. It can be an institutional reform such as revising ownership and user rights for land and water to create incentives for better resource management. Adaptation can be also a process which involves learning about risks, evaluating response options, creating the conditions that enable adaptation, mobilizing resources, implementing adaptations and revising choices with new learning (Leary *et al*, 2008).

In many cases, adaptation activities are local – district, regional or national–issues rather than international (Pavola and Adger, 2005). Because communities possess different vulnerabilities and adaptive capabilities, they tend to be impacted differently, thereby exhibiting different adaptation needs. As a result, adaptation largely consists of uncoordinated action at household, company and organization levels. But it may also involve collective action at the local, national, regional and international levels and cross-scale interaction where these levels meet (Pavola and Adger, 2005).

The most viable option that is open to Africa to manage the impacts of climate change in the region is through adaptation. However, the continents low adaptive capacity serves as a major constraint to her ability to adapt. This limited adaptive capacity results from the region's poor financial resources, low technical and technological capabilities, weak institutions and limited awareness of the devastating impacts of climate change. However, despite this limited adaptive capacity, several adaptation strategies are currently being practiced to cope with present climate variability in the region. For instances, within the agricultural sector, these strategies range from the development and deployment of early warning systems, better agricultural management systems, improved crop cultivars, better and more efficient irrigation systems and good grain storage systems. Strategies used in the other sectors include the construction of sea retaining walls to stop coastal erosion and storm surges, the use of insecticide-treated nets to reduce the incidences of malaria, etc (Nkomo *et al.,* 2006)

In Ethiopia, traditional and contemporary adaptation strategies to climate variability and extremes include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid, etc (NMA, 2007).

2.7. Review of Empirical Studies and Methodologies

According to Nelson and Naa (2005), the vulnerability of people in a given area to the effects of climate change depends on the vulnerability of the surrounding natural landscape unit to weather extremes and climatic shifts, and the adaptive capacity of the local population. The underlying factors determining climate vulnerability in Ghana tends to be widespread poverty, reliant on primary production, high population along the coastal zone, and over dependence on rain fed agriculture. Therefore, the country's climate, development status, food supply, dependence on natural resources, biodiversity loss, disease burden level, water and energy resources, coastal zone and advancing of desertification should be the important factors to be considered in assessing the nation's vulnerability to climate change.

The Allen consulting group (2005), also found that Australia is highly vulnerable to the harmful effects of climate change due to the industry's sensitivity to the impacts of climate change and can be attributed to a number of factors including: heat stress, availability of good quality water, susceptibility to pests and diseases, supply of high quality feed, frequency and number of drought years, and the ability to recover after drought. The extensive livestock industry is vulnerable to the impacts of climate change with few adaptive options available across most rainfall zones. The capacity to adapt will largely be through the introduction of drought tolerant pasture species and animal breeds. Reduced rainfall, drought, increased fire hazard, pest infestations and soil erosion could adversely affect forest productivity and the sustainability of native forests.

When we come to the Ethiopian context, Doty *et al.,* (2011) under the framework of his model indicated Ethiopia as the most vulnerable to climate change and ranks high on the scale of vulnerability to climate change out of the 11 countries in the east and central Africa region. It is highly affected by climate change because of the dependence of the majority of the population on rain-fed crops for food supply, and rainfall for irrigation. The human development dimension of the nation particularly, its health status is strongly affected by extreme climatic events.

Luni *et al.*, 2012, viewed vulnerability to climate change as multidimensional and determined by a complex inter-relationship of multiple factors. As to them, many variables representing components of vulnerability are not directly quantifiable. Nevertheless, devising an index to measure vulnerability is helpful to compare similar systems and provide insights into the underlying processes and determinants of vulnerability that is of relevance to policy makers. Therefore, they believed that the first step in constructing the index comprises the selection of indicators, then assigning weights to those indicators, and finally these indicators are aggregated to form an index. Indicators and indices are useful in representing a complex reality into simpler terms. However, the methodology adopted in the choice of indicators is very crucial, since choice of wrong indicators may lead to a construction of an invalid index. Choice of indicators to represent the index for vulnerability is constrained by the fact that vulnerability itself has no tangible element. They calculated vulnerability following the definition of IPCC (2001), vulnerability as a function of exposure, sensitivity, and adaptive capacity. Indicator variables for adaptive capacity, exposure and sensitivity were first determined based on some theories that provide insight into the nature and causes of vulnerability. Then, focus group discussion was conducted at local level to verify the representativeness of the theory-based indicators. After that principal component analysis was run to determine the weights of the selected variables and finally combined them using the formula given by IPCC (2001), and the normalized value was selected from their respective means and standard deviations. Ordinal values, number, livestock standard unit (LSU), percentages and hours were used as a units to measure the indicators of adaptive capacity where as values in Nepalese rupee, percentage, and numbers were also used as a units to measure the sensitivity. Besides, coefficient of trend and number/frequency was used as a unit to measure the exposure of the area. The result finally found local difference in vulnerability attributed to variations in the indicators of adaptive capacity, sensitivity and exposure.

Another study made by Glawdys and Claudia (2009) on the mapping of south African farming sector vulnerability to climate change and variability used an integrated vulnerability assessment approach based on indicator method. Accordingly, nineteen environmental and socio-economic indicators are identified to reflect the three components of vulnerability; exposure, sensitivity, and adaptive capacity. The weights for the variables was generated from principal component analysis where as the normalized values was also calculated using their means and standard deviations. The results of the study show that the region's most vulnerable to climate change and variability also have a higher capacity to adapt to climate change. Furthermore, vulnerability to climate change and variability is intrinsically linked with social and economic development.

An agro ecology level analysis made in North Shewa by Gutu *et al.,* (2012) also quantified vulnerability based on integrated vulnerability assessment approach. The normalized value was obtained from the means and standard deviations of the selected variables and the principal component analysis was run on 29 indicator variables to determine their weights. The vulnerability of different agro ecological zones was then calculated following the IPCC (2001) formula for measuring vulnerability and found highland as the most vulnerable agro-ecology which is attributed to its small land size, highly fragmented farm, low productivity of land due to fertility lose, high degradation of farmlands due to steep sloping, lower level of asset building like livestock and perennial crops, and generally lower level of experience to adapt to climate change impacts. The midland was found to be less vulnerable as compared to the highland areas, which is attributed to lower level of prevalence of pest and diseases, potential to grow diversity of crops, relatively gentle sloping of farmlands, moderate rainfall and low frequency of natural hazards. Contrary to the expectations the lowland area was not vulnerable when compared with the midland and high land. This is because of better experience of operating agricultural activities under stressful conditions, relatively larger farm size with optimal number of farm plots, moderate slope of farm lands, better fertility level of farmlands, better size of land under irrigation, better adaptation to changing climatic conditions and access to early warning information.

As far as the adaptation strategies is concerned, a study made by Yibekal *et al.,* (2013) in three purposively selected *Woredas* of Eastern Hararghe *Zone* examined smallholder farmers' level of perception about climate change, source of information on climate change, types of adaptation strategies, factors influencing adaptation choices and barriers to adaptation. The study then found that the surveyed farm households in the study area perceived at least one aspect of climate change primarily through their life experience. Deforestation is believed to be the main cause of climate change by most farmers. Planting trees is the major adaptation measure and has been employed by majority of the farmers as a primary adaptation strategy. Besides, other strategies such as early planting, terracing, irrigation and water harvesting have been using by the farmers. The main source of information for these adaptation strategies is from extension advice. However, the choice of adaptation strategies is affected by non-farm income, farmer- to-farmer extension, access to credit, distance to selling markets, distance to purchasing markets, and income. Finally, the study identified lack of information as the most important and lack of farm inputs, shortage of land, lack of money, lack of water and shortage of labor as other barriers to climate change adaptation.

Senait *et al.*, (2010) also conducted vulnerability and adaptation strategy related study in the Adamii Tulluu-Jido Kombolcha *Woreda* and showed that with some assistance from non-governmental organizations and the government, small-scale farmers and pastoralists are adopting a variety of context-specific coping mechanisms. In the farming areas, farmers shift to more drought tolerant crops and varieties, improve forest conversation and management practices, diversify energy sources, and seek alternative means of income from off-farm activities.

Dejene (2011) also assessed farm-level adaptation strategies in Adiha, *Kola* tembien *Woreda* and found that use of irrigation, planting early maturing and drought resistant crop varieties and soil and water conservation practices are the most important strategies used by the communities but changing of planting date and crop diversification are not commonly used in the area despite the effectiveness of the strategies in drought prone areas. The degree of sensitivity of the community as a whole or part of the community depends on household wealth, access to and use of resources/technology, ages, gender and literacy rates. Besides, farmer's willingness and capability to use different cultural and environmental signs and signals for weather prediction and forecast also determines their level of vulnerability to climate related hazards. Weather predication and forecast enables to devise appropriate coping and or adaptation mechanisms.

It is clear that the aforementioned studies have been made across different geographical areas, communities, households, and even different periods of time. It can be reflected that vulnerability and adaptation strategies in response to climate change varies spatially and even temporally. Different communities found across different geographical areas and even different periods of time have different vulnerability levels and different practices of adaptation strategies. Besides, the choices of adaptation strategies of different communities are influenced by different factors. Therefore, vulnerability and adaptation strategies are context specific and studies pertaining to it should be carried out at a particular scale.

2.8. Conceptual framework

According to IPCC (2001), vulnerability is a function of exposure, sensitivity and adaptive capacity. Therefore, an integrated vulnerability assessment approach is significant in addressing vulnerability issues as a whole.

As indicated earlier, the study area is among the vulnerable areas of Tigray region due to a number of biophysical and socio economic factors. The area is generally exposed to both climate variability (erratic and uneven rainfall) and extreme climate change (mainly drought and flood). However, rural communities are not only exposed to climate variability and extremes, their exposure to climate change are also determined by non climatic factors. Exposure affects sensitivity, which means that exposure to higher frequencies and intensities of climate risk highly affects outcome (e.g., yield, income, health). Sensitivity and adaptive capacity are also linked: the adaptive capacity influences the level of sensitivity. In other words, higher adaptive capacity results in lower sensitivity and vice versa. Therefore, sensitivity and adaptive capacity add up to total vulnerability. However, vulnerability and adaptation strategies are related in that better adaptation strategies could reduce vulnerability and vice versa. The vulnerable communities will have their own adaptation strategies based on their adaptive capacities. The range of adaptation strategies employed by the rural communities can also be directly or indirectly affected by their adaptive capacities. Graphically it can be shown as follows.

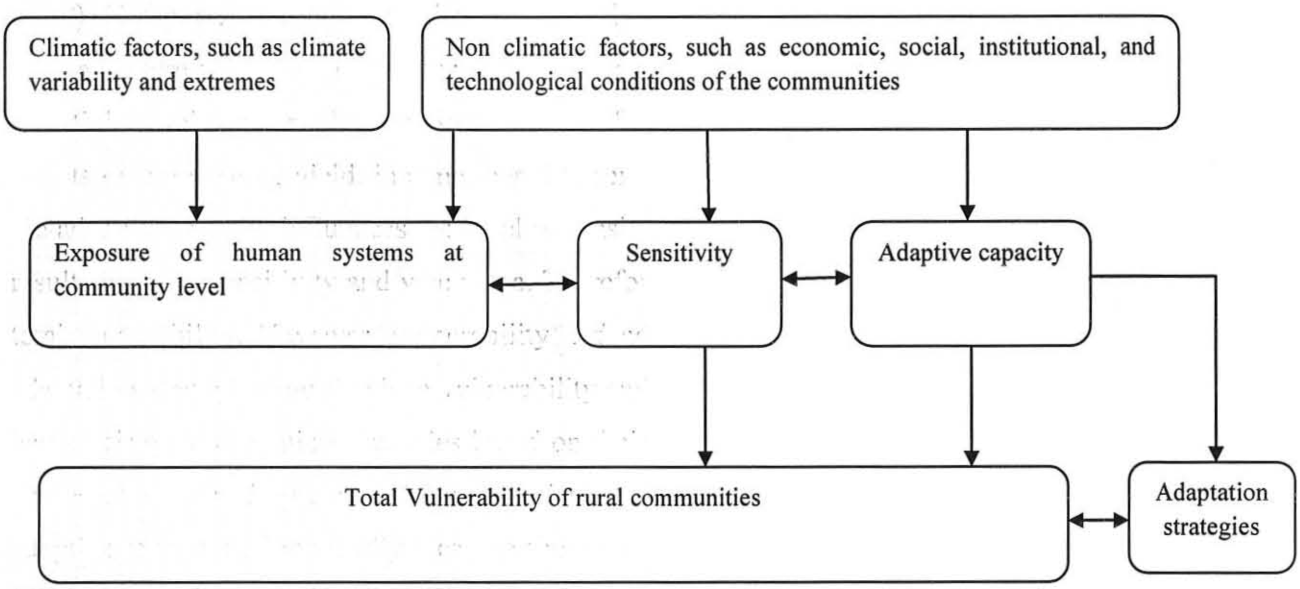


Figure 1: Conceptual frame work

Source: Adopted and modified from IPCC (2001) concept, Fussel (2005) and Daniel (2011)

CHAPTER THREE

3. Research Methodology

3.1. Study Area Description

3.1.1. Physical conditions

Location:

Kola Tembein Woreda is located at the southern part of central zone of Tigray. Geographically, it is located between 458,131-524,202E Latitude and 1,504,064-1,526,798 N Longitude (UTM).It has 28 *Tabias*, 97 *Kushet* and found in the nearby town, Abiyi- Adi which is 908 kilometers away from Addis Ababa. It is bordered in the North by Weri-Leke, in the East Hawzen and Degua Tembein, in the south Tankua Abergele and in the West Tselemti and Naeder Adet. The location map of the Woreda and the surveyed kebeles indicated in figure 2.

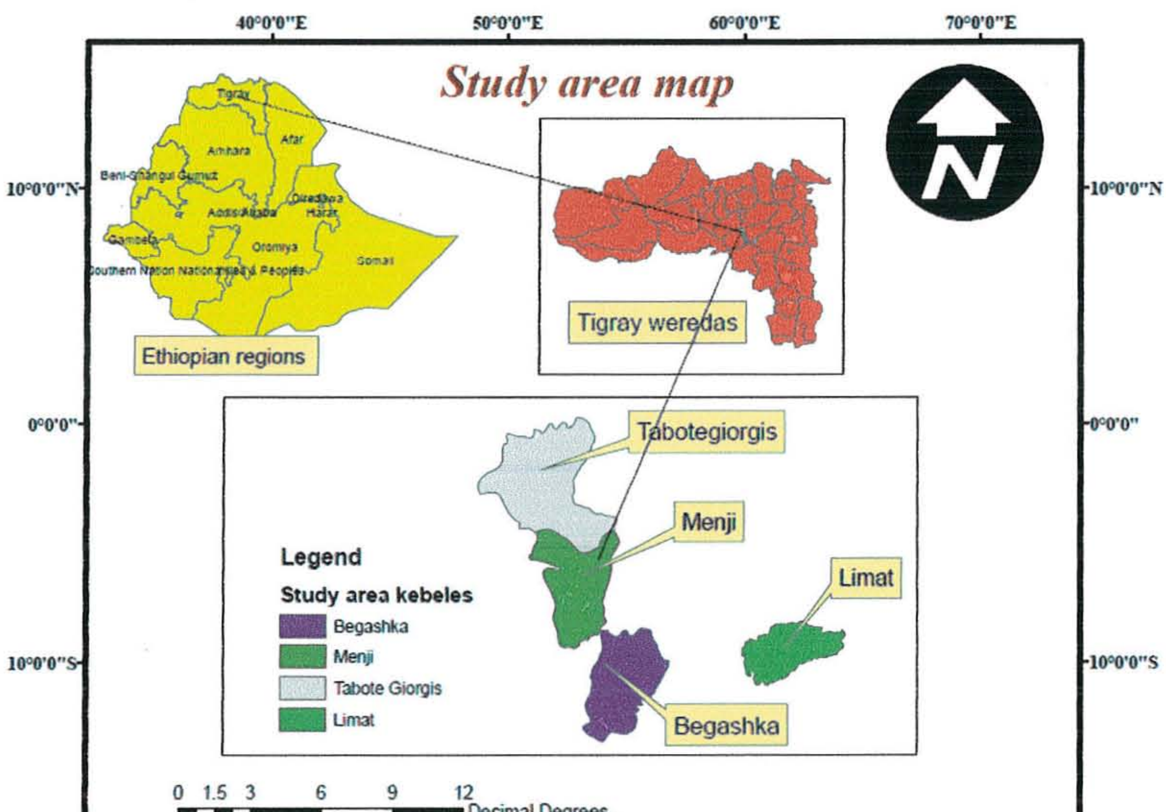


Figure 2: Surveyed kebeles of Kola Tembien

Source: Mearg, (2014)

As shown in figure 2, this study was conducted in 4 kebeles of Kola Tembien *Woreda*, namely, Begashka, Tabotegiorgis, Limat and Menji.

Topography: As its name indicated *Kola* Temben is dominantly lowland with an elevation ranging from 1400 to 2435 meter above sea level. Begashka is found at an altitude from 1650 to 1750, T/giorgis from 1850 to 2300, Limat from 1500 to 2300 and Menji is found from 1500 to 1800. The Woreda is generally characterized by mountainous, plateaus, undulating and rugged topographic condition. Soil type of the area is mainly sand, clay, silt and loam that cover 62%, 26%, 3% and 9% respectively (KTWARDB, 2012).

Climate

The *Woreda* is dominantly characterized by two agro climatic zones namely *Kola* and *woina dega* which constitutes 58% and 41 % respectively. The remaining 1% of the *Woreda* falls under the dega agro climatic zone. However, no *kebele* in the *Woreda* is represented by a single agro ecological zone. The average temperature of the *Woreda* ranges from 25 - 30 °C. The rainfall of the *Woreda* is mono-modal, received only during the main rainy season, June- end of August. Annual rainfall ranges from 500mm to 800mm. However, the *Woreda* is characterized by erratic rainfall and intense rain in a short period of time (KTWFB, 2012).

Area size:

According to the compiled report of the finance bureau of *Kola* Tembien (2012), the total area of the *Woreda* is 147,000 hectare of which 31,021 ha is arable, 47925.97 ha is grazing, 3421.26 ha is residence, 25, 058.2 ha is natural forest, 1070 ha is reforested and the remaining 29502 ha of land is wasteland.

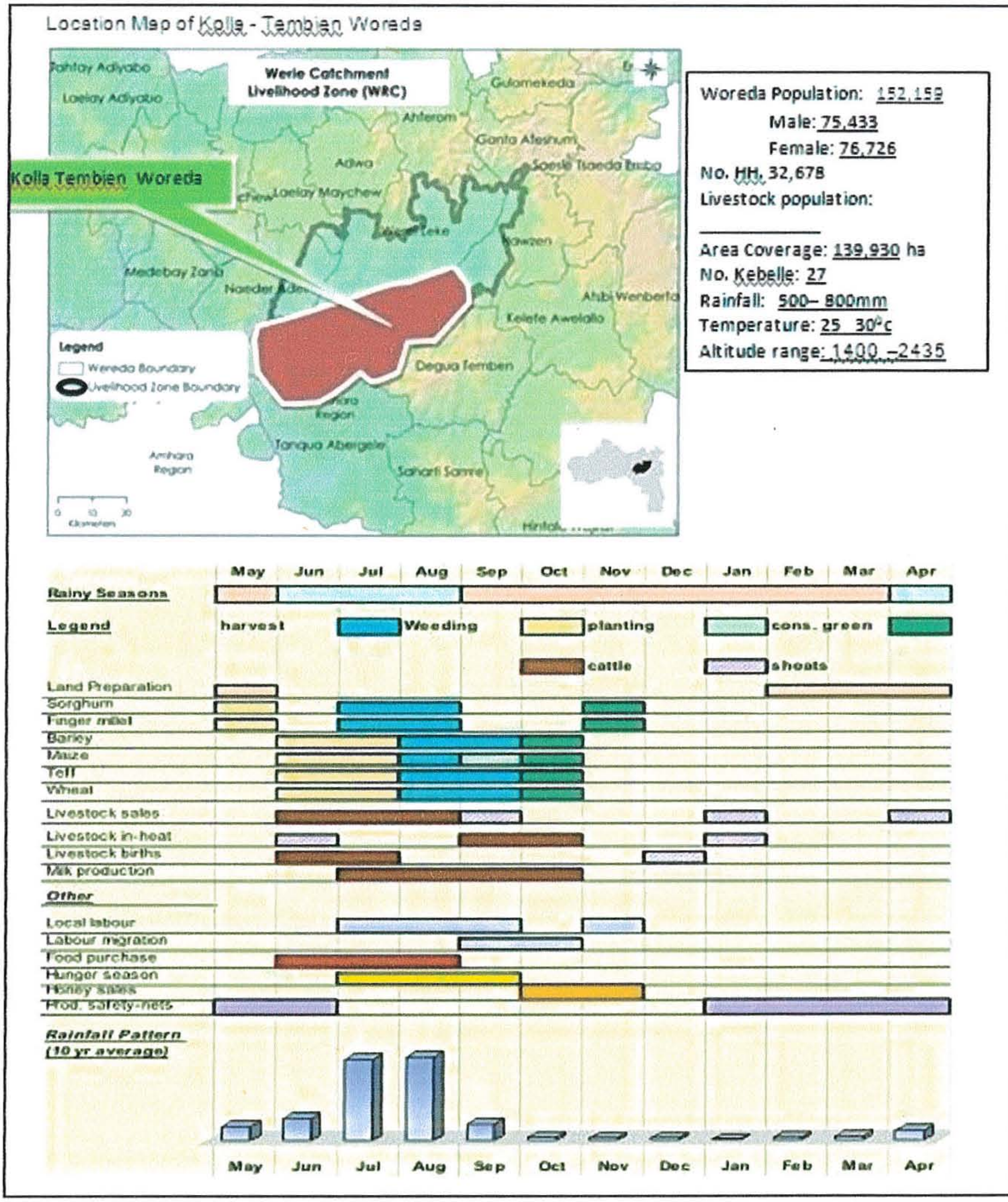


Figure 3: Seasonal calendar of farmers in Kola Tembien

Source: KTWARDB, 2014

3.1.2. Socio-economic conditions

Population size: The Woreda is one of the populous Woreda in the zone. It has an estimated total population of 160,639 of which 80,029 are male and 80,610 are female. The Woreda has a total of 34,922 households with an average family size of five people (KTWFB, 2012). Density of the population is 106 p/sq km.

Economic Activities: mixed farming is widely practiced in the Woreda where non farming activities are rarely dominant. The majority of the population is living in rural areas making their livelihood from agricultural production. Onion, Tomato, Cabbage, and pepper are grown by irrigation for their consumption and marketing. Honey and poultry productions also constitute some share of the economic activities practiced.

Total cultivated land versus agricultural production

There is a spatial and temporal variation between the total cultivated land and annual production in the last five years. This can be shown in the following table 2.

Table 1: Total cultivated land and agricultural output in Kola Temben (1998-2005 E.C.)

Production year	Cultivated land in hectare	Production in quintal
1998/1999	30950.37	374124.5199
1999/2000	31002.51	325329.36
2000/2001	30622.465	541232.855
2001/2002	30219.615	456346.472
2002/2003	30264.2255	1081816.6
2003/2004	30988	972710.98
2004/2005	30989.223	1,044,293.5

Source: KTWARDB, 2014

The main crops grown in the Woreda are; maize, sorghum, finger millet and teff by rain fed and irrigation. Different cereal pulses and oils seeds are also produced dominantly by rain fed per a given production year. Maize, sorghum, finger millet, millet, teff hagay[1] , wheat, barley, and teff are produced. Horse bean, field pea, lentils, haricot bean, chickpea are produced under the category of pulses and neug[2], flax and sesame also constitute the production under the oilseed category.

[1] *Teff hagay is a local term used to refer to dagusa*

[2] *Neug refers to the type of oil seed produced in the Woreda*

3.2.Sample size and sampling technique

The sampling process starting from the Woreda selection up to the household level follows a series of steps as shown below.

Step 1: *Woreda* selection: Tigray region has 46 *Woreda* and among which *Kola* Tembien *Woreda* was purposively selected for this study due to:

- ✓ As per the best knowledge of the researcher, no study pertaining to the assessment of vulnerability and adaptation strategies was made at local and agro-ecology level in the *Woreda* despite of the frequent disturbance of the livelihood of rural communities as a result of climate related occurrence,
- ✓ The researchers' familiarity with the *Woreda* and knowledge of the local language and culture.

Step2: selection of *agro-ecology*: This study was being carried out at agro-ecology level so that identifying priority areas was the primary concern. As indicated earlier, the Woreda was climatically divided in to *Dega* (1%), *woina dega* (41 %), and *Kola* (58%) agro ecological zones (KTWFB (2014). The latter two agro-ecologies constitute the lion's share of the Woreda. Therefore, having considered the size of the agro-ecological zones and the available resources of the researcher, high land (*dega*) agro ecological zone was purposively dropped from selection. Hence, both the low land (Kola) and mid land (*woinadega*) agro-ecological zones were deliberately selected for the study.

Step 3: The researcher selected four *kebeles* based on stratified sampling method. First, kebeles in the Woreda were divided in to two categories based on their agro ecological zones but no kebele was represented by a single agro-ecology. Since one of the objectives of the study was a comparative analysis of vulnerability at local level there by agro-ecology level, the same numbers of kebeles from each agro-ecological zone were selected. Accordingly, Limat and Menji kebeles from low land (*Kola*) and Begashka and T/giorgis kebeles from mid land (*woina dega*) agro-ecologies were selected. This selection was made purposively based on the expertise information of KTWARDB officials on the frequency of climate extremes.

Step 4: *Village* selection: *Village* selection follows similar pattern as of the kebeles. Daram *village* from Limat, Limat from T/giorgis, Wetlako from Begashka and Gbe *village* from Menji were purposively selected based on the expertise information of KTWARDB officials on the matters pertaining to the livelihood of the households and frequency of extreme climate related hazards.

Step 5: Selection of households

A simplified formula given by Yamane (1967:886) as cited in Israel (2012) was used to calculate the sample size of households in this study. A 95% confidence level and P = 50% were assumed.

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

Where n is the sample size, N is the population size, and e is the level of precision. Hence, based on the 2.1% predicted growth rate given by CSA (2007) for rural Woreda in Ethiopia, the Woreda has found 34,922 households by 2006 E.C. The actual numbers of households found across the sample villages were 1318 of which 950 of them were male headed while the remaining were female headed households. The size was calculated as follows.

$$n = \frac{N}{1+N(e)^2}, \quad = \frac{1318}{1+1318\,(0.09)^2} \approx 113 \text{ households}$$

However, since four kebeles were surveyed and in order to make the sample more representatives, 125 households were surveyed for the study and the distribution across their respective villages is clearly illustrated in Table 2 below. The level of analysis is kebele so that a relatively equal numbers of samples were taken from each kebeles.

Table 2: distribution of respondents across the selected villages

Agro ecology	Sample kebele	Sample village	Total HH	MHH	FHH	Sample MHH	Sample FHH	Total sample
Mid land	Begashka	Wetlako	503	386	117	21	11	32
	T/giorgis	Limat	368	292	76	23	7	33
Low land	Limat	Daram	174	136	38	27	6	30
	Menji	Gbe	273	136	137	16	14	30

Households with in kebeles in *Kola* Tembien *Woreda* in general and the sample villages in particular were organized under the name called *'Limat gujle*[3]*'*. Each *'Limat gujle'* has its own leader and consists of 20 – 30 households on average. The sample respondents were then selected using simple random sampling method from the list of development groups found at each of the surveyed kebeles. Accordingly, 32 households from Begashka (mid land agro ecology), 33 households from T/giorgis (mid land agro ecology), 30 households from Limat (low land agro ecology) and 30 households from Menji (low land agro ecology) were surveyed. Furthermore, key informants were selected from the *Woreda* and *kebele* experts where as focus group discussants were selected from sample villages.

3.3.Research approach

In this research both quantitative and qualitative approaches were applied in order to get reliable data. The qualitative approach was comprised of key informants interview, focus group discussion, and direct observation where as quantitative approach was employed through household survey on the selected 125 households.

3.4.Data sources

Both primary and secondary data sources were used in this study. Primary data was collected from the key informant interviews, focus group discussions and direct observation. The primary data was supplemented by secondary data sources such as office documents from the agricultural and rural development bureau, finance and rural development bureau, previous works done as Master's thesis and reports pertaining to the study of vulnerability and adaptation strategies of rural households. Besides, all climatic data of the Woreda was obtained from the NMA.

3.5.Data collection instruments

In this study both quantitative and qualitative data collection tools were used. Quantitative data was gathered using household survey where as the qualitative data was collected through structured open ended questions for key informants and focus group discussions along with personal observations through check lists and review of documents from relevant bureaus.

[3] *Limat gujle means a development group found in each kebele*

Household survey

Questionnaires were distributed for 125 households in order to assess both the biophysical and socio economic indicators used for quantifying vulnerability at agro-ecological level. Besides, it was also administered to collect information on the adaptation strategies used by communities in times of crop failure, improving livestock production, managing land degradation and in times of rainfall uncertainty. The barriers of communities to adapt to climate change were also addressed through this tool. The question items were both open and closed ended type. They were originally prepared in English and latter on translated to Tigrigna language. The survey was conducted by enumerators after being trained about the procedure by the researcher.

Focus group discussion (FGD)

FGD was employed to collect first-hand information on perceptions and thoughts of the groups about climate change and its impacts on their livelihood, adaptation strategies and barriers to adaptation. Focus group discussants were purposively selected in order to be representatives of different social groups and to get their long years of knowledge on climate conditions of their kebele. Accordingly, four mixed group discussions which consist of 7-9 individuals from elderly men, religious leaders, and female headed households were made across the sample kebeles. Guiding questions about the aforementioned matters were prepared to get in-depth information.

Key informant interview (KII)

Key informant interview was made with the selected female and male headed households in order to get information about their perception to climate change, impact of climate variability on their crop production, and the role of local government or community in averting climate change impacts. Likewise, agricultural and rural development officials from natural resource, water resource, and soil resource of the Woreda as well as development agents from the sample kebele were interviewed to collect primary information about adaptation strategies taken by their government, the effectiveness of such strategies and the factors influencing the adaptation strategies of farmers. Finally, a total of 9 interviews were made.

Direct Observation

A direct observation through transect walk was made in order to have firsthand impression on the existing adaptation strategies of the communities and responses undertaken by governmental and non-governmental organizations to reduce climate change impacts. Furthermore, captured photographs on some of the current adaptation strategies employed by the communities can clearly witness that.

3.6. Data Analysis and Processing

The bio physical and socio economic data that was collected using household survey on the selected 125 respondents was analyzed by using the indicator method of quantifying vulnerability. This method quantifies vulnerability based on selecting context specific indicators and systematically combining them. The indicators were selected based on reviewing literature and context of the study. Principal component analysis was used to determine the weight of the selected variables while constructing the vulnerability index. The climatic data that was obtained from the NMA was analyzed using time series analysis. Besides, chi square test was used to see the associations between the selected variables and localities/ agro ecological zones. Data obtained on adaptation strategies to climate change as well as the various factors influencing household's choice of adaptation strategies was analyzed and presented using simple descriptive statistics (tables and figures). The qualitative data collected by employing FGDs and interviews across the different agro ecological zones was analyzed qualitatively so as to assist the ideas obtained quantitatively and in cross checking results, consequently help to increase the validity and reliability of the findings. Besides, secondary data obtained from NMA, the Woreda and kebeles was also used and analyzed.

3.6.1. Constructing vulnerability indices of each kebele/agro-ecology

For the analysis of vulnerability in the study area both bio-physical and socio-economic vulnerability perspectives have been integrated. Fusel and Klein (2006) and IPCC (2001) have summarized the framework for vulnerability analysis to include adaptive capacity, sensitivity and exposure. In the framework, exposure to climate change and variability will lead to vulnerability based on the sensitivity level of the communities' lives and livelihood. Moreover, when the capacity to withstand the negative consequences of exposure and sensitivity become very low the vulnerability of climate change impact will be very much higher. Thus, from the IPCC (2001) concept, vulnerability can be calculated as the net effect of sensitivity and exposure on adaptive capacity.

However, vulnerability level or the comparative analysis of kebeles/agro ecologies in *Kola* Tembien Woreda was made based on the adaptive capacity and sensitivity of the surveyed rural communities under relatively similar level of exposure. Households were asked about their perceptions towards climate variables and a nearly similar result was found. All households perceived that climate is changing and then it was assumed that the surveyed areas have similar weather patterns.

Vulnerability level of rural communities in the surveyed areas was calculated using indicator method. This method quantifies vulnerability based on selecting context specific indicators and systematically combining them. The vulnerability indices were then obtained by applying Principal component analysis (PCA) on the adaptive capacity and sensitivity variables following the works of Deressa *et al*., (2008). PCA is frequently used in research that constructs indices for which there are no well-defined weights. It is a linear combination of optimally-weighted observed weights. Here, it is assumed that there are no well-defined weights assigned to the vulnerability indices. Therefore, PCA generated the weights, based on the assumption that there is a common factor that explains the variance in the vulnerability. Instinctively, the first principal component of a set of variables is the linear index of all the variables that captures the largest amount of information common to all the variables. Accordingly, the first component scores from the principal component analysis measured the weighted sum of score of all variables.
Following Deressa *et al*., (2008), I specified,

Vulnerability= (adaptive capacity) - (sensitivity + exposure).............................. (1)

Here, higher value (i.e. when adaptive capacity is greater than the sum of sensitivity and exposure) indicates less vulnerability while lower value indicates higher vulnerability. As explained above, each set (adaptive capacity, exposure and sensitivity) are composed of different indicators.

Suppose we have a set of k variables (a*1j to a*zj) that represents the k variables (attributes) of each agro-ecologies j. PCA starts by specifying each variable normalized by its mean and standard deviation. For Example: a1j= (a*1j-a*1)/s*1, where a*1 is the mean of a*1j across agro-ecologies and s*1 is the standard deviation. The selected variables are expressed as linear combinations of a set of underlying components for each kebele/ agro ecologies j.

$$\begin{cases} a1j = X_{11}Y_{1j}+X_{12}Y_{2j}+ \dots +X_{1z}Y_{zj} \\ \dots \\ az1j = X_{z1}Y_{1j}+X_{z2}Y_{2j} + \dots + X_{zz}Y_{zj}, \end{cases} \quad j=1 \dots J \qquad (2)$$

Where, Y's are the components and the X's are the coefficients on each component for each variable (and do not vary across agro-ecology). Because only the left side of each line is observed, the solution to the problem is indeterminate. PCA overcomes this indeterminacy by finding the linear combination of the variables with maximum variance (usually the first principal component y1j), then finding a second linear combination of the variables orthogonal to the first and with maximal remaining variance, and so on. Technically, the procedure solves the equations (R-λI) vn=0 for λn and V_n, where R is the matrix of correlations between the scaled variables (a's) and V_n is the vector of coefficients on the n^{th} component for each variables. Solving the equation yields the characteristic roots of R, λn (also known as eigenvalues), and their associated eigenvectors, V_n. The final set of estimates is produced by scaling the V_ns 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:

$$\begin{cases} Y_{1j} = f_{11}\, a_{1j} + f_{12}\, a_{2j} + \dots + f_{1z}\, a_{zj} \\ \dots \\ Y_{zj} = f_{z1} a_{1j} + f_{z2}\, a_{2j} + \dots + f_{zz}\, a_{zj}, \end{cases} \quad j=1, \dots, J\dots\dots\dots \qquad (3)$$

Where, the f's are the factor scores. The first principal component, expressed in terms of the original (un normalized) variables which is used as a weight of each variable, is therefore an index and finally, the vulnerability index of each kebele/ agro-ecology in Kola Tembien Woreda is obtained using the following equation.

$$VI_{1j} = f_{11}(a^*1j - a^*1)/(s^*1) + \ldots + f_{1z}(a^*zj - a^*z)/(s^*z) \quad \ldots\ldots\ldots \quad (4)$$

In calculating the direction of relationship in vulnerability indicators (i.e. their sign), a negative value was assigned to sensitivity. The justification is that areas that are highly sensitive to climate shocks will negatively affect adaptive capacity thereby increase vulnerability. Therefore, a higher net value indicates lesser vulnerability and vice versa. As cited in Deressa *et al.,* (2008), vulnerability analysis ranges from local or household (Adger, 1999) level to the global level (Brooks et al, 2005). The choice of scale is dictated by the objectives, methodologies, and data availability. For this study, the scale of analysis was local level and taken in to account local variations. This is because, all the earlier studies using aggregated regional and national levels data has overlooked local variations which is important for household level analysis.

3.6.2. Description of model variables

Vulnerability is highly dependent on context and scale (Alebachew, 2011). Thus, caution must be exercised to avoid interpreting indicators of vulnerability in an overly rigid fashion. Hence, the vulnerability analysis made to this study was based on different indicators obtained through reviewing literatures and context of the study. The variables were then grouped according to the study's conceptual frame work which includes the following indicators under adaptive capacity, exposure and sensitivity.

1. Adaptive capacity

According to IPCC (2001), the main features determining a community or region's adaptive capacity include: economic wealth, technology, information and skills, infrastructure, institutions and equity. Hence, adaptive capacity for this analysis was represented by wealth, technology, access to infrastructures and institutions, access to information, literacy level and potential for irrigation.

I. Wealth

Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets and entitlement programmes (Cutter *et al.,* 2000). The number of owned livestock, ownership of a radio and quality of residential homes are commonly used as indicators of wealth in rural African communities (Vyas and Kumaranayake, 2006). Wealth accumulation in the study area was explained by total livestock number of households, quality of residential home, non-agricultural income, farm size and saving in cash of the households. This was measured by the percentage of households who own or have an access to them.

A. Saving in cash

The assumption here is that households who have cash reserves are expected to withstand climatic shocks. This is to mean that households who save money in cash are expected to have higher adaptive capacity than those who save none. Therefore, the more they save money, the less they are vulnerable.

B. Quality of residential home

Here, it is assumed that households who live in a house with a corrugated iron roof are expected to be wealthy and less vulnerable to climatic impacts than those who live in a non corrugated iron roof.

C. Non agricultural income

In rural Ethiopia, agriculture may be viewed as a land use system, an economic mode of production and a way of life for many people who drive their main livelihood incomes or subsistence from crop farming and livestock herding largely dependent on feeds grown naturally (Alebachew, 2011). However, the sector is highly sensitive to climate change impacts (Temesgen, 2010) so that those households who earn more income from a non agricultural sector are believed to be less vulnerable than those who entirely depend on agricultural activities for their livelihoods. Hence, households who diversify their activity outside of the sensitive sector are believed to be less vulnerable than those who entirely rely on it.

D. Land size

Land, particularly farm land, is the most valuable resource and household asset in Northern Ethiopia (Alebachew, 2011). Majority of the households in the study area practiced a mixed farming system so that it is assumed households with large sizes of their cultivated land have higher adaptive capacity than those with the counter wise.

E. Number of livestock

in addition to serving as a source of power for farming (e.g. oxen) and manure for fertilizing soil, livestock can serve as assets and insurance against shocks (Yirga, 2007). The number of owned livestock as an indicator of adaptive capacity varied across households and it is assumed that households having higher number of livestock population have better adaptive capacity there by less vulnerable to climate change impacts than those with the counter wise.

F. Access to remittances

Here it is assumed that households who earn more livelihood income from remittance have better adaptive capacity to climate change impacts than those with the contrary. Therefore, those who have access to are relatively less vulnerable.

II. Access to modern technology

Technology can potentially play an important role in adapting to climate change, like improved seeds, fertilizer supply, insecticide & pesticide can lead to improved outcomes and increased coping under conditions of climate change (Smit and Skinner, 2002). IPCC (2001) also stated that lack of technology has the potential to seriously impede a community's ability to implement adaptation options by limiting the range of possible responses and interventions. Hence, households who have access to modern technology such as improved seed supply, fertilizer supply, and insecticide and pesticide supply are expected to have better adaptive capacity than those with no access. This was measured by the percentage of households with in 1-4 kms supply sources of these technologies.

III. Access to information

Information is a powerful tool for enhancing adaptation to climate change and variability. Successful adaptation requires recognition of the necessity to adapt, knowledge about available options, the capacity to assess the options, and the ability to choose and implement the most suitable ones (Lee, 2007). To this study, access of households to information is represented by radio ownership. It was measured by the percentage of the households who own radio.

A. Radio ownership

It is assumed that households who own radio are relatively close to information pertaining to climate change and technology usage than those who have not. They can hear so through the medium.

IV. Infrastructure and institutions

According to Temesgen, *et al.*, (2008), Well-developed institutions and infrastructure play important roles in adapting to climate change by facilitating access to resources. The availability as well as the proximity of infrastructures and institutions such as all weather roads, health services, schools, veterinary centers, market, and microfinance in the households determines their adaptive capacity. In addition, O'Brien *et al.* (2004), supports that areas with better infrastructure are expected to have a higher capacity to adapt to climate change. This was measured by the percentage of the households with in 1-4 kms of these infrastructures and institutions.

A. Weather roads

All-weather roads facilitate the distribution of necessary inputs to farmers and increase access to markets. It is assumed that households found within 1-4 kms proximity to road can easily withstand difficulties resulted from climate change impacts than those found far away.

B. Health services

Health services enable the provision of preventive treatments for diseases associated with climatic change, such as malaria. It is assumed that households who have access to health services are more likely to withstand effects of climate change than those with none.

C. Full cycle school

It is clear that educated households are more likely to survive in times of climate change variability and shock, as they are more likely to find any other adaptation option than those which are not. Therefore, households who have access to full cycle school are assumed to have stock of knowledge there by better adaptive capacity than those who do not have.

D. Veterinary services

Households in the study area practice a mixed farming system. Livestock production, being among the types of farming systems which are highly affected by climate change impacts should be taken in to account similar to other sectors. Hence, the provision of veterinary services is decisive in maintaining the health conditions of livestock population. It is assumed that those who are found close to veterinary services are more likely to survive with their stocks in times of climate shocks. Therefore, households with an access to such services have better adaptive capacity than the counter wise.

E. Market access

The proximity to markets is an important indicator in enhancing adaptive capacity of households, seemingly because the market serves as a means of exchanging information & various agricultural inputs with other farmers (Maddison, 2006). Therefore, Households found close to market centers can easily access various agricultural inputs and are more likely to have better job opportunity than the other ones.

F. Micro-finance

The availability of microfinance institutions close to households can contribute a lot in enhancing the adaptive capacity of respondents. It is assumed that the proximity of such institution to households can facilitate saving and credit services which will help them withstand shocks in times of rainfall uncertainty and crop failures.

V. Potential for irrigation

Irrigation potential is another important factor determining the adaptive capacity of households. This is because places with more potentially irrigable land are more adaptable to adverse climatic conditions (O'Brien *et al.,* 2004). Hence, households with a higher potential for irrigation activities are expected to have higher adaptive capacity than the other ones. The irrigation potential of each household was calculated as total irrigable land divided by total area.

VI. Education level

Households with a varied level of educational back ground are expected to be close to various types of climatic information and have a diverse option for mitigating impacts there by having higher adaptive capacity than those who are illiterate. This was measured by the percentage of households.

2. Sensitivity

According to IPCC (2001), sensitivity is the degree to which a system is affected by or responsive to climate stimuli. It is related to characteristics of the system and to broader non-climatic factors (e.g. land use, livelihood, infrastructure, government policy). It is clear that indicators for environmental vulnerability includes but not limited to slope of the land, soil fertility, rainfall, temperature, frequency of hazards such as drought, flooding, forest fire, disease outbreaks, etc (Deressa *et al.*, 2008; Glwadys and Claudia, 2009). Here, sensitivity is represented by soil fertility and slope of the cultivated land. It is assumed that households found in more productive soil and plain farm lands are expected to be less affected by adverse climatic conditions than households with the opposite features. This was measured by the perception of households towards the fertility and slope of their cultivated land.

A. Soil Fertility

Households who perceive their cultivated land is infertile may take a range of activities to overcome the problem and improve the productivity of their cultivated land. Therefore, it is assumed that cultivated lands which are poorly fertile and cannot produce without heavy fertilizer use are believed to be more sensitive than the counter wise.

B. Slope of farm land

Sensitivity and productivity of farm lands can be directly or indirectly affected by the nature of their topography. Households found in steep slopes are expected to be more sensitive and it is assumed that highly sloppy cultivated lands are relatively sensitive to the impacts induced by climate change than the counter wise.

3. Exposure

Exposure refers to the degree of climate variability (rate of temperature and rainfall change) and change that an entity (a country, community, individual or ecosystem) experiences (IPCC, 2001). To this study, the level of exposure was calculated at a more aggregate (Woreda) level. This was happened because of the lack of climatic data at either agro ecology, kebele or some other station level in the Woreda. However, the perception of households towards climate change was assessed at specific level in order to describe the behavior of climate variables. A similar result was found in that all of them perceived the change in temperature and rainfall. Besides, it was observed that the study areas did not have a significant distance in between. Hence, they were assumed to have a similar weather pattern so that level of exposure was assumed to be relatively similar.

Change in temperature

Data for the analysis of the rates of changes in temperature was obtained from the national metrological agency (2014). It was calculated from base year of 1994. Therefore, a higher rate of change positively contributed to exposure level. It was measured by the rate of change.

Change in rainfall

Data for the analysis of the rates of changes in temperature was obtained from the national metrological agency (2014) and was calculated from the base year of 1994. It was measured by the rate of change.

CHAPTER FOUR

4. Results and Discussions

4.1. Socio demographic characteristics of respondents

This sub-section provides a baseline socio-economic data of the area understudy in which the main findings should be viewed. Thus, results which are discussed in the forthcoming sections should be viewed and understood from this angle of perspective only.

Table 3: Socio demographic characteristics of respondents

Socio-demographic variables	Variable classification	Frequency	Percentage
Sex of households	Male	87	69.6
	Female	38	30.4
	Total	125	100
Age group	15 -30	22	17.6
	31 -65	98	78.4
	Above 65	5	4
	Total	125	100
Marital status	Married	105	84
	Divorced	16	12.8
	Widowed	4	3.2
	Total	125	100
Educational status	Illiterate	43	34.4
	Able to read and write	42	33.6
	Primary education	37	29.6
	Secondary education	3	2.4
	Total	125	100

Source: Own Survey (2014)

As illustrated in the above table 3, 69.6% of the sample respondents were male where as the remaining 30.4% were female headed households. The distribution of respondents according to their age group shows that majority of the sample respondents (78.4%) were found between 31 and 65 years of age. Respondent's marital status report also shows that 84%, 12.8% and 3.2% were married, divorced and widowed respectively. As far as their education level was concerned, 33.6% of them can read and write, a quite small proportion of them (2.4%) attended secondary school, 34.4% hardly got an education opportunity, and 29.6% of them had access to primary schools.

4.1.1. Sex of the Sample respondents

The sex distribution of the respondents was discussed in light of male headed and female headed households in both the selected agro-ecologies.

As clearly illustrated in Figure 4, about one-third of the sample respondents across all surveyed study kebeles were FHHs where as MHH constitute the remaining proportion. At kebele level, 76.7% (23) households in Limat, 65.6% (21) in Begashka, 81.8% (27) in T/giorgis and 53.3% (16) the surveyed households were male headed where as the remaining were female headed households. Apart from others a relatively equal number of male and female headed respondents were selected from Menji. A statistically significant association was found between sex and kebele of respondents. χ^2=7.027, *df*=3 and p=0.071.

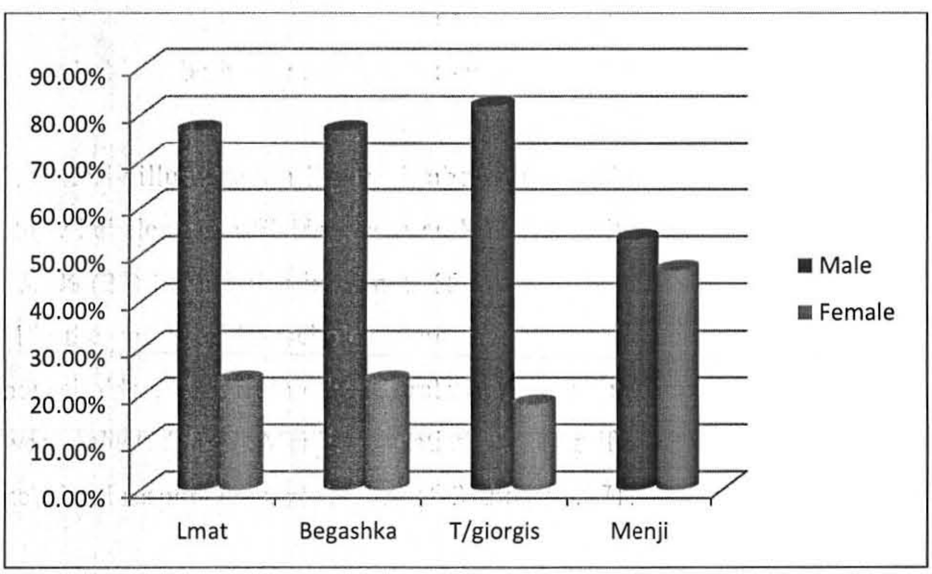


Figure 4: Sex of sample household heads

Source: Own Survey, 2014

4.1.2. Age distribution of respondents

The researcher here considered the age respondents because, the fact that the presence of various age groups in the family may determine the family's adaptive capacity to climate change in one or the other way. Hence, Table 4 below clearly provides the distribution of households across the different agro-ecologies.

Table 4: Age distribution of respondents

Kebele		15-30	31-65	Above 65	Total	χ^2
Limat	Count	6	24	0	30	*7.060*^{Ns}
	%	20	80	0	100	*df=6*
Begashka	Count	9	21	2	32	
	%	28.1	65.6	6.2	100	
T/giorgis	Count	3	29	1	33	
	%	9.1	87.9	3	100	
Menji	Count	4	24	2	30	
	%	13.3	80	6.7	100	

NS, not significant at 10%

Source: own survey (2014)

The age distribution of households in different agro ecological zones shows that majority of them (80%) in Limat, 65.6% in Begashka, 87.9% in T/giorgis and 80% in Menji were found between 31 – 65 age group whereas 20% in Limat, 28.1% in Begashka, 9.1% in T/giorgis and 13.3% of the surveyed households in Menji lies between 15-30 age group. No surveyed household in Limat were found in above 65 years age group while 6.2% in Begashka, 3% in T.giorgis and 6.7% of surveyed households in Menji lies under the same category. However, a statistically insignificant association was found between age and kebele/agro-ecology.

4.1.3. Marital status of respondents

As depicted in figure 5 below, majority of sample households in all the selected kebeles 76.7% in Limat, 59.4% in Begashka, 78.8% in T/giorgis and 53.3% in Menji were married. It is clearly shown that no single respondent was found among the selected kebele/agro-ecologies. Among the divorced respondents, 10%, 28.1%, 18.2%, and 26.7% were from Limat, Begashka, T/giorgis and Menji. No statistically significant association was found between marital status and kebele/agro ecology of respondents where χ^2= ***9.186, df=6, p=0.163***

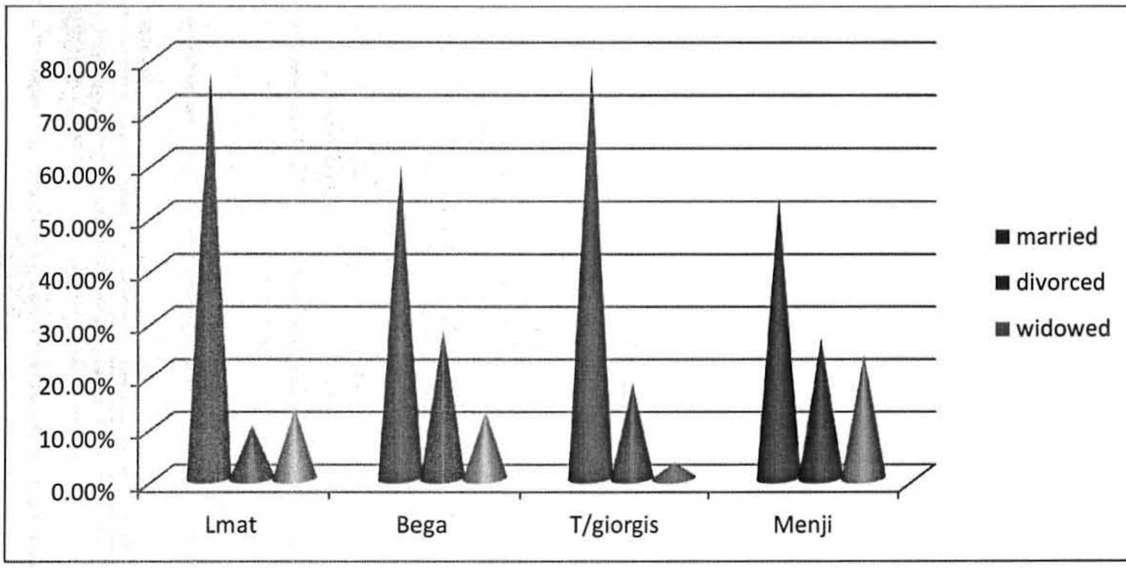


Figure 5: Marital status of households

Source: Own Survey, 2014

4.1.4. Educational status of respondents

Generally speaking, out of the 125 surveyed households, 34.4% of them were illiterate, 33.6% of them can read and write, 29.6% of them had primary education and 2.4% of them were with secondary education status. However, when we breakdown their status across agro-ecologies the following figure was obtained.

Table 5: Educational statuses of sample respondents

Agro ecology		Illiterate	Able to read and write	Primary education	Secondary education	χ^2
Limat	Count	11	9	10	0	*31.130****
	%	36.7	30	33.3	0	*df=9*
Begashka	Count	11	2	17	2	*p=0.000*
	%	34.4	6.2	53.1	6.2	
T/giorgis	Count	7	20	5	1	
	%	21.2	60.6	15.2	3	
Menji	Count	14	11	5	0	
	%	46.7	36.7	16.7	0	

Source: Own field survey, 2014

NB. *, **, *** represents significance levels at 10%, 5% and1% respectively

The above table 5 clearly shows that a relatively greater proportion of the households (36.7%) in Limat were illiterate where as none of the surveyed households in the same kebele had secondary education. Similarly, a relatively greater number of households in Begashka (53.1%), T/giorgis (60.6%) and Menji (46.7%) had primary education, can read and write and were illiterate respectively. A smaller proportion of households in Begashka (6.2%) and T/giorgis (3%) had secondary education where as no household in Menji was reported to have secondary education. A statistically highly significant association was found between educational level of households and kebele/agro-ecology.

4.1.5. Family size

The average family size of the surveyed households in the Woreda was 6 which is more than the national average (4.7) and the regional average (4.3) (CSA, 2007). However, variations were observed across the surveyed areas. Table 6 presents the average family size of sample respondents across the surveyed kebeles/agro ecologies.

Table 6: Family sizes of households

Kebele		Family size of households			χ^2
		1-3	4-6	Above 6	
Limat	Count	2	15	13	6.930 NS
	%	6.7	50	43.3	*df* 6
Begashka	Count	3	19	10	
	%	9.4	59.4	31.2	
T/giorgis	Count	2	18	13	
	%	6.1	54.5	39.4	
Menji	Count	0	12	18	
	%	0	40	60	

NS, not significant at 10% confidence level

Source: Own Survey (2014)

As illustrated in table 6, majority of the households in Limat (50%), Begashka (59.4%), T/giorgis (54.5%) and Menji (40%) have an average family size between 4-6 members. However, no household with a family size of less than 3 members was surveyed in Menji. Relatively speaking, surveyed households in Menji had a greater family size (60%) above 6 persons per household than any other surveyed area. Statistically, no association was found between family size and kebele/agro ecology of respondents.

4.2. Determinants of Vulnerability

4.2.1. Indicator variables of adaptive capacity

I. Wealth

It was recognized from the sample surveyed households that wealth accumulation mechanisms vary and diversify. Their wealth condition was then captured using the following determinants.

Quality of residential houses

Based on the context of the study area, quality of residential houses of the communities was identified as either corrugated iron with iron roofs or non corrugated iron with grass or mud roofs. Hence, it was found that 53% of households in Bega shka (Mid land agro-ecology), 29% in Limat (Low land agro-ecology), 18% in T/giorgis (Mid land agro-ecology) and 10% in Menji (low land agro-ecology) own corrugated houses with an iron roofs. It is clear that Bega shka had better quality of houses than the other areas.

Farm land size

The production and productivity of farmers can be directly or indirectly determined by the size of the cultivated land. Hence, it was found that the average size of land of the sampled respondents in Bega shka, T/giorgis, Limat and Menji was 0.43 ha, 0.85 ha, 0.58ha and 0.67 ha respectively. Sample households in T/giorgis kebele had a relatively greater size of cultivated land than the other study areas. Focus group discussants also reported that their farm lands are fragmented and too small to cover the farming household's annual consumption and expenditure and hence ensure their food security.

Non-agricultural income

With the increasing challenge of natural hazards and human induced climate risks, more and more farmers in the surveyed areas were trying to combine their earlier mode of production with on farm and off farm activities. According to KTWFB (2014), incomes from non agri-cultural activities are widely practiced in the Woreda as it is endowed with various minerals such as gold. Households who earn income outside of the agricultural sector are believed to be less vulnerable than those with the counter wise (Temesgen, 2010). Therefore, 69% of households in Bega shka, 64% in T/giorgis, 81% in Limat and 62% of the households in Menji had access to non agricultural income most particularly extraction/selling of gold. A relatively greater proportion of population in Limat had access to non-agricultural income than any other kebele in the study area. This could be attributed to the mechanisms they followed to accumulate their wealth as they build rental houses in urban areas and extraction of minerals.

Remittance

Despite its contribution to enhance adaptive capacity, this activity is relatively rarely practiced in the Woreda. 16% of households from Begashka, 9% from T/giorgis, 13% from Limat and 10% of households from Menji reported they had access to remittance.

Saving

It is assumed that those households who save money are relatively less vulnerable than those who do not. Therefore, despite its variation in its amount 53% of households in Bega shka, 45% in T/giorgis, 71% in Limat and 34% of respondents from Menji reported they save money in saving and credit institutions found across their respected kebeles and Banks as well.

II. Access to modern technology

Access to technology and the ability of farmers to use these technologies could have a significant contribution to the productivity there by enhancing the adaptive capacity of communities. To this research, access of households to modern technology was represented by the following.

Table 7: Insecticide and pesticide supply of respondents

Kebele	Insecticide and pesticide access					χ^2
	Yes	%	No	%	Total	3.171^{NS} df=3 p=0.366
Begashka	20	28.2	12	22.2	32	
T/giorgis	19	26.8	14	25.9	33	
Limat	19	26.8	11	20.4	30	
Menji	13	18.3	17	31.5	30	
Total	71	56.8	54	43.2	125	

NS, not significant at 10% confidence level

Source: Own Survey (2014)

As depicted in the above table 7, (28.2%) of households from Begashka, 19 (26.8%) from T/giorgis, 19(26.8%) from Limat and 13(18.3%) of households from Menji were found within 1-4 kms of the supply sources of insecticide and pesticide.

Table 8: Agricultural input supply of respondents

Kebele	Fertilizer supply		χ^2	Improved seed supply		χ^2	Improved seeds use		χ^2
	Count	%	32.086***	Count	%	22.067***	Count	%	20.948***
Begashka	12	48	df=3	23	48.9	df=3	25	45.5	df=3
T/giorgis	0	0	p=0.000	7	14.9	p=0.000	12	21.8	p=0.000
Limat	13	52		9	19.1		10	18.2	
Menji	0	0		8	17.0		8	14.5	

Source: Own Survey (2014)

NB. *, **, *** represents significance levels at 10%, 5% and1% respectively

It was clearly shown in the above table that access and utilization of various agricultural inputs varies spatially. A statistically significant variation in those inputs was reported by the sample households across the selected kebeles/ agro-ecologies in the Woreda. In Begashka, a relatively greater proportion of the selected households were found within 1-4 kms of improved seed supply sources (48.9%) and 45.5% of them utilize improved seeds as well. This could be attributed to the presence of improved seeds distributor organization at their kebele level. This was made in collaboration between Mekelle University and Wegenigen University. Besides, T/giorgis and Menji are relatively found far away from the supply sources of fertilizer.

Figure 6: Improved seed supply distributor cooperative in Begashka

Source: Own field photo (2014)

III. Infrastructure and institutions

Health access

Accesses of respondents to health services vary from place to place as other indicators of adaptive capacity. Therefore, it was found from the selected households that 81% of households from Begashka, 67% from T/giorgis, 83% from Limat and 67% of households from Menji were found within 1-4 kms of health centers.

Access to full cycle school

Households who are found close to educational centers are believed to have better adaptive capacity than those who are found far away. To this idea, 78% of households in Begashka, 91% from T/giorgis, 87% from Limat and 87% of sample households from Menji reported that they were found within 1-4 kms of school centers.

Access to saving and credit institutions

According to KTWFB (2014), every kebele in the Woreda has a saving and credit institutions. However, the presence of micro finance institutions by itself could not be enough to determine the adaptive capacity of households rather the number of people who accessed it could determine it. As far as the study is concerned, Ebyet in Begashka, Genet in T/giorgis, Lemlem in Limat, and Fthawit in Menji were the micro finance institutions found in their respective kebeles.

Therefore, the findings of the study shows that in Begashka only 66% of household respondents, in T/giorgis 36% of households reported the existence of micro-finance institutions within 1-4 kms in their kebele where as 37% of households in Limat and 23% of households in Menji reported they have access within 1-4 kms of it.

The focus group discussants also reported about the importance of micro finance institutions in their kebele. the presence of saving and credit institutions are helping them to have credit and use it mainly for fattening of animals and buying agricultural inputs.

IV. Irrigation potential

Out of the total cultivated land of the sample households on average 0.15 ha of land in Begashka, 0.12 ha in T/giorgis, 0.28ha in Limat and 0.07 ha of land in Menji had the potential to be irrigated. Therefore, irrigation potential was higher in Limat than the other kebeles.

According to secondary data from KTWARDB (2014), a total of 4996.935 ha of land in the Woreda were cultivated through irrigation per the production year of 2005 E.C. the same report also indicated that 44.24%, 31.77%, 8.7%, and 14.93% of the cultivated lands were irrigated in Limat, Begashka, T/giorgis and Menji respectively per the aforementioned production year.

Figure 7: Irrigated land in Begashka

Source: Own field photo (2014)

Besides, secondary data from KTWFB (2014) indicated that kebeles and villages in the Woreda were broadly classified in to three groups based on their moisture content as high, moderate and low/shortage of moisture. Out of the total 27 kebeles, 31% of them had enough moisture content where as the remaining 69% lies under the category of the counter wise. To be specific, Bega shka and Limat had high/enough moisture content, where as T/giorgis (Limat) was moderately moisture and Menji was under the category of kebeles with no/shortage of moisture.

V. Access to information

Household's adaptive capacity can be directly or indirectly affected by access to information about social, economic and technological conditions. Households with information about climate change are better to use various adaptation strategies than those with none. 50% of households in Begashka, 30% in T/giorgis, 37% in Limat and 23% of households in Menji reported they had ownership of radio so that the specified proportion were believed to have access to information. It can be relatively said from this information that households in Menji lacked information than others.

4.2.2. Indicator variables of sensitivity

In order to assess the sensitivity of the sample agro-ecologies perceptions on both slope of the cultivated land of households and its fertility was employed.

Soil fertility

Perception of households about the fertility level of their cultivated land was employed as an indicator of sensitivity. Accordingly, 41% of households in Begashka, 55% in T/giorgis, 57% in Limat and 67% of households in Menji believed their cultivated land as infertile and did not cultivate without the use of chemical fertilizers.

Slope of the cultivated land

In Begshka, 38% of the sampled households believed that there cultivated land was highly sloppy where as 73% of households in T/giorgis, 67% in Limat and 60% of sample respondents in Menji reported they perceive their cultivated land as sloppy. It was also observed that Begashka had a relatively plain surface than the other kebeles.

4.2.3. Indicator variables of exposure

In the construction of vulnerability index, indicators of exposure were assumed to be constant because of the lack of available data at either agro-ecology or some other station levels in the Woreda. Only one station was found so that it could be impossible to extrapolate data from that single station and therefore assumption was made that all kebeles were expected to have a similar weather pattern. However, the general trend, variability and amount of temperature and rainfall were assessed based on the data obtained from the NMA. Here comes the analysis across the Woreda level.

Temperature analysis of *Kola* Tembien

In order to see the long term temperature change in *Kola* Tembien Woreda relevant data was collected from the national metrological agency (NMA). However, the collected data was not full and enough to the needs of the study and even no recorded data on temperature were found for the periods between 1981 and 1993. In this case, it could be possible to make extrapolation from the temperature data of Mekelle (2257 m.a.s.l) with an altitudinal variation of 429 for the missed periods using the adiabatic lap's rate (assuming that if a parcel of air climb 100 m.a.s.l it would lose 1 °c) but the missed periods are so long that it could affect the validity and reliability of the data. Hence, a separate analysis was made for the periods from 1973 – 1980 and 1994 - 2013.

1. Temperature analysis of *Kola* Tembien Woreda 1973 -1980

Table 9: Temperature analysis of *Kola* Tembien (1973 - 1980)

Temperature	Summer	Winter	Yearly
Mean (°c)	21.65	21.60	22.15
Stdv	0.733519	0.488514	0.45754
Coeff.variation	0.607292	-0.10313	-0.30026

Source: Own Calculation (2014)

N.B. summer here refers to the months of June, July and August where as Winter refers to December, January and February

As depicted in Table 9, the statistical analysis of average temperature change for the periods between 1973 -1980 showed that there was a decreasing trend. Though the trend of average temperature change is decreasing, the area exhibits inter-annual temperature variability. As shown in figure 8 below, maximum mean annual temperature of the period (22.90°c) was observed in 1978 and a minimum mean annual temperature (21.53 °c) was observed in 1980. The statistical result shows that 9 % of the variation in temperature for the period was explained by the variations in year where as the rest proportion was explained by other outside factors.

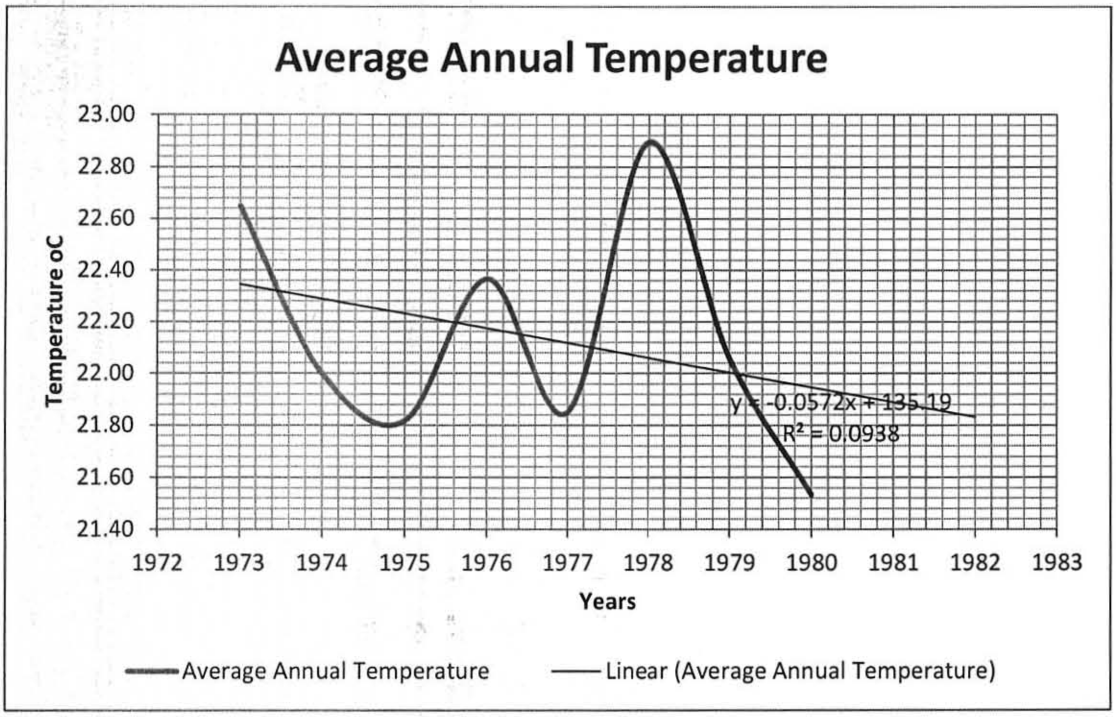


Figure 8: Trend of temperature change in *Kola* Tembien (1973 - 1980)

Source: Own Calculation, 2014

2. Temperature analysis of *Kola* Tembien *Woreda* 1994-2013

This section analyzes temperature change for the periods from 1994 – 2013 and a similar procedure was followed to determine the average seasonal and annual as well as the trend of temperature change.

Table 10: Temperature analysis of *Kola* Tembien (1994 - 2013)

Temperature	Summer	Winter	Yearly
Mean (oc)	20.65	20.8	21.45
Stdv	1.289499	0.981251	0.77156
Coeff.variation	2.335833	-0.01917	1.543958

Source: Own Calculation (2014)

The temperature analysis for the period 1994-2013 in *Kola* Tembien *Woreda* shows an increasing trend with a greater inter-annual variability. On average, the amount of temperature for the period has been changing by 0.0034 °c. As clearly shown in figure 9, a minimum mean annual temperature (19.28) of the period was observed in 1998 where as the maximum mean annual temperature (22.69) of the period was observed in 2003. The statistical result shows that 12% of the variation in temperature was explained by the variation in year where as the remaining was explained by outside factors. Results from the FGD and household surveys also indicated that the long term temperature and amount of solar radiation is increasing. This increasing trend of the average annual temperature was supported by 72.8% (91) respondents of the study areas.

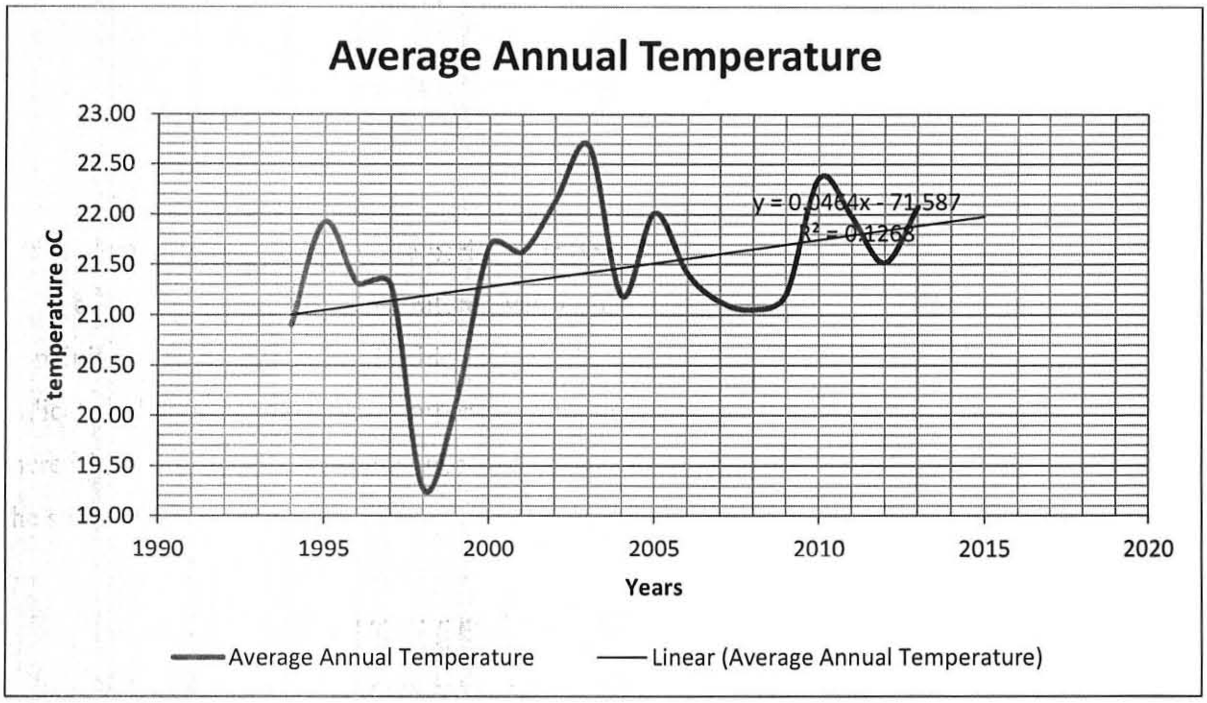


Figure 9: Temperature analysis of *Kola* Tembien (1994 - 2013)

Source: Own Calculation, 2014

Rainfall analysis of Kola Tembien

According to NMA, (2007), no statistically significant trend in mean rainfall was observed in any season in the last 55 years country wide. However, a greater inter-annual variability was recorded. Therefore, it is difficult to detect long term rainfall trends in Ethiopia due to the high inter-decadal rainfall variability (Alebachew, 2011). Similar to temperature, rainfall data was collected from the national metrological agency in order to see the long term change in rainfall. The rainfall analysis of *Kola* Tembien followed the same procedure as the analysis of temperature changes due to the aforementioned reason. The rainfall pattern of the Woreda is mono modal with a high amount of rainfall during the summer season (June to August). Table 11 and 12 below shows the analysis of rainfall from 1973 – 1980 and 1994– 2013 respectively.

1. Rainfall analysis 1973-1980

The rain fall analysis for the period is also calculated by defining the mean, standard deviation, coefficient of variation and even trend.

Table 11: Rain fall analysis of *Kola* Tembien (1973 - 1980)

Rainfall	Summer	Winter	Yearly
Mean (mm)	188.83	2.55	61.17
Stdv	67.61318	6.857227	20.59823
Coeff.variation	-81.95	-3.92708	-28.4896

Source: Own Calculation (2014)

A statistical result from table 11 shows that the mean annual rainfall for the periods from 1973 - 1980 shows a declining trend followed by various periods of wet and dries. The average rainfall for the period 1973 – 1980 was 61.17 mm and the standard deviation was 20.6. Therefore, periods of wet and dry years were calculated using the standard deviation and mean of the total 7 years. Hence, it is clearly illustrated in Figure 10 that the periods above the straight line represents periods of wet years where as the periods below that line were periods of dry seasons. The coefficient of determination (R^2) showed that 41% of the variation in rainfall was explained by the variations in year and the remaining proportion was explained by other external factors. The year 1978 was the wettest period and 1980 was the driest period in the history of the 9 years.

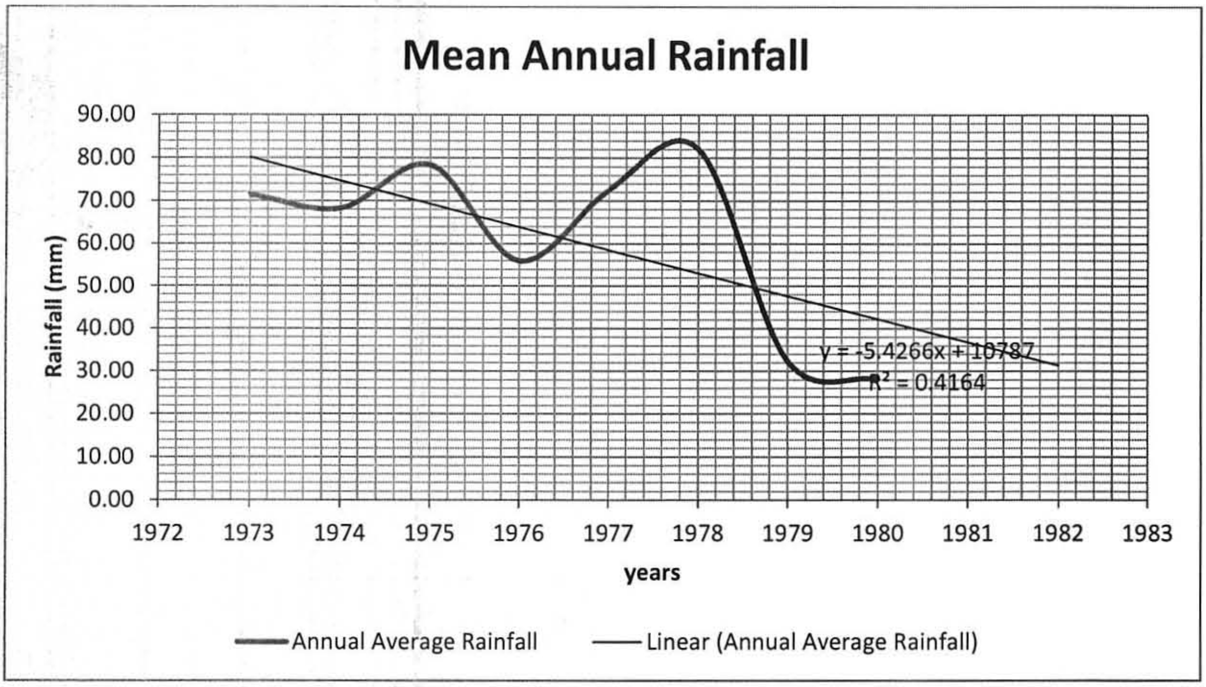


Figure 10: Rain fall analysis of Kola Tembien (1973 - 1980)

Source: Own Survey (2014)

2. Rainfall analysis 1994 – 2013

The analysis of rainfall for this period also follows the same procedure as the above calculation for the prior period.

Table 12: Rain fall analysis of *Kola* Tembien (1994 - 2013)

Rainfall	Summer	Winter	Yearly
Mean (mm)	287.92	1.43	94.00
Stdv	117.979	2.914924	33.38963
Coeff.variation	17.13083	-3.52583	-0.00131

Source: Own Calculation (2014)

As depicted in table 12, the rainfall analysis of the period based on its mean shows that there is no change in the amount. On average, the amount of rainfall for the period was changed by 0.0037 mm. However, the period exhibits a significantly greater inter annual variability. Based on the similar procedure given in the analysis of the previous periods, there were also years in the period of 1994 – 2013 which experience the wettest and driest conditions. Figure 11 clearly indicated that 1998 was the wettest period in the era between 1994 – 2013 and 2002 was the drought-prone period in that era. Besides, a similar finding was found from the FGD discussants and the surveyed households that they did not question the amount of rainfall but 48.8% (61) believed they experienced changes in the timing of the rains.

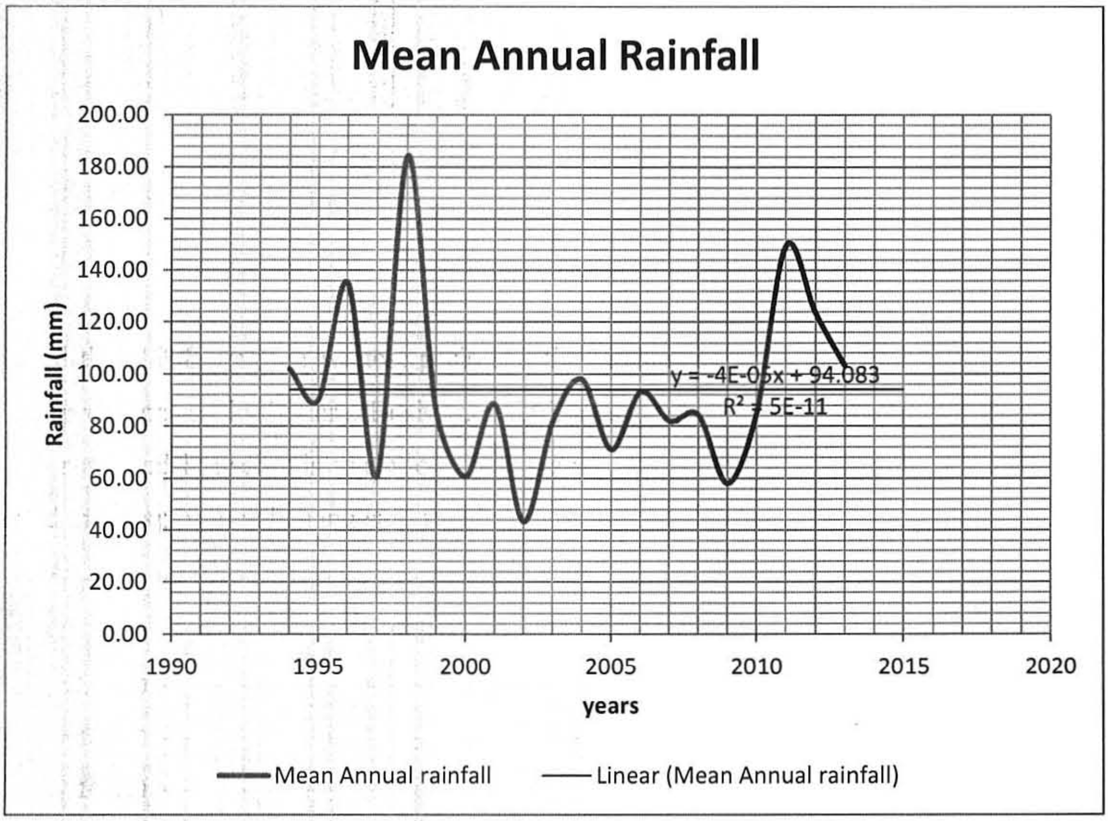


Figure 11: Rain fall analysis of Kola Tembien (1994 - 2013)

Source: Own Calculation, 2014

4.3. Perception of climate change by rural communities in *Kola* Tembien *Woreda*

Farmer's perception of long term temperature and rainfall changes

Adaptation to climate change is a two step process which involves perceiving that climate is changing in the first step and then responding to changes through adaptation in the second step (Maddison, 2006). Hence, by taking the objective of the study in to account, this section briefly summarizes household's perception of climate change and the existing adaptation strategies believed appropriate to these changes.

In order to obtain information pertaining the perception of households towards climate change, the surveyed households were asked questions about their observations in the patterns of temperature and rainfall over the last 20 years.

Table 13: Perceptions about changes in temperature and rain fall over the last 20 years

Kebele		Yes	No	Total	χ^2
Limat	Count	27	3	30	*2.970^{NS}*
	%	90	10	100	*df=3*
Bega	Count	26	6	41	*P=0.396*
	%	81.2	18.8	100	
T/giorgis	Count	31	2	33	
	%	93.9	6.1	100	
Menji	Count	25	5	30	
	%	83.3	16.7	100	

NS, not significant at 10% confidence level

Source: Own Survey (2014)

As can be seen from the above table 13 no statistical significant variation was found among household respondents and there is no association between perceptions and agro-ecological settings. The majority of the sample respondents i.e. 90% (27) household respondents in Limat (low land agro-ecology), 81.2% (26) respondents in Begashka (midland agro-ecology), 93.9% (31) households in T/giorgis (mid land agro-ecology) and 83.3% (25) respondents from Menji (low land agro ecology) perceived that the condition of temperature and rainfall over the last 20 years never stayed the same. The result was also aggregated based on agro-ecological zones and found that 87.7% (57) households from the mid land and 86.7% (52) households from the low land agro ecological zones perceived a change in temperature and rainfall over the last 20 years.

Table 14: Perceptions about the trend of temperature over the last 20 years

Agro ecology		Increasing	Decreasing	No change	I don't know	Total	χ^2
Limat	Count	24	3	2	1	30	*16.544**
	%	80	10	6.7	3.3	100	*df=9*
Bega	Count	19	3	6	4	32	*P=0.056*
	%	59.4	9.4	18.8	12.5	100	
T/giorgis	Count	30	2	0	1	33	
	%	90.9	6.1	0	3	100	
Menji	Count	18	5	6	1	30	
	%	60	16.7	20	3.3	100	

* Significant at 10% confidence level

Source: Own Survey (2014)

Farmer's were also asked whether the trend of temperature/number of hot days had increased, decreased or stayed the same over the last 20 years and a statistically significant difference was found among the responses of households across different agro-ecological settings (p=0.056). out of the total sample respondents taken, 80%(24) respondents from Limat, 59.4% (19) households from Bega, 90.9% (30) households from T/giorgis and 60% (18) of households from Menji perceived trend of temperature over the last 20 years increasing. Generally speaking, 75.4% (49) households from the midland agro ecology and 70% (42) of households from the lowland agro ecology believed the trend of temperature increasing where as believed the trend increasing. Whereas 9.2 %(6) households from the mid land and 13.3% (8) households from the lowland agro-ecology perceived the amount of temperature stayed the same. This variation can be more or less attributed to the variations in the agro-ecological settings of the sample study areas.

Table 15: Perceptions about the trend of rainfall over the last 20 years

Agro ecology		Increasing	Decreasing	Change timing	I don't know	Total	χ^2
Limat	Count	7	6	14	3	30	*4.477*^{NS}
	%	23.3	20	46.7	10	100	*df=9*
Bega	Count	5	8	14	5	32	*P=0.877*
	%	15.6	25	43.8	15.6	100	
T/giorgis	Count	8	5	18	2	33	
	%	24.2	15.2	54.5	6.1	100	
Menji	Count	5	8	15	2	30	
	%	16.7	26.7	50	6.7	100	

NS, not significant at10% confidence level

Source: Own Survey, 2014

Similar to the above figures, questions about the trend of rainfall was administered to the selected households and a statistically no significant difference was found among the responses of respondents with different agro-ecological setting (p=0.877). 46.7% (14) households from Limat, 43.8% (14) households from Bega shaka, 54.5% (18) households from T/giorgis and 50%(15) respondents from Menji reported there is no change in the amount but change in timing of rainfall. The aggregate result also gave 49.2% (32) households from the mid land agro-ecology and 48.3% (29) households from the low land agro-ecology believed the amount of rainfall stayed the same but experienced variations in the timing only. On the other hand, 20% (13), 20% (13), 10.8% (7) households from Midland agro-ecology perceived an increasing trend, decreasing trend and never felt trends respectively where as 20% (12), 23.3 (14, and 8.3% (5) households from the low land agro ecology experienced and increasing, decreasing and never felt trends respectively. This can also be attributed to agro-ecological variation.

Interviewed development agents in Daram kebele revealed about the effect of climate change on the livelihood of the households in the village and showed how much the area is vulnerable to climate extremes, particularly flood. He stated,

> '.......*climate variability is highly affecting our village like never it has been before. I have been here for the last 10 years and I found 2005 E.C as the worst period in history. Crops in the village were completely damaged and mass livestock has been exposed to death as a result of the severe hailstorms and flood drained from Dramba. Our communities were even asking for plots of land to be given outside their village. I don't know what will happen in the near future if this problem continues......*'

According to the result from the FGD and interviewed households the indicators used to measure climate is changing were moisture content of the air (before air during winter was moist, but now it is very hot and dry), lasting of rainfall (before it was stopping on average by mid of September but now lasts by early September) and reduction of indigenous trees.

The agricultural and rural development bureau officials also given that there are different forms of climate change in the *Woreda*. This is mainly attributed to the variability of temperature and rainfall. Temperature varies very highly across times. The numbers of hot days are increasing followed by the frequent occurrence of extremes in rainfall such that it rains early and last early, rain accompanied by hailstorms and floods which completely devastates their crops is also observed in the last years. In line with climate variability, different types of crop diseases have been frequently strike the crops of households. With respect to increase in temperature sheet fly frequently affects teff production in the *Woreda*.

4.4. Assessing Vulnerability at kebele/agro-ecology level

For the assessment of the level of vulnerabilities at local agro-ecology level, indicators of adaptive capacity were systematically combined with that of sensitivity. This was made based on the assumption that the selected representatives of the two agro-ecological zones are found not far away from the single station found in the Woreda so that they are expected to have similar weather patterns.

Results of vulnerability indices

As explained earlier comparison and analysis was made based on adaptive capacity and sensitivity of the area assuming constant exposure. PCA was employed to determine the weights of indicators of adaptive capacity and sensitivity.

To this research, 22 indicators were identified and processed (see annex 3) in to correlation matrix and a Varimax orthogonal rotation with Kaisar normalization using PCA and all the communalities were found greater than 0.5 that suit with Kaisar requirement. The KMO measure of overall sampling adequacy (annex 2) value is 0.540 which falls above the minimum requirement and Bartlett's test is highly significant ($p=0.000$) and therefore, factor analysis is appropriate using the data (Field, 2005). The principal component analysis revealed nine components with Eigen value of 1 and greater accounting 61.6% of the total variance. The first PCA has an Eigen value of 2.46 and explained most of the variation (11.2%), the second has an Eigen value of 1.96 which explained 8.9% and the third has an Eigen value of 1.6 which explained 7.5% of the variance. According to Temesgen (2010), for the use of PCA in constructing indices, the first principal component, which explained most of the variation in the data, can be taken.

While calculating the indices, indicators of adaptive capacity were positively attached with the PCA factor score so that those with negative values were rejected from further calculation and all the indicators of sensitivity as they are negatively associated with our PCA were selected. This is because, indicators of sensitivity and exposure negatively affects vulnerability where as indicators of adaptive capacity could do the contrary. A higher value indicates less vulnerability and a lower value indicates the counter wise.

Finally, the vulnerability of each kebele/agro-ecology can be calculated using equation four after the factor score (weight of each indicators) was obtained and the indicators of each determinants of vulnerability were normalized. This was made based on the assumption that people with higher adaptive capacity are less sensitive to climate change-driven damages, keeping the level of exposure constant. Hence, the vulnerability index of each kebeles/agro-ecologies was found following the same procedure. As an example, the vulnerability index of Bega shka (mid land agro-ecology) can be calculated as follows and the same pattern was followed to calculate the vulnerability index of other agro-ecologies.

$VI_{Begashka} = f_{11}\,(a^*1j - a^*1)/(s^*1) + \ldots + f_{1z}\,(a^*zj - a^*z)/(s^*z) = -0.16$

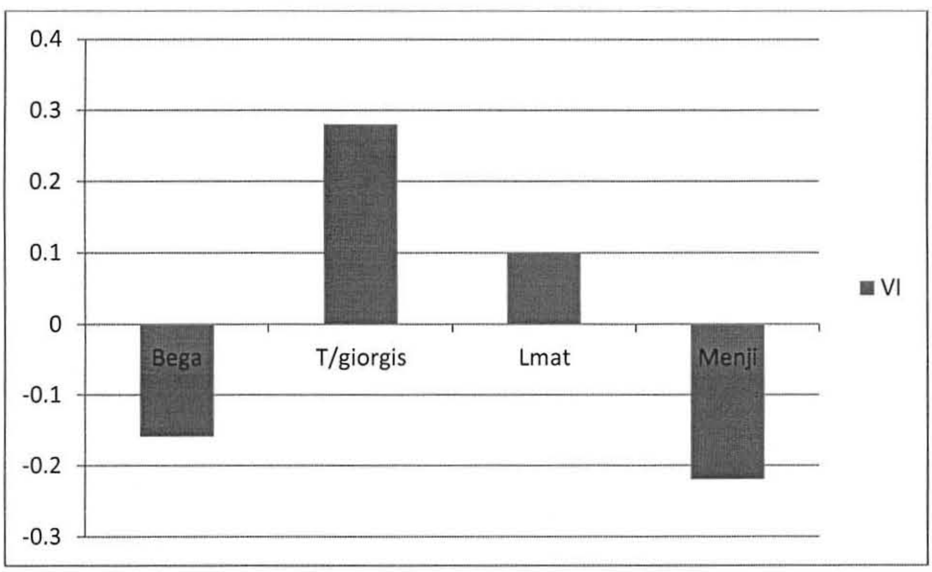


Figure 12: Vulnerability indices

Source: Own Calculation, 2014

Bega (mid land) -0.16, *T/giorgis* (mid land) 0.28, *Limat* (lowland) 0.10, and *Menji* (low land) -0.22

As shown in figure 12, the net effect of adaptive capacity and sensitivity is positive for T/giorgis (Mid land agro-ecology) and Limat (low land agro-ecology) but negative for Bega (midland agro-ecology) and Menji (low land agro-ecology). Here, the index value is used to compare the vulnerability levels of kebeles/agro ecologies. This indicates that T/giorgis and Limat are relatively less vulnerable than Bega and Menji. The relatively less vulnerability of T/giorgis (mid land agro-ecology) is associated with its relatively higher livestock population (4.61 TLU per hh) and large farm land size (0.85 ha per hh). The less vulnerability of Limat (low land agro-ecology) is associated with its relatively higher proportion of saving (71%), irrigation potential (27%) and relatively higher livestock number (4.05 TLU) than Bega (midland agro-ecology) and Menji (lowland agro-ecology). Besides, the vulnerability of Bega (mid land agro-ecology) is associated with its relatively smaller size of the farm land (0.43 ha on average) and livestock population (3.57 TLU). The vulnerability of Menji is associated with its relatively lower irrigation potential (7%) and access of households to saving and credit institutions (24%). However, the aggregate result showed that mid land agro ecological zone is less vulnerable than low land. But the most important point here is that since the data was collected at household level, internal variability in the level of vulnerability was highly witnessed in the selected agro ecological zones.

4.5. Adaptation strategies to climate change

Adaptation is improved society's ability to cope with changes in climatic conditions across time scales, from short term to the long term (Charles and Rashid, 2007). As per the definition given by the IPCC (2001), adaptive capacity refers to the ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. The goal of an adaptation measure is to increase the capacity of a system to survive external shocks or change. Hence, assessing the adaptation strategies of communities found in different agro-ecological zones is important to convey information that can be used to formulate policies that enhance adaptation as a tool for the management of various climate related risks in the agricultural sector. Climate elements by their nature are very local so that climate change studies should be conducted at very local levels. Besides, not all systems are equally vulnerable and have equal adaptive capacity towards the effects of climate change (PECCN, 2011; Senait *et al.*, 2010).

In view of the ongoing changes and variability in weather conditions, farmers in the study areas were using different strategies to survive the emerging impacts of climate change. However, some of which can be classified more under coping mechanisms than adaptation strategies. Therefore, based on the data collected using household survey from 125 households, this section briefly summarizes the existing adaptation and coping strategies believed appropriate to the perceived changes in climatic conditions. However, the adaptation measures that farmers report may be profit driven, rather than climate change driven. Despite this missing link, we assume that their actions are driven by climatic factors because they are reported by the farmers themselves (Maddison, 2006; Nhemachena & Hassan, 2007). The surveyed households were then asked questions about their commonly practiced adaptation strategies against climate change impacts. In this section assessment was made against five farming systems which are highly affected by climate change impacts and their respective responses namely farming, crop production, livestock population, land degradation and rainfall variability.

4.5.1. Adaptation strategies against crop failure

Farmers in the study areas never give up to the impacts of climate change rather they responded to it by practicing a combination of activities ranging from temporary modifications in their livelihood and farming systems towards a major modifications in the production systems. Therefore, when crop failure happened as a result of either climate variability or other effects pertaining to climate change, farmers responded by either taking an immediate actions or devising a long term solution if they believe the problem could be permanent.

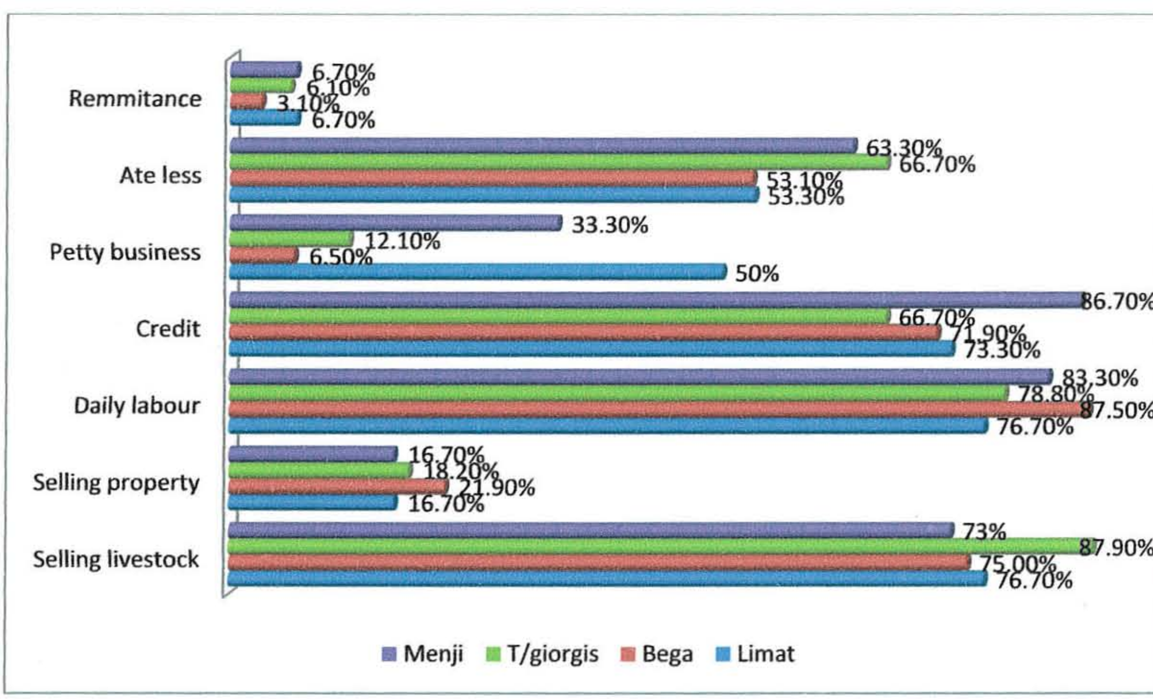


Figure 13: Farmer's coping mechanism against crop failure

Source: Own Survey, 2014

Households found across different geographical areas and agro-ecologies employed a number of common as well as different strategies as a response to crop failure and agricultural output insufficiency. It can be said from figure 13 that farmer's widely practiced immediate actions in times of crop failure were selling livestock, credit, labor migration, petty businesses and reduction of daily meal both in its amount and frequency to eat.

The dominant activities taken in Limat (low land agro-ecology) as a measure to the aforementioned problem were selling livestock (76.7%) and daily labour (76.7%) followed by credit (73.3%), reducing consumption (53.3%), petty business (50%), selling properties (16.7%) and remittance (6.7%). The coping mechanism in Bega shka also constitutes daily labor (87.5%), selling livestock (75%), credit (71.9%), and reduction in consumption (53.1%), selling properties (21.9%), petty business (6.55) and remittance (6.2%). In T/giorgis (87.9%) of the households sell their livestock in times of crop failure followed by daily labor (78.8%), credit (66.7%), and reduction in consumption (66.7%), selling property (18.2%), and remittance (6.1%). Majority of the surveyed households in Menji also relies on credit (86.7%), followed by labor migration (83.3%), selling livestock (73.3%), reduction in consumption (63.3%), borrowing money (72.3%), petty business (33.3%), selling property (16.7%) and remittance (6.7%).

Sample respondents from T/giorgis and Limat reported that they frequently practiced selling livestock as a primary option and this could be attributed to their relatively greater number of livestock population. On the other hand, labor migration is widely practiced in Begashka and Menji and this could be attributed to their relatively smaller sizes of their cultivated lands. Besides, selling fuel wood/charcoal also contains greater share of the options employed in Limat (low land agro-ecology). This could be attributed to their relatively greater wilder areas.

Table 16: Adaptation strategies made in farming to increase communities' agricultural out put

Type of activity	Percentage of respondents							
	Limat (N=30)		Bega (N=32)		T/giorgis (N=33)		Menji (N=30)	
	Count	%	Count	%	Count	%	Count	%
Change crop variety	19	63.3	27	84.4	23	69.7	23	76.7
Buy insurance	1	3.3	7	21.9	0	0	0	0
Build a water harvesting scheme	15	50	18	56.2	25	75.8	19	63.3
Soil conservation techniques	25	83.3	22	68.8	31	93.9	27	90
Changing planting dates	25	83.3	31	96.9	29	87.9	27	90
Irrigate more	7	23.3	6	18.8	3	9.1	2	6.7
Reduce number of livestock	13	43.3	11	34.4	10	30.3	7	23.3
Find off-farm job	24	80	27	84.4	27	81.8	20	66.7
Lease your land	7	23.3	2	6.2	13	39.4	6	20
No adjustments	5	16.7	5	15.6	4	12.1	5	16.7

Source: Own Survey (2014)

As indicated in the above table 16, rural communities are shifting to more drought tolerant crops and varieties, widely practicing a water harvesting techniques, soil and water conservation practices, and seeking an alternative means of income from off farm activities. majority of the households in Limat (mid land agro-ecology) practiced soil conservation techniques (83.3%) and changing planting dates (83.3%) as a strategies to increase their agricultural output where as buying insurance (3.3%) and no adjustments were very rarely practiced options in the study areas. Adjustments made on planting dates were the commonly practiced adaptation strategy in almost all agro-ecological zones of the study area (83.3%), (96.9%), (87.9%) and (90%) in Limat, Begashka, T/giorgis and Menji respectively. On the contrary, buying insurance was an activity very rarely practiced across the study areas (3.3%), (21.9%) in Limat and Begashka respectively and it was never employed in Menji and T/giorgis.

At agro-ecology level, 95.1% of the households practiced changing crop varieties followed by changing planting dates (97.6%), soil and water conservation (65.9%), build water harvesting scheme (56.1%), and reduce number of livestock (39%). On the other hand, communities in the Kola agro-ecology practiced mainly soil conservation techniques (60%), change crop variety (57%), changing planting dates (48%), and build water harvesting scheme (56.6%).

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However, shifting from crop to livestock and urban migration were hardly practiced under the surveyed households.

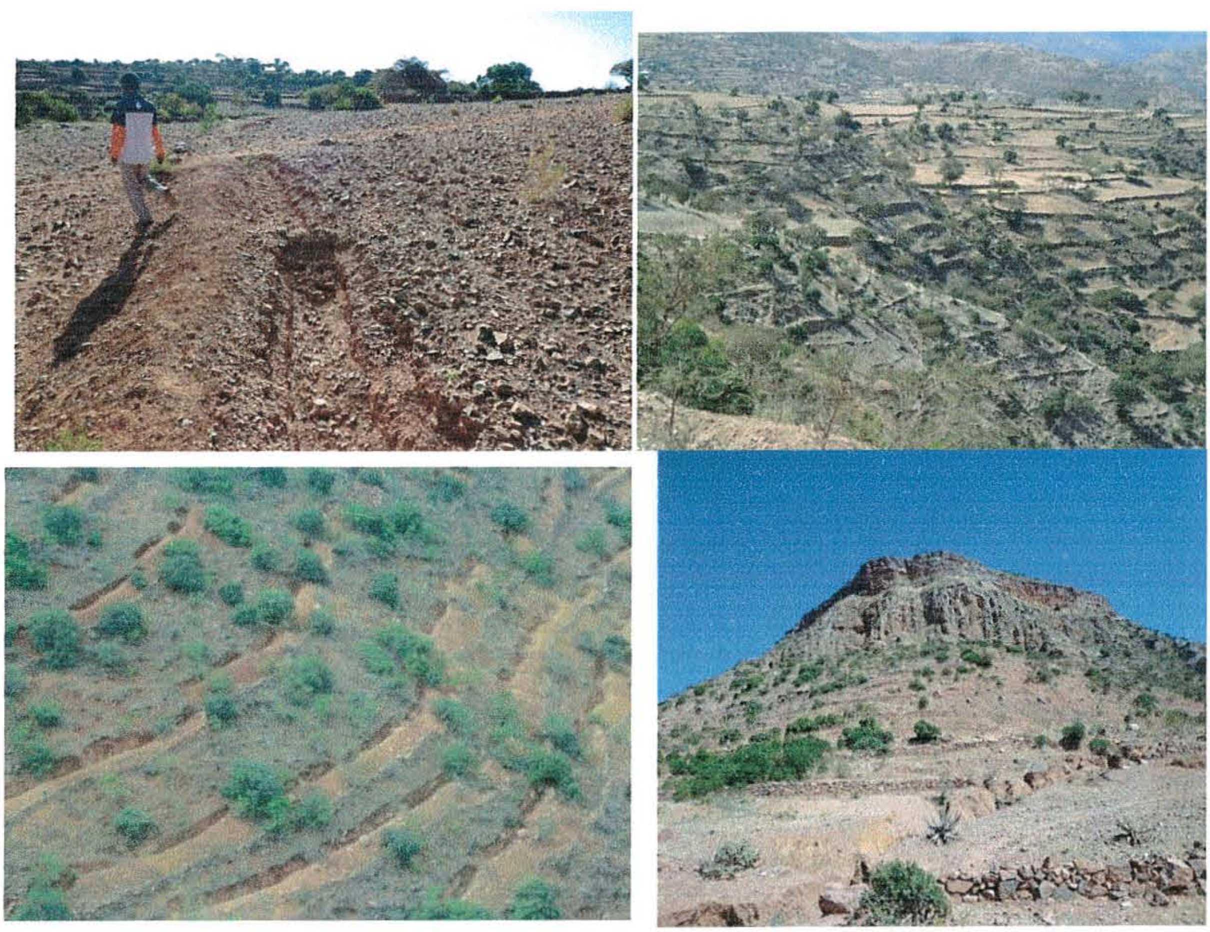

Figure 14: Adaptation strategies against land degradation in Menji and T/giorgis

Source: Own field photo, 2014

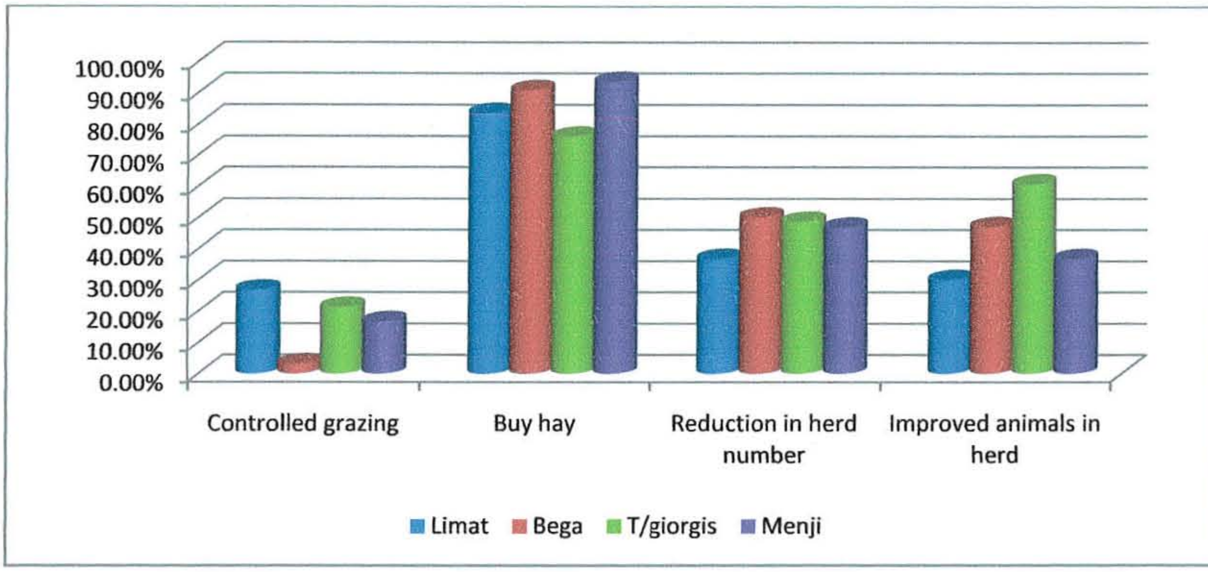

Figure 15: Adaptation measures to improve livestock production

Source: Own Survey, 2014

It is also revealed by the focus group discussants and key informant interviewee that new varieties of livestock are introduced to their localities. The agricultural and rural development officials reported that new and improved varieties of livestock are introduced in the Woreda in order to increase the livestock production of the communities not in response to climate change. Questions about the trend of their livestock was also raised and found that the number of goat population is increasing where as other types of livestock is decreasing. This could be another result of climate change.

4.5.3. Adaptation strategies against land degradation

Table 17: Perception to land degradation

Kebele		Yes	No	Total	χ^2
Limat	Count	21	9	30	*6.527**
	%	70	30	100	*df=3*
Bega	Count	18	14	32	*P=0.089*
	%	56.2	43.8	100	
T/giorgis	Count	27	6	33	
	%	81.8	18.2	100	
Menji	Count	24	6	30	
	%	80	20	100	

* Significant at 10% confidence level

Source: Own Survey 2014

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T/giorgis	Count	27	6	33	
	%	81.8	18.2	100	
Menji	Count	24	6	30	
	%	80	20	100	

* Significant at 10% confidence level

Source: Own Survey 2014

In order to get information on the perception of respondents towards land degradation, respondents were asked whether it is a factor for decreasing their agricultural output and a statistically significant difference was found among the responses of households found in different kebeles/agro-ecologies (P=0.089). 70% (21) households from Limat, 56.2% (18) from Bega, 81.8% (27) from T/giorgis and 80% (24) households from Menji reported land degradation as a factor for the year to year decrease in their agricultural output. The variation in perception was mainly attributed to the slope of their landscape. Observations show that T/giorgis, Menji, and Limat were relatively highly sloppy than Bega shka.

Table 18: Strategies employed to manage land degradation and increase productivity

Type of activities	Percentage of respondents							
	Limat (N=30)		Bega (N=32)		T/giorgis (N=33)		Menji (N=30)	
	Count	%	Count	%	Count	%	Count	%
Terracing	25	83.3	19	59.4	31	93.9	28	93.3
Mulching	9	30	16	50	5	15.2	7	23.3
Tree planting	19	63.3	19	59.4	23	69.7	14	46.7
Contour ploughing	23	76.7	20	62.5	24	72.7	23	76.7
Check dams	22	73.3	19	59.4	27	81.8	26	86.7
Changing tillage operations	13	43.3	26	81.2	22	66.7	20	66.7
No adaptation	6	20	8	25	0	0	2	6.7

Source: Own Survey, 2014

Terracing was highly practiced by the communities in T/giorgis 93.9% (31) followed by Menji 93.3% (28) and Limat 83.3 (25). Relatively speaking, the aforementioned activity is rarely employed by the communities in Begashka 59.4% (19). This could be attributed to its relatively plain surfaces of their cultivated land. The major adaptation strategies practiced in the low land agro-ecology were terracing (90.8%), tree planting (95.4%) and contour ploughing (93.8%) where as in midland terracing, tree planting, check dams and changing tillage operations all constitute 61% of adaptation strategies. The variations in taking such adaptation options can be emanated from the slope of their cultivated land.

One important experience found in Begashka to prevent soil degradation and maintain the fertility of their cultivated land was that households left up to 5 centimeter of their crop residuals while harvesting.

4.5.4. Adaptation strategies against Rainfall uncertainties

Table 19: Adaptation strategies employed in times of rainfall uncertainties

Type of activity	Percentage of respondents							
	Limat(N=30)		Bega (N=32)		T/giorgis (N=33)		Menji (N=30)	
	Count	%	Count	%	Count	%	Count	%
Adjustments of planting dates and crop variety	27	90	29	90.6	29	87.9	28	93.3
Rain water harvesting	24	80	28	87.5	24	72.7	21	70
Soil and water conservation	27	90	24	75	30	90.9	25	83.3
Changing tillage operation	16	53.3	25	78.1	19	57.6	14	46.7
Reducing consumption	21	70	24	75	22	66.7	23	76.7
Collection of wild foods	1	3.3	6	18.8	9	27.3	5	16.7
Inter-household loans	19	63.3	15	46.9	21	63.6	25	83.3
Petty commodity production	11	36.7	6	18.8	8	24.2	8	26.7
Labor migration	26	86.7	28	87.5	25	75.8	29	96.7
Sale of assets	5	16.7	9	28.1	12	36.4	14	46.7
Mortgaging of land	7	23.3	2	6.2	11	33.3	4	13.3
Credit	4	13.3	7	21.9	7	21.2	11	36.7
Use of early warning system	5	16.7	15	46.9	11	33.3	7	23.3
Food aid/safety net	13	43.3	11	34.4	22	66.7	19	63.3
Livelihood diversification	17	56.7	20	62.5	21	63.6	18	60

Source: Own Survey, 2014

As can be seen in the above table 19, different adaptation strategies were used by the surveyed households when they believe the rain fall is uncertain. Different types of strategies employed in different proportions across the study areas. However, changing the planting dates and even varieties of crops were reported to be the dominant strategies employed by majority of the surveyed farmers 90.4% (113). Besides, soil and water conservation was found to be another stretegy widely practiced by majority of the surveyed households in Limat 90 %(27) and T/giorgis 90.9% (30) next to the aforementioned strategy. This could be attributed to the nature of their topography. Whereas, the other dominant adaptation strategy employed by farmers in Bega and Menji were both rain water harvesting and labor migration 87.5% (28), and labor migration 96.7% (29) respectively. This could be also attributed to the land size of the kebeles. On the contrary, collection of wild foods in Limat 3.3% (1), mortgaging of land in Begashka 6.2% (2), credit in T/giorgis 21.2% (7) and mortgaging of land in Limat 13.3% (4) were reported as relatively rarely practiced activities in their respected kebeles. Results from the focus group discussion also revealed that variations in the timing of rainfall forced farmers to adjust both the planting calendar of crops as well as adopt different varieties.

The focus group discussants in all surveyed kebeles reported new varieties of crops are adopting and the cropping calendar was also shifting following the pattern of rainfall based on their local knowledge. They have traditionally classified types of crops as *Azmera*[4] and *tsdya*[5] crops. When rain fall falls in the periods starting from early April to late may, they started to sow Azmera crops such as maize, barley and dagusa where as when the rain comes after mid July, they began to sow tsdya crops like teff, sorghum, wheat and beans. In line with this, they are using agricultural extension services which helped them adopt newly introduced and drought resistant varieties of crops. To this effect, a new variety of teff called 'kuncho', and new varieties of maize by the name melkassa 2 and melkassa 4 have been adopted and used by the farmers and are being distributed by the Woreda officials.

Communities in almost all kebeles of the Woreda are executing a range of adaptation strategies individually and communally under the scheme of safety net, food for work and voluntary programmes. According to the ARDB officials and focus group discussants the major adaptation strategies applied and adopted by the local government and communities respectively were emergency aids, distribution of new/short term crops and food for work activities. the other and believed most common and important activity widely practiced in water prone areas of the Woreda were water harvesting activities like deep trench, soil and water conservation activities, water bank and broad bed making. Broad bed making is widely practiced in Begashka and Limat kebeles in order rain water to be drained slowly. Such activities have become effective in reducing land degradation, maintaining soil fertility and increasing agricultural outputs.

[4] *Azmera is a local term used by farmers to refer to long term crops. It is a time when rainfall falls early than the usual and believed to be good enough to produce their crops*

[5] *Tsdya is also a local term used by farmers to refer to short term crops. It is also a time when rainfall falls later (mid july)*

4.6. Factors affecting the adaptation strategies of respondents

Households in the study areas employ a wide range of measures to curb erosion and retain soil moisture, improve quality of their livestock, and maintain agricultural output in the changing environment. But, a range of factors influence their ability to respond to environmental conditions. When asked about the constraints or factors they faced in adapting to the effects of climate change, respondents frequently reported lack of information and financial limitations (fig 10). Constraints, such as labor shortage, land shortage and poor potential for irrigation, were given as other important factors.

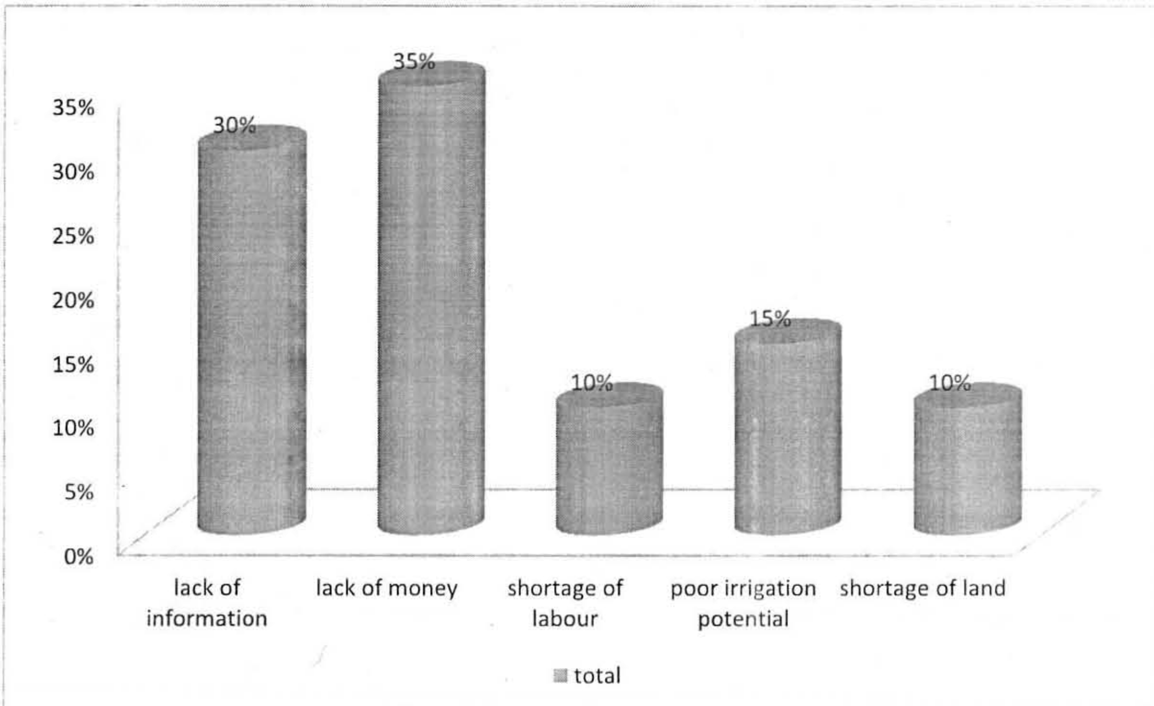

Figure 16: Local barriers to adaptation

Source: Own Survey, 2014

Though a range of activities were employed to survive the emerging impacts of climate change, a very small number of them reported they were not making adjustments. Their failure to adapt was emanated from different factors. Although some local variations were obvious the major factors affecting the households in the surveyed areas of Kola Tembien Woreda were, lack of money (35%), lack of information (30%), poor potential for irrigation (15%) and shortage of land (10%). However, the sub aggregated result showed a relative difference among the factors and found that in Limat, lack of information (10%) and lack of money (10%), in Bega lack of money (15%), in T/giorgis lack of information (10%), and in Menji lack of money (10%) and poor irrigation potential (10%) were the main factors affect farmers for not to make any significant amendments towards the harmful impacts of climate change.

As per the words of the focus group discussants and interviewed households in the surveyed areas, the major factors affecting their agricultural output were failure to use newly introduced agricultural technologies due to lack of awareness and financial means to access them.

In order to overcome such barriers respondents in the surveyed areas were keen for the government to provide greater financial support including the expansion of credit and extension facilities to increase investments on irrigation development. Besides, awareness creation activities will be better to enhance adaptation to climate change.

CHAPTER FIVE

5. Conclusion and Recommendation

5.1. Conclusion

This study was based on local/agro ecology level assessment of vulnerability and adaptation strategies of rural communities to climate change and has addressed three basic research questions.

The first and basic research question tried to analyze the vulnerability of rural communities to climate change at local/agro ecology level. The vulnerability analysis was made based on integrated assessment approach following the IPCC (2001) definition. However, the comparative analysis was made based on adaptive capacity and sensitivity assuming a relatively similar level of exposure. Analysis of the historical climate data in the Woreda has been done at a more aggregate level and the result reveals that there has been an increasing trend of temperature and rainfall with inter-annual variability. Generally speaking, mean annual rainfall distribution and temperature trends are going to be varied temporally. The vulnerability index showed that T/giorgis (mid land agro ecology) and Limat (low land agro ecology) were relatively less vulnerable than Begashka (midland) and Menji (low land). Their relative vulnerability is attributed to their relative variations in the ownership of different possessions. The aggregate result generally found that mid land agro ecological zone is less vulnerable than the lowland agro ecological. However, it is found that vulnerability calculations at aggregate levels could give wrong results.

The distribution of vulnerability to climate change impacts and environmental degradation is not equal across communities and localities in different geographical settings. Although location specific climatic patterns are key factors to assess risks and adaptation potentials, the adaptive capacity of households and communities to climate change is largely determined by household or community characteristics such as wealth status, education levels, information access, access to various infrastructures and institutions, agricultural technologies and irrigation potentials. To be specific, Menji and T/giorgis kebeles do not have markets and fertilizer supplies in nearby. Therefore, as far as communities or households have unequal access to such variables, they are going to be affected disproportionately.

The second research question assessed the adaptation strategies practiced in *Kola* Tembien Woreda and found that various adaptation strategies related to crop, livestock, land degradation and rainfall uncertainty has been used. The major crop production related adaptation strategies employed by the surveyed communities were soil conservation techniques, change crop variety, changing planting dates, and build water harvesting scheme. The adaptation measures taken towards the livestock population also includes buy hay, controlled grazing, reduction in herd and decreasing animal herd. Terracing, mulching, tree planting, checking dams and changing tillage operations were among the widely practiced adaptation strategies towards land degradation. Different strategies were followed by farmers in times of rain fall uncertainties but changing the planting dates and even varieties of crops were reported to be the dominant strategies employed by majority of the surveyed farmers. Moreover, majority of the surveyed communities responded to the adverse effects of climate change by selling their assets. Though, selling of possessions could help communities to cope up in times of shocks and adversities, it could potentially challenge future planning so that their sustainable livelihood is going to be disturbed.

The diversity of livelihood sources plays a vital role for survival in that when one means is damaged due to climate change impacts, the other means could be survived. It is generally found that as the surveyed communities were rural, they depend on agriculture as their main livelihood. However, there obtained a small number of the surveyed households diversifying outside the sector. Extraction of minerals (gold) is found to be the commonly practiced alternative income source across all the kebeles/agro ecologies. A small numbers of households in Limat reported that their livelihood depend on alternative income earned from rental houses in the nearby town. But depending on the information gathered it is found the communities do not have a diversified livelihood opportunity.

The third research question was regarding the barriers of rural communities to climate change. Although some local variations were obvious, the major factors affecting the communities in the surveyed areas of *Kola* Tembien *Woreda* were lack of money, lack of information, poor potential for irrigation and shortage of land. As climate has been changing and the fact that it is going to be changed in the future, communities of the Woreda having the aforementioned characteristics could be under the threatening impacts of that change.

5.2. Recommendation

- ✓ To enhance the adaptive capacity of rural communities, there should be equal access to agricultural inputs, infrastructures and institutions, and new agricultural technologies. Improved seeds, fertilizer supplies, pesticide and insecticide supplies, and markets should be accessible to the communities in Menji and T/giorgis as the other surveyed kebeles.
- ✓ To convey farmers with relevant information about climate change and its expected impact on their livelihoods, metrological stations should be there at either agro ecology level or some other selected sites in the Woreda.
- ✓ In order to reduce the vulnerability of rural communities and improve their income level, the local government as well as NGOs should promote the off-farm income-earning opportunities to the communities. Besides, awareness should be made so that they can diversify their livelihoods to survive in times of shocks.
- ✓ The commonly practiced extraction of gold should be shifted from its traditional form of artisanal towards a more modernized one.
- ✓ Selling wood is widely practiced by households in Limat kebele. This will lead to deforestation there by positively affect the vulnerability of the area in particular and the Woreda in general. Therefore, the local government should take some strong action to alleviate the problem.
- ✓ The local government must aim at promoting local/farm-level adaptation strategies by giving due attention to the early warning systems and disaster risk management and also, giving awareness on effective participation of households in adopting better agricultural and land use practices.
- ✓ Adapting agriculture to climate change may require adapting good practices to meet changing and often more difficult environmental conditions. It was documented in the study that a range of older indigenous and local soil and water conservation practices has been employed. Such activities may be limited in providing high yield and are being implemented even in areas where new conservation practices are introduced and implemented. Therefore, indigenous resource management practices should be compatible with the type of land use and strengthened by modern technologies in order to enhance crop productivity and limit land degradation.

- ✓ In order to overcome the barriers to adaptation, efforts are needed to increase awareness there by overcome maladaptive perceptions and even financial assistance should be made to encourage the existing irrigation sector as well as emphasis should be given towards the expansion of irrigation projects.

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Annex 1: Normalized values of the original data by their respective means and standard deviations

Kebele	Education level	Quality of house	Ownership of livestock	Ownership of radio	Non-agricultural income
Begashka	0.02103	0.557335	-0.23207	0.308645	-0.00107
T/giorgis	0.162898	-0.32534	0.302927	-0.10844	-0.18918
Limat	0.047583	0.051087	0.079241	0.024267	0.214713
Menji	-0.23767	-0.32534	-0.14255	-0.24747	-0.04586

Farm land size	Remittance	Saving	Insecticide supply	Fertilizer supply
-0.41688	0.111105	0.100624	0.177441	0.384829
0.55178	-0.0613	-0.15675	-0.13673	0
-0.13794	-0.08916	0.428943	0.198386	0.577354
0.044629	0.040866	-0.42242	-0.27077	0

Improved seed supply	Improved seed use	Weather roads	Health center	Full cycle school
0.640513	0.62201	0.194723	0.172853	-0.21206
-0.29335	-0.14714	-0.45684	-0.08134	0.124822
-0.15004	-0.15322	-0.02221	0.117221	0.064646
-0.22481	-0.34779	0.273575	-0.23198	0.03026

Veterinary service	Credit and saving institutions	Telephone access	Market	Irrigation potential
0.3676	0.439769	0.199559	0.374402	-0.01988
-0.34316	-0.01621	-0.13136	0	-0.05649
0.086092	-0.08991	0.16719	0.253902	0.307532
-0.14365	-0.35398	-0.26541	0	-0.26058

Land fertility	Land slope
-0.21297	-0.43977
-0.02133	0.218871
0.063507	0.151318
0.178644	0.083766

Annex 2: KMO and Bartlett's Test

KMO measure of sampling adequacy	0.540
Bartlett's Test of Sphericity	
Approx. chi square	328.128
df	231
Sig.	0.000

Annex 3: Factor scores of the principal components

Vulnerability indicators	Factor scores of the components								
	1	2	3	4	5	6	7	8	9
Education	-.012	-.011	-.126	.079	.067	-.061	.695	-.009	.059
Quality of house	-.100	.002	.342	-.072	.079	.067	-.074	.222	.098
Livestock ownership	.308	-.004	.173	-.127	-.233	.088	.295	.083	.210
Radio	-.053	.302	.019	-.051	.184	-.139	.008	.099	-.011
Access non-agricultural income	-.019	-.021	.050	.082	.014	-.047	.075	.013	.636.
Farm land size	.365	-.176	.013	-.088	-.093	.068	.057	-.025	-.044
Remittance	-.015	.001	.053	.127	-.045	.025	.000	.642	.058
Saving	.111	.317	-.144	-.200	.092	.091	-.087	.010	.364
Insecticide n pesticide access	.092	-.007	-.158	-.038	-.074	.534	-.184	.044	.121
Fertilizer supply	-.030	.212	.094	.161	-.057	.190	.071	-.225	-.012
Improved seed utilization	.046	-.139	-.050	.065	.400	.047	-.037	.003	.068
Improved seed access	.020	.008	.026	-.181	.490	-.030	.080	-.011	.014
Weather roads	-.047	-.105	-.100	.382	.070	-.102	-.219	.170	.108
Health access	.351	.188	.110	.109	.000	-.090	-.153	.104	-.109
School access	.402	.016	-.141	-.055	.229	-.027	.021	-.085	.078
Veterinary access	-.009	-.035	.037	.360	-.073	.014	.011	-.423	.202
Credit and saving access	.098	.135	.314	.033	.089	-.070	.096	-.002	-.241
Telephone access	-.030	.043	-.029	.447	-.128	.009	.206	.065	-.066
Market access	-.129	-.054	.033	-.079	.058	.488	.118	-.022	-.092
Irrigation potential	.030	.497	.007	.048	-.253	.005	.018	-.051	-.070
Land fertility	-.004	.061	-.463	.075	.087	.135	.169	.168	-.156
Land slope	-.056	.127	-.220	-.075	-.006	-.257	.052	-.130	.142
Eigen value	2.461	1.967	1.649	1.373	1.310	1.302	1.274	1.145	1.089
Proportion of variance	11.188	8.940	7.496	6.243	5.953	5.920	5.789	5.205	4.950
Cumulative proportion	11.188	20.128	27.624	33.867	39.820	45.739	51.529	56.734	61.684

Annex 4: Conversion scale to compute tropical livestock unit

Animal type	**Unit**
Ox	1.0
Cow	1.0
Calves	0.2
Sheep and Goat	0.1
Horse and Mule	0.8
Donkey	0.4
Chicken	0.013

Annex 5: Household survey

<u>Household survey to be completed by household heads</u>

Title: vulnerability and adaptation strategy of rural communities to climate change: In the case of Kola Tembien Woreda, Tigray Region

This study is being carried out by Esie Gebrewahd, a graduate student of Addis Ababa University, to collect basic information/data about climate change and Community-based adaptation in Kola Temben Woreda to assess the problems of the surrounding communities to plan for sustainable adaptation and development activities.

The objective of this questionnaire is to collect primary data on socio-economic, vulnerability, and existing adaptation strategy related information that are required to assess the vulnerability and adaptation strategy of rural communities in Kola Tembien Woreda. Therefore, you are kindly requested to give your response freely and accurately to the success of this study.

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

Lastly, I thank you for your cooperation

Name of data collector________________________Date____________Code_________

AES:_________________

Woreda:_________________

Kebele _________________

General information

1. **Socioeconomic Characteristics:**

    1. House Code__________________
    2. Sex 1. Male 2. Female
    3. Age 1. <15 (child headed family) 2. 15-30 3. 31-65 4. >65
    4. Religion 1. Christian orthodox 2. Muslim 3. Protestant 4. Other---------
    5. Marital Status 1. Single 2. Married 3. Separated 4. Divorced 5. Widowed
    6. Educational Status 1. Illiterate 2. Capable of reading and writing 3. Primary school 4. Secondary school and above
    7. Responsibility in the community 1. Member of the community 2. Religious leader 3. Coordinator of community development work 4. Kebele Administrator 5. other, please specify______________________________
    8. Size of family

No	Age	Sex (in number)		
		Male	Female	Total
1	<14 year			
2	15-65 years			
3	> 65 year			

2. Wealth, economic activities, and household income

1. In what type of house do you live?
    1. Corrugated 2. Non corrugated 3. Others (Specify)?
2. Do you have your own farm land 1. Yes 2. No
3. If your answer to the above question is yes, how much in ha/Timad is
    1. The cultivated area________________
    2. Individual grazing land ______________
    3. Irrigated Land__________________
    4. Other(specify)_________________
    5. Total_____________________
4. Has your farm land size decreased or increased since you start farming?
    1. Increased 2. Decreased 3. No change

5. What are the production and area for the last 5years

Crop	Year	Production (Qt)	Area (ha)
	2013		
	2012		
	2011		
	2010		
	2009		

6. What are the reasons for the increment of your cultivated land productivity?
   1. Increased soil fertility 2. Strong extension services (improved seed supply, agrochemical use, organic fertilizer) 3. Suitable weather conditions 4. Soil and water conservation practices 5. Other, please specify________________________
7. What are the reasons for the decrease of your cultivated land productivity?
   1. Land degradation 2. Lack of timely input supply 3. Lack of oxen 4. Rainfall variability 5. Drought 6. Pests and Crop diseases 7. Other, please specify________________________
8. Do you rare animals? 1. Yes 2. No
9. If your answer is yes to question 8, indicate the size, their feeding source and problems related to the fodders you owned in the following table.

Type of animal	Size in number	Their feeding source*	Problems related to the fodders
Ox			
Cow			
Sheep			
Goat			
Horse			
Mule			
Donkey			
Poultry			
Bee colony			
Other (specify)			

*Source of fodder 1= own private grazing land 2= communal grazing land 3= crop residue 4= buying fodder 5= other, please specify____

10. How do you see the trend of livestock ownership in your household for the last 10 years?
    1. Increasing 2. Decreasing 3. No change 4. I don't know

11. 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
Farm activity	Selling of crop production		
	Selling of livestock and their products		
	Selling of fruits, roots and vegetables		
Off farm activity	Labor wage		
	Engaging in fetching water		
	Selling of fuel woods		
	Selling of grasses		
	Selling of timbers and wooden trees		
Nonfarm activity	Mat, basket, and spinning		
	Bamboo work		
	Weaving		
	Tannery		
	Blacksmithing		
	Tela and Areki		
	Cooking egg, kolo and kita		
	Food aid		
	Food-for-work		
	Grain and livestock		
	Consumer goods (salt, soap, kerosene etc.)		
	Remittance		
	Others(specify)		
Total /year			

12. How do you see the trend of income level in your household for the last 10 years?
    1. Increasing 2. Decreasing 3. No change 4. I don't know
13. Do you save money? 1. Yes 2. No
14. If your answer to question 13 is yes, how much do you save? ____________ birr/year
15. If you save money, where do you save it?
    1. Home 2. Bank 3. Friends/families 4. others (specify)
16. With this total capital, in which socio-economic group do you put yourself?
    1. Rich 2. Medium 3. Poor
17. 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. Others (specify)? ________________________________

3. **Technology**

18. What is the main energy source for cooking your food?

1. Electricity	4. Charcoal Only	7. Firewood and Charcoal
2. Gas	5. Charcoal, Gas and Fire	8. Crop Residue
3. Electricity and Gas	6. Dung Cake	9. Firewood Only

19. What kind of power do you use for farming?
    1. Family labor 2. Shared labor 3. Animal traction 4. Tractor 5. others (specify)?_________
20. Do you have access to farm machineries and tools? 1. Yes 2. No
21. If yes where do you access them?____
22. Do you have access to improved seed supply? 1. Yes 2. No
23. Do you use improved seeds? 1. Yes 2. No
24. If your answer to question 23 is yes, how far do you travel to access them? ________ kms/hr
25. If no, why?
    1. It is expensive 2. Lack of regular supply 3. Lack of awareness 4. Others (specify)?
26. Do you have access to agri-chemicals? 1. Yes 2. No
27. If your answer to question 25 is yes, how far do you travel to access them? ________ kms/hr
28. Do you use fertilizer? 1. Yes 2. No
29. if yes, on average how much kg per year do you use _________________
30. If no. why? 1. Lack of access 2. Expensive 3. Lack of awareness 4. others (specify)?___________________
31. Do you use insecticide and pesticide whenever necessary? 1. Yes 2. No
32. If yes, how much ml/ha per year do you use? _________________________
33. If you say no, why? 1. No supply 2. Expensive 3. Lack of awareness 4. others(specify)
    ____
34. Do you have access to irrigation schemes? 1. Yes 2. No
35. If yes, how much lands do you irrigated?
    1. ½ timad 2. 1 timad 3. 1.5 timad 4. 2 timad 5. above 2 timad
36. 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. others(specify)______________________________

4. **Institution and infrastructure**

37. Do you have agricultural extension services (AES) in your area? 1. Yes 2. No
38. Does the presence of extension services help you to improve productivity and production?
    1. Yes 2. No
39. Do you have access to information? 1. Yes 2. No
40. If your answer to question number 3 is yes, identify your source?
    1. Radio 2. TV 3. Journal/ newspaper 4. Agriculture experts 5. Neighbors 6. Others (specify)? ____

41. Have you ever heard climate related information in one of the above source(s)? 1. Yes 2. No
42. Have you participated in skill-upgrading training to improve your knowledge about climate change adaptation? 1. Yes, 2. No
43. Do you have access to saving and credit services? 1. Yes 2. No
44. What is the distance to saving and credit institutions from your home? 1. 1-4 km 2. 4 and above kms
45. Do you use the credit? 1. Yes 2. No
46. If your answer to question 43 is yes, for what purpose do you borrow money? 1. Consumption 2. Medication 3. Petty trading 4. Fattening of animals 5. To buy agricultural inputs 6. Other (specify)? ______________________
47. If your answer to question number 43 is no, why don't you use the service? 1. Difficult criteria 2. I don't want 3. Other(specify)______________________
48. Do you have market access nearby? 1. Yes 2. No
49. If your answer is yes, how far is it from your home? 1. 1-4 km 2. 4 and above km
50. Do you have weather-roads of vehicle that connect you with nearby neighbors, towns or cities? 1. Yes 2. No
51. If yes, what is the distance to all- weather roads from your home (how long does it take (hours))? 1. 1-4 km 2. 4 and above km
52. Are the roads ok to use in rainy seasons? 1. Yes 2. No
53. Do you have health posts at your village/localities? 1. Yes 2. No
54. If yes, how far is it from your home? 1. 1-4 km 2. 4 and above kms
55. Do you have veterinary services in your kebele? 1. Yes 2. No
56. If yes, how far is it from your home? 1. 1-4 km 2. 4 and above
57. Do you have education centers in your locality? 1. Yes 2. No
58. If yes, how far is it from your home? 1. 1-4 km 2. 4 and above km
59. Do you send your children to school? 1. Yes 2. No
60. If no, why? ______________________
61. Do you have access to telephone services? 1. Yes 2. No
62. What is the distance to water source from your home? 1. 1-4 km 2. 4 and above kms
63. Do you have land use right/ownership certificate? 1. Yes 2. No
64. If your answer is yes for question 63, do you apply land management (SWC, terracing, agro forestry,) better than before? 1. Yes 2. No
65. Are you member of social institutions in your village? 1. Iddir, 2.Equb, 3. Religious groups 4. Others
66. Did you participate in the identification and adoption of sustainable adaptation strategies by your communities? 1. Yes 2. No
67. What are the numbers of no-working days in a month? _______

5. Adaptation strategies and the factors influencing it

1. Have you noticed any changes in temperature over the last 20 years? 1. Yes 2. No
2. If your answer to the above question is yes, what do you say about the trend of temperature over the last 20 years? 1. Increasing 2. Decreasing 3. No change 4. I don't know
3. Have you noticed any changes in rainfall over the last 20 years? 1. Yes 2. No
4. If your answer to the above question is yes, what do you say about the trend of rainfall over the last 20 years? 1. Increasing 2. Decreasing 3. No change 4. I don't know
5. Do you think your crop production is being affected by climate change impacts?
   1. Yes 2. No
6. If your answer to question 2 is yes, what adjustments in your farming have you made to increase your agricultural output?
   1. Change crop variety 2. Buy insurance 3. Build a water harvesting scheme
   4. Implement soil conservation techniques 5. Changing planting dates 6. Irrigate more
   7. Change from crop to livestock 8. Reduce number of livestock 9. Migrate to urban area 10. Find off-farm job 11. Lease your land 12. No adjustments
7. If you are not making adjustments towards your farming, what are the reasons?
   1. Lack of awareness 2. Lack of money 3. Shortage of labour 4. Poor irrigation potential 5. Shortage of land
8. When crop failure happened or your agricultural output is not sufficient to fulfill your needs, which of the following coping mechanisms have you used to overcome the problem?

No	Coping mechanism	In the last year (2005 E.C)	
		Yes	No
1	Selling livestock		
2	Selling other household property		
3	Daily labor		
4	Borrowing money or grain		
5	Selling fuel wood/ charcoal		
6	Reducing consumption		
7	Remittance		
8	Migration to other area		
9	Others …….		

9. Do you think your livestock production is being affected by climate change impacts?
   1. Yes 2. No
10. If your answer to question 4 is yes, what climate related problems are affecting your livestock production?
    1. Animal diseases 3. In sufficient grazing land
    2. Shortage of water 4. Others (specify________________________
11. What adaptation measures did you take to improve your livestock production?
    1. Controlled grazing 3. Reduction in herd
    2. Buy hay 4. Improved animal herds 5. No adaptation
12. If you are not making adjustments towards your livestock population, what are the reasons?
    2. Lack of awareness 2. Lack of money 3. Shortage of labour 4. Poor irrigation potential 5. Shortage of land
13. How is the slop of your cultivated land?
    1. Plain 2. Hilly 3. Highly sloppy 4. Mountainous 5. Other, please specify____.
14. Do you think that, land degradation is the major problem in your farm lands? 1. Yes 2. No
15. If your answer for question 9 is yes, what are you doing to manage the problem and to increase the productivity of the cultivated land?

Land conservation activities	Individually (1=Yes, 2=No)	In group (communally) (1=Yes, 2=No)
1. Terracing		
2. Mulching		
3. Tree planting		
4. Contour ploughing		
5. Check dams		
6. Changing tillage operations		
7. Others(specify)		
8. No adaptation		

16. If you are not making adjustments to manage land degradation, what are the reasons?
    3. Lack of awareness 2. Lack of money 3. Shortage of labour 4. Poor irrigation potential 5. Shortage of land
17. Who do you think are the most affected when drought takes place in your locality?
    1. Women and children 2. Elderly people 3. Poor households 4. Others_________

18. Which of the following options are you using in times of Rainfall uncertainties?

No	**Adaptation options**	Yes	No
1	Adjustments of planting dates and crop variety		
2	Expanded rain water harvesting techniques		
3	Soil and water conservation		
4	Changing tillage operation		
5	Reduction of consumption levels		
6	Collection of wild foods		
7	Use of inter-household transfers and loans		
8	Increased petty commodity production		
9	Labor migration		
10	Sale of assets such as livestock and agricultural tools		
11	Mortgaging of land		
12	Credit from merchants and money lenders		
13	Use of early warning system		
14	Food aid/safety net		
15	Diversifying from farming to non-farming activities.		
16	Others................		

19. If you are not using any of the above listed options in times of rainfall uncertainties, what are the reasons?

    1. Lack of awareness 2. Lack of money 3. Shortage of labour 4. Poor irrigation potential 5. Shortage of land

20. How many hectares/Timads did you farm last year? ____________________
21. What is the size of your land with improved SWC Practices in ha/Timad?____________
22. Do you practice crop rotation in your locality? 1. Yes 2. No
23. What are the sequences of crop rotation? ________, ________, ________, ________
24. What cropping patterns do you use in your farm land? 1) Mono cropping 2)Mixed cropping 3)Both 4) Other, if any ____________________________________

Check lists to guide key informant interviews:

Address (location) of the village: ______________________________

1. Selected female and male headed households 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? If you perceived it is changing, how do you know? What is your local indicator?
   3. Do you farm on the same plot of land where your father or fort father was farming?
   4. If yes, how do you see the level of your crop production? Is it increasing or decreasing? If decreasing, what do you think the reason? What options are you using to increase your production? Do you think the options undertaking are effective enough to overcome the problem?
   5. Do the crops you growing now are similar to the crops your father or fort father was growing? If no, why do you shift to other varieties?
   6. If no, where is your farming land now? And why do you shift to the area you are farming now?
   7. What climate related hazards have you seen in the last 10 years? How frequently does it happen? (Erratic rain, drought, flood)? How did you manage the hazard? (eg. selling of property or livestock)?
   8. What do you think is the role of the local government or the community to avert the impact of climate change in your locality? What should they do to minimize the impacts?
2. **Agriculture and rural development officials and development agents**
   1. Name:______________________________ position:______________________________
   2. Is there any form of climate change in your Woreda/kebele? What change have you observed in rainfall and temperature?
   3. How these changes affect the productivity of farmers?
   4. Do you think that there is a shift in cropping calendar? Why?
   5. What changes have you observed in crop and livestock type?
   6. Have you seen any changes in the number of malaria cases over the last 10 years?
   7. Did you face any climate related hazards in the last 10 years? How frequently did you affect?
   8. Is there any appropriate adaptation strategies taken by the local government?
   9. If yes, what kinds of adaptation strategies are commonly used? If no, why?
   10. How do you rate the adaptation strategies employed by the local farmers? Do you think that such measures are effective enough to minimize any climate related impacts of the locality?
   11. What do you think are the factors influencing the adaptation strategies of farmers?

3. **Focus group discussion**

1. Have you heard about climate change? From where did you hear? What adjustments have you made in your farming? What were the main constraints/difficulties in changing your farming ways?
2. Have you observed any climate extremes in the last 10 years in your locality? How frequently did occur?
3. How these climate extremes affect your productivity? Your livelihood? Who do you think are most affected in the society?
4. What do you do if the raining season is changed from its usual way? Have you started sowing new varieties of crops that you hadn't cultivated before?
5. Do you have access to fertilizers and variety seeds?
6. Are there any social institutions you can directly or indirectly engage in your locality? What do you think their roles in your community?
7. Are there any micro finance institutions nearby which help you to buy agri technology? Are they working close to your communities? How do you rate the benefit of your communities from such institutions?
8. Do you get extension services in your kebele? What services do you get from extension workers?
9. What are the numbers of no-working days in a month? Do you think your production is affected of doing so?