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IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON FOOD SECURITY AND FARMERS' ADAPTATION STRATEGIES IN GUBALAFTO WOREDA, NORTH WOLLO, ETHIOPIA

BY

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Impacts of Climate Variability and Change on Food Security and Farmers' Adaptation Strategies in Gubalafto Woreda, North Wollo, Ethiopia

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Dedication

In

Memory of My Grand Father

Tefera Nigus Feleke

Where are your arms which swallow my troubles?

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Abstract

Climate change and variability is an emerging serious global environmental problem affecting many sectors in the world. In many areas of Ethiopia, it is affecting the status of food security by causing crop failure, drought, and flood. This study was conducted to assess the status of climate change and variability and its impact on food security in line with farmers' adaptation strategies by taking two villages in Gubalafto Woreda of North Wollo. Both primary and secondary sources were used. Primary data was obtained using household questionnaire (from 100 households), focus group discussions, and key informants interviews. The results showed that the major livelihood activities are crop farming and livestock rearing, being climate dependent. From the survey, it was noted that most of the respondents were not food self sufficient and food aid was the major source of additional food requirement. Finding showed that both perception and analysis of climate data indicated change in temperature, rainfall amount, rainfall timing, and increase in frequency of drought. The empirical analysis of rainfall suggested declining rainfall trends. Onwards 2001, except for 2005 and 2006, annual rainfall of the area has shown decreasing trend from the average annual rainfall. The average maximum and minimum temperatures are increasing by 0.025^0c and decreasing by 0.02^0c. The changes have resulted in depleting of water resources and declining agriculture productions and, thereby, having negative effects on food security. Sources of household's vulnerability were assessed and vulnerability induces were developed. Low educational level of head of households, temporal and chronic illness, small land ownership, lack of access to means of information as well as climate information, and limited participation of households on non-farm source of incomes were identified as major source and indicators of vulnerability. Gubarjja kebeles was found to be more vulnerable than Dorogibr. Though the existing strategies are not enough, farmers are using different adapting and coping strategies. The study suggests that there should be unreserved effort to address the existing challenges through short term and long term measures.

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Acronyms

ANRS	Amhara National Regional State
ALZR,	Amahara livelihood Zone report
GHGs	Green House Gasses
IPCC	Intergovernmental Panel on Climate Change
CC & V	Climate Change and Variability
CSA	Cntral Statics Agency
CFC	Cloro Floro Carbon
DAs	Development Agents
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
HDR	Human Development Report
IRI	International research institute
NAPA	National Adaptation program of Action
LVI	Livelihood vulnerability index
DCA	Dan Church Aid

Chapter One

Introduction

1.1 Introduction

Now a day, it has been widely agreed that climate change is already a real phenomena. Although the degree of the impact and its distribution is still debatable, many scientists, economists and policy makers agree that the world is facing a threat of global warming. Change in the green house gases (GHGs) concentration due to human activities are the dominant cause of global warming that has taken place over the last half century (Balling, 1992). Since the beginning of the industrial revolution, atmospheric CO_2 has increased by 25% (Kenneth, 1995) and consequently, over the last 100 years surface temperature has been increased by 0.3^{o}C to 0.6^{0}C. Further, it has been estimated that doubling of the atmospheric concentrations of green house gases by the end of the century relative to pre-industrial level is going to raise the mean global temperature by a range of 2–5. 8C changing the global climate (Mideksa, 2009; IPCC, 2007).

The unimpeded green house gasses emission increases the earth's temperature, which results in melting of glaciers, more precipitation or drought and other extreme weather events. In the past 50 years, earth temperature is increasing, sea level is rising, climatic extreme events such as droughts, floods, storms and heat waves are becoming more frequent and intense than ever before (Daniel, 2009; Abebe, 2002).

Climate change has wide ranging effects on the environment, socioeconomic and related sectors (Malla, 2008). It is a real threat to the lives in the world as it largely affects water resources, agriculture, freshwater habitats, vegetation covers, snow cover, landslide, desertification and floods. Eventually, its long-term effects would be on food security and human health. The problem is expected to be worse in many countries of tropical and sub-tropical regions.

Climate change would likely impact agricultural yields negatively as it would reduce soil moisture, faster depletion of soil organic matter, pre-mature drying of grains, and increased

heat stress. Declining yield, all other things held constant, would lessen food availability and consumption. This also resulted in worsening of food security conditions (Butt, 2003).
Food insecurity in1970s and 1980s was largely attributed to technological bias which was stressing on production rather than equitable distribution, access and utilization of resources. Since then, it has become clear that food insecurity revolves around complex issues that encompass a wide range of interrelated environmental, economical, social and political factors (Zierrvogel, 2008). Due to recently emerging climate change induced phenomena, the food security is to be threatening everywhere (Gerald et al., 2009).

Global environmental changes and increased climatic variability demands adaptation options and ways to minimize risks (Getachcew, 2010). Increased impacts of climate change and variability make the rural agrarian people to practice various adaptation and coping strategies. These include mainly indigenous knowledge and wide variety of skills developed outside the formal education over a long period of time among the rural communities (Mongi et al., 2010). Rural producers of arid and semi-arid areas where there is recurrent drought and unreliable rainfall have learned to cope with the existed situations. However, in the course of widespread poverty, highly unpredictable rainfall pattern and frequent extreme events coupled with increasing population and fragile resources, these coping strategies are becoming insufficient (Getachew, 2010).

Vulnerability, which is unevenly distributed among nations, communities or households, is a function of physical, social, economic and institutional factors (IRI, 2007, Fussel, 2006). Resource limitations and poor infrastructures limit the ability of people to take up adaptation measures in response to change in climatic conditions.

Recurrent extreme climate events such as floods, storms, and droughts could be particularly damaging to many countries of Africa (HDR, 2007) such as Ethiopia, since they are, on the one hand, dependent on climate sensitive subsistence and rain fed agriculture and, on the other hand, food insecurity, famines and droughts are prevailing phenomena (Hassan, 2006; IRI, 2007*)*. This climate sensitive subsistence rain-fed agriculture is the mainstay of most African economies, contributing to GDPs that range from 10% to 70%. African agriculture has the slowest record of productivity increase in the world (Kurukulasuriya et al., 2007)

and is the only major region with a decline in food production per capita during 1980–2000 (UNDP, *2007*).

Coping with climatic variability is certainly not new for African farmers, but the problem is that existing coping mechanisms may not match with the level of prevailing challenges that are likely to be faced in the future.

Current climate variability is already imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters *(NAPA, 2007)*.

Ethiopia's agricultural sector, which is dominated by small scale, mixed crop and livestock farming, is the mainstay of the country's economy. It constitutes more than half the nation's gross domestic product (GDP), generates more than 85 percent of the foreign exchange earnings, and employed about 80 percent of the working population (Yesuf et al.,2008; Deressa.et .al., 2008). Its dependence on agriculture makes the country particularly vulnerable to the adverse impacts of climate change on crop and livestock productions (Deressa et al., 2008). Generally, increased frequency of droughts and floods negatively affects agricultural production, demonstrating agriculture's sensitivity to climate change.

Recent attention to the issue of global environmental change is focused on the potential agricultural impact and global and regional food security implications because food security is closely aligned to agriculture. In developing countries, like Ethiopia, food security status primarily depends on rain fed agriculture, which is frequently affected by rainfall irregularities and drought.

Some studies, mostly at national level, are conducted to assess the impacts of climate change and adaptation (for example, Deressa et al., 2008; Yesuf et al., 2008; weldeamlak, 2009) these studies made assessment on vulnerability and determinants of vulnerability, estimation of climate impacts, rainfall variability and crop production. (In Amhara region), and measuring economic impacts of climate change. But not many studies have been done in Ethiopia both at local and national level that gives special emphasis on the impact of climate change and variability on food security. The aim of this study was to address the gap of knowledge on climate variability, change and their impact on agricultural practice and food security of the rural households of Gubalafto district.

1.2 Statement of the problem

Climate change and variability have adverse impacts on environment, human health, food security, economic activity, resources and physical infrastructures. Although all social, economic and political sectors face the impact of climate change and variability at varying degrees, the worst hit is supposed to be on rain fed agriculture due to its high sensitivity to climate stimuli. For this reason, when this sector is impacted, it disrupts the food production system, food security status of households and domestic industries. It is also very well recognized that the consequence of climate change and irregularities are different from region to region and nation to nation depending on their vulnerability and adaptive capacity. For example, the countries of Sub-Saharan Africa are the most vulnerable and since many countries of this region are already food unsecured; climate change and variability aggravates and worsens the problem (Daniel, 2009).

Climate related disasters like droughts and floods are becoming among the key factors affecting the Ethiopian agriculture despite its huge contribution to national economy and livelihood source for millions of smallholders (Temesgen, 2008) and despite its aims at initiating development of home industries, stimulating the service sectors and creating additional purchasing power (Assefa, 2005).

In many areas of Ethiopia, climate change and variability are affecting the status of rural household food security, because they are subsistence agrarian communities exclusively dependent on rain fed agriculture with low adoptive strategy to cope up with the changes and variability. The same is true for subsistence agrarian communities of North Wollo Zone of Amhara region, where this study has been conducted. In the past few decades, this zone has been stricken by droughts, unreliable rainfall and consequently to abject poverty and acute food shortage (Seid, 2002). Rainfall irregularities are becoming common phenomena affecting adversely the agricultural activities. For example, North Wollo Zone in general and Gubalafto district in particular, was very well known for its two (*belg*[1] and *meher*[2]) seasons of production, but at this time production in *belg* season is insignificant and limited to pocket highland areas of the zone (ALZR, 2007).

[1] Small rainy season of Ethiopia, occurs from March to May
[2] Main rainy season and major production season of Ethiopia, which occurs from June to September

In Gubalafto district, the crops commonly grown are too sensitive to climate variability. For example, they are vulnerable to little changes in onset and cessation time and amount of rainfall and extreme cases such as drought and frost. Since the agricultural production in this district is adversely affected by climate variability and change; the livelihood of the people has been put at risk and their vulnerability to food insecurity has been increased (Derbew, 2009; ALZR, 2007).

Farmers need to be aware of the changes and improve their adaptive capacity. This can happen when development stakeholders and policy makers assist farmers based on empirical evidences. Therefore, the ultimate goal of this study is to generate empirical evidence about climate variability, change and their impact on agricultural practices and food security of the rural households of Gubalafto district. Moreover, the results can create awareness among households about the impact of climate change and variability and how to maintain sustainable adaptation strategies.

1.3 Objective of the study

The general objective of the study is to study climate variability, change and their impact on agricultural practices and hence on food security.

The following specific objectives have been put forward to address the general objective of this study.

1. to establish the trends of temperature and rainfall changes,
2. to assess level of households' perception on climate change and variability,
3. to assess the status of food security of household,
4. to analyze household and social group vulnerability to climate change,
5. to examine the farmers adaptation mechanisms to climate change and variability, and
6. to assess the major limiting factors of food security in relation to climate change and variability.

1.4. Research questions

1. What is the status of climate change and variability?
2. What are the determinants of vulnerability to climate change and variability in the study area?
3. What are the major climate related problems that affect crop production?
4. How food security is impacted by climate change and variability?
5. What are farmers' adaptation mechanisms to the impacts of climate change and variability?
6. What is the understanding of the rural households on climate change and variability?

1.5 Significance of the study

In order to improve the ability of communities and households to adjust to ongoing and future climate change, we need improved understanding of the risk they are facing. Therefore empirical researches are important to identifying the magnitude and impacts of climate variability and change as well as to see the level of communities' vulnerability and their adaptations strategies. This study was designed to establish the status of climate change, variability, to study impact along with the adaptation strategies of farmers, in order to provide a meaningful insight and contribute to efforts aimed at ensuring increased food security by developing sustainable adaptation strategies. It provides realistic information to formulate policies and develop intervention mechanisms that are tailored to the specific need of the study area. Furthermore, this study can be used as a source material for further studies.

1. 6 Limitation of the study

Insufficient finance and duration were major problems that hinders the in depth analysis of the problem. The problem could have been better explained and investigated if enough time and finance were available. Hesitance and unwillingness of selected respondents to be interviewed was another problem faced by the researcher while conducting house hold survey.

1.7 Organization of the paper

The paper has been organized into 5 chapters, including the introduction and conclusion and recommendation. Chapter one presents introduction, statement of the problem, objectives and significance of the study. The second chapter provides review of some related literature, including the general frame work of the study. Research methodology, sampling method and sample survey, types of data, and methods of data collection and analysis along with description of the study area is also presented in the third chapter. Chapter four deals with the main body of the paper, it presents result of data analysis and their interpretation. The last chapter is about conclusions and recommendations of the study.

Chapter Two

Literature Review

2.1 Climate Change

There is always confusion when defining climate change and climate variability, for both terms there is no internationally agreed single definition. In the most general sense, the term "climate variability" denotes the inherent characteristic of climate which manifests itself in changes of climate with time. The degree of climate variability can be described by the differences between long-term statistics of meteorological elements calculated for different periods. In this sense, the measure of climate variability is the same as the measure of climate change. The term "climate variability" is often used to denote deviations of climate statistics over a given period of time, such as a specific month, season or year, from the long-term climate statistics relating to the corresponding calendar period

Climate change is the variation in global or regional climates over time. It reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. It is a change in the statistical distribution of weather over periods of time that range from decades to millions of years. Or it can be a change in the average weather or a change in the distribution of weather events around on average (*http://en.wikipedia.org/wiki/Natural_climate_variability*).

The term "climate change" is sometimes used to refer to all forms of climatic inconsistency, but because the Earth's climate is never static, the term is more properly used to imply a significant change from one climatic condition to another (www.natsource.com/markets/index.asp).These changes can be caused by processes internal to the Earth, external forces (e.g. variations in sunlight intensity) or by human activities. A change of climate which is attributed directly or indirectly to human activity is in addition to natural climate variability over comparable time.

2.2 Controversial Issues on Climate Change

Climate change and variability is probably the most debated phenomenon of our time. Debates indicate a broad consensus among the public that climate change has happened.

Whether global warming is the result of anthropogenic CO2 emission or it is a natural process as it has been occurred in the ancient age of earth: or whether global warming is real or not if it does to what extent? These issues are debatable among scientists.

The current scientific consensus on climate change is that recent warming indicates a fairly stable long-term trend that the trend is largely human-caused, and that serious damage may result at some future date if steps are not taken to halt the trend. Since the industrial revolution CO_2 from coal burning, automotives and methane by termites and cow will double in the later half century. Beside this, the rise of CFC and nitrous oxide in the last 100years has raised CO_2 from 270ppm to 350 ppm. This increase and projected doubling of CO2 leads to scientific prediction of temperature rise from 3^0F to 9^oF (Balling 1992).

Although scientists agree with all this, there are also a small but vocal number of scientists in climate and climate-related fields that disagree with the consensus view and they fall in line and hesitate to lead the march of preventive measures. Some believes that the earth will either adapt to or compensate for any large effects; others also may fear the immense cost to remove CO2 and other gasses from the environment. Balling, (1992), states that it would not be worthwhile to undertake huge, expensive, and disruptive measures to deal with the phenomena. His argument is that global warming may never occur or, if it does, much latter and to lesser degree than contemplated. Burroughs, (1997), also states that there is no a better understanding of the extent of past natural climatic change. So it is not realistic to conclude current changes are the consequence of human activities.

While there is little debate on the existence of global warming amongst mainstream published climate scientists, there is an ongoing debate about human-caused global warming theories in the popular media and on a policy level. There has been considerable opposition from parts of the political and business communities both to the conclusion that humans are causing climate change, and to the need to take action to reduce human effects on climate. Chiefly, opposition arose because of claims that these actions would cause enormous expense and disruption to the current geopolitical and economic situation, with no obvious recognizable short-term benefits.

There is public and political debate on that the Political and economic effects of both climate change by global warming and reduction strategies are more difficult to quantify. As an example, in asking whether the costs of reducing fossil fuel dependency compare with the costs of not taking action, one is confronted by the fact that it is difficult to anticipate social or technological changes that affect such costs.

Individuals or groups who disagree with claims that emissions of man-made CO2 significantly enhance the natural atmospheric greenhouse effect disputes with the IPCC a along one or more of the following lines:

1. There is no conclusive evidence that climate change is happening;
2. The changes in measured temperatures are part of the natural cycle;
3. Even if the changes are human induced, the scale is not sufficiently large to make changes beyond least cost measures; and The economic impact of making substantial cuts in greenhouse gas emissions on the scale suggested by the IPCC or other groups is too large

It should be noted that questioning and challenging of a theory is an essential part of the scientific process. Scientists who support the global warming and climate change usually incorporate the challenges to develop a better hypothesis to explain the environmental data. Against the skeptics, IPCC and other scientists who support human induced climate change are presenting different evidences. Calvin, (2008), shares the idea of human induced climate change, he suggested that we cause our planet to run fever and now we have entered a period of consequences. The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society. American Geophysical Union stated that "Human activities are increasingly altering the Earth's climate. These effects add to natural influences that have been present over Earth's history. Scientific evidence strongly indicates that natural influences cannot explain the rapid increase in global near-surface temperatures observed during the second half of the 20th century (http://www.globalissues.org/issue/178/climate-change-and-global-warming).

The world has approximately 100 years of climate records throughout the globe. These 100 years have witnessed an increased of GHGs and change in the climate system. Extreme

weather events and longer term climatic change have both exerted substantial influences on economical and social history (Balling1992). Climate change, driven by fossil fuel combustion and deforestation, is a becoming threat to lives and livelihoods in every part of the world at this time (Ackerman**,** 2009**).** Evidence of climate change and variability has been presented both from empirical data and perception. In the light of incontrovertible evidences of a more fundamental shift in the climate, research in to how we could adapt to this would be paramount.

2.3. Food Security and Climate Change

Food security, which becomes catch- phrase in the mid 1990s, can be defined as, according to the 1996 world food summit, food security exists when all people, at all time, and have physical and economic access to sufficient, safe and nitrous food that meets their dietary need and food preference for an active healthy life (FAO, 2008). Its definition has been modified and redefined many times.

Food security depends on availability of food, access to food and utilization of food which all of them access, utilization and availability of food can be impacted by climate change and variability (www.foodsec.org).

In the tropics and subtropics, where some crops are near their maximum temperature tolerance and where dry land, non-irrigated agriculture dominates, yields are likely to decrease for even small changes in climate, especially in Africa and Latin America, where decreases in overall agricultural productivity of up to thirty percent are projected during the next century. Therefore, there may be increased risk of hunger in some locations in the tropics and subtropics where many of the world's poorest live (IPCC, 2001). It is established that climate change, mainly through increased extremes and temporal/spatial shifts, will worsen food security in Africa and food insecurity vulnerability patterns will be modified by climate change (IPCC, 2007).

Climate change is creating additional food insecurities, particularly for the resource poor in developing countries who cannot meet their food requirements through market access. It is imperative to identify and institutionalize mechanisms that enable the most vulnerable to

cope with climate change impacts. This requires collaborative thinking and responses to the issues generated by the interaction of food security, climate change and sustainable development.

Climate change acts as a multiplier of existing threats to food security. Achieving food security under a changing climate requires substantial increases in food production and improved access to adequate and nutritious food.

Vulnerability to food insecurity is common across the world in semiarid and arid areas where marginal groups rely on rain-fed agriculture), climate variability directly affect agricultural production, as agriculture is inherently sensitive to climate conditions and one of the most vulnerable sectors to the risk and impacts of global climate change. In most developing countries, agriculture remains the largest employment sector and international agriculture agreements are crucial to a country's food security (Parry et Al., (1999) cited in FAO, 2008).

2.4 Vulnerability to Climate Change

Global climate change presents serious challenges to future livelihood strategies of third world peoples especially for those social groups which are currently poor and vulnerable as the consequences of climate change and variability are not distributed equally. Those most prone to suffer the effects of climate related hazards are often marginalized geographically, socially, economically and politically (Gaillard, 2010). Particularly in the least developed countries and small island developing states the livelihoods and lives of the poorest are at greatest risk to suffer from to the impacts of climate change. Generally small-scale rain fed farming systems, pastoralist systems, inland and coastal fishing and aquaculture communities, and forest-based systems are particularly vulnerable to climate change.

Moreover, the urban poor, particularly in coastal cities and floodplain settlements face increasing risks (FAO, 2008). This is due to their high exposure to natural hazards, their direct dependence on climate sensitive resources such as plants, trees, animals, water and land, and their limited capacity to adapt to and cope with climate change impacts (ISAC, 2009). The ability to adapt to and cope with depends to a large extend on the level of economic development and the means required for adaptation, such as economic

entitlements, land, capital, credit and/or tenure rights. It also depends on institutional support and the possibility to influence decision making. Vulnerability determines the extent to which individuals or a community will potentially suffer from climate-related events.

The biophysical, economic, and social dynamics causes of vulnerability to climate change can be decisive in determining the susceptibility to harm and level of resilience of different social groups. Assessing vulnerability to climate variability and change is an important component of any attempt to define the magnitude of the threat (Kelly and Adger, 2000).

The term 'vulnerability' is used in many different ways by various scholarly communities. The ordinary use of the word 'vulnerability' refers to the capacity to be wounded, i.e., the degree to which a system is likely to experience harm due to exposure to a hazard (Turner II et al., 2003, as cited in Fu¨ssel, 2007). There is confusion arising from different usages of the term vulnerability. Brooks, (2003) has grouped the term vulnerability as "social vulnerability" and "biophysical vulnerability.

Kelly and Adger, (2000), defines social vulnerability in terms of the capacity of individuals and social groupings to respond to , to cope with, recover from or adapt to – any external stress placed on their livelihoods and well-being. The focus is on socioeconomic and institutional constraints that limit the ability to respond effectively.

The term "biophysical" suggests both a physical component associated with the nature of the hazard and its first-order physical impacts. Biophysical vulnerability is concerned with the ultimate impacts of a hazard event, and is often viewed in terms of the amount of damage experienced by a system as a result of an encounter with a hazard. It is a function of the frequency and severity (or probability of occurrence) of a given type of hazard (Brooks, 2003).

Downing et al. (1996) also define vulnerability as the exposure to contingencies and stresses, and difficulty coping with them. In this definition vulnerability has two sides; an external side of risk, shocks and stresses which an individual or household is subject; and an internal side which is lack of means to cope without damaging loss. From this point of view the most vulnerable individuals, groups, classes, and regions are those most exposed to

perturbations, who possess the most limited coping capacity and suffer from the impacts of climate change and who are endowed with tightly circumscribed potential recovery.
Definitions of vulnerability in the climate change related literature tend to fall into two categories, viewing vulnerability either (1) in terms of the amount of or potential damage caused to a system by a particular climate-related event or hazard or (ii) as a state that exists within a system before it encounters a hazard event (Brooks, 2003).Vulnerability is intrinsically linked to the process of adaptation through this definition; adaptation is facilitated by reducing vulnerability.

2.5 Adaptation and mitigation of climate change

Adaptation to climate impacts is not a new phenomenon. Natural and socioeconomic systems have continuously been adapting autonomously, or in accordance with a plan, to a changing environment throughout history with various natural and socioeconomic constraints that required surmounting (Kurukulasuriya et al., 2007). Historically, people whose livelihoods depend on agriculture have developed ways to cope with climate variability autonomously. Today, the current speed of climate change modifies known variability patterns to the extent that people will be confronted with situations they are not equipped to handle. Thus, anticipatory and planned adaptation is an immediate concern. However, vulnerabilities are mostly local and, thus, adaptation should be highly location specific (FAO, 2008).

Adaptation is recognized as a critical response to the impacts of climate change, because current agreements to limit emissions, even if implemented, will not stabilize atmospheric concentrations of greenhouse gases and climate change (NAPA, 2007). Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities whereas mitigation of climate change is a human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases (F¨ussel, 2007).

In spite of the need for mitigation there are also convincing arguments for a more comprehensive consideration of adaptation as a response measure to climate change. First of

all, given the amount of past GHG emissions and the inertia of the climate system, the earth is already bound to some degree of climate change which can no longer be prevented even by the most ambitious emission reductions. Second, the effect of emission reductions takes several decades to fully manifest whereas most adaptation measures become effective immediately. Third, adaptations can be implemented on a local or regional scale, and their efficacy is less dependent on the actions of others. Fourth, adaptation to climate change typically also reduces the risks associated with current climate variability. Climate related hazards constitute a significant threat in many parts of the world already now.

According to the IPCC Third Assessment Report, adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages. Furthermore, it is argued that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation. However, options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems (IPCC 2001, quoted in Olmes, 2001).

As future climatic conditions unfold and farmers learn how to implement adaptive strategies (which in turn will depend on the form of tenure, incomes, etc.), farmers could make long term adjustments such as changing crop varieties that are grown as well as where they are grown (i.e. location). Potential options include switching to more robust varieties that are better suited to the new environment. For instance, Matarira, (1996) highlights that in Zimbabwe farmers have switched successfully to the use of more drought tolerant crop in areas where the frequent recurrence of droughts has made agriculture production difficult using the traditional crop varieties. In the extreme case, where agriculture is no longer viable, farmers have converted land use from crop production to game ranching (Abate, 2009).

2.6. Conceptual Framework

Climate change has far-reaching consequences for agriculture that affect the poor disproportionately. Greater risks of crop failures and livestock deaths are already imposing economic losses and undermining food security and they are likely to get far more severe as global warming continues

Impacts of climate variability and change on the agricultural sector are projected to steadily manifest directly from changes in land and water regimes, the likely primary conduits of change. Changes in the frequency and intensity of droughts, flooding, and storm damage are expected. Climate change is expected to result in long-term water and other resource shortages, worsening soil conditions, drought and desertification, disease and pest outbreaks on crops and livestock, sea-level rise, and so on. Vulnerable areas are expected to experience losses in agricultural productivity, primarily due to reductions in crop yields (Kurukulasuriya, 2003).

Agriculture is important for food security in two ways: it produces the food people eat; and it provides the primary source of livelihood for 36 percent of the world's total workforce so agriculture is at the core of food security. In turn climate is also the most decisive factor for agriculture (FAO, 2008).

Food systems exist in the biosphere, along with all other manifestations of human activity. some of the significant changes in the biosphere that are expected to result from global warming will occur in the more distant future, as a consequence of changes in average weather conditions. The most likely scenarios of climate change indicate that increases in weather variability and the incidence of extreme weather events will be particularly significant now and in the immediate future. The projected increases in mean temperatures and precipitation will not manifest through constant gradual changes, but will instead be experienced as increased frequency, duration and intensity of hot spells and precipitation events. Whereas the annual occurrence of hot days and maximum temperatures are expected to increase in all parts of the globe, the mean global increase in precipitation is not expected to be uniformly distributed around the world. In general, it is projected that wet regions will become wetter and dry regions dryer (FAO, 2008).

Climate change variables influence biophysical factors, such as plant and animal growth, water cycles, biodiversity and nutrient cycling, and the ways in which these are managed through agricultural practices and land use for food production. Because for climate variables such as rainfall, soil moisture, temperature and radiation, crops have thresholds beyond which growth and yield are compromised.

IPCC, (2007) concluded that climate variability and change would severely compromise agricultural production and access to food. An increase in temperature will speed up plant growth. In the case of an annual crop, the duration between sowing and harvesting will shorten. The shortening of such a cycle could have an adverse effect on productivity. In the long run, the climatic change could affect agriculture in several ways: productivity, agricultural practice environmental effect, soil erosion reduction of crop productivity etc. (http://en.wikipedia.org/wiki/Climate_change_and_agriculture).

Weather-related disasters, crop failure, flood, and drought which resulted from extreme weather events will increase in frequency. As the result of this the livelihoods and food security status of millions of people in disaster-prone areas will be adversely affected. In countries with severe resource constraints, farmers will not be able to adapt to climate change without outside help and thus the poor will need additional help in adapting

As it is shown in figure 1, the climate change and variability components are interrelated and their impact, directly or indirectly, feels by the food security. Kenneth M, (1995), reported that the continued addition of green house gases in to the atmosphere will alter global climate, increasing temperature and changing the rain fall and other weather patterns. The unlimited interference of human activities in the natural climate system increases the concentration of CO2 in the atmosphere which in turn increases the green house effect of the atmosphere. Finally the increased concentration of GHGs will result in increasing mean, maximum and minimum temperatures which causes global warming and climate change (fig.1).

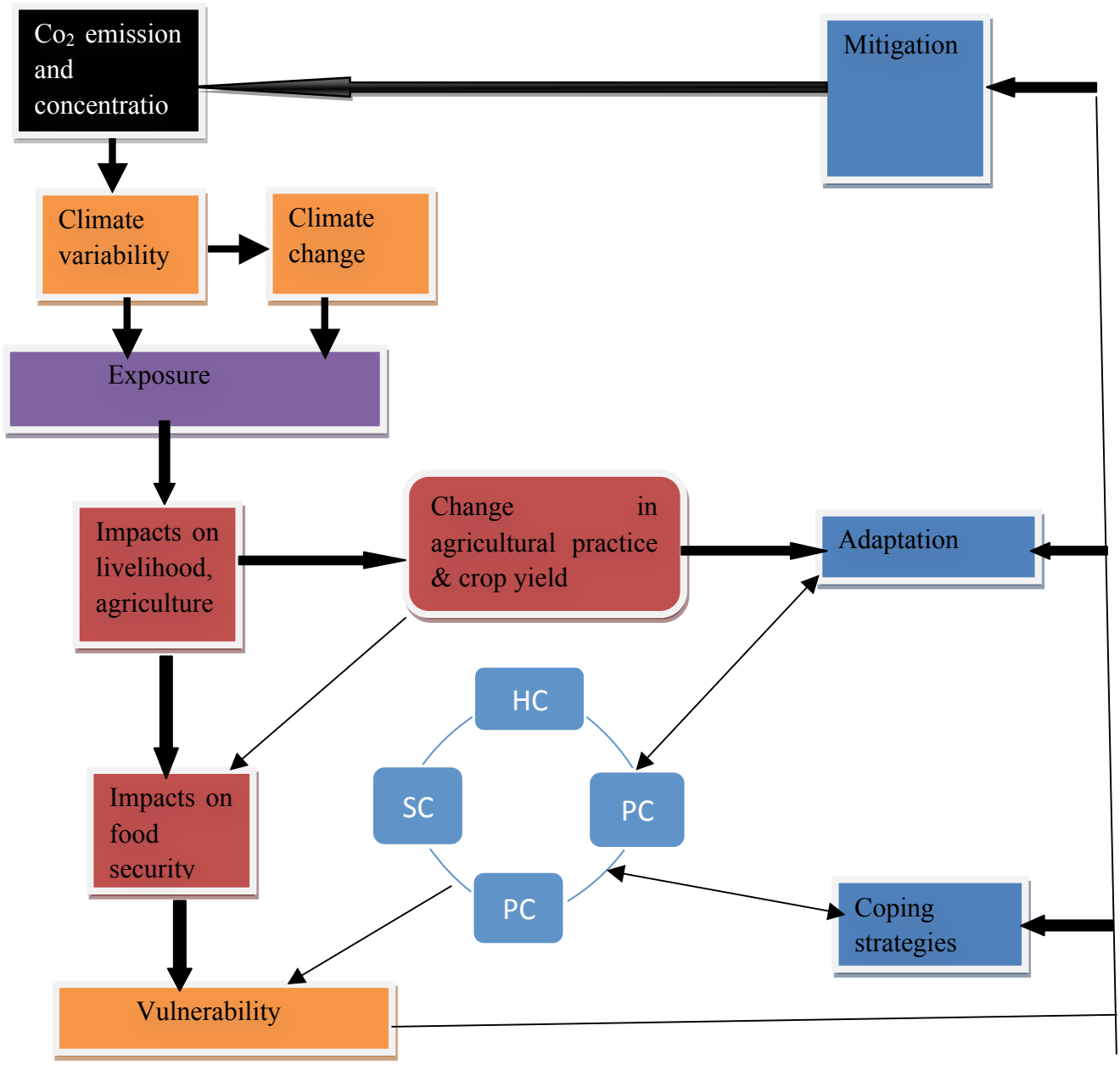

Figure 1: Schematic presentation of some of the variables/concepts of climate change and variability and their interaction/flow of impacts

Climate change and variability will also change climate variables like precipitation, temperature, and other related variables. As temperature is one drive of precipitation, the spatial and temporal pattern and amount of precipitation will be changed. Beside this, increase in the frequency, duration and intensity of dry spells and droughts; changes in the

timing, duration, intensity and geographic location of rain and snowfall; increase in the frequency and intensity of storms and floods are all the effect of temperature increase.

Finally agricultural practice will be challenged by greater seasonal weather variability and change in the start and end of growing seasons. And climate related risks like flood and heavy rain in the harvesting seasons result post harvest crop failure. From all direction the consequences is worsening of food insecurity.

Food security depends on many factors, including social, economic and environmental determinants (FAO food security, 2008), but in this study the main emphasis has been given to agriculture sector on which the local people relied.

2.7 Empirical Studies

Climate change and variability studies are getting attention of most researchers from different discipline .most studies are focusing on the impacts of climate change and variability on different sectors and adaptation strategies of systems to the change. Empirical studies on climate change and variability and, adaptation and vulnerability at local level in Ethiopia are at early infant age. In this section different studies, both in and outside Ethiopia, are reviewed giving due emphasis on studies dealing to climate change impacts, adaption on agriculture and food security.

The study conducted by DCA, (2009), in Uganda for assessing climate change and adaptation strategies in Karamoja district has concluded that climate change and variability is presenting profound environmental and economic risk on the people of Karamojja. Both the perception and climatic date analysis showed that temperature and increasing and rainfall is decreasing in the area. Crop failure before maturity, water scarcity and frequent drought were reported as the major consequences of climate change and variability in the study area. In this study water scarcity has been identified as serious problem caused by lowering of water table which this was also caused by high surface temperature and deforestation. Food security is challenged by the existing impacts of climate change. The study reported that reduced meals and hunger were major indicators of food insecurity in

karamoja. Finally the report also presented that the peoples are adapting and coping with the problem by applying different methods.

The second study reviewed was conducted in Tanzania by Mary and Majulle, (2009), the impacts of climate change, variability and adaptation strategies on agriculture in Manyoni district. The study was aimed at understanding of local community's perception on climate change and variability issue and establishes its impact and adaptation within agricultural activities. The finding of this study, according to the perception of local peoples and statistical climate data, showed that the temperature and rainfall has changed. The study reported that climate change and variability is the major challenge of crop production. In response to the impacts associated with climate change and variability, communities in study villagers are implementing different adaptation measures such as Soil fertility improvement management, practices soils tillage practices, and staggered seed crop planting.

The third study, the impact of climate change and variability on rural small holders and their adaptation strategies, was conducted by Daniel (2009), in central rift valley area of Ethiopia. The study showed that climate change and variability is occurred in the area and it is further hampering the livelihood of smallholder farmers. The study conducted by Meseret (2009), to assess the economic impact of climate change on crop farming activities in Nile basin of Ethiopia using Ricardian model showed that an annual increase of 1°C in temperature will have a positive impact

Chapter Three

Research Methodology

3.1 Description of study area

3.1.1 North Wollo

The North Wollo Administrative Zone is one of the eleven zones of the Amhara National Regional State. The administrative Zone has nine Woredas, namely Gubalafto, Habru, Kobo, Delanta, Meket, Wadla, Bugna and Gidan. Its administrative town, Woldiya, is located 380km North East of Bahir Dar and 521km North of Addis Ababa.

The North Wollo Zone is geographically located between 11^0N-13^0N and 38^0E to 40^0 E. The zone has an estimated area of 1,902, 200 hectares, which is about 20 per cent of the region. The altitude of the zone varies from 600 to 4284meter above sea level (Masl). The North Wollo administrative Zone has four agro-ecological zones, namely, lowland (*Kolla*) 500-1500 Masl 38 per cent, Mid-altitude (*Woina-Dega*) 1500-2300 masl is about 34 per cent, Highland (*Dega*) 2300-3200 masl is 21% and *Wurch* >3200 is about 7 per cent of the Zone.

3.1.2 Gubalafto Woreda

3.1.2.1 Location

Gubalafto Woreda is one of the nine Woreda of North Wollo zone. Geographically the area is located between 39012’9” and 39045’58’’East and 11034’54’’and 11058’59’’North. . It is bordered on the south by the Debub wollo zone on the west dawuntna Delanta, on the North West by Meket, on the north by Gidan, on the northeast by kobo on the east by afar region on the south east by Habru Woreda.

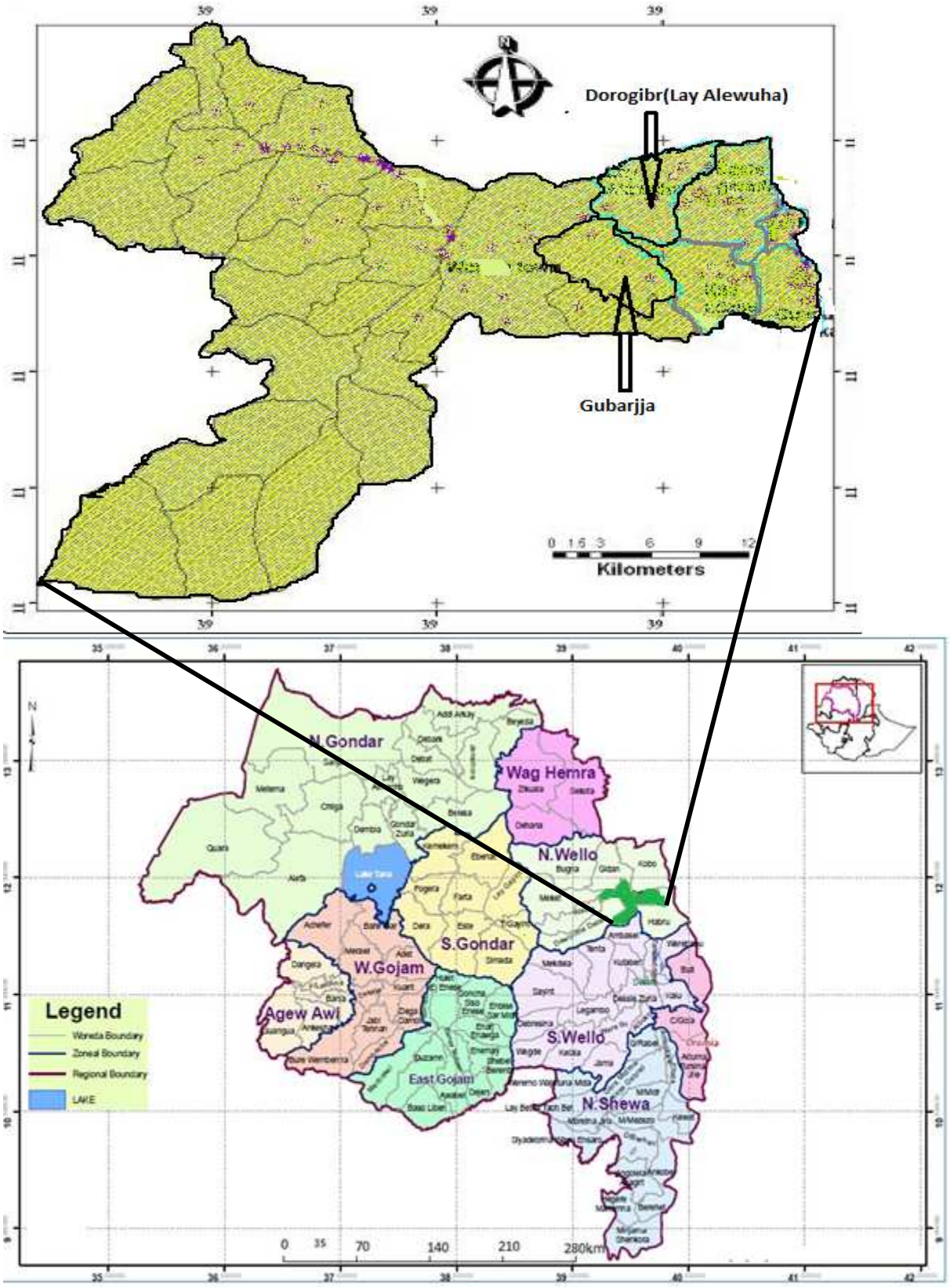

Figure 2: Location map of the study area Source: (Estifanos, 2010)

3.1.2.2 Topography and Climate Characteristics

The topography of the Woreda is mostly characterized by a chain of mountains, hills and valleys ranging from 1379- 3809 meter above sea level (masl). It is characterized by 20% flat, 30% undulating, 35% mountainous and 15% gorges or Valleys. Gubalafto Woreda has four agro-ecological zones, namely, lowland (Kolla) 1379-1500 m a.s.l, Mid-altitude (Woinadega) 1500-2300 m a.s.l, Highland (Dega) 2300-3200 m a.s.l, and Wurch >3200 m a.s.l. Most of the rural population is settled on the highlands and plateaus.

The mean monthly temperature at Sirinka (which is 12 km south of Woldya) ranges from 21^0C to 25^0C. The annual mean minimum and maximum temperatures are ranging from 13.5 to 25.4^0C. June is the month with the highest record of maximum and minimum temperature. Annual rainfall of Gubalafto district is one of the lowest in the region and it is less than the annual evaporation (Derbew, 2000). The nature of the rainfall is so erratic, short in duration and poorly distributed temporally and spatially. The livelihood of farmers is endangered by seasonality of rainfall, drought and moisture stress. The annual mean rainfall of the district for the last 18 years was 1078.9 mm. It has bimodal characteristics. The small rainy season (*Belg*), occurs between March and May and the long rainy season (*Meher*), occurs between June and September. In most cases, for crop production, the highland areas (*Dega*) depend on *Belg* rain whereas, the *Woinadega* and *Kolla* areas depend on *Meher* rain.

3.1.2.3 Socio-economic Activities and Livelihood Strategies in Gubalafto

Gubalafto district has a total population size of 139,825, out of which 70,750 men and 69,075 women (CSA, 2007). Out of this total population 4,886 or 3.49% were urban inhabitants. Gubalafto with an area of 900.49 square kilometers has a crude population density of 155 km^{-2}, which is greater than the Zone average of 123 persons per km^{-2}. A total of 33,676 households were counted in this woreda, resulting in an average of 4.15 persons to a household, there were 32,824 housing units in the woreda.

About 96.51% rural households depend on agriculture for their livelihoods. These subsistence farmers practice mixed farming, where crop and livestock productions are

managed under the same farming unit. Agricultural land is scares in the high land areas. Income from sale of livestock and livestock products has considerable contribution to household's food security. The low land agroecology zones have better agricultural land and some kebeles like, Sanka, Lay Alewuha (Dorogibr), Laste-gerado, have access to irrigation. The most commonly produced crops in the zone are annual crops such as sorghum, wheat, teff, maize, haricot beans, horse bean, cheek pea and cash crops like onion, pepper. The major roads crossing the Woreda have to a certain extent promoted farmers' exposure to trade. As a result a number of farmers are engaged in petty trading. Nonetheless, cash crops production is under developed. Vegetable and fruit production are yet to be promoted. Seeds and planting materials are in short supply, and efficient utilization of water resources is very low. Veterinary services are inadequate. As elsewhere, institutions of rural credit are also recent and underdeveloped.

Natural resources are declining and soil erosion is marked by the presence of expanding gullies. Population expansion has resulted in shrinking farm sizes and grazing lands. Declining soil fertility, increased incidence of crop pests and weeds, coupled with cultural and attitudinal problems have made the Woreda one of the food insecure woredas of the ANRS (AMAREW, 2007).

3.1.3 Food Security Situation in North Wollo and Gubalafto Woreda

North Wollo has a lot of records of frequent drought occurrences and often suffers from to acute food shortages. This zone is one of the food insecure areas in the region. The cause of food insecurity in the area revolves around many interrelated factors. Low natural resource endowment, rugged topography (mountainous), drought, unreliable rainfall pattern and other social factors are among the major ones. The progressive decline of the inherent fertility and organic content of the soil and erosion induced land degradation have reached to critical point in the zone. Moreover, the low income of the farmers is the result of the absence of diversification of employment or lack of off-farm employment opportunities. The major activities of farmers' i.e agriculture, livestock, petty trade and labour contribute, respectively, 70, 25, 2 and 3% to the income.

The highland *belg*-dependent zone of North Wollo is one of the areas in receipt of food aid for many years, and considered chronically food insecure. At an altitude of 2,000–3,500m,

with the major harvest after the minor *belg* rains, the dominant crop is barley, with wheat, oats, pulses and flax also common, as well as cows, oxen and sheep.

In Gubalafto majority of the households do not produce enough food to feed themselves. Some do not have access to enough land to produce the minimum for subsistence and some households do not have oxen to cultivate their land. Landholdings are small. At wereda level, the average land holding size for a farmer has been estimated to be 0.78 hectare ranging from 0.4 hectare in the highland areas to 1.93 hectare in the Kolla (lowland) areas of the Woreda.

The number of landless people is increasing, and land degradation is common. Gubalafto is one of the wereda of North Wollo Zone where both chronic and transitory food insecurity are persistent problems. . A substantial number of households are chronically food insecure, that they are not able to produce enough for their subsistence even in years of normal rainfall. As a result, food aid through productive safety net program and direct food aid has become an institutional feature.

The Productive Safety Net Program (PSNP) was initiated in 2005 (1997 E.C). It is designed to protect the assets of chronically food insecure households through the provision of food and cash entitlements. Households with able-bodied members' access their entitlements through public work activities, undertaken over 5 days in a month; households without labour, receive direct support. Very poor and poor households receive 6 ETB daily wage from January to March, and 15kg cereal ration per /month during the stress season from April to June.

3.2 Sample Survey and Sampling Methods

3.2.1 Selection of the study villages

Among the zones of Amhara regional state, North Wollo zone has been selected. The rationale for the choice was that this zone is one of the drought prone areas of Amhara region. Large parts of the zone experience frequent droughts and chronic food insecurity. North Wollo is divided into 10 districts. From these districts, Gubalafto has been selected based on its representativeness of the different agro ecological conditions and socio economic activities of the zone. Furthermore, Gubalafto district is divided into 34 kebeles of

farmer's administration political unit. Using stratified random sampling technique, the 34 kebeles have been stratified into two agro climatic zones (highland; *dega* and *weynadega,* and low land; *Kola)* and Dorogibr from the low land (Kola agro ecology) and Gubarjja from the highland (*dega* and *weynadega* agro ecology) have been selected randomly. The villages provide an opportunity to study the impact of climate change and variability on food security because there is a frequent rainfall irregularity and post harvest crop failure in Gubalafto district.

3.2.2 Selection of Sample Households and Questionnaire Administration

From the two selected villages, a total 100 households (50 households from each village) have been randomly selected from the lists of the households of the two villages.

Sample survey method was applied to collect primary data from sampled households/farmers through structured questionnaire with closed ended and open option questions. The information collected included farmers' perception of historical climatic extremes, trend of temperature and rainfall, the situation of climate variability, its impact and adaptation methods which they used to cope up with the changes and variability. The questionnaire also included information about the households' socio economic status. To make the data collection processes effective and to control the quality of the data which has been collected, the researcher employed different methods throughout the data collection process. Firstly, the researcher is familiar and has a good understanding of the area under study and this helped him to develop proxy and understandable questionnaire to the local people.

The data collection process was through face-to-face contact and interviewing heads of the samples households. The heads were oriented by the kebele administrator about the purpose of the survey. To enhance the chance of meeting the household's heads in their villages and homes, early mornings and late afternoon were found to be an appropriate time.

3.3 Focus Group Discussion (FGD)

In total four focus group discussions have been administered. Two different group discussions, group one consisting of only females and group two consisting of only males, in each study villages, have been administered. There were 7 members in each group. The aim

of the discussion was to understand the major impacts of climate variability and change, the relationship of climate change and food security, farmer's adaptation mechanisms and other related issues.

3.4 Key Informant Interview

For the sake of in depth understanding of historical trend of rain fall variability, some climate change and variability induced perceived change in the crop production and remembered climate risks in the study area, the researcher conducted in-depth interview with 2 kebele administrators, 3 DAs, 1Woreda disaster prevention and preparedness officer and 2 local elders.

3. 5 Secondary Data

In order to establish historical trend and variability of climate, recorded climate data from the National Meteorological Agency was used. In addition, different statistical data was obtained from the disaster prevention and preparedness office of North Wollo Zone. Books, journals and reports were used as sources of secondary data.

3. 6 Data Analysis

Qualitative data from various sources was examined and presented in different form. It was discussed under different headings. Quantitative data also were edited, coded and entered in a SPSS and Microsoft Excel spread sheets and analyzed. Descriptive statistics were run to give frequencies and then cross-tabulation was undertaken. Multiple response questions were analyzed so as to give frequencies and percentages. Tables and graphs were used to present different variables. Temperature and rainfall data from meteorological stations were analyzed using Microsoft Office Excel 2007 and SPSS 15 version to present patterns and trends of rainfall and temperature. Seasonal and annual trends of rainfall .means and coefficients of variations were calculated and used as statistical descriptors of rainfall variability.

Chapter Four

Results and Discussions

4.1 Household Profile

Table 1 shows the category of respondents surveyed in Dorogibr and Gubarjja, sex composition and house hold educational status. Out of the total respondents of the two villages 79% were males. In Gubalafto like other parts of Ethiopia, male headed household is dominant.

Table1. Profile of respondents

Category of respondent	Dorogibr		Gubarjja		(%) of total
		%	N=50	%	
Sex	No.	%	No.	%	
Male	37	74.0	42	84.0	79
Female	13	26.0	8	16.0	21
Total	50	100	50	100	100
Educational status of the house hold head					
Illiterate	13	26	24	48	37
Write and read	14	28	15	30	29
1-6	17	34	9	18	26
7-8	4	8	2	4	6
9-12	2	4	0	0	2
Total	50	100	50	100	100

Source: Field survey (2010).

Over all 37% of the respondents were illiterate, while village wise the highest is in Gubarjja (48%). About 29% of the total respondents were reported that they can read and write but have no formal education. The rate was highest in Gubarjja, i.e., 30%, while it was 28% in Dorogibr. Those who have primary education (1-6), 7-8, and secondary education were 26%, 6%, 2% respectively. There is also significant difference between the two villages in secondary school attendance.

Farmer's education has serious implication with regard to adoption of technologies and practices in agriculture in general and for adapting CC & V in particular.

Table2. Distribution of respondents by age group and family size

	Average		Dorogibr N=50		Gubarjja N=50		T=value
age	Mean	SD	Mean	SD	Mean	SD	0.218*
	47.56	12.296	47.28	11.925	47.84	12.772	
Family size	5.94	1.613	5.72	1.457	6.04	1.678	-1.370**

Source: Field survey (2010). *not significant **significant at 0.1

The overall average age of the respondent was 47.56 years. Children with less than 15 years were accounted for 22.07% in Gubarjja and 19.58% in Dorogibr. The household members whose ages were above 65 were accounted for 4.22% and 2.44% in Gubarjja and Dorogibr respectively. Over all 75.96% of member of the households were between the age group of 16-64. However, it is reported (Azeget, 2009) that in Ethiopia all age groups above the age of ten years in the rural area are involved in agricultural activities. Thus, the result of the survey indicates that the number of person in productive age group is greater than the unproductive age groups. In this case both kebeles can have low vulnerability due to labour force.

4.2 Food Security Situation and Livelihood Sources in the Study Area

For most farmers in Gubalafto Woreda, food security is determined by access to and availability of grain, especially, sorghum, teff, wheat, maize. In the highland part of the Woreda pea, and bean, supplement the diet.

In the study area the key livelihood sources reported by respondents can be divided in to two; crop farming and mixed farming (livestock and crop). Mixed farming is the major economic activity for 66% of the respondents in Gubarjja, whilst crop farming is major livelihood support for 30% of the respondents (Table 3). In Dorogibr 42% of the respondent reported that crop farming is their primary source of livelihood whilst 32% reports that both livestock and crop farming are primary bases of their livelihood.

Petty trading is less important as livelihood source in both Gubarjja (4%) and Dorogibr (18%), although its proportion is higher in Dorogibr than Gubarjja. This difference has been reflected as the result of relatively higher level of urbanization and better accessibility of farmers of Dorogibr to the road that leads to Mekelle, market and electricity. This, in turn, gives higher opportunity for petty trade for farmers of Dorogibr in times of climatic shocks. Thus, farmers in this village can easily diversify their economic activities and can have better coping strategies under the stress of climate change and variability. However, it is important to note that given the crop farming and both farming and livestock keeping are the main livelihood sources (Table 3) in the two kebeles, CC & V will have far-reaching effect on their food security.

Table 3. Distribution of Respondents by major sources of livelihoods in the study area.

Major Sources of Livelihoods	Dorogibr N=50		Gubarjja N=50		Average
	HHC	%	HHC	%	%
Farming	21	42	15	30	36
Farming and livestock	16	32	33	66	49
Trade	9	18	2	4	11
remittances	4	8	0	0	4

Source: Field survey (2010). HHC:-household count

Only 8% of the respondents of Dorogibr reported that remittance is their primary source of livelihood. Focus group discussant reported that this remittance is from household members who have been sent to and working in the Middle-East countries, especially in Saudi Arabia and Dubai. Further, it has been indicated by the group discussants that members of the household have been sent to these countries when the farming activities are discouraged by frequent drought and unreliable rainfall pattern.

4.2.1 Crop Production and Food Self Sufficiency

Crop production is the major activity in Gubalafto *Woreda* together with livestock production. In the past farmers used to produce in small rainy *(Belg*) and main rainy (*Meher*) seasons. Recently, food crop production is largely from main rainy seasons whereas belg production is mainly in areas of irrigation schemes. By rain fed agriculture only 7% of

respondents reported that they produced from belg season last year (2009/10). Both in *meher* and *belg* seasons, different types of food crops produced and their respective areal coverage in 2009/10 in the two study kebeles were summarized in table 4. One thing to note is that year 2009/10 was not agronomically a normal year. There was no rainfall during the major planting times. As the group discussants reported, rain fall started in late July, and also the rain fall in March and April was very poor. So it was difficult to prepare the farmland as well as to sow long cycle crops. Rainfall in August was poorly distributed among the days in the month. Generally in this production year the harvests of the small rainy season were very poor and out puts of long maturing crops were severely compromised.

Table 4. Major crops produced by respondents (2009/10).

Crops	Dorogibr		Gubarjja	
	Average area (ha/hh)	Average yield (quintal/hh)	Average area (ha/hh)	Average yield (quintal/hh)
Sorghum	0.415	1.360	0.225	1.450
Teff	0.333	2.270	0.097	0.635
Maize	0.234	2.870	0.127	0.780
Wheat	-	-	0.110	0.890
Others (pea, bean.)	-	-	0.083	0.230
Total	0.982	6.5	0.642	4.07

Source: Field survey 9201).

Adopting high value crops (vegetable and fruits), especially in areas where irrigation water is available round the year water supply, is one of the adaptation mechanisms frequently reported by many studies and IPCC reports. However, in the study area the production of cash crops is under developed. Dorogibr has relatively a better potential for cash crop production using the available irrigation scheme. However, the practice of cash crop productions is underdeveloped, probably due to lack of experience in production of cash

crops. Even out of the 43 respondent who were reported have access to irrigation, only 16 (37.2%) were reported produced cash crops (onion, sugar cane, banana and pepper) in2009/10 production year. the rest produced only teff and maize..

Mr. Molla, the agricultural expert in Dorogibr, explained that the major use of the irrigation is for production of maize with intensification two times a year. Only few farmers produced some cash crops on their irrigated plot. Seid, (2002) reported that the irrigation scheme in Dorogibr is the least performing scheme in terms of cash crop production. The major constraints are lack of knowledge and experience to cultivate vegetables, settlement pattern, and culture of open grazing system in dry seasons. Distance of the scheme from the residence also makes it difficult to protect the crops from damage by livestock. The existing practices indicate less crop diversification (mostly maize and teff) and under utilization of the available opportunity of irrigation by the people of Dorogibr. So, the contribution of the irrigation in minimizing vulnerability and impacts of rainfall failure is not maximized.

Among the cereal crops, respondents indicated important food crops according to their contribution for food security in the order of sorghum > maize > teff > wheat, and among cash crops as onion > pepper > sugarcane > banana in descending order of their importance.

To see household food security condition, examining the number of months on which households depend on their own farm production is important. Farm level productions, in rural Ethiopia are not enough, even in the normal rainfall year, to feed the member of the household for the whole year period. There are months the household struggle to get additional food from other sources. CC & V will increase the number of months with food shortage for households by affecting crop production which subsequently caused by unreliable rainfall pattern and shorter growing seasons.

Table 5 shows the number of months the household stayed food self-sufficient from own production. Self sufficiency periods of 34% and 33% of the respondents fall in 9-11months and 6-9 months respectively. 17% of respondents reported that they are self sufficient the whole year.

Table 5. Distribution of respondents by durations in months with food sufficiency

Food sufficiency status	Dorogibr		Gubarjja		Total	
	HHC	%	HHC	%	%	
excess of the requirement	2	4	0	0	2	T=
sufficient but not excess	10	20	7	14	17	-2.695*
Covers 9-11 months	21	42	13	26	34	
covers 6-9 months	13	26	20	40	33	
Covers 3-6 months	4	8	10	20	14	
Total	50	100	50	100	100	

Source: field survey (2010). HHC-household count * Significance at 0.01

4.2.2 Ways to Meet the Food Requirements

Now we have seen that majority of respondents were not self sufficient. Most farmers cannot feed their household from their farm production for the whole year. The reason why their production is not fully enough to feed the family may be a function of different factors, like climatic fluctuations, depletion of soil fertility, or the loss of household productive assets or some other related problems. But in the case of the study area the major factor for household food insecurity has been identified as unreliable rainfall pattern. There will be months with food scarcity, hence additional food requirement must be fulfilled elsewhere. Households respond to the problems caused by seasonal and disaster related food insecurity in different ways. The range of responding to food shortages differs according to the particular conditions, accessed means, and created opportunities.

It includes filling of additional food requirement through sales of livestock, borrowing, receiving food aid, remittance or engaging in daily labour, etc. Here, food aid (33%), selling of firewood and charcoal (13%), and remittance (10%) are the most important ways to fill the food shortages. In the discussion it was noted that there is difference in the ways of responding to food deficits. The better-off respond by selling livestock. The poor households by selling firewood and charcoal and borrowing from better off households.

Table 6. Respondents response to source of additional food.

Mechanisms to fill additional food requirement.	Dorogibr		Gubarjja		Average
	N=32	%	N=43	%	%
Aid	17	34	31	62	33
Borrow	2	4	3	6	5
Remittance	7	14	3	6	10
Petty trade	4	8	1	2	5
Selling of asset	-	-	2	4	2
Engaging in daily labour	1	2	-	-	1
Selling local alcohol	4	8	2	4	6
Selling of fire wood	9	18	4	8	13

Source: Field survey (2010).

4.3 An Overview of Climate Change and Variability in Ethiopian

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

The year-to-year variation of rainfall over the country expressed in terms of normalized rainfall anomaly averaged for 42 stations shows that the country has experienced both dry and wet years over the last 55 years (Fig. 3). Years like, 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. The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country.

Furthermore, precipitation is projected to decrease from an annual average of 2.04 mm/day (1961-1990) to 1.97 mm/day (2070-2099), for a cumulative decline in rainfall of 25.5 mm/year (NAPA, 2007).

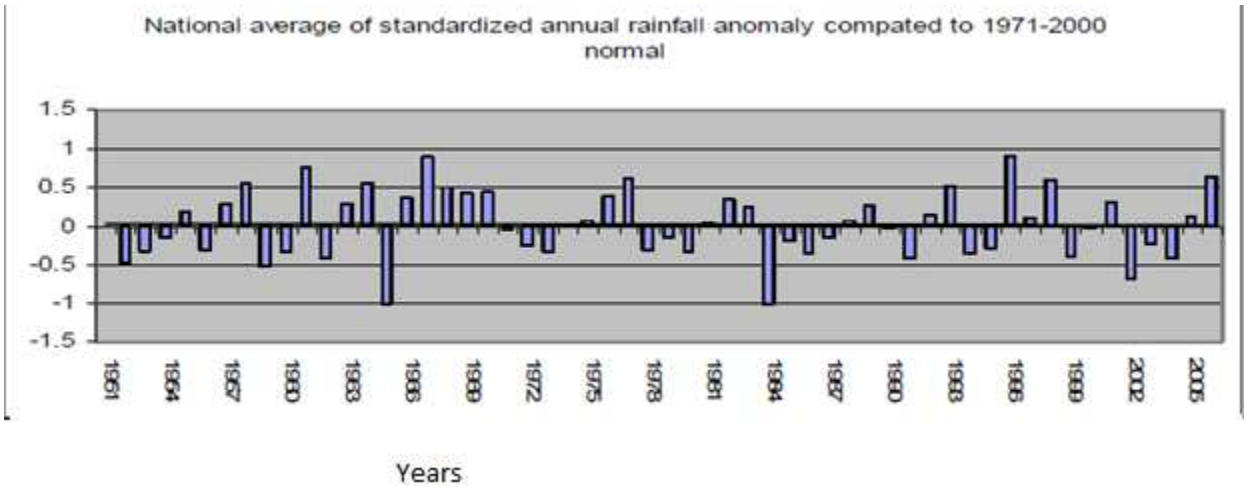

Fig. 3 Standardized average annual rainfall variability[3] of 42 stations for the years 1971-2000 over Ethiopia (NAPA, 2007).

In Ethiopia, it is assumed that the temperature has been increasing annually at the rate of 0.2°C over the past five decades (Yohannes, 2009). The annual time series of minimum and maximum temperature for 40 stations averaged over Ethiopia reveals a warming trend in temperature and it is evident that the average annual minimum temperature is increasing much faster than the average annual maximum temperature (HDR, 2007).

There is a warming trend in the annual minimum temperature over the past 55 years (Fig. 4) with an increasing rate of about 0.37^0C in every ten years period. It has been projected that temperature could rise by 3.1^0C and 5.1^0C respectively by 2090 and 2060 (NAPA, 2007). This rate of change is assumed have notable impact on the livelihood and food security of rural households in particular and the agricultural activities and economy of the nation in general.

[3] Standardized average rainfall variability is calculated by subtracting the long term average rainfall from the annual rainfall of a given year and dividing by standard deviation of rainfall over the period of observation.

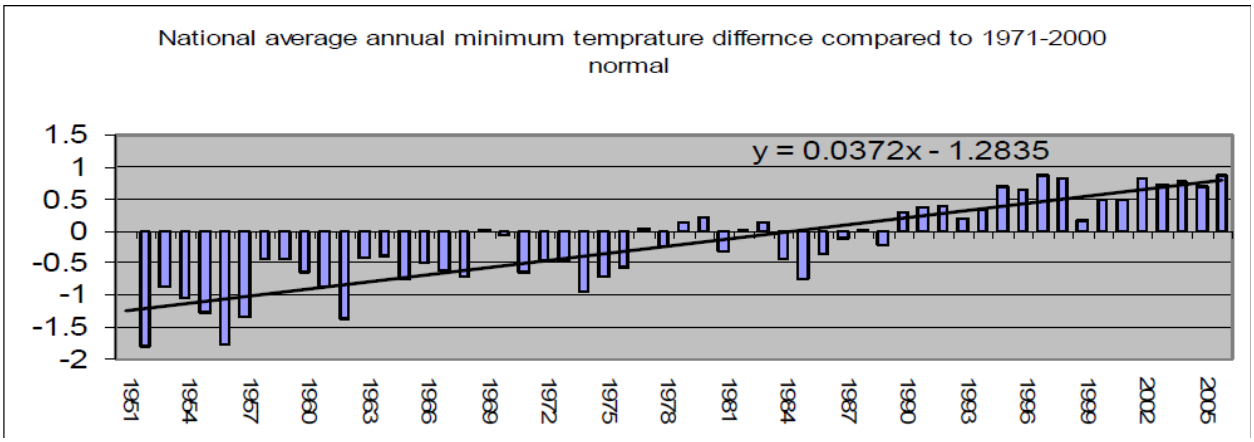

Fig. 4. Of standardized average annual minimum temperature variability and trend of 42 stations compared to 1971-2000 average annual minimum over Ethiopia (NAPA, 2007).

According to Ringer, (2008), as cited in (Yohannes, 2009), the increased temperature has already led to a decline in agricultural production, and cereal production is expected to decline still further (by 12%) under moderate global warming. Moreover, it has led to a decline in biodiversity, shortage of food and increase in human and livestock health problems, rural-urban migration and dependency on external support.

In Ethiopia the agriculture sector is dominated by small-scale farmers who employ largely rain-fed and traditional practices. The dependency of most of the farmers on rain fed agriculture has made the country's agricultural economy extremely vulnerable to the adversities of weather and climate. Thus, the amount and temporal distribution of rainfall and other climatic factors are key determinants of crop yields, and poor annual rainfall has been strongly associated with high number of people needing food aid (Fig. 5).

Food insecurity is an integral part of poverty in Ethiopia. Though food shortages resulting from adverse weather conditions are not new in this country, they have increased in severity and there have been shortages every two years since 1950 (Giorgis et al., 2006). Rainfall in much of the country is often erratic and unreliable; and rainfall variability and associated droughts have historically been major causes of food shortages and famines (Pankhurst and Johnson, 1988: cited in Weldeamlak, 2009).

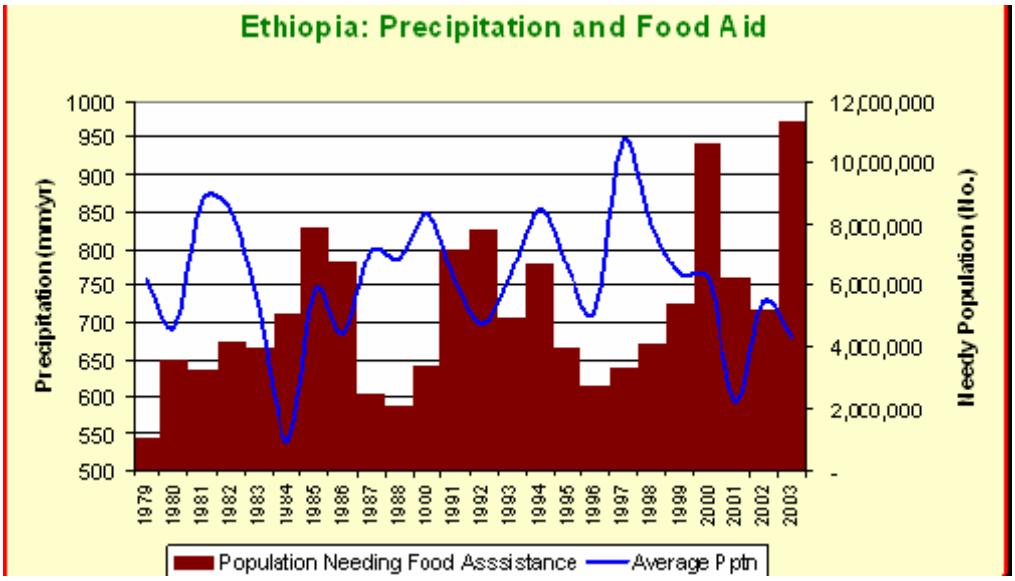

Fig. 5. Relationship between annual rainfall and number of people needing food aid in Ethiopia (source: siteresources.worldbank.org/.../Ethiopia_Country_Note.pdf (2007).

Ethiopia has experienced at least five major national droughts since 1980, along with literally dozens of local droughts (**siteresources.worldbank.org/.../Ethiopia_Country_Note.pdf (2007)).**

Cycles of drought create poverty traps for many households, constantly thwarting their efforts to build up assets and increase income.

4.4 Perceptions of Respondents on CC & V

One of the pre requests to adapt to changes occurring in the climate system is recognition of the change taking place. In cases of climate change, farmers must first perceive that changes are in fact taking place. Respondents were asked whether they perceive changes in different climate parameters (temperature, rainfall and climatic extremes). Fig. 6 shows that 48% of the respondents in Dorogibr and 30% of in Gubarjja perceives that there is significant increase in the temperature over the past 20-25 years. About 34% of the respondents in Dorogibr and 52% in Gubarjja reported that currently they feel that temperature has increased compared with the temperature what they had experienced 25 years ago. Out of the total respondents only 7% reported that the temperature is decreasing while the rest 11% indicated that there is no change in the temperature. In the study district 82% of respondents believed that temperature is increasing.

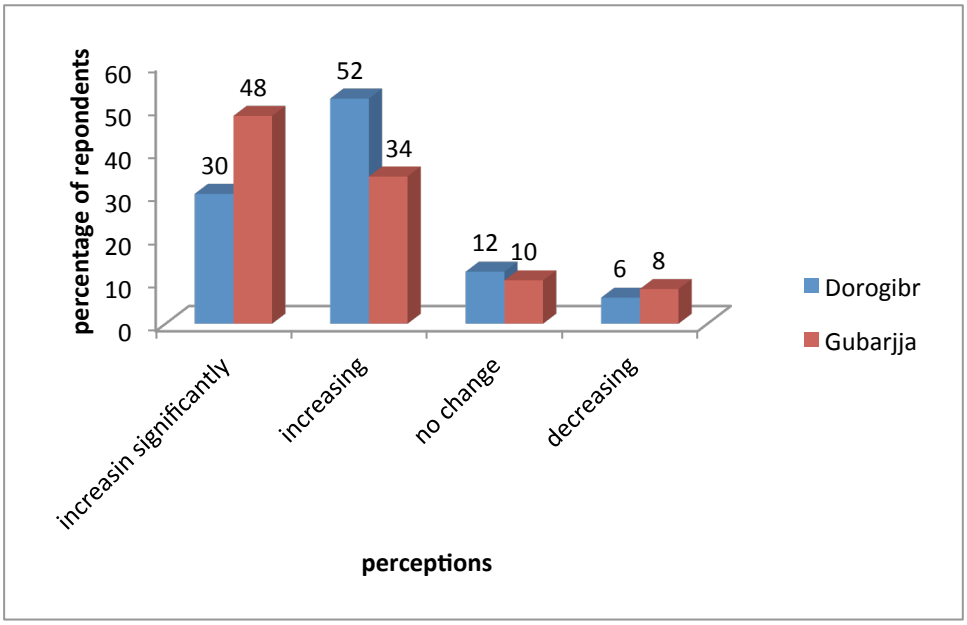

Fig. 6 Respondents' Perception on Temperature Change over the last 25 years

Views regarding change of rainfall pattern were also enquired from the respondents. And 34 and 54% of respondents respectively, of Dorogibr and Gubarjja reported that they have perceived significant decline in the annual rainfall amount in their village. About 54 and

36% of respondents respectively in Dorogibr and Gubarjja reported that they fell rainfall is decreasing but not significantly. In general, in the district, 89% of the respondents perceive that the rainfall is decreasing (Fig. 7).

Respondents were provided with five choices to know if rain fall timing (onset and cessation) had changed and causes a problem. Of the five choices, over whelming majority of the respondent, 62% in Dorogibr and 56% in Gubarjja declared that the rainy season onset late and ends up early. Respondents also reported that the rainy season onsets on time but ends up early (14%and 18%), it onset late and ends up late (8% and 6%), it onsets early and ends up early (12% and10%) in Dorogibr and Gubarjja respectively. Only 7% of the respondent in the two kebeles perceive no change on the timing of rain fall they indicated only the amount of rain fall is a problem (Fig.8).

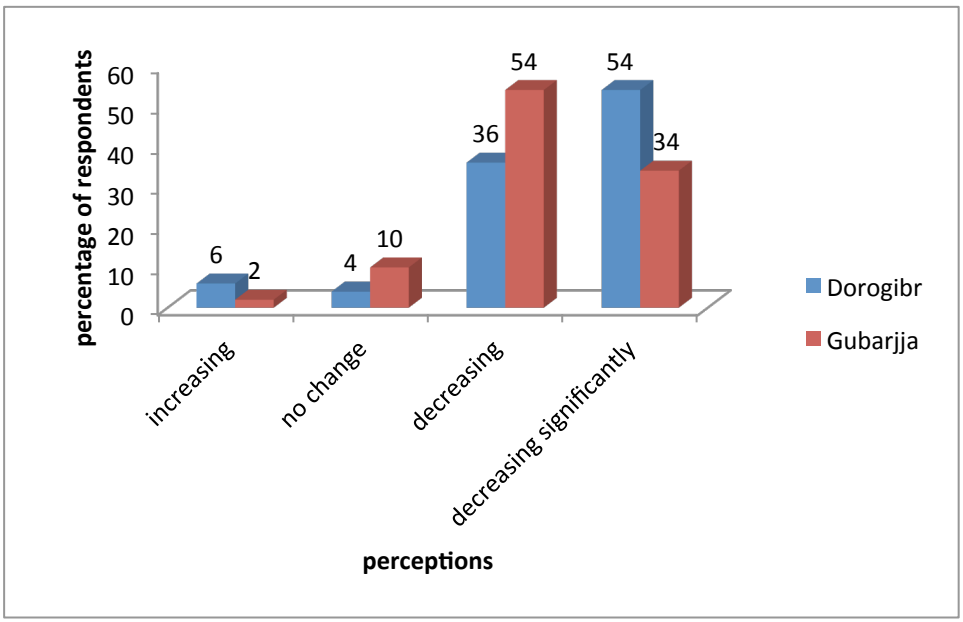

Fig. 7. Respondent's perception on trends of rainfall .

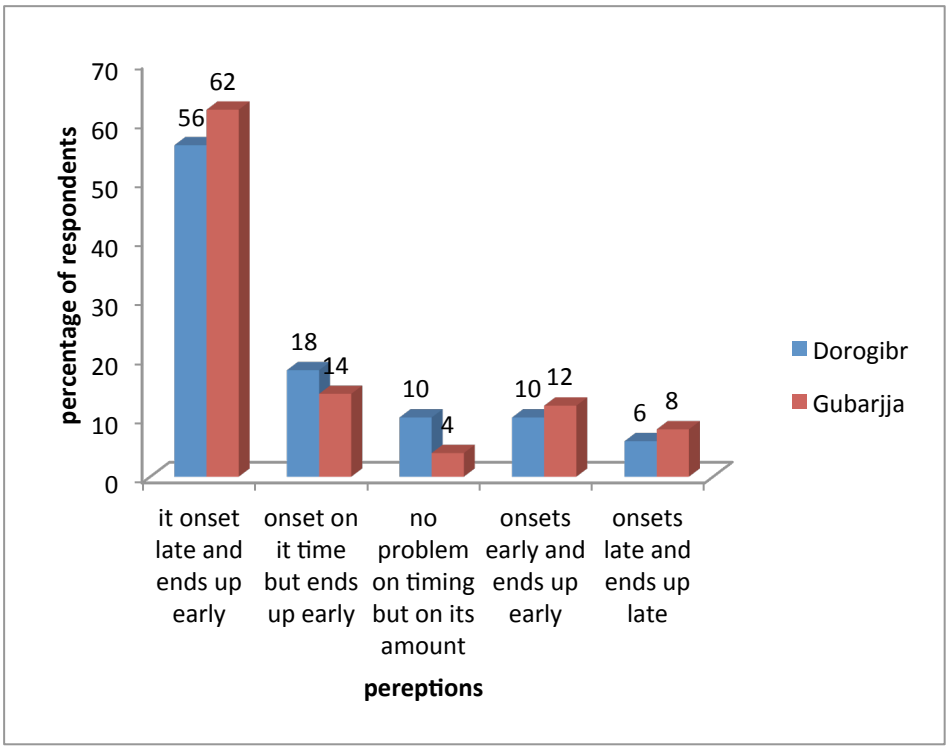

Fig. 8. Respondent's perception on timing of rainfall

4.5 Respondent's Perception on Cause of Climate Change

CC & V may be caused by human as well as natural phenomena. Many studies (Calvin, 2008; Ackerman**,** 2009; IPCC, 2007) are supporting the significant role of human action on the contemporary global warming and climate change. However, among the communities of the world there are different understandings regarding whether human action or natural processes have caused the current climate change.

In this study, respondents were asked to state their agreement or disagreement for the proposition that states "climate change is induced by human activities" and 78%% of the respondents have indicated their agreement (agree + strongly agree) on the proposition. Furthermore, the proposition was also supported by informants and discussants (table 7).

Table 7. Respondent's agreement and disagreement on human cause of climate change.

Climate change is induced by human activities		kebeles		
		Gubarjja	Dorogibr	Total (%)
Alternative responses	strongly agree	12	13	25
	agree	25	28	53
	neither agree nor disagree	4	2	6
	disagree	9	7	16
Total		50	50	100

Source: field survey (2010).

4.6 Temperature and Rainfall Trends Based on Meteorological Data

4.6.1 Temperature Trends

Perceptions of farmers with respect to changes in temperature as well as increasing rainfall variability was in line with empirical analysis of rainfall and temperature trends using the

data obtained from meteorological station (see appendix C). The analysis of rain fall data obtained from Sirinka meteorological station tends to support the perception of majority of respondents regarding rainfall trends. The data indicates that the maximum temperature is increasing by 0.025^0C annually or 0.25^0C per decade (Fig. 9).

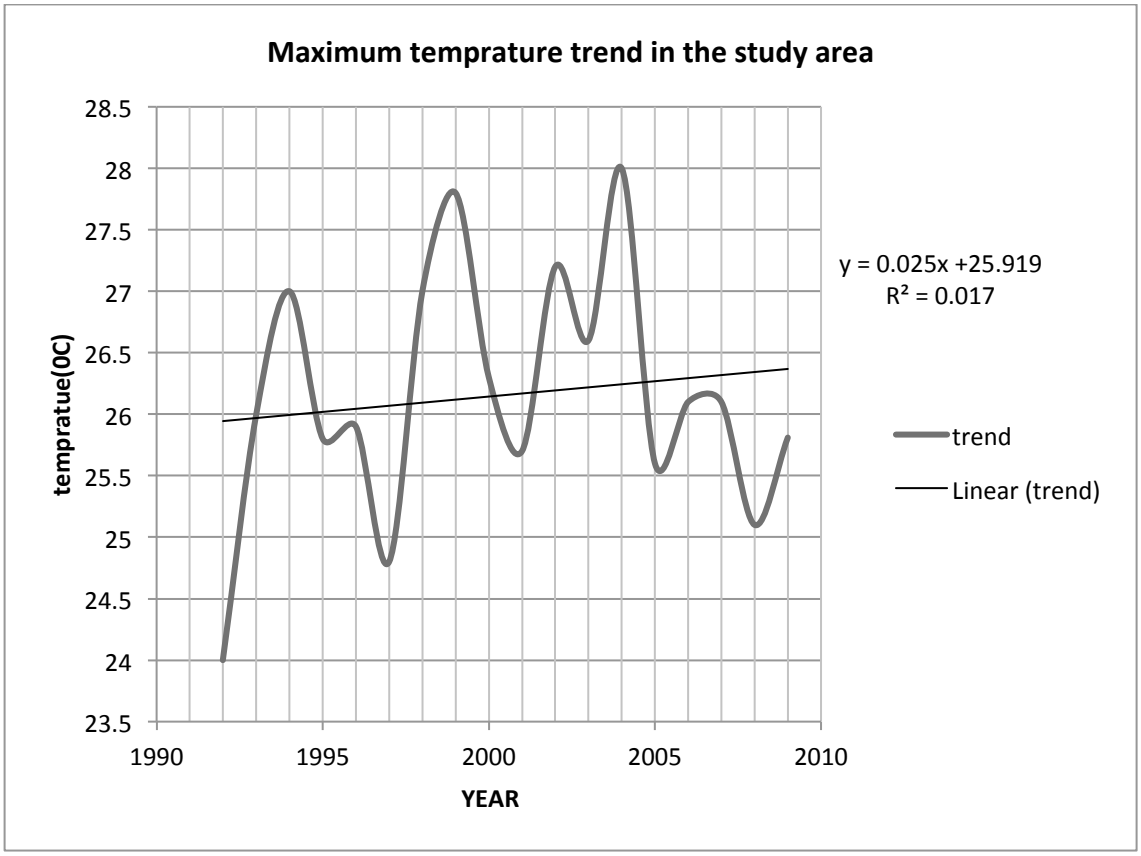

Fig. 9. Annual (1992-2009) maximum temperature of Sirink

The minimum temperature at Sirinka station is decreasing by 0.02^0C annually, especially the minimum temperature record of the last 5 years is below the mean minimum temperature (Fig. 10). However the average temperature is increasing influenced by the increment of the maximum temperature. The maximum temperature is increasing annually by 0.025^oc while the minimum temperature is decreasing by 0.02^0C. This indicates that night times are getting cooler and the day times are getting hotter.

The perception of majority of respondents indicated that the temperature is increasing .in addition to the increased temperature, the increased frequency of droughts and increased

length of the dry periods make people feel that the temperatures are on the increase by significantly.

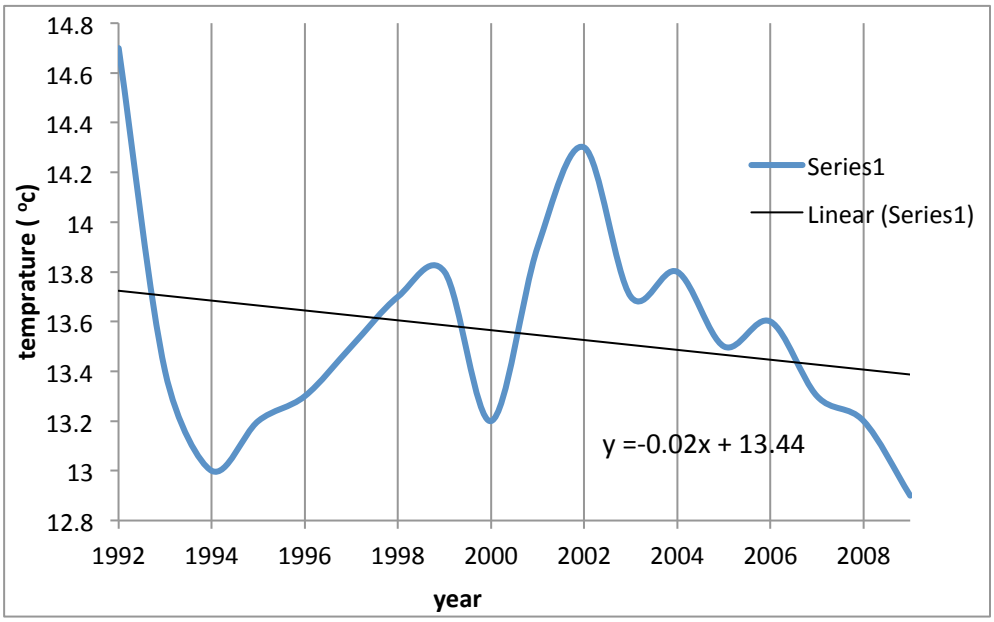

Fig. 10. Trend of minimum temperature in the study area

4.6.2 Rainfall Trend and Variability

The annual average rainfall in the Amhara region is 1194 mm, with a standard deviation of 124 mm and coefficient of variability of 10.4%. The rainfall in the region is characterized by alternation of wet and dry years. Of the 29 years of observation, 17 years (59%) recorded below the long-term average annual rainfall amount while 12 years recorded above average ((Woldeamlak, 2009).

In the study area, the average rainfall (1992-2009) is 1079mm with standard deviation of 189mm. The annual rainfall ranges from780.5mm in (2004) to 1528.2mm in (1999) with 17% coefficient of variation, which is higher than the coefficient of variation of the region (10.4%). Onwards from 2001, except for 2005 and 2006, annual rainfall of the area has shown decreasing trend from the average annual rainfall (Fig. 11). This probably explains the frequent droughts and chronic food insecurity of the area and the fact that heavily rely on relief food handouts.

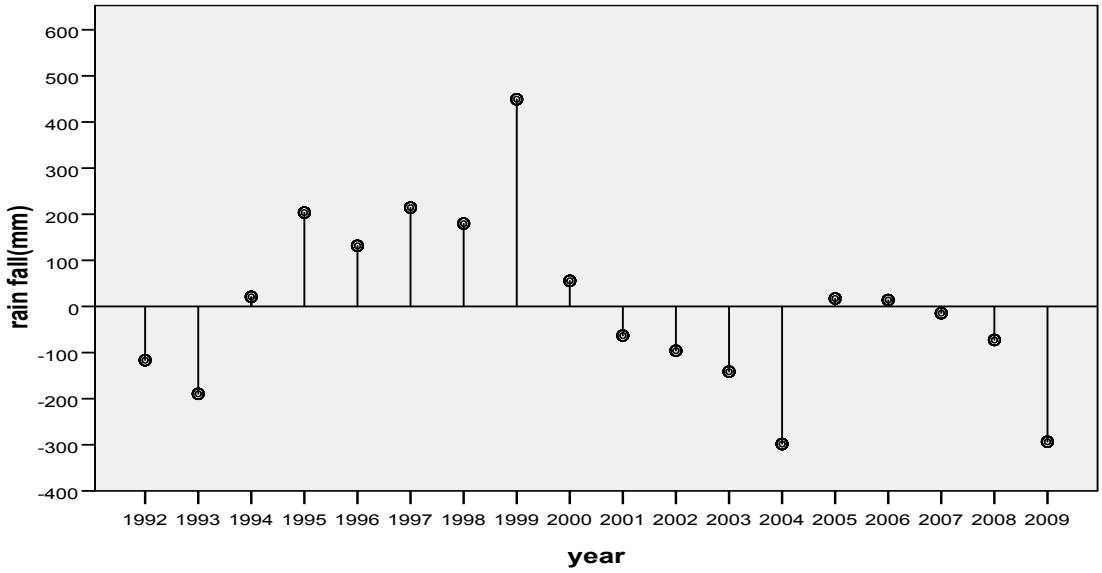

Fig 11. Annual rainfall deviation from mean (1079) at Sirinka station

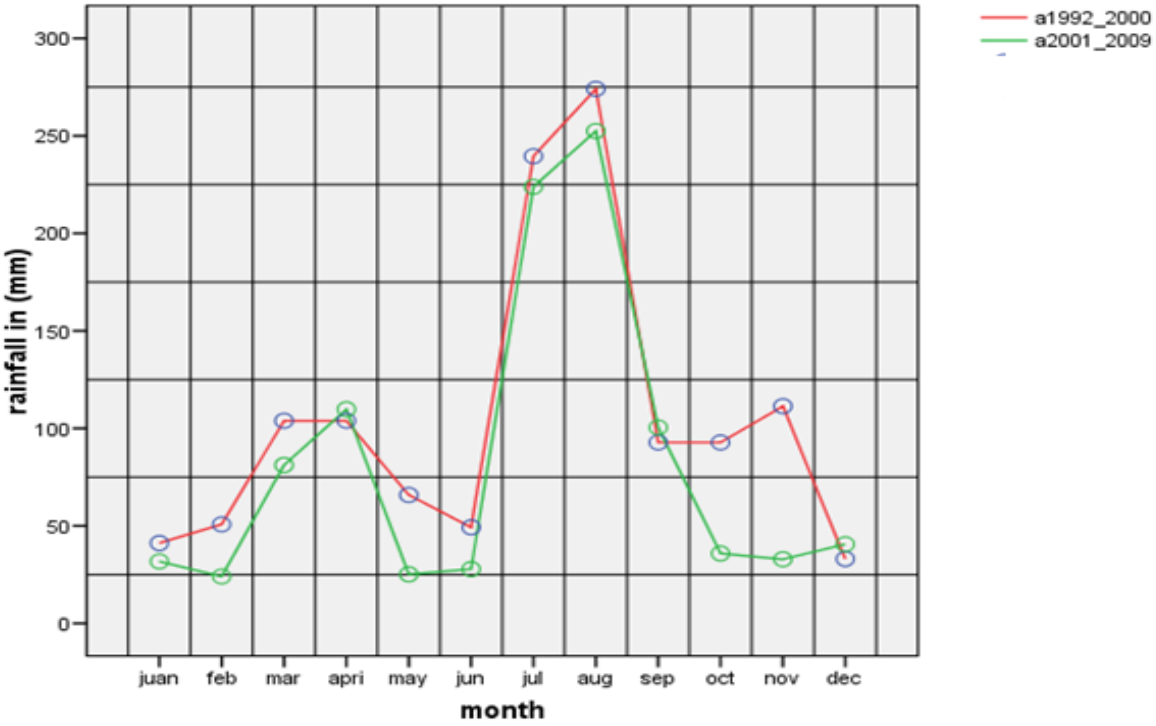

Fig. 12. Average monthly rainfall trend in the area

Average monthly rainfall for the years 2001-2009 has decreased when it is compared with monthly rainfall of 1992-2000. The pronounced reduction is seen in May, June, October and November months (Fig. 12). The average monthly *belg* (February, March and April) rainfall

of 2001- 2009 also had decreased from the average monthly rainfall of the same season of 1992-2000.

The distribution of *belg* rainfall shows higher year to year variability (Fig. 14). Decreasing rainfall of June has an implication on cropping practice. A moderate rain on the outset of the month has important role for crop growth. And respondents indicated that in the earlier times, normally the rain has had been started late at second half of June and stayed until mid of September, but now this is not the case. About 66% of the respondents have reported that these days the rain starts late and ends up early. Crop yields are highly sensitive to variation in the timing of growing season, especially to the start and cessation of rainy season.

The observed decrease in rainfall at the beginning (June) and at end (October) of the season (Fig. 12) is detrimental as it shortens the already short annual length of the potential crop growing period of the region, posing challenges to pasture and crop growing.

Rainfall in October which is very important for long maturing crops at their final stage of maturity has decreased. This rain strongly determines the productivity of crops like (all sorghum types). The rain may not be required to be available throughout the month but it has to rain at least until half of the month up to 2-3 times with considerable amount. The decreased rainfall in October coupled with low rainfall in September has an impact on crops. Given decreasing trend and high variability of short rainy season (*belg*), very low rainfall in June, and early cessation of rainfall in September, the rainy season is getting shorter and shorter. This is also to mean the potential plant growing period is decreasing acquiring farmers to think over the plant types that fit the existed length of growing period.

Study by Thronton (2007: cited in Majule and Maya, 2009), indicated that in parts of eastern Africa reduction in length of growing period is likely to result in substitution of some crops species. This implies that CC & V might result into change in plant and crops in a certain agro ecological zone to suit the prevail condition. Generally the decreased growing period has implication for farmers to switch to short maturing crops which gives yield in this narrow rainy season. More than the decreasing of monthly rainfall, the pronounced problem is the high variability and episodic natures of rainfall in the main rainy seasons (July, August and September). Figure 13 shows the distribution of *kremt* rainfall (1992-2009) in the area.

Year to year variation of rain fall is high and varies from the highest to the lowest at least yearly. June and September rainfall varies by 96.45% and 44.86% respectively. *Kremt* rainfall in the study area has 20.255% coefficient of variation. May has the highest variability with 103.51% coefficient of variation. The *belg* rain showed higher variability than *kremt* rainfall.

Table 8. Average rainfall and coefficient of variation for kremt and belg months.

seasons	Months	Mean	CV
Kremt months	June	38.60	96.45
	July	231.76	34.00
	August	263.31	28.71
	September	96.65	44.86
	Average for *kremt*	157.58	20.25
Belg months	March	92.57	79.31
	April	105.20	62.34
	May	45.54	103.51
	Average for*belg*	81.10	47.84

Weldeamlak, (2009), concluded that the *belg* (small rainy season, March-May) and the *bega* (dry season, October-February) rainfalls are much more variable than the *kiremt* (main rainy season, June-September) rainfall.

Apparently, there are ever changing situations in the study area; the annual rain fall is highly variable from year to year with its general decreasing trend. The rainy seasons are shrinking making growing periods shorter. These situations make farmers vulnerable to food insecurity because they are totally dependent on rainfall to produce their food

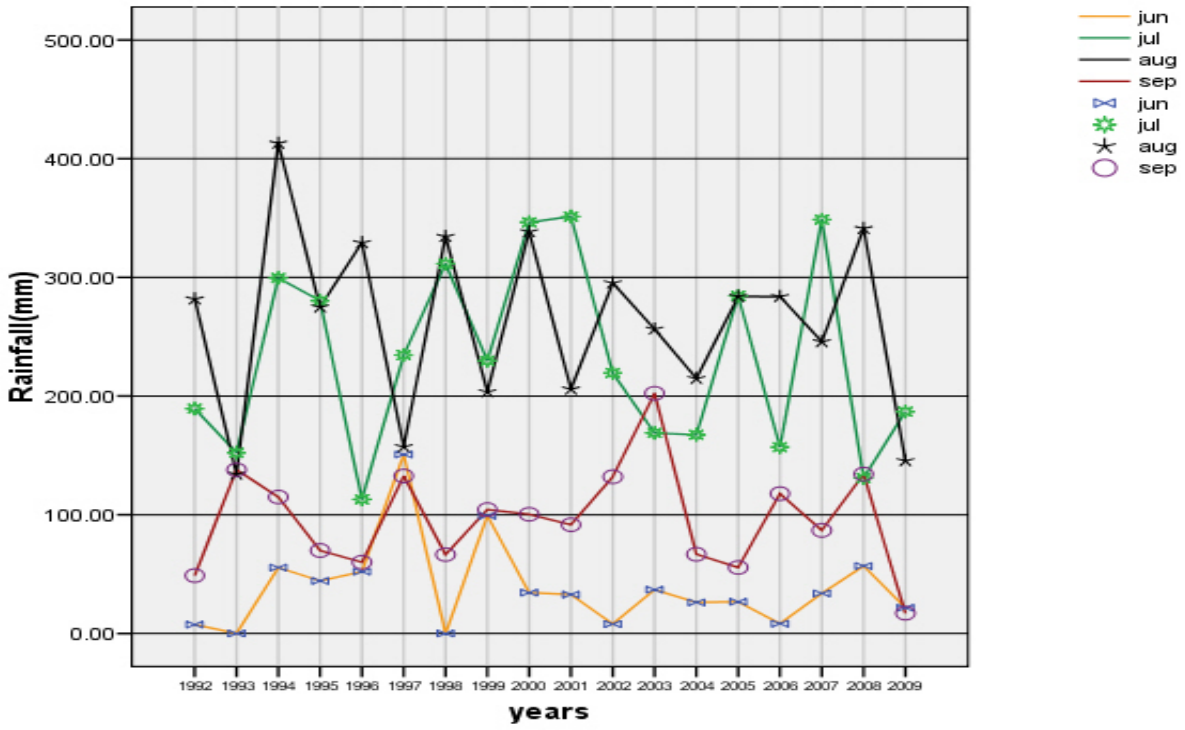

Fig.13. Average kremt (june,July, August & September) rainfall distribution (1992-2009).

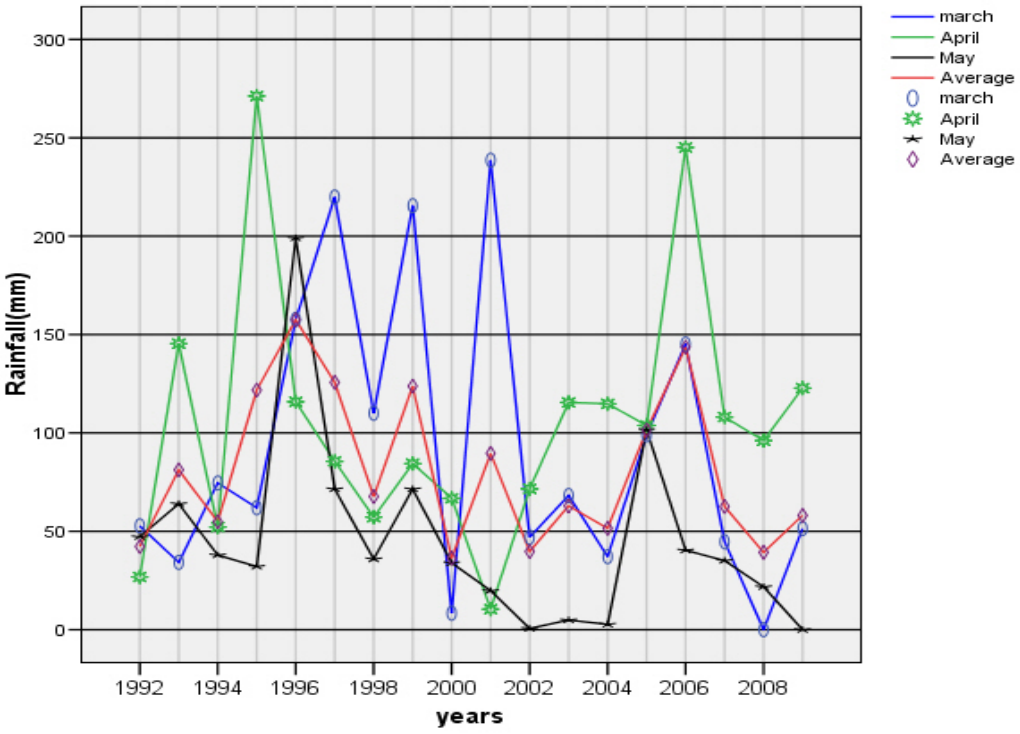

Fig. 14. Average monthly rainfall trends for belg (February, March & April) months

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In general the observed and perceived variation in rainfall onset has an implication for crop yield reduction and risk of food insecurity.

4.7 Frequent Drought and Flood

All respondents reported that they recognize that there have been climatic extremes, particularly drought, in the past 20-25 years. They explained that climatic extremes are to mean to them unusual phenomena either in drought, flood or harsh frost that affect significantly human life, animals, crops as well as other natural resources. They reported that years with climatic extreme events in the area were 1993, 1997/98, 2001/02 and 2004/05 droughts, 2006 flood and 2009 drought & flood. The informants and discussants revealed that the frequency and intensity of droughts has increased unlike the situation before 20-25 years. Molla Baye, a key informant farmer explained the frequencies of drought and floods in Dorogibr as follow

"Now we will not be surprised if droughts or floods occur, because we have experienced that in every alternate year or after each 2 to 3 years drought will occur and we are also aware that unexpected flood will come from the surrounding highlands and will carry away our livestock, crops and fertile soil."

Ethiopia has been affected by flood at different times. Major floods which caused loss of life and property occurred in different parts of the country in 1988, 1993, 1994, 1995,1996 and 2006 (NAPA, 2007).

The underlining cause of drought is increased variability in rain fall and the reduced amounts which have been triggered by global warming. Despite the fact that people in developing countries like the communities of Gubalafto district have contributed very little to global warming, they cannot entirely be free of being blamed from deforestation because in the study area many farmers cut trees for firewood and charcoal for sales in Woldya and nearby small towns.

In the study area flood is one of climate related disaster that causes damage to crops and livestock. But the impact of flood is different in the two kebeles. In Gubarjja the impact of flood is more pronounced on farm land, especially on sloppy lands.

Table 9. Variability of climate variables in Dorogibr and Gubarjja as prioritized by respondents based on their frequency of occurrence.

	Dorogibr (N=50)		Gubarjja (N=50)		Average	
Climate variables	WM	Rank	WM	Rank	WM	rank
Pattern of temperature change	5.30	6	5.48	6	5.39	6
Change in rainfall amount	1.84	1	2.93	3	2.38	1
Rainfall variability on timing	4.64	4	2.65	2	3.64	3
frost occurring	7.94	8	7.95	9	7.94	9
Moisture deficiency at the time of crop maturity	4.8	5	4.78	3	4.79	5
Snow	8.28	9	7.30	8	7.79	8
Pest and diseases caused by climate change	6.58	7	5.73	7	6.15	7
Drought	2.32	2	2.60	1	2.46	2
Flood	3.24	3	5.40	5	4.32	4

Source: Field survey (2010). WM=Weighted Mean

In terms of frequency, changes in rainfall amount ranked first and followed by drought and rainfall variability on timing by the respondents of the study area, while ratings by kebele indicated that changes in rainfall amount and drought were ranked 1st respectively in Dorogibr and Gubarjja(Table 8).

4.8 Impacts of CC & V on Different Sectors

According to informants and group discussants, climate change has had negative consequences on forest biomass production and density, ecological balance, productive

capacity of agricultural land, spread of human and animal diseases, drought, flooding, poverty, famine, migration, and supply of water, grazing land, food security, etc.

4.8.1 Impact of Climate Change on Agriculture and Crop Production

In the study area, since agriculture is totally dependent on rain fed practices, it is the most impacted system by climate change and variability. In this regard, the general consensus of informants and discussants was that changes in temperature and precipitation will result in changes in land and water regimes that will subsequently affect agricultural productivity.

Though there is micro-irrigation scheme in one of the study villages (Dorogibr), the lion share of the food grains is produced in rain fed agriculture. On the other hand, discussants reflected that the amount of water that will be available for irrigation will be significantly reduced during dry/small amount of rain and hence, will affecting the production capacity of irrigated fields. Furthermore, it was mentioned that, previously when rainfall was less variable, farmers used to grow different types of crops. But these days as the result of unreliable rainfall, farmers of the study area are growing largely and more frequently sorghum (which is relatively resistant to moisture stress).

Shrinking of rainy season, low rainfall of the small rainy season and late onset of the main rainy season is affecting agricultural product and cropping system. During drought and delayed onset of rain, land becomes dry and difficult to plough. There will be shortage, which in turn, leads to weakness of oxen, i.e. the drought power, and will affect the agricultural activities. Lack or insufficient amount of precipitation hinders seed cultivation and germination of cultivated seeds. Moreover, it created confusion on the planting time and crop types to be planted at the time whenever the rain starts. The discussants mentioned that a week delay in the onset of rain could result in significant differences on the t yield of crops and hence serious impact on household's food security. When the expected and common rainy days stay dry farmers forced to wait for the next days and weeks at the expense of the best and common planting/sowing times.

From interviews with agricultural experts and key informant farmers, it was noted that in the study area there is slight changes in agricultural system due to the current climatic situation. It was reported that the farm lands which were not suitable for teff production due to excess

water and soil nitrogen content (which make the teff to have much leaves and laying on the ground before maturity), have now become suitable for teff due to reduced amount of rainfall. Regarding some changes in the crop types in the study area, farmers strongly stated that the production of *degalet*[4] is decreasing from year to year. Now they consider the year on which they produced *degalet* as a blessed year. It was possible to know also that some farmers call this sorghum by saying *"keda-let"* which means breaking "a promise in the early morning/being unfaith full", to express the absence and reduction of its product. Instead of *degalet* other short maturing sorghum verities[5] are becoming common but according to informants, they provide lesser yield and have low market value and also farmers are not comfortable with its consumptions.

Unseasonal rainfall also results in seed drop, crop desiccation delay and harvested crops spoilage and deprives the farmer's livelihood. Farmers reported that they were forced to re sow their seeds because unseasonal rain falls before the seed finishes its germination. Also in the late maturing period of crops (e.g. Teff) unseasonal heavy rainfall resulted in crop damage leading to reduction in yield. On the highland farmers were relating the poor yield of pulses with unseasonal rainfall which creates favorable condition for pests and diseases.

Informants and discussants reported that high surface temperature linked with reduced number of rainy days is causing shortage of soil moisture in cropping seasons which always leads to poor seedling setting and slow growth, hence low productivity of crops. Most of discussants agreed on declining crop yield. They listed a number of reasons for yield reduction among these declining soil fertility, frequent droughts, and low rainfall in cropping seasons.

Respondents were asked to rank the major climate variables according to their impact on agriculture (table 9).

[4] Local name for long maturing sorghum type.it is relatively productive.
[5]Eg. jigurtee, wedhakr, e.tc. Sorghum types with thin stalk and small seeds.

Table 10. CC & V impacts on agriculture, as prioritized by respondents.

	Dorogibr		Gubarjja		Average	
Climatic variables	WM	Rank	WM	Rank	WM	Rank
Pattern of temperature change	5.90	7	5.38	6	5.64	6
Reduced rainfall amount	2.48	2	2.7	2	2.64	2
Rainfall variability on timing	4.39	4	4.3	5	4.34	4
frost occurrances	8.23	9	8.18	8	8.20	9
Moisture deficiency at the time of crop maturity	5.58	6	4.22	4	4.90	5
Snow	7.71	8	8.28	9	7.99	8
Pest and diseases caused by climate change	5.35	5	6.5	7	5.90	7
Drought	1.77	1	2.02	1	1.89	1
Flood	3.71	2	3.4	3	3.55	3

Source: Field survey (2010).

Based on the negative impact on the agricultural activity, drought has been ranked 1st followed by Reduced rainfall amount and flood 2nd and 3rd respectively. Key informants had indicated that drought and rainfall variability on timing are the most impacting climate change variables. Zewdu Gobeze expresses this by saying that "let the temperature increases but the rain being normal, it is not matter for the crops. But if there is no rain in the main seasons, no crops will be harvested".

Respondents ranked cereal crops, cash crops, livestock, vegetables and livestock productivity according to their sensitivity to climate change impacts. Group discussants also indicated that cereal crops are the most impacted by CC & V as they are totally dependent on rainfall.

The survey result from the two villages also showed that climate related factors are the most important constraints to crop production (table 11).

Table 11. Respondent's response on factors that affect crop production in the study area.

Factors affecting crop production	Dorogibr N=50		Gubarjja N=50		Overall N=100	
	Count	%	Count	%	Count	%
Unpredictable rainfall pattern	34	68	27	54	61	61
Low soil fertility	6	12	9	18	15	15
In adequate farm land	4	8	11	22	15	15
Increased pest and disease	5	10	3	6	8	8
High price of farm implements	1	2	0	0	1	1
Total	50	100	50	100	100	100

Source: Field survey (2010).

Majority of respondents (61%) reported that the major factor that affects crop production is unpredictability of rain fall. Low soil fertility, inadequate farm land, pest and diseases and high price of farm implements are also factors influencing crop production in the area.

In Gubalafto the impact of climate related disasters are making many people food insecure from time to time. Different climatic disasters occur alternately every year and affect crop yields. Lack of rain fall, flooding, pest and diseases, snow, and heavy rain fall, etc are the major and frequently occurring disasters. The date summarized in table12 indicates the loss t of production in quintals by these climate related disasters. Low rainfall in cropping season is the major factor that causes failure of harvest followed by pest and diseases.

Table 12. Estimated crop yield loss in Gubalafto Woreda.

	Estimated lost (in quintal) due to the following reasons						
Production year (EC)	Low rainfall	Heavy rainfall	flood	Pests and diseases	Snow	Frost	Total lossl (quintals)
1994/95	-	-	-	-	-	-	54782.33
1995/96	-	-	-	-	--	--	72735.85
1996/97	-	-	-	-	-	-	25266.22
1997/98	23749	-	513	6345.7	-	-	30607.7
1998/99	54716	1048	-	10691	-	-	66455
1999/00	-	10920	2627	15956	1257	11067	27467
2000/01	40355	-	-	272	2178	-	42805

Source: Gubalafto Woreda disaster prevention and early warning office (2010).

4.8.2 Water Scarcity

The residents of the study area believe that the frequently occurring drought and low annual rainfalls had lead to water scarcity. The available soil moisture has decreased due to frequent shortage of rainfall, resulting in low recharging and filling of the available small ponds and springs. Water scarcity is the major threat on the highland. Females travel far off distances to get water from natural springs and ponds, even these spring and ponds can't fulfill the water demand of households and livestock. The available hand dug water sources fail to support the residents. The major months with water scarcity are April, may and June. Mekdes Taddese, development agent in Gubarjja kebeles, explained water scarcity as follow

"The major problem what I have seen since I started living in Gubarjja (2007) is water scarcity. The area has no river or spring that flows throughout the year, the springs which the people are using now will dry up in May and June. To fetch water from another spring which is called Mendek*, females and livestock travel up to 5 kilometer on difficult up and down topography. Since there is no ground water potential, it is difficult to get water even by digging deep''.*

In the case of Dorogibr, though drinking water has increased due to availability of water storage tanks and water pipes, local people said that they were facing longer drought periods resulting in decreased water flow from natural springs and irrigation channels. This was evidenced by reduction of the annual flow of Aleweha River from time to time.

4.8.3 Food Insecurity

The current and future situation of the climate is very likely to affect the livelihood of peoples in the area. The single most important source of livelihood for the local people is agriculture which is entirely dependent on rainfall. CC & V is affecting the agriculture sector as it has been discussed earlier. The reduced growing seasons, unreliable rain fall, late onset of rainy season, recurrent drought and flood are seriously harming the food security status of the households. 56% 18% and 26% of respondents reported that CC & V is affecting their food security by causing recurrent drought, shortening of seasons and unpredictability of rainfall respectively. For the question "what makes people food insecure in this area?" land shortage and unreliable weather were cited as the major reasons.

Group discussants also strongly underlined that the only case that makes the household to fear becoming food insecure in the future is the probability of lack of rainfall and the occurrence of drought. Food security of Farmers, in woiynadega and dega zones of Gubarjja kebele, who were dependent on *belg*-crops (maize and *"bunegn"), their* food security is highly compromised by poor and unreliable *belg* rainfall. In cases when both *Belg* and *Meher* harvests fail, the situation is even worse.

Apparently, climate change or variability has brought new threats to the people of Gubalafto, increasing their risk of food insecurity and affecting their general well being. The recurrent drought is causing low production of cereal crops and shortage of livestock feeds which resulted in loss of livestock. Drought, unusual high temperature, unseasonal and unpredictable rainfall are adding additional stress on the livelihood of the people. The impacts of CC & V on different sectors noted from the group discussion are presented in table 10.

Table 13.Climate change impacts and their consequence on different sectors.

Sectors	Impact	Consequences
Agriculture	Drought	Crop failure, low productivity, food insecurity, livestock loss
	Rainfall variability in amount and timing	Un predictability of rainfall, poor harvest, crop failure before maturity, crop pests and diseases etc.
	Flooding	Reduction of soil fertility on farm land, crop damage,
	Increased temperature	Soil moisture stress, low productivity, fast growth; leading laying before maturity(locally-*megasheb* seen on teff),high temperature in June result in slow growth of sorghum
Water	Prolonged drought	Water scarcity, drying up of streams, rivers, wet land, water hole.
	High temperature	Water loss from irrigation canals through evaporation.
Health	Drought and famine	Malnutrition ▶ migration▶death
	Increased temperature	Spreading of eye disease (in summer)
Forest cover	Drought	Decreasing of forest cover, degradation of grazing lands, etc.
	Flooding	Forest/biodiversity damage
On socioeconomic	Drought	Migration of young male and females to arb countries being discouraged by poor harvests.

Source : Field survey (2010).

4.9 Sources and Indicators of Vulnerability

In this section household vulnerability to CC & V impacts was assessed by studying/surveying the major contributing factors to vulnerability. As vulnerability is not a function of single factor, household head education, health, asset ownership, access to means of getting information and information, access to modern agricultural technologies, credit, and access to infrastructures etc. are major determinants of households vulnerability, capacity to cope with and recover from the adverse impact of climate change. Livelihood vulnerability index is also developed for the two study kebeles.

4.9.1 Education

As it is depicted on the demographic profile of the sampled households, out of the total respondent (HHH) 37% are literate while 63% are illiterate. But out of the literates 46% didn't attend formal education. Illiteracy is higher in Gubarjja (48%) as compared with Dorogibr (26%). As Daniel, (2009), the head of a household is the key decision maker in the family, the more she or he learns the better he or she will be likely to aware of information and faster to adopt adaptation options and technologies. This will give the household a better position to cope with existing effects and hence low household vulnerability. On the contrary the educational level of the respondents was very low and thus it aggravates farmer's vulnerability.

4.9.2 Household Head and Family Health Status

Majority of farmers in Ethiopian and as also in Gubalafto wereda, employ labour intensive methods of food production, any changes in the health status of the household head, will affect food security.

Generally illness, especially chronic has negative impacts on income of households by limiting the numbers of h working days. Chronic illness was reported by 44 % of the total respondents. While village wise, 62 and 26% of respondents in Gubarjja and Dorogibr reported chronic illness. 40% of the total households said that a family member missed work due to illness in the past 2 months. And 23% of respondents themselves reported that they got sick in the past two months. As they are the heads of the households their sickness has greater impact on the agricultural works to be done. This condition will be worse if the head of the household is the only person to do the works and decisions. Regarding this, 48% of respondents said that no one can replace their role in household (table13). This condition will aggravate household vulnerability to the impacts of climate change and food insecurity.

Table 14. Distribution of responses on health status

Description of health status	Dorogibr (%)		Gubarjja (%)	
	Yes	No	yes	No
Is anybody in your family chronically ill (get sick very often)?	62	38	26	74
Has anyone in your family been too sick in the past 2 months and missed work or school?	46	54	34	66
Have you (the HHH) been sick and missed work in the past two month?	32	68	14	86
Is there someone else in your household works instead of you when you get sick	36	64	68	32
Average distance to get clinic(Km)	1.3		3.7	

Source: Field survey (2010).

4.9.3 Water Source and Quality

Water source and access to safe water determines the range of household capacity to resist the impacts of CC & V. The assumption is that if a household or a community has access to safe water and if there are rivers, natural springs, and good ground water potential, the household or the community can cope with short term water scarcity caused by climate variability. A number of countries in sub-Saharan Africa already experience considerable water stress as a result of insufficient and unreliable rainfall, changing rainfall patterns or flooding. The impacts of climate change including predicted increases in extremes are likely to add to this stress, leading to additional pressure on water availability, accessibility, supply and demand (Ludi, 2009).

For 66% of the respondent in Gubarjja, their water source is natural spring and ponds compared with 12% in Dorogibr. The remaining 34% of respondents in Gubarjja reported using hand dug water source. In Dorogibr 87% of respondent reported their water source is tap water from public bono and in their home compound. In Gubarjja 56% and 54% of respondents indicated that the water is not safe and is not available round the year

respectively. But all the respondents in Dorogibr reported that the water is available throughout the year and safe.

4.9.4 Land Holding

Land is the most important asset of rural household on which their food production and food security status depends on. In the *Kolla Woredas* of Gubalafto, Kobo and Habru, land is divided into two categories: *Wojed* land (land close to home) and *Berha* land (land found far from home). Family size and fertility of the land primarily determined the amount of both *Wojed* and *Berha* land received by each household. Beside this, amount of land received by each household varied in each agro-ecological zone according to the availability of land. by the fact that Dorogibr is located in the *lowland (kolla)* agro- ecological zone where the land plots generally are bigger than in the highland dega zone, the average land holding of respondents in this kebele appears to be higher (0.9837 hectare with std 0.305) than Gubarjja which is 0.5714 with Std 0.251 hectare. The land ownership differs significantly between the two kebeles. Though shortage of land was reported as a challenge of household food security in both kebeles, it seems to be serious problem in Gubarjja.

4.9.5 Livestock Ownership

Livestock are the major source of income in rural area where mixed farming is practiced. Particularly the ownership of farm oxen forms the cornerstone of farm economy in the rural households. It determines the household's food security status and the level of vulnerability to climate change impacts. In North Wollo in general and in Gubalafto *Woreda* in particular, shortage of oxen is a problem of subsistence agriculture (Seid, 2002).

An ox-sharing practice is one of the major means of solving ox shortage whereby a household shares his/her oxen with other partner for a particular workday. However, given the rain fed agriculture, erratic and unpredictable rainfall pattern and where the calendar should perfectly match with rainfall regime, ox- sharing practice hinders to cultivate the available land timely thus be one of the cause of low production and household food insecurity**.**

Table 15. Respondent's livestock ownership (/household).

Livestock type	Dorogibr	Gubarjja	Overall	
	Mean	Mean	Mean	T= -4.473*
Cattle	3.16	4.82	4.0	
0xen only	1.40	1.80	1.57	
Goat	1.58	2.46	2.02	
Sheep	-	1.38	0.69	
Donkey	.66	.50	0.58	
Camel	.28	-	0.14	
Mule	-	0.14	0.07	
Average livestock ownership	5.68	9.28	7.48	

Source: Field survey (2010). *not significant

As shown in table 14, average livestock holding of the sampled respondents were 7.48. Respondents in Gubarjja owned greater numbers of livestock (9.28) than respondents in Dorogibr (5.68).

Table 16. Respondent's distribution on ox holding.

	kebele		Total
Oxen holding	Dorogibr	Gubarjja	
0	10	6	16
1	15	10	25
2	20	22	42
3	5	12	17
Total	50	50	100

Source: Field survey (2010).

Table 15 shows respondents oxen holding in the two kebeles. 20% and 12% of sampled households didn't have ox and 30% and 20% of respondents have only one ox in Dorogibr and Gubarjja respectively. Overall in the two kebeles 16 % of the respondents didn't have ox.

4.9.6 Household Access to Non- Farm Sources of Income

Rural household income can be supplemented by income generating activities other than the crop production and animal husbandry. Household's opportunity to access non-farm income sources has an important role in assuring food security and, hence, having a better capacity to cope with shocks and stresses caused by CC & V. But, if the source of income that the

farmers depend on is single, that is agriculture, they will be totally vulnerable for CC & V impacts. According to Adger, (2009), diversification of income sources is an effective means of reducing vulnerability by diffusing risk. In the case of this study only 29 % of respondents indicated that they have participation in non-farm activities. The rest of respondents (71%) have no participation in any non- farm activities (table 16). As it is explained, they entirely depend on farm production; their livelihood is therefore at greater risk when they encounter adverse climatic conditions.

Table 17. Respondents participation in non- farm income sources (multiple answers were possible

None farm activities	Dorogibr			Gubarjja		
	N=18	% of responses	% of households	N=11	% of responses	% of households
Petty trade	11	30.5	22	2	13.3	4
Remittance	7	19.4	14	5	33.3	10
Selling of local alcohol(*tella*)	5	14	10	2	13.3	4
Selling of fire wood and charcoal	9	25	18	6	40	12
Renting out house	2	5.5	4	-	-	
Daily labour	2	5.5	4	-	-	
Total	36	100		15	100	30

Source:-Field survey (2010).

4.9.7 Access to Information and Means of Information

Given the unreliable rainfall pattern and amount, climate information is a decisive for farmer's decision making process on what and when to plant. Traditionally farmers adjust to variability in rain fall pattern by replanting their land. But, they may not be doing this at the right time or with the right crop but if they get appropriate and timely information they can be much effective. So access to information is one way to reduce vulnerability to CC & V impacts.

Better climate information is potentially cost-effective way of adapting to climate change. Evidence from Mali indicate that an agro meteorological support program initiated in 1982 in response to the Sahelian drought, timely weather information and technical advice helped farmers better to manage climate risks and reduce the economic impact of droughts.

Out of the total respondents 86% reported that they do not receive any information. Furthermore, majority of the respondents 58% and 74% in Dorogibr and Gubarjja respectively reported that they have no access to any means of getting information. In Gubarjja, 26% of respondents have access radio. While 28%, 10% and 3 % of respondents in Dorogibr have access to radio, mobile telephone and both radio and TV respectively.

Some communities have traditional weather prediction methods. Daniel, (2009), reported that communities in central rift valley area of Ethiopia use voice of birds, dropping of leaves from trees and behavior of children to predict the situation of future weather and other social cases. Though such predictions are not authenticated o by scientific studies, they have value and implications to warn the communities. In this study, except the reports of discussants that there are some elders predict the future situation, no respondent reported having traditional weather prediction methods. We can conclude from the survey result that the people of Dorogibr and Gubarjja are not getting climate related information from local administrators and also they have low access to means of information like TV, radio, magazine, etc.

4.9.8 Social Networks and Access to Credit

The severity of the existed risks or impacts of CC & V can be minimized by extending supports among the community through loans, gifts, and other social self helping programs. Community bonds and high levels of trust among households are important for decreasing vulnerability to climate change impacts.

Out of the total respondents, 37% reported to have received helps or gifts from their relatives or friends in the past two month. Regarding lending money to friend 26 % of respondents reported that they have loaned money to relatives, friends and other peoples in the past two months. Dorogibr shows greater number of respondent that received gift and helped and lend money. Data from key informants and informal diagnosis showed that the families who have relative abroad or somewhere far from the family have good access to assistance. In Dorogibr the households with relatives in Middle East countries (Dubai, Saudi Arabia) have a better opportunity to receive assistance. Group discussants reported that this assistance and family help has significant importance to support the household when food

shortage and risks are occurred. But on the high land (Gubarjja) the peoples have not experience of working in abroad. High proportion of Christian population, limited access to information road and other social infrastructures have constrained the mobility of the people.

Access to credit is an important means of adjusting income deficit in times of low harvest and drought. In Gubalafto Woreda the credit system plays pivotal role for the purchase of oxen and seed. The sources of credits are ACSI, cooperatives and other NGOs .ACSI is the main credit provider for farmers in the study area. Key informants reported that all social classes, the poor, the rich, and the medium classes have engagements in loan. In the study area, regarding the availability of accessible credit from different loan institutions, 87 % of respondents' accesses credit. Availability of affordable and accessible credit enables farmers to do sensible adaptation and be getting ready for the impacts of CC & V.

4.9.9 Access to Modern Agricultural Inputs

Despite the affordability of modern agricultural inputs like fertilizer, improved seeds and pesticides, 94% of respondents reported that they have access to these inputs. According to the interviewee most of the farmers in the study area frequently use pesticides. But the use of fertilizers is at a very low level; especially for Gubarjja it can be concluded that fertilizer is not used. In Dorogibr some farmers use fertilizer and improved seeds of maize for the land under irrigation. Generally, using fertilizer for the crops, sorghum and teff are not common. The result indicates that the local people are not getting benefit from the use of fertilizer.

4.10 Livelihood Vulnerability Assessment (LVA)

One of the objectives of this study is assessing the vulnerability of farmers to climate change (CC) and variability (V) shocks. Identifying the major sources of vulnerability in the community is one step to give response and plan for the future to reducing the potential impacts of CC & V.

Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine interactions between humans and their physical and social surroundings (Hahn,

MB., et al., 2009).In this study, Hahn's (2009) livelihood vulnerability index (LVI) approach has been used.

The LVI includes four major components: Socio-Demographic Profile, Livelihood Strategies and food, Health, and Water. Each is comprised of several indicators or sub-components. Each component was obtained from primary data collected by household survey.

The LVI uses a balanced weighted average, where each sub-component contributes equally to the overall index even though each major component is comprised of a different number of sub-components. The measurement of each sub component may be different and for this reason it is necessary to standardize each value. The formula used to standardize the values is adopted from HDR (Human Development Report).

$$\boldsymbol{INDEXsk} = \frac{\boldsymbol{S_k - S_{min}}}{\boldsymbol{S_{max} - S_{min}}} \text{----------} 1$$

Where sk, represent observed value of the sub component in kebele k, and Smin and Smax are the minimum and maximum values, respectively, for each sub-component determined using the observed minimum and maximum values from both kebeles. For example for the question how far the clinic from your home, the minimum value was 200m in Dorogibr and 4 km in Gubarjja. For sub components which are expressed in percentage the minimum value and the maximum values were set as 0 and 100 respectively. Once the individual subcomponent is indexed, the vulnerability index for major component $\boldsymbol{M_k}$ in kebele, k can be calculated as follow:

$$\boldsymbol{M_k} = \frac{\sum_{i=1}^{n} \boldsymbol{INDEXski}}{\boldsymbol{n}} \text{----------} 2$$

where Mk = one of the four major components for kebele k [Socio-Demographic Profile (SDP), Livelihood Strategies and food (LSF), Health (H), Water (W), and INDEX ski represents the sub-components, indexed by i, that make up each major component, and n is the number of sub-components in each major component.

Once values for each of the four major components for a kebeles were calculated, they were averaged using Eq. 3) to obtain the kebele LVI:

$$LVIk = \frac{\sum_{i=1}^{4} w_M M_{ki}}{\sum_{i=1}^{4} w_{Mi}} \text{ Or } \frac{w_{SDP} SDP_K + w_{LSF} LSF_K + w_w W_K + w_H H_K}{w_{SDP} + w_{LSF} + w_W + w_H} \text{----------3}$$

Where LVIk, is the Livelihood Vulnerability Index for kebele k, equals the weighted average of the four major components stands for weight and ^{W}Mi stands for weight of major component indexed by i. The weights of each major component w_{Mi} , are determined by the number of sub-components that make up each major component.

4.10.1 LVI of Gubarjja and Dorogibr

Table 18 presents the major and subcomponents of vulnerability which were used to assess the vulnerability of the two study kebeles. The values of the indices of each major and sub component for the study kebeles is presented in the table

Table 18 Vulnerability indices for major and Sub Components of Vulnerability

Major components	Sub-components	Indexed sub components		Index for major components	
		Dorogibr	Gubarjja	Dorogibr	Gubarjja
Socio demo-graphic	percent of illiterate household heads	0.26	0.48	0.39	0.32
	Percent of female headed households	0.26	o.16		
	Percent of household heads reported there is no other member of the household who works instead of them.	0.64	0.32		
Health	Percent of households reported chronic illness	0.62	0.26	0.45	0.31
	Percent of households reported temporal illness in the past 2 months	0.46	0.34		
	Average distance to clinic	0.28	0.34		
Water	Percent of respondents reported they depend on ponds and springs for water source	0.13	0.66	0.06	0.6
	Percent of respondents reported that the water is not available the whole year.	0	0.54		
Food and livelihood	Average number of month households can't cover by their farm production.	0.25	0.68	0.29	0.64
	Percent of households reported that they have no non-farm source of income	0.64	0.78		
	Percent of respondents reported they have no access to irrigation	0.07	1		
	Percent of respondents reported that they have no farm oxen	0.2	0.12		

Vulnerability index score of education was higher in Gubarjja (0.48) than what it was in Dorogibr (0.26).however the number of female headed respondents was higher in Dorogibr (26%) than in Gubarjja (16) and the indexes were 0.26 and 0.16 in Dorogibr and Gubarjja respectively. dependency ratio was found to be small in the two kebeles. overall Dorogibr (0.4) showed greater vulnerability to climate change and variability and food insecurity on socio demographic aspect than Gubarjja (0.32).

On food and livelihood components Gubarjja was found to be more vulnerable (0.64) compared with Dorogibr (0.29). In both kebeles, the participation of respondents on non-farm activities was very limited. The indices were 0.64 and 0.78 for Dorogibr and Gubarjja respectively. The average numbers of months the households can't get food from their own production were 1.7 and 5.15 in Dorogibr and Gubarjja respectively. The indexed values were also 0.25 and 0.68. Beside these, under the food and livelihood component the indexed values for the respondents who reported no irrigation access and who had no oxen were 0.07and 1.0 and 0.2 and 0.12 for Dorogibr and Gubarjja respectively.

Water problem in Gubarjja was found to be very serious and thus increase the potential consequence of climate change and variability. Despite the absence of clinic in the village, the reported health status in Gubarjja was better than Dorogibr. Generally, Gubarjja kebele showed greater vulnerability on food and livelihood components and water where as Dorogibr is more vulnerable on health and socio demographic components. However, the general LVI indicated that Gubarjja is more vulnerable to climate change and variability impacts (0.47) than Dorogibr (0.29).

4.11 Sensitivity of Respondents to Climate Related Shocks.

All households are not equally sensitive and vulnerable to the climate related shocks. The above explained components of vulnerability are the major determinants of household's sensitivity to climate hazards. The effects of climatic variability are felt according to household's wealth status. The main determinants of wealth reported by the interviewee and focus group discussants are the number of livestock owned or oxen and the amount of land owned. The size of irrigated land, availability of daughters or other close relatives working in Arab countries were also reported in Dorogibr as a criteria to be better off household. But

differences in wealth groups arise primarily from the ownership of oxen. Oxen ownership determines the amount of land the household can cultivate. The very poor have no oxen, and the poor have on average 1.The middle and better-off have between 1 and 3 oxen, and between 3 and 4 oxen respectively, and have the capacity to cultivate more land than what they own.

Respondents have reported their sensitivity level by referring to highly sensitive, moderately sensitive, and low sensitive. According to this 38% and 54%, 40% and 34% and 22% and 12% reported highly sensitive, moderately sensitive, and low sensitive in Dorogibr and Gubarjja respectively. From overall, 46, 37 and 17% of respondent were highly sensitive, moderately sensitive, and low sensitive to climate induced shocks.

4.12 Coping Strategies as Reported by Respondents

Coping strategies are immediate adjustment or actual responses to the existing risks due to climate variability. Table 19 shows the reported coping strategies by respondents from the two kebeles. Out of the total respondents, 80% of them cope by food aid. While 22%, 21%, 20% of respondent cope by borrowing, selling of fire wood and charcoal and by selling of livestock respectively.

In addition to the coping strategies reported by the formal survey, planting using irrigation, Migration to Arab countries, selling of grass and burning charcoal and cutting trees for sale were reported by the informants and group discussants. Female discussants were indicated petty trade, engaging in selling of local alcohol *(Tella)* and consumption adjustment as coping mechanism.

Coping strategies like selling of fire wood and charcoal have negative effect on the environment and further aggravate the negative impacts of climate change. Out of the total 21% of respondent reported selling of firewood and charcoal as coping strategy

Table 19. Coping strategies of respondents (multiple answers were possible).

Coping strategies	Dorogibr N=50		Gubarjja N=50		Overall
	responses	% of respondents	responses	% of respondents	%
Aid	37	74	43	86	80
Selling of fire wood	12	24	9	18	21
Selling of livestock	7	14	13	26	20
Engaging in daily labour	8	16	2	4	10
Migration	NC	NC	3	6	3
Using stored grains	8	16	5	10	13
remittance	11	22	4	8	15
Borrowing	9	18	13	26	22
Total	92	141	92	184	184

Source: Field survey (2010). NC: not considered as coping strategy

4.13 Adaptation Strategies

The knowledge and practices that rural farmers, indigenous and other vulnerable communities have accumulated to cope with past environmental unpredictability are a powerful resource for confronting global climate change. They serve as a springboard for community-level adaptation, bring recognition to local resilience and bolster community self-confidence.

The people in the study area are using different strategies to adapt the existing climate variability and change. Some of them are spontaneous which farmers gain through experience while dealing with climate variability and gradual change and some are adopted. As the report of focus group discussant several of adaptation strategies (use of improved seeds and new varieties, applying fertilizer) are used by few farmers due to financial constraints, awareness, and position of the head of the household in the community.

Table 20. Respondent's distribution on adaptation strategies.

Adaptation strategies	Dorogibr		Gubarjja		overall Average
	N	%	N	%	%
Using improved seeds	11	22	7	14	18
Fertilizer	7	14	3	6	10
Growing new varieties	5	10	-	-	5
Drought resistant crops	6	12	11	22	17
Switching to short maturing crop	11	22	17	34	28
No adaptation mechanism	10	20	12	24	22

Source: Field survey (2010).

28% 18% and 17% of respondent indicated that they were adapting the ongoing climate variability and change by switching to short maturing crops, using improved seeds and drought resistance crops respectively. However, still a large number of respondents (22%) are not doing any adaptation mechanism (table 20). Important climate change/ variability adaptation methods such as manure, new crop varieties and agro-forestry were reportedly not being practiced. The study has established that the existing adaptations are not enough to adapt the contemporary impacts of climate change and variability. There should be intervention in developing effective and feasible strategies. Mixed farming, water and soil

conservation, giving mach emphasis for irrigation production, tree planting on hills and mountains, etc were reported from discussion.

Mixed coping

Mixed cropping is commonly practiced in both kebeles. It is growing of two or more crops in proximity in the same field. Farmers have a good experience of mixing of crops in the field (teff, early maturing sorghum), (maize and *zengada*) (sorghum and seasam) and (cereal and legumes plants) are grown together. Pea and bean are always planted between and around the other crops. From discussions with farmers, it was noted that they have wide field knowledge on advantages of mixing crops with varying attributes in terms of maturity period, drought tolerance (maize and sorghum), and end use of the product (e.g. sorghum as food and seasam for cash).

Soil and water conservation methods

From field observation and discussion with local agricultural experts, it was noted that farmers are adopting and using water and soil conservation methods, like making cannel to collect and use surface run off making counter ridges to improve infiltration of water and efficiently using the soil moisture. , Adaptation to impacts of CC & V in farming systems requires are silence against both excess of water (due to high intensity of rainfall) and lack of water (due to extended drought periods).the key mechanism in response to the both problems is also to improve the soil organic matter by applying different soil fertility improvement methods (Majule, 2009). The study revealed that only few farmers apply manure and fertilizer on cereal crops.

Producing using irrigation

Interviewee from Dorogibr noted that because it becomes uncertain about the rainfall amount and onset, they give much emphasis on the irrigation and begin preparation of the cannels just immediately after the crops harvested. They produce maize between march and may, this provide food in the food scars seasons.

Chapter Five

Conclusion and recommendation

5.1 conclusion

This study is an attempt to establish the trend of climate change and variability and assess the impact of climate change on food security activities and farmer's adaptation strategies in Gubalafto Woreda.

Crop production and livestock rearing, being highly dependent on climate, are the major livelihood sources in the study area. Yields are very low and many households are unable to meet their yearly food requirement from their own production. Food aid is playing an important role in filling food shortage. The production of cash crops is under developed in the study area.

Perception of respondents indicated that temperature and rainfall are increasing and decreasing respectively and the onset of the rainfall has changed over the past decades. The rain starts fades away in July and ends up in late August. The climate data analysis shows the same as perceived by the local peoples. The trend of temperature and rainfall is increasing and decreasing respectively and the rainy seasons are shrinking. Change in Rainfall amount, drought and rainfall variability on timing were reported as frequently occurring climate change variables.

Increased temperature, the changing onset of rainfall and the cyclic extreme weather conditions (drought, flood) have affected agriculture and crop production and thereby having negative effect on food security of the peoples. The reduced growing seasons, unreliable rain fall, late onset of rainy season, recurrent drought and flood are seriously harming the food security status of the households. Respondents reported that CC & V is affecting their food security by causing recurrent drought, shortening of seasons and unpredictability of rainfall. The survey result showed that the major factor that affects crop production was unreliable rainfall pattern.

In assessing sources of farmer's vulnerability, poor access to climate information, minimum fertilizer application, limited non-farm sources of incomes, household's low educational

level and temporal and chronic illness were identified as major sources vulnerability of farmers to climate change. The vulnerability indices indicated that Gubarjja is relatively vulnerable than Dorogibr. Household sensitivity is different among the different wealth groups and 46, 37 and 17% of respondent were highly sensitive, moderately sensitive, and low sensitive to climate induced shocks.

Food aid, selling of fire wood and charcoal, engaging in daily labour and selling of local alcohols are used as immediate adjustment in case of food insecurity which resulted from deteriorated climate system(frequent drought, unreliable rainfall, flood). The current adaptation methods are using short maturing crop varieties, growing drought resistance crops, mixed farming, and soil and water conservation methods, giving more emphasis for and enhancing production by irrigation. However it has been understood that many of the existing strategies were used by few farmers. A considerable number of respondents were not doing any adjustment to adapt the ongoing change in the climate. Moreover the existing strategies are not sufficient to adapt the existing impacts of climate variability. If they continue with these available strategies, climate change will have a serious impact on their agricultural practice and food security.

5.2 Recommendation

Based on the findings of the study the following points are recommended.

- ✓ Developing effective early warning system: with ever increasing weather unreliability and unpredictability, effective delivery of climate information and service is crucial. There should be a mechanism through which farmers are informed about the coming weather problems and what they can do to minimize the effect. The early warning system should be integrated with the extension system so that farmers can get proper and timely agro-climatic information and advices.
- ✓ In the finding it has been established that the rainy seasons are shrinking, this requires adoption of short maturing crop varieties which can escape early season droughts and be able to mature earlier than those of the existing varieties. Since drought is the most frequently occurring climate factor that puts the livelihood of

farmers at precarious situation, introduction of drought resistance crop varieties should get emphasis.

- ✓ Diversification of economic activities can help minimize the risks of climatic disasters. Diversification of agricultural product and moving to more modern and high value crops is an important way of reducing vulnerability of climate dependent rain fed agriculture that have to be suggested for farmers. Specific to the study area, agricultural experts and concerned bodies must do heart full effort to create awareness and give skill for management of cash crops. Intervention should be done in the creation of non-farm activities. Effort should be put on enhancing the benefit of migration by reducing the possible risks.
- ✓ Developing small scale irrigation schemes, improving the capacity of existing schemes, generating more water for irrigation and advising farmers how to plant and what to plant on the irrigated plots will have an important role in minimize the risk of climate change and variability by reducing dependence of agriculture on rainfall..
- ✓ Improving the existing water sources and developing more sustainable water sources. Conserving water by construction of ponds to collect surface runoff which could be used for watering animals and vegetables, especially on the highland this will be more practical where water sources in the mountains can be utilized through gravitational water flow systems. Rain water harvesting so as to use in drought seasons
- ✓ Helping farmers improving their saving habit and creating a range of credit institution and self helping mechanisms.
- ✓ Financing of the rural area by developing suitable financial systems that will allow rural farmers to have access to affordable credit which will play a role in promoting adaptation.
- ✓ Improving access to external inputs such as improved seeds, fertilizer and tools. Using effective level of fertilizer input under increasing land scarcity, improving the efficiency of inorganic fertilizer and promoting sustainable cropping practices is crucial to reduce the impacts of climate change and variability.
    - ✓ Generally to reduce the level of communities' vulnerability, constructing basic infrastructures like road, clinic and school as well as empowering communities

with information, technological skills, education and employment is the best way the government has to focus on. Promotion of development programs and addressing vulnerable groups through development of better proxy indicators of societal vulnerability, addressing them from short and long term perspectives.

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Appendix1

Questionnaire for household survey

The objective of this questionnaire is to collect information which will be used for the study on the impacts of climate variability and changes on food security and farmers adaptation strategies in Gubalafto wereda. This study is going to be conducted for the partial fulfillment of MA degree in Geography and Environmental Studies at Addis Ababa University. Your full support and willingness' to respond to the question is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give clear, appropriate and reliable information on the issues. Be sure that the information you provide is only for the purpose of this study.

Personnel and Household Data

Sex of the respondent (HH head): Female ☐ Male ☐

Age of the respondent: _____ kebeles: Dorogibr _____Gubarjja _____

Family size including the HHH:

Male ---------- Female ---------- Total ----------

Size of the Family, Under 15 years old _____, 16 to 64 years_____, 65+ Years _____

Educational level:

No		Male	Female	Total
	Illiterate			
	Write and read (non-formal education)			
	1-6			
	7-8			
	9-12			
	College deploma			

Marital status (HH):

Single ☐ married ☐

Widowed ☐ separated ☐

Food security and livelihood assessment

1. What are your sources of livelihoods?

   a. Farming
   b. Petty trading
   c. Both livestock and farming
   d. Wage laborer
   e. remittance
   f. Livestock
   g. Selling of fire wood and charcoal
   h. Others_____?

2. Among the above listed which one is your primary livelihood activity?_____

3. What kind of farming do you practice?

   a) Crop farming
   b) Mixed farming
   c) Agro forestry

4. What kind of agriculture are you practicing?

   a) Rain fed agriculture
   b) Irrigated agriculture
   c. Both rainfed and irrigated agriculture
   d. Other_____?

5. In **2002**, what are the major crops grown by your household? Put the answer in the table as required.

Cereal crop	Acreage (tmadi)	Yield (quintal)	Cash crops	Acreage (tmadi)	Yield (quintal)
Maize			Sugar cane		
Teff			Onion		

Sorghum			Garlic		
pea			Potato		
bean			Vegetables		
barley			Chat		
wheat			Banana		
others					

6. Rank the following cereal crops as per their importance for food security (rank 1 the most important and last rank for least important)

Type	Rank
Maize	
Teff	
Sorghum	
pea	
bean	
barley	
wheat	
others	

7. Rank the following cash crop as per their importance for food security, saving and investment, high agricultural productivity (rank 1 the most important and last rank for least important)

Type	food security	saving and investment	high agricultural productivity
Sugar cane			
Onion			
Garlic			
Potato			
Vegetables			
Chat			
Banana			

8. What is the amount of your agricultural product in relation to your domestic requirement?

A) Every year excess of the requirement

B) Sufficient for the whole year but no excess beyond the requirement

C) Covers only 9 -11 months of requirement

D) Covers 6-9 months of requirement

E) Covers only 3-6 months of requirement

9. If your answer is C, D or E for question No 8, from where you fill your additional food requirement?

A. Borrowing D. Selling of assets

B. from government food aid E. receiving remittance

C. Engaging in daily laborer F. Other sources_____?

10. Are you safety net user? Yes NO

12. What is the major source of water for domestic use?

1. Tap water 3. ponds

2. Natural spring water 4. Others _____?

13. Do you think the water is safe? YES☐ NO☐

14 Does the water available throughout the year? ☐ ☐

If your answer is no, name the probable cause of along with seasons

_____ _____ _____

_____

Farmer's perception on climate variability and change

15. How do you describe the pattern of current temperature compared to the temperature pattern that was before 10- 25 year ago?

a) Increasing significantly

b) Increasing

c) Neither of the two (no change)

d) Decreasing

e) Decreasing significantly

16. How do you describe the current amount of rain fall compared to the rainfall amount that was before 10- 25 year ago?

a. Increasing significantly
b. Neither increasing nor decreasing
c) Increasing
d. Decreasing
e. Decreasing significantly

17. Do you feel that the timing of rain fall is a problem?

a) Yeas, it onsets late and ends up late

b) Yeas, it onsets early and ends up early

c) No there is no problem on timing of rainfall but on its amount

d) Yes it onsets on time but ends up early

e) Yes, it onsets late and ends up early

18. If for questions 15 to 17 your response is there is temperature and climate change, rank the following climate variables as per their negative impact on agricultural products (rank 1 the most impacting one and last rank the least impacting)

No.	Climatic variable	Rank
1	Pattern of temperature change	
2	Chang in rainfall amount	
3	Rainfall variability on timing	
4	Frost occurring	
5	Moisture deficiency at the time of crop maturity	

6	Snow	
7	Pests and diseases caused by climate change	
8	Drought	
9	Flood	

19. If for questions 15 to 17 your response is there is temperature and climate change, rank the following climate variables as per their frequency of occurrence (rank 1 the most frequently occurring one and last rank the least frequently occurring one)

No.	Climatic variable	Rank
1	Pattern of temperature change	
2	Chang in rainfall amount	
3	Rainfall variability on timing	
4	Frost occurring	
5	Moisture deficiency at the time of crop maturity	
6	Snow	
7	Pests and diseases caused by climate change	
8	Drought	
9	Flood	

20. If for questions 15 to 17 your response is that there is temperature and climate change, rank the following agricultural activity as per their vulnerability to climate variability (rank 1 the most vulnerable one and last rank the for least vulnerable one)

No	Product type/ farming	Rank
1	Cereal crops	
2	Cash crops	
3	Vegetables	
4	Livestock	
5	Livestock productivity and products	

21. The causes of climate change are induced by human activities. Express your agreement or disagreement of this statement by supporting one of the following options.

a. Strongly agree c. Neither agree nor disagree

Agree d. Disagree e) strongly disagree

22. Can you remember that had there been years of climatic extreme events like drought and flood since 1977? ☐ Yes ☐ no

22.1. If your answer is yes, how many times the event occurred? if you can remember please least the years of such phenomena?

_____ _____ _____

23. Did the extreme events were disastrous? Y☐ ☐)

23.1. If your answer is yes in the above question how was the degree of the effects of these events on the following items? Explain the degree by indicating low, medium, and high

Climatic extreme events	Impact on life	On crop	On farm land	On water	Forest cover
Flood					
Drought					
Others					

24. In the last five year, had your family affected in the above fact☐ YE☐ NO

25. What are the major factors affecting crop production in this area?

1. Unpredictable rain fall
2. Increased pest and disease
3. Low soil fertility
4. Lack of farm implements (fertilizer, improver seeds, pesticides etc)
5. High price of farm implements
6. Shortage of laboure

Inadequate farm land

26. How climate change and variability affects your food security status?

1. By causing drought
2. Flood
3. Shortening of seasons
4. Unpredictability of rain fall
5. Others?

27. Have you ever cultivated during the Belg season? 1) Yes 2) No

If yes to Q.10 what was the total amount you produced

Cereals	Amount Produced
Teff	
Sorghum	
Maize	
Others	

28. Which crop you often produce in the belg season?_____

3. Vulnerability assessment

29. Is there any school in your village? ☐ES☐ NO

30. Do you have children who didn't attend school? Y☐ ☐

30.1. If your answer is yes to the question No30, what is the reason?

1. Below school age
2. They follow a cattle
3. Work on the farm land or at home
4. No school
5. Others ____?

31. Is there health institution in your area (village)? ☐ES NO☐

32. How long far is the clinic from your home?_____

33. Is anybody in your family chronically ill (get sick very often)?

34. Has anyone in your family been so sick in the past 2 months that they had to miss work or school?

35. Have you (the head of the household) been sick and stay on bed so that miss work in the past two months? YES ☐ ☐

36. Is there someone else in your household works with you or instead of you when you get sick? YES ☐ NO ☐

37. Do you receive any warning about weather issues from the local government offices? ☐ YES ☐ No

38. Do you have any traditional weather prediction methods ☐ YES ☐ NO

38.1. If your answer is yes, what are the traditional indicators that there will be

A. much rain_____

B. prolonged drought_____

C. pest invasion_____

D. others_____?

41. To which one of the following you have access?

A. Telephone C. TV

B. Radio D. No access for all

42. Do you have access to modern agricultural inputs? ☐ YES ☐ NO

42.1 If your answer is yes for question No 42, to which your access is? Multiple answers are possible.

Fertilizer

A. Improved seeds

B. pesticides

C. new agricultural practices

43. What kind of livestock do you have? Fill the answer it table below

Livestock	**Number**	**Use**
Cattle		
Ox		
Sheep		
Goats		
Poultry		
Mule		
Horse		
Donkeys		
Camel		

44. Do you Owen land to be ploughed? YES NO

44.1 If yes, how much is the land holding size of the family? _____

45. Do you have access to cultivate land that is not your own? YES NO

44.1. If your answer is yes in the above question, how did you get it?

A. Crop sharing

B. Land renting

C. Gift from families

D. Gift from parent in law*(amach)*

E. Other_____?

46. Do you have access to irrigation? YES ☐ NO ☐

47. Do you have none-farm source of income? YES NO

47. 1. If your answer is yes in the above question, please indicate your source in the following table by putting **X** mark.

Non farm incomes	
Remittance	
Petty trading	
renting Out house	
Selling fire wood and charcoal	
daily laborer	
Selling of local alcohol drinks(Tella)	
Others	

48. In the past month, did relatives or friends help you and your family? ☐es ☐ no

48.1. If your answer is yes, please specify the type of help

A. Grains B. clothes

C. Live stocks D. Livestock products(milk, butter,etc)

E. Send you remittance

F. Others _____?

49. Have you ever lent money to your relatives or friends?

49.1 If your answer is yes, in what condition was it?

1. With interest (*arata*) 2. Without interest (*arata)*

50. Do you have access to credit from micro finances, traditional saving institutes, etc?

YES ☐ NO ☐

51. What factors do you think are making you more vulnerable to climate change and variability impacts? Multiple answers are possible.

Unreliable rainfall patterns

1. Low level of education
2. Poor infrastructure (roads, schools, clinics)
3. Limited access to credit
4. Shortage of land
5. Limited access to new improved seeds
6. Limited access to crop/ livestock treatments
7. others_____?

4. Coping and adaptation strategies

52. How was you managed to cope with the adverse effects of rain fall failure? Multiple answers are possible.

1. Food aid
2. Sale of livestock
3. selling of fire wood and charcoal
4. Alternative livelihoods e.g. engaging in daily labor
5. using stored grains
6. Migration
7. Borrowing
8. Remittance
9. Others----------

52. In the agricultural activities, what are your adaptation strategies to the existing climate change and variability?

1. Using improved seeds
2. Using fertilizer
3. Changing sowing and harvesting times
4. Growing drought resistance crop varities
5. Switching to short maturing crops
6. Growing new crops

54. What interventions can be promoted by the development actors/ community people to minimize effects of climate change? _____

55. What is your recommendation to government/ development agencies/ NGOs, for mitigating the impacts/ effects of climate change?

_____ _____

Appendix 2

Check lists for Focus group discussion

Farmer's perception on climate change and variability

- Do you know what climate variability means? Is the pattern of weather is changing? How do you explain the change? What would be the cause?
- In the past 25-30 years how would you describe the rainfall pattern in terms of -

  i. Rainfall on-set and Cessation

  ii. Rainfall amount

  iii. Rainfall seasonal distribution.

  iv. Temperature
- Do you have any event that you remember causing life and property damage?
- What are the manifestation of climate change and variability? Are flood, drought, heat wave, and *wurch* frequently occurring? Has it impact on agricultural practice? Could you tell us the major impacts that you perceived?
- What are the major effects that the climate variability and change has caused? indicate in the area of

  1. Water resource
  2. Agriculture
  3. Forest cover
  4. Social aspects(conflict, migration, etc)
  5. Other

  What are the local adaptation strategies by which the community uses to cope with the changes? _____

Agricultural practice, crop yield and cropping calendar

- How do you explain the agricultural potential, crop productivity, soil fertility, and total crop yield in this area?
- What are the major limiting factors of crop production? Is there any crop type the farmers switched off or less frequently used than before (20-30years ago)? What is the reason for this?
- If you agree there is crop yield reduction what will be the possible cause?
- What are the old ageds, much known, cropping calendars (seasons) in this area? Is there a change in the cropping calendar (sowing and harvesting time) compared to the past 25-30 years?
    - What methods the farmers use to cope with the existing changes of cropping calendar?

Food security issues

- What are the major sectors on which you the local people relied on? Explain the resource availability in this area (agricultural land, water, grazing land etc).
- What are the major activities undertaken by households to generate income other than agriculture?
- How would you explain food security? In this area, what are the major criteria to say a household is food secured? What are the major determinants of food security? Do you think that the people in this area are all food secured? What makes people food insecure in this area?
- Who is rich and who is poor? What are the criteria for categorization of households in to rich, middle, poor and very poor applied by the local community?

How do you explain the relationship between food security status and climate change and variability? What threatens people in this area not to be food secured in the future?

Appendix 3

Rainfall and temperature data

Monthly rainfall at Sirinka station

years	Juan	Feb	mar	April	May	Jun	July	august	sep	Oct	Dec	Nov
1992	84.10	65.20	52.80	26.80	47.20	7.50	189.40	281.80	48.80	48.80	47.90	62.00
1993	29.40	87.00	34.20	145.40	64.00	.00	152.20	134.20	137.90	93.30	.00	11.40
1994	.00	.00	74.60	52.20	37.90	55.50	299.50	413.00	115.00	1.70	44.40	5.80
1995	.00	125.80	62.00	271.20	32.10	44.30	280.30	275.00	69.90	24.60	.00	97.10
1996	78.60	.00	157.70	115.90	199.00	52.10	113.00	329.20	60.00	37.10	51.50	16.30
1997	32.20	3.80	219.90	85.60	71.50	150.80	234.60	157.30	132.70	229.80	.00	104.00
1998	114.00	172.00	110.00	57.20	35.90	.00	311.50	334.40	66.50	57.00	.00	.00
1999	32.50	3.80	215.50	84.40	71.50	99.20	229.80	203.60	104.30	379.60	104.00	.00
2000	.00	.00	8.40	66.80	33.90	34.40	346.40	338.50	100.40	130.80	49.70	25.20
2001	6.90	21.70	238.60	10.40	19.80	32.80	351.30	205.90	91.60	26.30	5.00	5.40
2002	87.10	6.20	47.00	71.60	.60	7.90	219.50	295.30	132.00	17.70	.00	104.90
2003	64.90	60.40	68.20	115.50	4.90	36.90	168.90	256.40	202.30	.00	10.80	48.30
2004	.00	11.00	37.10	114.80	2.70	26.20	167.40	214.80	66.70	57.70	63.90	7.90
2005	25.60	7.80	99.00	103.80	101.50	26.70	284.40	283.90	55.60	36.30	71.10	.00
2006	1.60	36.20	145.20	245.10	40.40	8.30	157.00	283.80	117.80	38.60	2.60	26.20
2007	34.80	73.30	44.70	108.10	35.10	33.80	348.70	245.80	86.90	48.20	5.00	.00
2008	42.80	.00	.00	96.10	21.80	56.90	131.00	341.20	134.30	48.40	132.70	1.00
2009	23.20	.00	51.40	122.80	.00	21.60	186.90	145.50	17.10	50.40	4.80	161.60

Maximum and minimum temperatures

Years	Maximum temperature(^{o}C)	Minimum temperature(^{o}C)
1992	24	14.7
1993	26	13.4
1994	27	13
1995	25.8	13.2
1996	25.9	13.3
1997	24.8	13.5
1998	27	13.7
1999	27.8	13.8
2000	26.3	13.2
2001	25.7	13.9
2002	27.2	14.3
2003	26.6	13.7
2004	28	13.8
2005	25.6	13.5
2006	26.1	13.6
2007	26.1	13.3
2008	25.1	13.2
2009	25.81	12.9

Declaration

This thesis is my original work and has not been presented for a degree in any other university.

Name: _____

Signature: _____

Date: _____

This thesis has been submitted for examination with my approval as a university advisor

Name: _____

Signature: _____

Date: _____