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DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

CLIMATE CHANGE/VARIABILITY, FOOD SECURITY STATUS AND PEOPLE'S ADAPTATION STRATEGIES IN DAMOT WOYDE WOREDA, WOLAYTA ZONE, SNNPR,ETHIOPIA

BY

TEGEGN BERGENE

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BY

TEGEGN BERGENE ZEMA

Approved by:	K.N.Singh(PhD)	________	____________
	Advisor	Signature	Date
	______________________	____________	______________
	External Examiner	Signature	Date
	______________________	________	____________
	Internal Examiner	Signature	Date
	______________________	________	____________
	Chairman, Department of GeES	Signature	Date

DECLARATION

I, Tegegn Bergene Zema, do hereby declare that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than those of another are duly acknowledged.

Name: Tegegn Bergene Zema

Signature: ______________________

Date of Submission:

May 2014

Department of Geography and Environmental Studies,
Addis Ababa University

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ACRONOMS

ADLI: Agricultural Development-Led Industrialization

BMI: Body Mass Index

BWARDO: Beddesa Woreda Agricultural and rural development office

DA: Development agents

FANTA: Food and Technical Assistance Project

FDRE: Federal Democratic Republic of Ethiopia

FIS: Food Insecure

FS: Food Secure

FSS: Food Security Strategy

GDP: Growth and Development plane

GHG: Green House Gas

HDWWA: Head of Damot Woyde Woreda administration

HFBM: Households food balance model

HFIAS: Household's food insecurity access score

HHs: Households

HWZED: Head of Wolayta zone Education Department

IFPRI; International Food Policy Research Institute

IPPC: Intergovernmental Panel on Climate Change

Kcal/Adu.equ:Kilo Calorie Daily per Adult Equivalent

MDG: Millennium Development Goal

NAPA: National Adaptation Program of Action

NMSA: National Metrological Service Agency

NOAA: National Oceanic and Atmospheric Administration

PSNP: Productive safety net program

SPSS: Statistical Package for Social Science

SSA: Sub-Saharan Africa

TLU: Tropical Livestock Unit

UNDP: United Nation Development program

UNEP: United Nations Environmental programs

WFS: World Food Summit

WZA: Wolayta zone administration

DEFINITION OF LOCAL TERMS

Kebele: Lowest administrative unit in Ethiopia

Kola: lowland agro-climate

Woina Dega: Moist highland agro-climate

Woreda: District

Abstract

The main objective of this paper was investigating climate change/variability, food security status and people's adaptation strategies in Damot Woyde Woreda. As many as 117 sample households from the two agro-ecological zones of study area were included in the sample frame. Household survey, focus group discussions and key informant interviews were held for collecting data. Basic descriptive statistics were used for assessing quantitative data. Household food balance model (HFBM) and Households food insecurity access scale (HFIAS) were used to determine food availability and accessibility of sample households respectively. The results of the study indicated that 56.4% of households are food secured and the remaining 44.6% are food insecured. The prevalence of food insecurity is more sever in lowland agro-ecology. Food insecured households are characterized by larger family members, smaller out number of livestock, smaller land holding, lower fertility status of land and low productivity and production. Agricultural production varies from one agro-ecological zone to the other due to their varied climatic conditions. Rain fall amount is by far lower in Kolla agro-ecologiy. Frequency of drought and severity of land degradation also are higher in lowland agro-ecological zone than Dega and average temperature increase in both sample kebeles. The study examined climatic and other related factors of food production. Farmers reported that, erratic rain fall in terms of time and space, drought, land degradation, pest and weed infestation, lack of non-farm activities and lack of access to credits are the more severe constraints in food production. However the levels of severity of the factors were not the same in two sample kebeles rather the impacts of these factors are more sever in lowland kebeles. The study also shows that Decline in atmosphere and surface moisture and prevalence of disease are also the effect of climate change/variability in the study area. Kolla kebele is most vulnerable to malaria. Thus, food security interventions need to support livelihoods in ways that protect resilience of households, and providing direct assistance to ensure households remain resilient to the weak and variable natural situations in which they exist.

CHAPTER ONE

1. INTRODUCTION

1.1. Background

In the coming decades, global climate change/variability may have an adverse overall effect on agricultural production and, thus, bringing several regions of the world on the dangerous thresholds in many regions. Areas currently suffering from food insecurity are expected to experience disproportionately negative effects. To reduce the effect of climate change on food supplies, livelihood and economies, we must greatly increase adaptive capacity in agriculture –both on long term climatic trends and to increasing variability as an urgent policy (Beddington et al., 2011). This problem is more serious in developing countries as they lack adaptive capacity.

Variability of climatic elements, specially rainfall and temperature, may affect agricultural production as they influence the production elements like soil moisture and soil fertility, length of growing season and increased probability of extreme climatic conditions (McGuigan *et al.*, 2002 cited in Leta, 2011), although with special variations. The degree of impacts of climate change varies from one agro-ecology to another. The common adverse impacts of climate change/variability, however are crop damage, lower yields, income lose, harvesting difficulties, increased pest activities and delayed seeding (Pearce, 2009) irrespective of ecological variations.

Africa is commonly identified as the region highly vulnerable to climatic vagaries of the tropical rain i.e. uncertainties of commencement, termination, continuity and intensities, mainly because it is the continent which has its major areal spread within the tropics. And as a matter of fact it is the tropical land which is full of uncertainties of climatic attributes. In addition to this the social, economic, and political constraints that determine the capacity of human systems to cope with climate change/variability, and the existing burden of climate-related hazards, including high prevalence of food insecurity. Africa is also sensitive to climatic hazards, as its people are mainly dependent on natural resources for their livelihoods such as agriculture, pastoralism, and fishing. Environmental stressors, thus, place a large proportion of the population at risk of adverse outcomes **(**Ford et al., 2010).

Two factors critical to assuring food security, at the local as well as global level, are increasing crop productivity with available water resource and increasing access to sustainable water supplies. These factors are also vital to the efficient economic performance of agriculture, which is particularly important in Ethiopia that the sector accounts for about 41 percent of the country's gross domestic product (GDP), produces 80 percent of its exports, employs 80 percent of the labor force, and is a major source of income and subsistence for the nation's poor (You, G. J.-Y., and C. Ringler, 2010). These situations indicate that Ethiopia is vulnerable to the impacts of climate change in Africa. Some thesis reviewed also indicated that climate irregularities affecting Ethiopian agriculture.

Wondmunegn, (2012) assessed the effect of adverse climate change induced declining agricultural productivity on food security and food market of Ethiopia, findings revealed that food availability problem is stressed with a decline in per capita food production as a result of negative yield growth elasticity and an increase in food prices of items under climate change. In addition, food access problem is also stressed with a reduction in per capita income and per capita food consumption expenditure. Generally, food poverty is deepening from a general welfare loss. His finding was good but the livestock production component was not included as food resource.

Meron, (2012) has attempted to investigate the impact of climate change on the livelihood of farmers and agricultural practices. To identify the reasons while natural resource managements are applied in the area, food insecurity and other environmental problems are threats. The findings show that impact of climate change in Konso is noticeable in two extreme weather events; drought and flood which lead to severe socio-economic harms and repeated food insecurity. Furthermore, it indicates that the Konso people are well known for their natural resource conservations and various agro ecological practices. However, there are determinant factors or constraints to apply agro-ecological farming practices as it needed in the Wereda. The adverse impact of climate change in Konso have increased the vulnerabilities of the society and resulted in repeated severe food deficiency and poverty troubles. The study produced interesting findings; but it did not consider models like HFBM and HFIAM that help to understand the severity of food security at household level through household survey.

As agriculture is the main source of livelihood of the people in Damot Woyde Woreda, farmers face both agricultural drought problems and socio-economic problems. The rapidly growing population (3%) in the Woreda increased the demand for food, resources, land and other basic needs of life, especially, during drought time the problem becomes very challenging for the community. But very few studies have been done in Ethiopia at local/micro level that gives special emphasis on the impact of climate change/variability on food security. The aim of this study is to fulfill the gap and to explore possible but environment friendly ways and means to counter the adverse impacts.

1.2. Statement of the problem

Climate change and variability impacts adversely the environment, human health, food security, economic activities, 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 the 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 consequences of climate change and irregularities vary spatially in magnitudes. For example, the countries of Sub-Saharan Africa are the most vulnerable and since many countries of this region are already food insecured; climate change and variability aggravate and worsen the problems (Daniel, 2009 cited in Alemu, 2011). The impact of climate change on agriculture and human well-being can be viewed under 3 components i.e. biological on crop yields, impacts on outcomes including prices, production and consumption and impacts on per capita calorie intake of people consumption and child malnutrition (Nelsson et al., 2009).

According to IFPRI (2007), “global climate change poses great risks to poor people whose livelihoods depend directly on agriculture, forestry and other natural resources”.

Though Ethiopia is endowed with varieties of natural resources suitable to produce wide range of crops, it is frequently challenged by shortage of food and its insecurity, due to unpredictability of climatic elements especially rainfall. Particularly, since 1959, the domestic production of food has never been sufficient to meet the food requirements of the national population. Indeed, since the 1960s, the number of food insecure households has been increasing, and per capita food availability has been decreasing. The per capita food availability was, on an average, 128.08kg for the period 1961- 1974, and it declined to 119.99kg in 1975-1991. Though average per capita food availability increased to 125.41kg during 1992-2001, still it remained far below the recommended average per capita daily requirement of calorie intake of 2100kcal set by the Ethiopian government. It is equivalent to 225kg of grain per annum per head (Markos, 1997).

It can be justified by the increasing frequencies of drought in Tigray and Wollo (1965, 1974, 1983, 1984, 1987, 1990, 1991, 1999, 2000, and 2002) and recent floodings in Somali region, South Omo and Dire Dawa (1997 and 2006) leads to negative effects on food security (Abebe, 2013).

Ethiopia is one of the examples of how climate change affects Africa (Haakansson, 2009). Based on UNDP human development report of (2007/2008) 46% of the population in Ethiopia was malnourished and 77.8% of the population earned daily amounts, which was very low purchasing power.

Moreover, The World Bank (2012), states that “Ethiopia is one of the countries extremely vulnerable to drought and natural disasters such as flood, heavy rain, frost and heat waves. Such extreme weather causes the losses of people and livestock and disrupts livelihoods of farmers.”

Similar to the Ethiopian highlands Wolaita zone is also faced with climatic variability. Livelihoods of most of the people in Wolayta zone is based on agriculture (mixed crop-livestock production) which is greatly climate sensitive in its nature and slight irregularities in climatic conditions adversely affect agricultural production and hence the livelihoods of households. Some of the signs of this effect are drought, food insecurity, failure of crop production, death of livestock, loss of biodiversity and even famine.

Human and livestock health are also the main problems of the area. Loss of agricultural outputs and deteriorating conditions in rural areas caused by such conditions directly increase the poverty status of households in already poverty stricken areas like Wolaita. The magnitude of adverse impacts of climate change/variability in this area has been intensifying and is expected to be more severe (UNEP, 2006).The problem is further compounded by prevailing poverty, high population growth (2.9%) and resource degradations.

Some studies have been conducted on food security issues in Damot Woyde Woreda. But none of them addressed food security in relation to climate change. Since the area is practicing climate sensitive agriculture (rain-fed agriculture), it is obvious that climate is one of influential factor for food security status of the Woreda. Many governmental and Non-governmental organizations have been providing food aid for food insecured households that are large in number. This problem in the study area prompted the researcher to study climate change/variability and its impact on food security of rural households.

1.3. Objectives of the study

The main objective of this study is to investigate the impact of climate change/variability on food security of the local community in spatial as well as temporal perspective by analyzing the existing situations and metrological data in the study area.

1.3.1 Specific objectives:

- To assess trends of temperature and rainfall so as to establish the change/variability of climate in the area.
- To establish relationship between climate (temperature and rainfall) and (1) crops and livestock production (2) availability of water for different uses in the woreda.
- To assess how climate change/variability influenced the situation of food availability.
- To assess the effects of households food accessibility and climate change/variability in the study area.

- To identify the relationship between household’s food utilization situation and climate change/variability.
- To identify the major adaptation strategies being practiced by the people to climate change or variability.

1.4. Research question

- Are available meteorological informations able to infer about the changing/variability trends of climatic parameters?
- What is the perception of people regarding impacts of climate change/variability on crop and livestock production and hence the status of food security?
- How change/variability of climate affect food availability in a study area?
- What looks like the influence of climate change/variability on food accessibility?
- What are the main constraints of food utilization in relation to climate change?

1.5. Significance of the study

The study will have at least the following contributions.

- Studying the impacts of climate change/variability on food security may initiate academicians and researcher to carry out an in-depth investigation of food security situations in the study area.
- Development performer may make use of the paper as an input for planning, executing and targeting the need segment of the society in their development programs especially for agro-based technologies to increase the value of agricultural produces, education, training and extension services. This will help to increase the adoption of modern farming methods, founding of local market centers to open up markets for farmers’ produces, rural electrification to facilitate agro-processing and safe storage for produces.

- This research may also be essential so as to fight food insecurity with right adaptation strategies of climate change/variability and to enhance resilience Green economy.

1.6. Scope and Limitation of the study

The researcher made choice to delimit the scope of this thesis to only in two rural kebeles from 23 kebeles of Woreda in order to manage the size of the study.

Both food security and climate change are multidimensional, dynamic and broad concept and climate change have adverse effect on food security: on food availability, accessibility, utilization and stability. Thus, only the three pillars (availability, accessibility and utilization) were considered. All the determinants of these pillars were not also covered in the study like exchange and distribution from availability as it more reliable at regional and national level. Moreover, food utilization of household is concerned about nutritional value of a food based on BMI (Body Mass Index). But, in this study none of measurements will be used rather it only concentrates on indicators like availability of water and prevalence of disease through household survey. Data from NMA was not complete what required by this thesis in the study area; therefore, the temperature data were taken from Boditi and Billate meteorological stations (nearest stations) to represent the highlands and lowlands temperature condition of the study area respectively. Time and financial problems were also the main constraints that the sample size of households was delimited to only 10% of total population.

1.7. Organization of paper

The thesis has five chapters. The first chapter deals with background of the study, problem statement, research objectives, research questions, significance of the study, scope of the study and limitation of the study. Chapter two is all about review of related literature. Chapter three presents the description of study area and the approaches and methods applied in the analysis. Chapter four presents the results and discussions that start with analysis of the pattern and trend of climate variability in the study area and the last chapter five concludes the major findings of the study while recommending some potential measures that should be undertaken by the different stakeholders in the study area in the future.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Theoretical literature

2.1.1. Concept and definition of climate change

Most people define “climate change” as the variation of the world’s climate that humans are causing, through fossil fuel burning, deforestation and other practices that raise the concentration of greenhouse gases (GHG) in the atmosphere. However, scientists often use the term for any change in the climate, whether arising naturally or from human causes.

Climate change in IPCC the usage refers to alteration in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that continue for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is accredited directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007). Each of these two definitions is relevant and important to keep in mind.

When dealing with issues of climate change, it is important to understand the different terms used as “packages” in understanding the system. Accordingly, “climate variability” is the fluctuation in climatic parameters from the normal or baseline values, whereas “climate change” is a change in the long-term mean value of a particular climate parameter (Abebe Tadege, 2008).

2.1.1.1. Causes

According to Ahren (1988), Earth’s climate change is not stagnant rather it is dynamic. It is always changing through natural cycles. Changes in the strength of sunlight reaching the earth causes cycles of warming and cooling that have been a regular feature of the

Earth's climatic history. There are two major causes of climate change namely natural causes and human factors.

Natural Causes

According to National Oceanic and Atmospheric Administration (NOAA) US National, weather service (2007), climate change is a normal part of the earth's natural variability, which is related to interactions among the atmosphere, ocean, and land, as well as changes for radiation reaching the earth, and the amount of volcanism experienced. Similarly, U.S Global change research program also indicates that two important natural factors influencing climate system of the earth: the sun and volcanic eruption. When volcano erupts, they throw out large volumes of SO_2, water vapor, dusts and ashes into the atmosphere. Scientists agree that the volcanic eruptions having the greatest impact on climate are those rich in sulfur gases (Ahrens, 1988). They explained the natural causes of climate change as the most prominent natural factors that causes of climate change are continental drift, volcanoes, ocean currents, the earth's tilt, and comets and meteorites. Continental drifts affect the climate by changing the physical features of landmasses, their position, the position of water bodies and the flow of ocean current and winds (Ahren, 1988). Although the climate of the earth has changed and is changing due to natural causes, these changes occur over long periods, affecting the climate system only slightly in the short term.

Human Induced Climate Change

The IPCC fourth assessment report (AR4), provided the World with definite confirmation that humans are changing the climate. The (AR4) concludes that, "most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations" IPCC (2007). The American meteorological society (2009), human activities have become a major source of environmental change because human being use large-scale fossil fuels (oil, coal and natural gases) for industrial activities since industrial revolution. The combustion of fossil fuels for industrial activities releases large amount of green house gases (GHGs) in to the atmosphere. The world has experienced the twenty warmest years in record since the 1980s. Top ten warmest years occur after 1990s (Haakanson, 2009). Burning fossil fuels such as coal, oil and natural gas has led to atmospheric content of CO_2 increasing sharply.

In addition to combustion of fossil fuels deforestation also contributed to global climate change. According to Gorte and Sheikh, 2010, deforestation releases about 5.9 Giga ton CO_2 (17%) of all annual anthropogenic greenhouse gas (GHG) emissions. Deforestation caused by land clearing for agriculture, timber harvesting and forest fires.

2.1.1.2. Evidences

The Intergovernmental Panel on Climate Change (IPCC), the body scientist who are authorities on the subject of climate change, in its fourth assessment report concluded that there is “noticeable evidence” that humans through accelerating changes in multiple forcing factors—have begun to alter the Earth’s climate regime.(IPCC, 2007). In addition, the most recent and relevant data from the physical and biological sciences indicate a significant warming trend this century (IPCC, 1997). Similarly, Epstein et al (1998) explains that there is increasing evidence of decadal-to-centennial warming at high elevations and at deep ocean depths, while many parts of the globe are experiencing increasingly extreme weather patterns.

According to Climate Change Science Compendium (2009), “Accelerated shrinking of mountain glaciers on every continent, rapid reduction of Arctic sea-ice, disintegration of floating ice shelves, and increased melt rates of Earth’s three Ice Sheets—Greenland, West Antarctic, and East Antarctic provide compelling evidence of our changing climate”.

The study of the geological evidence left behind by advancing and retreating glaciers is one factor suggesting that the global climate has undergone slow but continuous changes (Ahrens, 1988).

Another indicator of global climate change is that over the last 100 years (1906-2005) the global average temperature has risen by 0.74 degree Celsius. The global sea level has risen by seventeen centimeters during the twentieth century, primarily due to melting of snow and ice from the mountains and Polar Regions (Haakanson 2009).

2.1.2. Definition of food security

The Food and Agricultural Organization (FAO) has anticipated that the total number of undernourished people in the world will turn down by 9.6 percent to 925 million in 2010, after persistently rising during the preceding five years (FAO, 2010). Though this is a constructive indication and a welcome relief, this number remains unacceptably high at 16 percent of the world's population and far above the hunger diminution targets set at the World Food Summit in 1996, as well as by the Millennium Development Goals (MDGs). Developing countries explanation for 98% of the world's malnourished people and have an occurrence of malnutrition of 16%. The origin of the operative term 'food security' may be traced back to the Universal Declaration of Human Rights in 1948, under the guidance of the United Nations, which acknowledged the right to food as a core element of standard of living. However, the writing on food security explode since the publication of the report of the World Food Conference held in 1974 consequently to the global food crisis of 1972-74 (Bipul, 2011 cited in Markos, 1997).

Food security was first defined in the Proceedings of the 1974 World Food Summit as 'availability at all times of adequate world food supplies of basic foodstuff to keep up a steady increase of food consumption and to balance fluctuations in production and prices' (WFS, 1992). In 1983, FAO stretched out its concept to incorporate a third point: 'Ensuring that all people at all times have both physical and economic access to the basic food that they need'. In the World Bank's report of Poverty and Hunger, this notion of food security has been more explained in terms of: 'access of all people at all times to enough food for an active, healthy life' (WB, 2008).

The 1996 World Food Summit in its Plan of Action adopted still more complex definition: Food security, at the individual, household, national, regional and global levels is attained when all people, at all times, have physical and economic access to enough, safe and nutritious food to meet their dietetic needs and food preferences for an active and healthy life (WFS, 1996). This definition is again refined as: Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2001; Maxwell and Smith, 1992).

The current concept of food security has given more concentration to households and individuals than its availability at international, national, regional, woreda or kebele levels. This is because increasing food production, supply and sufficiency at broader levels does not necessarily guarantee that each and every individual is food securing and become food insecure (FAO, 2001).

Food insecurity prevails when people do not have sufficient physical, social or economic access to food. Food insecurity is a blend of many factors, Degefa and Tesfaye (2008) categorized this in to five: environmental, demographic, economic, social and political.

Devereux, 2010 and Woldeamlak, 2009 point out different human and natural stimulated factors that made Ethiopia a food insecure country at a national level over past few decades. These are weak natural resources base, insufficient and erratic rain fall in terms of amount and distribution pattern, inappropriate farm activities, inaccessibility to productive resources, declining land assets and tenure insecurity, poor development of human resources, poor storage technologies that leads to high post-harvest losses, inaccessibility to transport infrastructure, lower productivity of animals.

2.1.3. Effect of climate change on food security/Agriculture

Scientific evidences are now available from a variety of different studies to indicate that changes of climate would have an important effect on agriculture and livestock. Studies have not yet conclusively determined whether, on average, global agricultural potential will increase or decrease. Negative impacts could be felt at the regional level as a result of changes in weather and pest associated with climate change, and changes in ground-level ozone associated with pollutants in technology and agriculture management practices. There may be severe effects in some regions, particularly decline in production in regions of high present-day vulnerability that are least able to adjust. These include Brazil, Peru, the Sahel regions of Africa, south East Asia, the Asian Region of the USSR and China (IPCC, 1992). There is a possibility of high and mid latitudes may increase because of prolonged growing season, but it’s not likely to open up large new areas of production and it will mainly confined to the Northern Hemisphere.

Climate change affects agricultural production through influencing atmospheric carbon dioxide (CO_2), temperature, precipitation, agricultural pests and diseases, soil characteristics are among other things which are all direct or indirect inputs for production.

2.1.3.1. Effects of climate change on atmospheric carbon dioxide.

Since CO_2 is an essential factor in photosynthesis, its increasing levels have received considerable attention in evaluating impacts on agriculture, In most instances the effects of doubling of the concentration of CO_2 have been considered to be advantageous for photosynthesis, and hence for crop productivity. The reviews of Kimball(1983) and Cure and Acock(1986) based on survey of publication on the effects of CO_2, have been used to predict an improvement in crop productivity substantially in C3 crops (wheat, rice, and soybean) and C4 plants(maize, sorghum, sugarcane, millet). Plant species with the C3 photosynthetic pathway tend to respond more positively to increased CO_2 than C4 plants because it tends to suppress rates of photorespiration. The IPCC report (1992) gives the impression that an increased concentration of carbon dioxide may lead to improvements in crop yields as well as their adaptation to stress environments.

2.1.3.2. Effects of climate change on soil properties

New work has improved knowledge of the soil as a source of GHGs and of the potential impacts of climate change on soils (Buol *et al*., 1990; Bouwman 1990; US National Science foundation 1992). Global climate change will affect soils primarily through changes in soil moisture, soil temperature and soil organic matter. Higher air temperature will cause greater potential evapo-transpiration and higher soil temperatures, which could increase solution chemical reaction rates and diffusion- controlled reactions solubilities of soil and gaseous component, may increase or decrease, but the consequences of these changes may take many years to become significant.

A study of potential land degradation in New South Wales, Australia, predicted significant increase in soil erosion sedimentation and salinity in rainfall intensities increase (Aveyard, 1988), Higher temperature will accelerate the decay of soil organic matter, resulting in release of CO_2 to the atmosphere and decrease in carbon/nitrogen ratios.

2.1.3.3. Effects of climate change on the prevalence and distribution of agricultural pests and diseases.

The prevalence of pest and diseases is among the major constraints to achieving higher yields. This is particularly true of the tropics where more disease and pests occur because of higher temperatures and where humidity provides favorable conditions for infestation. The increase in temperature and precipitation in the 2xCO2 climate could create more conducive conditions for pest infestation. Pest and diseases, which today are unimportant and cause little harm, could become devastating under changed conditions.

Pimentel (1992) consider the effects of a 2^0c temperature rise in the US and Africa and found out that if North America becomes warmer and drier, crop losses due to plant disease are expected to decline as much as 30% below current levels. If Africa becomes warmer and wetter, crop losses to diseases will increase up to 133% above current levels for some crops. Higher percentages of crop losses to pest are expected to be sustained in Africa because effective pest control technologies are not extensively in use, nor are they expected to improve appreciably in the future. US crop losses to weeds are estimated to rise between 5% and 50 % (depending on the crop) because intensified competition from weeds, which are often better adapted to arid conditions than are crops. Herbicidal controls tend to be less effective under hot/dry conditions than they are under the cooler/ wet current conditions (Pimentel *et al.*, 1990)

2.1.3.4. Effects of Temperature.

Day length, temperature and their interaction regulate flowering in plants. In most instances, particularly at low and mid-latitudes the increase in temperature results in reducing the total deviation of the crops by inducing early flowering and shortening the grain fill period. The shorter the crop duration, the lower is the yield per unit area. Most importantly, higher temperatures reduce crop yields due to greater stress and increasing evaporation from the soil. A rise in temperature will result in decreasing agricultural production in low and mid latitudes. However, in higher latitudes where crop duration is limited by low temperature, the crop duration could increase resulting in improved productivity.

2.1.3.5. Effects of water availability.

Reduced water availability below a threshold reduced productivity of almost all crops. A crop need sufficient amount of water (rainfall) on timely basis to complete its life cycle. Any slight shift in timing of rains in the agricultural calendar brings sever damage on crops as the critical water demand of crops does not coincide with the disturbed rainy season. Besides, unwelcomed rain just before harvesting period brings spoilage to standing crops through damaging physically, making seeds to germinate, and/or proliferating crop diseases and pests. Thought its excess may not necessarily benefit crop production, it may sometimes cause crop losses if it falls in heavy storms that destroy crops and cause soil erosion. Therefore, the occurrence of unpredictable droughts has caused concern around the world. In the general circulation models the simulation of precipitation is not satisfactory. Nonetheless, it's clear that any reduction in precipitation will not only influence the monsoon season crops that also cause shortage for irrigation. In this respect the run-off and water collection could differ vary significantly in low latitudes in comparison with the mid-latitude s and high latitudes. Warming plus reduced rainfall in time of demand reduces the length of the growing season, which means that many of the traditional varieties of crops are not able to complete their growing cycle. The principal impacts on crops will result from a combination of higher water demand linked to raising temperature and decreased rainfall.

In addition to the agronomic impacts mentioned above, climate change is likely to produce various socio-economic consequences by affecting price of agricultural products, consumer welfare, number of persons at risk of hunger or food security, water and land market, production pattern of countries and comparative advantage and trade structure (Gbetibouo, G.A., 2004). Since regional changes in crop yields and productivity are expected to occur in response to climate change, there is likely to be an increased risk of famine, particularly in subtropical and tropical semi-arid and arid location (Rosenzweig *et al*., 1993 cited in Gbetibouo, G.A., 2004).

2.1.4. Food security and its vulnerability

2.1.4.1. Availability

Climate change/variability slow down food availability in two ways; it directly affects food production as the result of land productivity and other natural input declining owing to the variability of climate. It also indirectly affects food availability through the change in some economic factors particularly income of household and technology set up to undertake agricultural activity. Climate changes are understood to have effects through green house fertilization effect, rainfall, soil moisture, temperature and radiation variability effects (*Leff, et al., 2004*).

The green house fertilization effect is considered to do well to temperate zones by motivating plant growth from higher level of atmospheric CO2 level; but this is particular only for temperate zones (FAO, 2008). But temperature variability is expected to have a poles apart effect for different locations (Leff, *et al.,* 2004). For example, moderate warming (increases of 1 to 3 ºC in mean temperature) is expected to benefit crop and pasture yields in temperate regions, while in tropical and seasonally dry regions it is likely to have negative impacts particularly for cereal crops. Warming of more than 3 ºC is expected to have negative effects on production in all regions (IPCC, 2007). The effects of rainfall, soil moisture, temperature and radiation on crop yield depend on certain threshold of the set of the climate condition. If a variability beyond or below the threshold happened, crop yields will be negatively affected (Wheeler *et al.,* 2000). But the threshold level depends on the agro-ecological system of the location. Increased intensity and frequency of storms, altered hydrological cycles, and precipitation variance also have long-term implications on the viability of current world agro-ecosystems and future food availability (FAO, 2008). A study of (IPCC, 2007) shows that increases in mean temperature (6°C above long-term means) in European countries in 2003 led to a significant drop in crop yields. Generally, increased intensity and frequency of storms, altered hydrological cycles, and precipitation variance also have long-term implications on the viability of current world agro-ecosystems and future food availability (Felix and Romuald, 2009).

2.1.4.2. Accessibility

Food access is economically described on the trend and levels of food allocation and affordability or purchasing power. Climate changes apparently constrain these two indicators directly and indirectly.

Allocation: food is allocated through market and non market mechanisms. The non market mechanisms include those farmers who produce food for their own consumption. In this circumstance, as climate change makes food production to decline, it may reduce availability to the point that allocation and consumption choices have to be made within members of the producing family (FAO, 2008).

Regarding food allocation through market -mechanisms, it includes those household who acquire their food from market in exchange for money. Even though the households may have enough money to buy the food they intend to consume, there may not be enough food supply. Because food supply in the market may reduce as food production will decline inherently as the result of climate change (FAO, 2008).

Affordability: Generally, all preferred food is not produced by individual households but acquired through buying, trading and borrowing (Du and Ziervogel, 2004). On this instance climate change will affect the purchasing power of individuals in two ways.

First, because of climate change, national food yield will decline triggering food price to go up thus challenging the purchasing capacity of households. An increase in food prices has a real income effect, with low-income households often suffering most, as they tend to devote larger shares of their incomes to food than higher-income households do (Thomsen and Metz, 1998). High prices may make certain socially preferred foods unaffordable and will have an impact on individuals' nutrition and health. Second, climate change will affect the income of individuals who are rendering their food demand through purchasing from market. As production dwindles because of the effect of climate change, demand for labor will decline which will make the market wage to decrease for farm labors (Felix and Romuald, 2009).

2.1.4.3. Utilization

Generally it is known that climate change impacts the food use or utilization trend of households. Food utilization refers to the nutritional value of the food availed for households. Nutritional content of a food can vary as the result of a change in environmental condition, which imposes an alteration in the photosynthesis process of plants (Rosenzweig and Binswanger, 1993).

Climate change will also affect the micronutrient content of a food in the way that it renders a favorable condition for revival and expansion of new plant and animal diseases.

Even new diseases that attack human will be inborn as the result of climate change; typical to this is malaria. These diseases are lowering people's capacity to utilize food effectively and often resulting in the need for improved nutritional intake (McMchael, *et al.,* 2006). In addition, climate change can shape the decisions of farmers regarding the type of crops to cultivate as adaptation strategy; may be in case they will tend to stop cultivation of socially preferred crop for food. This happened mainly at the result of climate change, food price gets higher and become unbearable with the limited purchasing power of households especially for socially highly valued food items. Then, households will tend to abandon their tradition and starts to adopt new crop system and the crop type in resisting climate change. This makes households to forgo their socially valued crop or food (FAO, 2008).

2.1.5. Household food security indicators and measurement

Food security is complex and multifaceted phenomenon. Theoretically, food security is usually divided into three unlike parts – availability, access and utilization – each capturing different, but overlapping, dimensions of the occurrence. Indicators have traditionally focused on specific, easily measured aspects, such as current food supply, individual caloric intake, and so on, often without capturing the complexity of the concept. Common consensus exists that no single indicator can capture all aspects of food insecurity while also providing policy makers with relevant and timely information in a cost-effective manner. For this reason, efforts have been put into finding easy to implement and reliable alternative indicators which complement each other (FAO, 2008).

Maxwell and Smith (1992) list 25 broad indicators and a host of other indicators related to the different aspects of food security. They distinguish between “process indicators” - capturing food supply and food access - and “outcome indicators” - describing nutritional status. Gero et al., (2005) note that even a single composite indicator can come with many different permutations and list some 450 variations of testable indicators. They make the distinction between “generic” indicators applicable to a variety of settings and “location-specific” indicators.

A first indicator can be labeled undernourishment, a measure commonly identified with the Food and Agriculture Organization of the United Nations (FAO). This FAO method begins with the estimate of per capita dietary food energy supply, derived from aggregate food supply data. Assumptions regarding the distribution of this supply across households are made based on income or consumption distribution, or other available data. The proportion of undernourished in the total population is then defined as that part of the distribution lying below a minimum energy requirement level (Gero et al., 2005).

A second indicator measures the amount of food actually consumed at the individual or household level. Food consumption is usually measured indirectly through household surveys. Household-level data can be used to construct a number of measures of food insecurity, including food energy deficiency and poor diet quality and diversity. The level and depth of household food energy deficiency can be measured based on household consumption (Gero et al., 2005).

As the same source indicates, a third approach deficiency is to measure food utilization through nutritional status. Anthropometric measures of children are regularly collected in random sample surveys in many countries. Anthropometric measures, as outcome measures, are well suited for monitoring and evaluating interventions, and can be collected with socio-economic information in order to analyze the determinants of malnutrition. Anthropometric attainment, however, is a nonspecific indicator, because it is the result not only of food intake, but also of factors such as sanitation, health and child care practices.

2.1.6. Coping mechanisms to climate change/variability

Concepts of Adaptation and resilience to climate Change/variability

Resilience is a term and concept first developed by ecologists to describe the characteristics of Ecosystems that maintain themselves during a disturbance produced by various (Pearce, 2009). This notion has since been used in the realm of social science to describe social resilience as "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change". As a result of the dependency of social resilience on ecosystem services socio-ecological resilience is coined to describe holistically as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedback"(Walker *et al*., 2004).

Adaptability is closely connected to the notion of resilience. Essentially adaptability is the capacity of the actors in a system to influence resilience (Walker *et al.,* 2004). Adaptation can be described by different scholars based on level/scope, time and management plan.

According to Burton *et al.* (1993), the term "adaptation measures" covers eight categories : bearing losses (doing nothing), sharing losses, modifying the threat and thus preventing effects, changing use, changing location, accessing new research based technologies ,disseminating knowledge through education to change behavior, and restoration. Others have classified the different forms of adaptation as anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC, 2001).

National Adaptation Program Action of Ethiopia (NAPA)

Adaptation should be considered as an integral part of the response to the climate variability and change (Green Forum proceeding No. 2 2007). Ethiopia also recognized climate change and its impact; has already attempted to set up coping mechanisms for the likely consequences.

National adaptation programs of action (NAPAs) provide a process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs to adapt to climate change – those for which further delay would increase vulnerability and/or costs at a later stage (Abebe Tadege, 2008). The NAPA for Ethiopia intended to address common climate related hazards such as drought, floods, heavy rain, strong wind, frost, and lightening. The main human vulnerability and livelihood impacts include land degradation, soil erosion, and deforestation, loss of biodiversity, desertification, recurrent drought, flood, and water and air pollution.

Farm level adaptation practices: adaptations to climate change and weather variability are extremely varied and may occur at varying scales. According to Pearce (2009), adaptation measures may occur at organizational level through technological advances such as crop development, machinery improvements and weather forecasting. Adaptation also occurs at the farm level through tactical and strategic adaptations. Tactical adaptation would include practices such as changing planting times, input uses and harvesting to accommodate weather variability. Strategic farm-level adaptation would take the form of alteration of soil management practices, selection of crop varieties, purchasing crop insurance, or diversifying their farming operation. Smit and skinner (2002), group agricultural adaptation options into four non-mutually exclusive categories. The first technological development which is the most frequently advocated strategies for adaptation to climate change. The second category identified by Smith and skinner (2002) is government program and insurance. These programs include income stabilization and disaster reliefs that have the potential to stabilize farming incomes during times of weather variability associated with climate change. Farm production practices are third category which involves changes in the actual operation of the farm. This category ultimately describes farm level decisions with respect to farm production such as land use, irrigation and operational timings (Smit and Skinner, 2002).The final category is farm financial management highly influenced by government agricultural support. It is a farm level response using farm income strategies to reduce the risk of climate related income loss. Few researchers have addressed adaptation in analyzing the decision making process at farm level (Smit and Skinner, 2002).

A. Tactical (Short term) adaptation measures

Tactical adaptation would include systematic practices such as changing planting time (early planting or late harvest), input uses and harvesting to accommodate weather variability (Pearce, 2009).

Modification of crop calendars and input uses: farmers make adjustments of time of sowing based on the prevailing trend of precipitation. Early sowing of crops that can mature within a short period of time such as chickpea, potatoes, haricot bean and katumani maize is practiced in most part of Ethiopia (Abate, 2009). According to studies conducted on Ethiopian highlands by Astatke *et al.* (2003), the early crop harvest associated with the minimum tillage system was highly beneficial for small-holder farmers-since the early harvest coincided with the cyclical period of severe household food deficits and high grain prices in local markets.

According to OCDE (Organic Chain Development in Ethiopia) report 2007, Ethiopia is a country of mostly smallholder farmers and its agricultural systems are a mix of animal and crop production. It is one of major centers of crop genetic diversity in the world. Because of these strengths, it has suffered relatively insignificant crop genetic erosion. This makes it easy to intensify agricultural production in Ethiopia without resorting to industrial agriculture. The large crop genetic diversity will also enable Ethiopia to adapt to climate change more easily than most other countries in the world. Strengthening its existing organic agriculture with needed scientific inputs will, therefore, give Ethiopia a globally competitive edge in agriculture. Hence it can be concluded by stating his belief that organic agriculture can ensure that the children and grandchildren of Ethiopia and their following generations into the future are healthily fed in a hospitable biosphere.

Harvesting to accommodate weather variability: farmers have experience of harvesting their crops whenever they have expectation that extreme weather event is going to happen in the near future. People in the rural area exchange information in various ways and also usually people travelling from one place to the other to exchange information about the potential risk of extreme weather events.

B. Strategic (Long-term) adaptation Measures

Strategic adaptation measures at farm level adaptations would take a form of alteration of soil and water management practices, selection of resistant crop verities that can withstand adverse weather shocks and diversifying the farm operation (Bradshaw *et al.*, 2004).

On- farm water management: on farm water management is one of the strategic adaptation measures that involves efficient utilization and proper water management for farm operations. It includes modification of irrigation techniques, adoption of water efficient technologies, and improved water harvesting practices.

2.2. Empirical studies/literatures

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 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 second study, the impact of climate change on rural livilihood and thier adaptation methods was conducted by Niguse (2011), the case of Alemata Woreda, southern Tigray. The general findings of the study shows that the climate of the woreda has show variability and in turn this climate change and variability has impact on the woredas livelihood sources like: crop production, cropping pattern, availability of long cycle crops, and availability of livestock feed and loss of livestock were the major ones. To minimize the impacts of climate change and variability the farmers of the woreda had adopted different coping strategies like; decrease on amount of meal, selling labor, food aid, selling livestock and other assets and eat less expensive foods. Beles feeding for livestock, migration, early maturing crop varieties, water and soil conservation, rehabilitation of gullies and area closure were long term adaptation practices applied by farmers and woreda office of agriculture.

Another study that reviewed is in Gonder by Marye Belete (2011), local peoples' perception on climate change, its impact and adaptation measure. His finding revealed that both maximum and minimum temperature had increased, belg rainfall had decreased whereas annual and meher rainfall had increased and proved inter annual and seasonal difference. People in the study area perceived climate variability and change-induced hazards such as drought, flood, pests and disease, land slide, erratic and heavy rainfall influence the environment and their livelihood. For the perceived changes, local people took corrective action to compensate the impacts of climate change. The most common adaptation options include: reforestation, terracing, rain water harvest, change in cropping pattern, growing short maturing crops, family planning and diversification of income. But, poverty, water scarcity, land scarcity, market problem, lack of information about the weather or long-term climate change, forage and feed scarcity, lack of agricultural technologies and appropriate seed and lack of health service were major limitation of adaptation in the study area.

The study carried out in Konso by Meron (2012), how the impact of climate change through time influences the livelihood of konso farmers. He concluded that impacts of climate change in Konso have increased the vulnerabilities of the society and resulted in frequent severe food shortage and poverty problems. This study indicate that the Konso wereda is affected by the impact of climate change not because of the working culture of the society rather there are factors which can affect or reduce the resilience of the society and their adaptation of agro ecological farming practices.

This review so far was quite useful and relevant to this study. It helped to develop clear understanding on the issue climate change/variability, food security status and people's adaptation strategies

2.3. Conceptual framework

Conceptual framework on the concepts climate change and food security (FAO, 2008) is modified and used in this study.

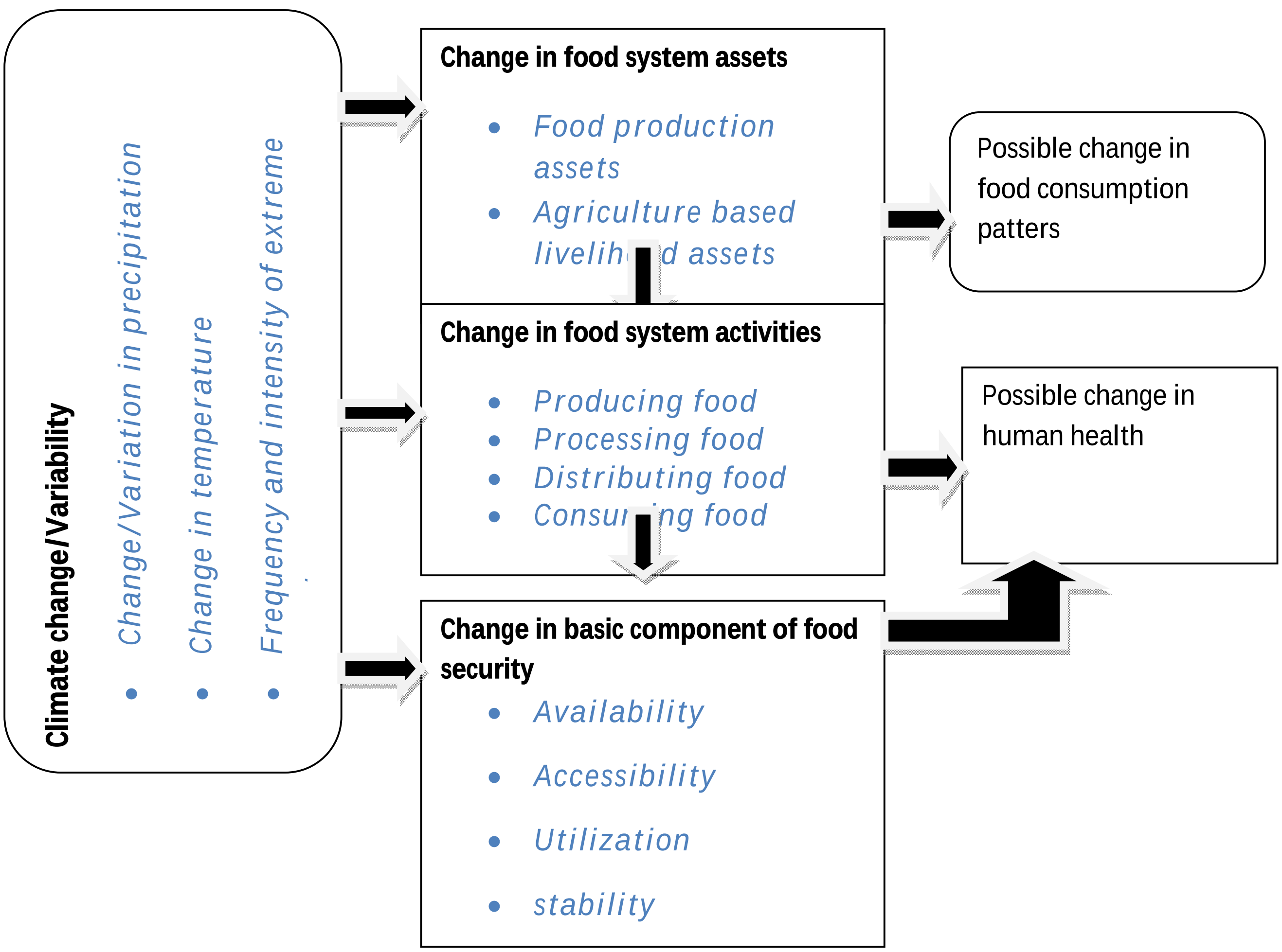

Fig 1: Conceptual framework: climate change and food security.

Source: adapted from FAO.2008

The framework shows climate change and food security outcomes on the three components of food security – food availability, food accessibility and food utilization.

For the poor - agricultural production is both a source of food and a source of income; climate change affects three pillars of food security in various direct and indirect ways (Schmidhuber and Tubiello, 2005). Availability of agricultural product is affected by climate change directly through its impacts on crop yields, crop pests and diseases, and soil fertility and water-holding properties.

Physical and economic access to food would be affected negatively by climate change as agricultural production declines, food prices rise, and purchasing power decreases. This is due to poor infrastructure and low utilization of modern technology that climate change and variability cause. More frequent and more intense extreme weather events (droughts and floods) and increasing irregularities in seasonal rainfall patterns are already having immediate impacts on not only food production, but also infrastructure, incidence of food emergencies, livelihood assets and human health. Last but not least, climate change poses threats to food utilization through effects on quantity and quality of water and human health. In general, climate change has an impact in the overall livelihood system of the vulnerable societies, as they are highly dependent on rain-fed climate sensitive economic activities and overall household food consumption pattern changed.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location

Damot Woyde is one of the 12 rural woredas of Wolayita zone in the Southern Nations Nationalities Region. The capital of the woreda, Bedessa, is located about 335 kms away from Addis Ababa to the south and 26km, away from Soddo, the capital of Wolaita zone, to the east. Damot Woyde woreda lies between $6^0$40’48’ and $6^0$57’36’ N latitudes, and $37^0$49’48’ and $38^0$4’48’ E longitudes. This woreda is surrounded by other woredas like Soddo Zuria, Damot Gale, Humbo and Duguna Fango to the west, north, south and east respectively. Damot Woyde woreda has a total area of 352 km^2, which makes up about 7.8% of the total area of the zone (4511.7 km^2).

There are 23 administrative units (kebeles) in the woreda. As it has been indicated in the methodology section, out of 23 Kebeles in the woreda, two kebeles were selected as the study sites from two agro-ecological zones (*kolla* and *woina dega*). These are Tora sadebo from *kolla*, and Kindo Koyo from *woina dega*. The altitude and geographical coordinate of each village was specified below. All the physical and demographic characteristics described for the woreda are reflected in these Kebeles.

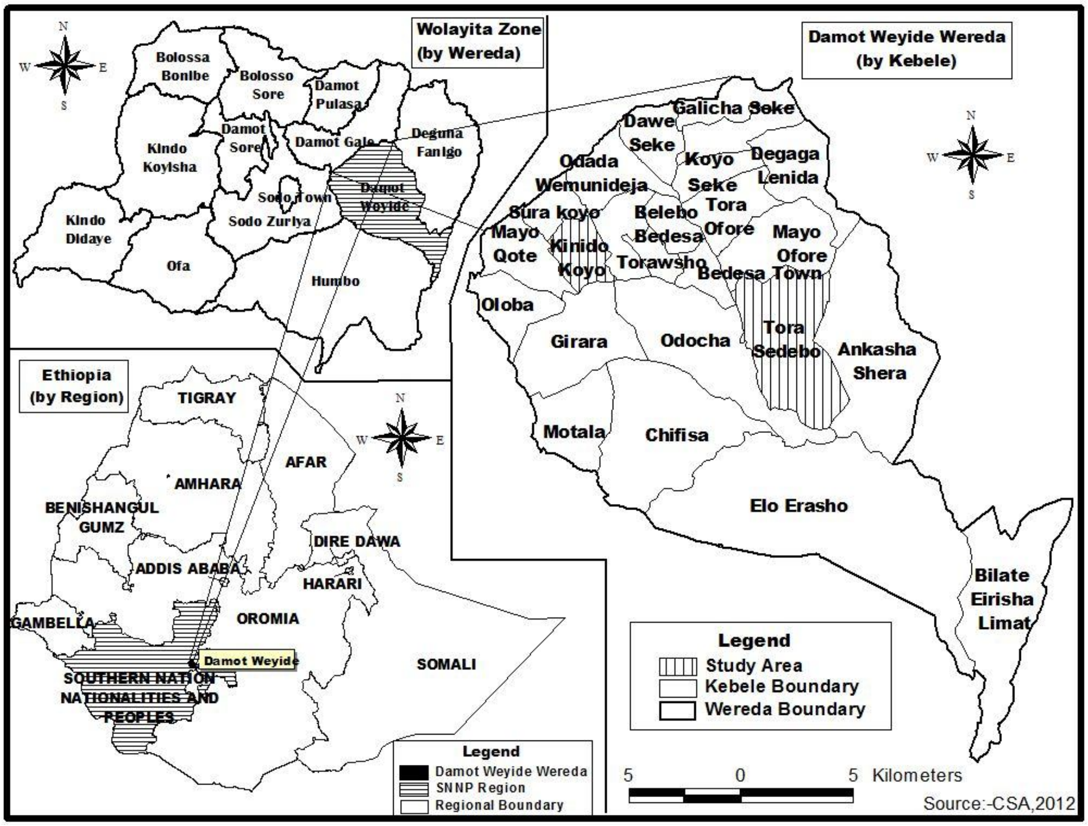

Fig 2: Study area map

Table 1: Some Geographical Characteristics of Kebeles in the Study

Major Geographical Characteristics	**Names of Selected Kebeles**	
	Tora sadebo	**Kindo Koyo**
Latitude	$6^0$49’27”N	**$6^0$51’21”N**
Longitude	37º59’57”E	**$37^0$52’10”E**
Altitude	1087-1465m	**1700-2100m**
Agro-ecology	Lowland	**Highland**
Main agro-ecological zone	Dry *kola*	**Moist *woina dega***
Topography and Main Land forms	Flat-lowlandplain intensive with gullies	**Degraded gentle slopes with gullies**
Temperature	22-25^0C	**20-23^0C**
Rain fall	**700-950 mm**	**1000-1350mm**

Source: WZSEP, 2010 and Field survey, 2014

3.1.2. Physical Characteristics

3.1.2.1 Relief and Agro-Ecology

The altitude of Damot Woyde woreda ranges from 1001m to 2100m above sea level which represents the two agro-ecological zones is kola(lowland) covering eastern part of Woreda and Woyna Dega embracing the western part (WZSEP, 2004).

a) Lowlands (1000m-1600m above sea level). The lowlands comprise about 40% of the total area of the woreda. Climate is warmer and drier in these plains where malaria mosquitoes and tsetse flies are found. Water is scarce and soil is not very fertile. These lands are referred to as *kolla.*

b) Highlands (1600m-2100m above sea level). The highlands share 60% of the total area of the woreda. These lands experience relatively lower temperature and adequate rainfall. The conducive climatic condition and fertile soil, make this part is more densely populated. Locally these areas are known as woyna dega

3.1.2.2 Climate

As it has been mentioned earlier, in Damot Woyde Woreda, there are two agro-ecological zones, namely *kolla* and *woina dega*. From the above agro-ecological zones in the area, the largest part is covered by *woina dega* which accounts for 60 percent of the total area. On the other hand *kolla* account for about 40 percent of the total area. Climatic data, temperature and rainfall of the study area for the last 28 years (1985-2013) are given in fig 3 and 4. The long term annual mean maximum and minimum temperatures are respectively 30.3^{0}C and 15.8^{0}C. The total mean annual rain fall is 804.1mm in lowland area to 1116.5mm in higher part of the study area and the highest monthly rain fall recorded is mostly seen in April month of a year. Even though there are variations in the amount of rainfall from year to year, the area has two main rainy seasons: *belg* (March-May) and *meher* (June- October), meaning thereby that the rain fall is bimodal with short rain season (*belg*) and long rain season (*meher*). However, the apparent determinant factor for the spatial variation of climatic elements (rain and tempreture) in the area is the altitudinal variation which ranges 1600m and below in lowlands and from 1600m and above in highlands (WZSEP, 2010).

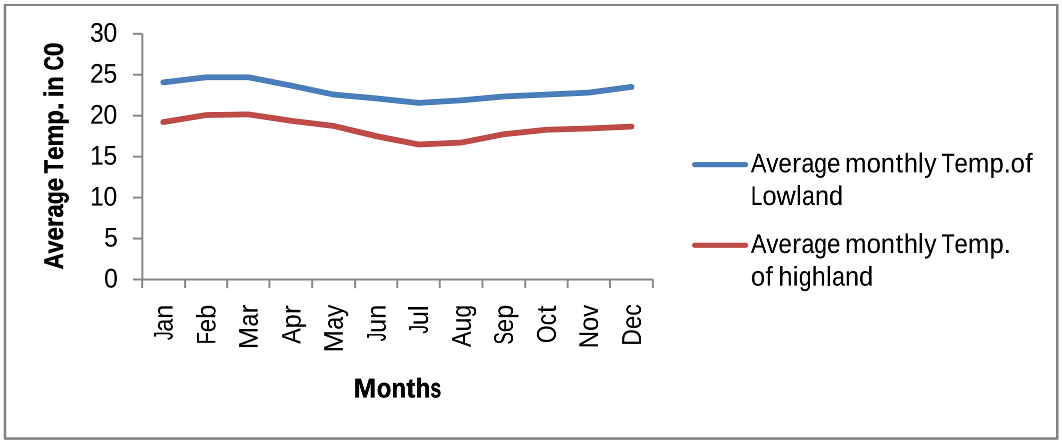

Fig3. Monthly Average Temperature of Beddessa and Billate Station (1985-2013)

Source: National Metrological Agency

The highlands are characterized by undulating plateau and plain and have a sub-humid to humid climate with heavy rain fall (1000 to 1350mm per year). On the other hand, the lowlands have a drier climate with lower rainfall of 700mm per annum, which is more variable in amount and distribution.

3.1.2.3 Natural Vegetation

Since there is scarcity of reliable data on vegetation types dominating Damot Woyde Woreda, it is difficult to produce a clear description of the vegetation types and their distribution. However, what is clear is that due to the human interaction, the vegetation types had registered significant changes. In the past, highland areas were dominated by *Wanza* (cordial Africana), *Tid* (Juniperus procera), Weira (Olea europea), *Bisana* (Croton macrostachys) and *Korch* (Erythrina Abyssinia) (Eyasu, 2002). Nowadays, the area is almost bare with little vegetation coverage dominated by eucalyptus tree. There are only a few remnants of these indigenous forests in some Church compounds, along banks of stream and in other sacred places access to which is very difficult. The vegetation in the lowlands is naturally dominated by acacia tree, grass and tsetse infested thorny bushes (See plate 1).

Plate1. Vegetation Types of Lowland Area (Tora sadebo)

Degraded land

Shrub land

Source: Photo by Author, 2014

Eucalyptus, an exotic species, is now the dominant tree in the highlands of the woreda. This tree is planted around farm boundaries and in private woodlots at the edge of farmlands, as live fences by the front yard and as wind breakers. The tree provides wood for fuel, poles to house construction and making farm tools and other implements. It is used as a source of income by selling standing trees to nearest urban dwellers. But the tree does not assist soil and water conservation. Researches confirm that expansion of planting eucalyptus for its economic contribution has encouraged the elimination of broad-leaved indigenous species which are economically more beneficial in terms of soil fertility, maintenance and conservation of surface water (Eyasu, 2002).

Plate2. Eucalyptus Dominant Vegetation at highland Area (Kindo Koyo Site)

Source: Photo by Author, 2014

3.1.2.4 Soil Types

The areas are dominated by chromic vertisols(see table below). According to Eyasu (2002) two-third of the area of the woreda is estimated to be covered by eutric nitosols, the dominant arable soils in the Ethiopian highlands that this finding differs from the findings of this research. This difference may be due to the fact that the previous study simply took the estimation of soil type without having real fact, and; but the eutric nitosols cover the smallest portion of the Woreda. The other soil types widely covered the area are Pellic Vertisols,Vetric Andosols and Dystric nitosols.

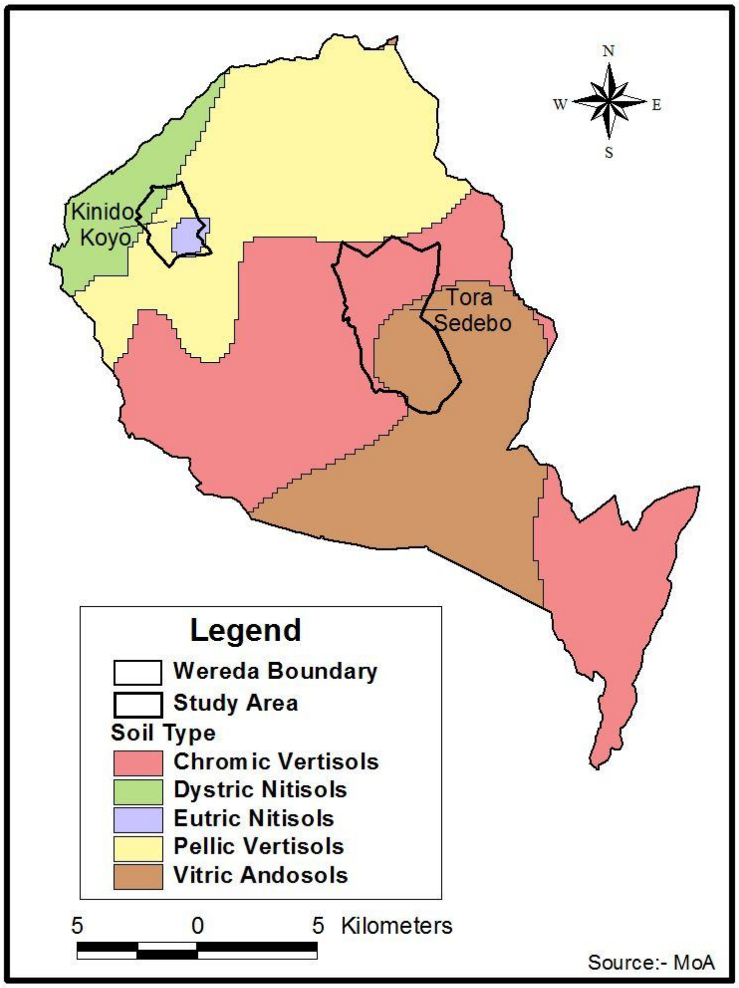

Figure4: Soil Map of Damot Woyde Woreda

Farmers in the study area do not use the standard soil maps or soil surveys in order to classify soil types. They make their own elevation and classification based on the level of fertility, physical properties including level of coolness, water holding capacity, and susceptibility to erosion, drainage and a major indicator of productivity with black soils considered to be most productive.

3.1.2.5 Drainage Pattern

The drainage system of the woreda is dominated by Bisare drainage system; which is the drainage system in the western part of the woreda. Some of the streams in this drainage system are Bedessa, Lade, Hamanche, Wotagishe and Olafino. After leaving the boundary of Damot Woyde, Bisare Stream joines Billate River and finally empty into Lake Abaya.

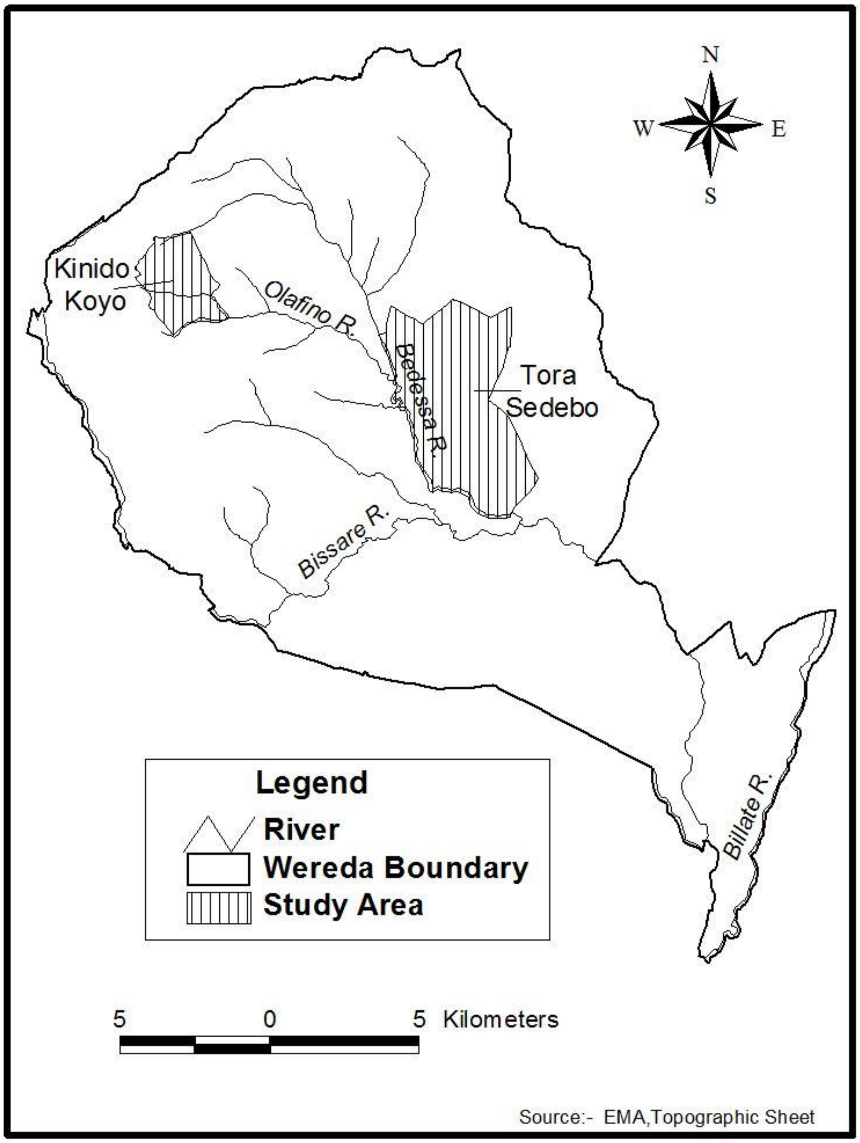

Figure5: Drainage pattern of Damot Woyde woreda

3.1.3 Demographic and Socio-Economic Characteristics

This part of the thesis briefly highlights the demographic and socio-economic characteristics of the study area which includes population size and density, age-sex composition, fertility and mortality, education, drainage systems and cropping patterns.

3.1.3.1 Population Size and Distribution

According to the 2007 population and housing census of Ethiopia, Damot Woyde woreda had a total population 91602, making up about 6% of the population of Woilaita Zone. Out of the total population of the woreda, 86300 or 94.2119% was rural whose livelihood was mainly based on subsistence agriculture and the remaining 5.788% was urban in 2007. The average annual growth rate of population between two national censuses was above 3%). On the basis of the data in the Socio-economic Profile of Wolaita Zone, crude density of Woreda population about 300p/ kilometer square respectively (WZSEP, 2010). However, there is great variation on high land and lowland areas, highland areas have high population pressure over land in woreda.

Table 2: Population Size and Density of Damot Woyde Woreda (2008-2014).

Year	Male Population	Female Population	Total Population	Total Area (km^2)	Density/ km^2
2008	46093	48088	94175	352	267.54
2009	47241	49347	96586	352	274.4
2010	48425	50636	99059	352	281.4
2011	49646	51950	101593	352	288.6
2012	50884	53283	104164	352	295.92
2013	52141	54635	106778	352	303.34
2014	53427	56012	109434	352	310.9

Source: Computed from CSA, 2007, WZSEP, 2004.

3.1.3.2 Age-Sex Composition

Age and sex structures are one of the basic demographic issues in examining population characteristics. These demographic variables have direct implications for several issues related to socio-economic aspects of a population such as trend of population growth, size of farmland holding, labor force, food supply, size of school age population and female population in the reproductive age. Therefore, any socio-economic development planning should take into account the age-sex composition of the population of a given area. Regarding the age structure of Damot Woyde woreda, it is more or less a reflection of the total country's age-structure. According to the statistics of 2007, people within the three age range groups: 0-14, 15-64 and above 64 constituted 48.39%, 49.338% and 2.269% of the entire population of the woreda respectively (CSA, 2007).

Table 3: Age-Sex Composition of Damot Woyde Woreda (2007)

Age group	Male size		Female size		Total	
	No	**% of males**	**No**	**% of females**	**No**	%
0-14 years	22407	49.9	21922	46.9	443290	48.39
15-64 years	21331	47.549	23864	51.06	45195	49.338
Above 64 years	1123	2.5	955	2.04	2078	2.269
Total	44861	100	46741	100	91602	100

Source: Computed from CSA, 2007

As Table 3 showes the three age groups are almost proportional in male and female populations. But the proportion of working age group (15-64 years) is slightly higher for female population (51.06%). This may be male population at working age group is migrating to different places i.e. state farm and others. The proportion of dependent population group is almost similar to the working population (i.e 49.338%). This indicates that the woreda has high proportion of children age group (48.39%), which is increasing in rapid rate. The overall Age Dependency Ratio for Damot Woyde woreda was found to be 100.2%, which means for every 100 working people there were, on the average, 102 dependents for their basic needs.

Concerning sex structure of the population of Damot Woyde, 48.97% was male population and 51.03% was female population in the year 2007 (CSA, 2007). This depicts that female population is a bit greater than male population in the woreda as a whole.

3.1.3.3 Fertility and mortality

The birth rate of Damot Woyde Woreda is high, women are getting married younger, having babies younger and abandoning traditional birth spacing practices. Now, the child health is improving and more children are surviving compared to the past unless there is severe malaria epidemic.

The rate of mortality is also relatively high in the woreda due to malaria infection and water born diseases in lowlands and nutritional deficiency as a whole. There slight disparity in the rates of mortality between rural and urban (WZSEP, 2010).

3.1.5 Educational Attainment

Education is a key factor for any development effort. Therefore, looking in to the educational background of the population in a given environment is the most significant element in the study of demographic and social characteristics of the people.

Educational attainment of the woreda is low. There is a wide disparity between male and female, and rural and urban literacy status. The respective literacy rates of males and females are 79% and 71.8% for the whole woreda. Urban and rural areas of the woreda have 95.4% and 75.9% of educational attainment respectively.

However, there is an improvement in the education coverage of woreda from time to time. The school population has steadily been increasing since 2009. Today, education coverage of primary and secondary levels in the woreda is 98% and 73% respectively.

Table4: Growth of school facilities (Damot Woyde, 2013).

Number of school facilities	2009	2010	2011	2013	2012	2013	2014
Primary schools	20	21	23	27	29	33	33
Secondary schools	1	1	1	2	2	2	2

Source: Damot Woyde Woreda Office of Education, 2014

3.1.7 Cropping Patterns

Farm sizes in Damot Woyde woreda are very small and the majority of farmers cultivate holdings much less than one hectare. However, farmers cultivate cereals and root crops in different forms of multiple cropping systems such as double cropping and intercropping.

The staple crops of the areas can be divided into three categories: *enset*, cereals and root crops. *Enset* is cultivated mostly in the densely populated *woina dega* areas where the climate is suitable for its production.

The major cereal in the areas is maize, which is the co-staple crop with *enset*, and together they form the basic diet of the population. Teff cultivation for home consumption is of minor importance in the area. It is cultivated for income generation in lowlands and midlands of the study areas. Other cereals that are cultivated only to a limited extent are barely in the highlands and sorghum in low lands. Sorghum is becoming more important in the lowlands due to its good productivity on poor soils and drought resistance compared to maize. Bean is the only legume crop that is cultivated in mixture (intercropping) or rotation with maize, particularly in the *woina dega* areas due to land scarcity.

Various types of root crops are grown, but the most important one are sweet potato, taro and cassava. Taro is a tropical plant cultivated for its starchy roots. It is grown in wetlands or planted to break new or fallow land for cultivation. Cultivation of long season crops like sorghum and taro less frequent in highlands because these crops take about a year to ripen for harvest, which does not allow farmers to practice double cropping. But recently, the new Taro (bereket its local name) now dominating the midland areas because it resists the current erratic and unpredictable rain of the area. Less important root crops include Irish potato and Yam (*Boye* in Wolaitigna), which is another typical crop for the area and grown only in the midlands. Cassava has become a more important food security crop in lowland area, like *enset* in highlands agro ecology, due to its drought resistance.

Concerning the cropping season, there are two seasons of cropping in the area: *Belg* and *Meher*. Crops like maize and *teff* are planted in only one of the two seasons while root crops like sweet potato can be cultivated in both seasons. *Teff* and wheat are usually cultivated in *Meher* season. Long season crops like maize, taro and yam are planted during the short rains and extend their growth into the main rains. Maize is planted in March and harvested in September, but sweet potato, *teff* and kidney bean are rarely intercropped under maize after maturity. *Meher* crops are planted in July and harvested in

October. The fields are generally occupied by taro, sweet potato, cassava and yam during the dry season, and there are no fallow periods particularly in the highlands. The system of sequential crop production continues from one season to the other throughout the years.

3.2. METHODOLOGY

3.2.1 Research design:

The researcher has used of both the qualitative and quantitative approaches. The mixing of the two is expected to enhance the overall strength of the study. To put it in a specific form, social survey design (cross sectional) was used as a research design and both qualitative and quantitative data collection method were employed.

3.2.2 Sample design and sampling size

Since the field involved in the study was not handled properly by the researcher considering the census survey method, the data analysis was taken by collecting information's regarding some, as far as possible, representative items, called the samples.

Damot Woyde Woredara is divided into 23 kebeles. Using stratified random sampling technique, the 23 kebeles were stratified into two agro climatic zones highland; *weynadega,* and low land; *Kola* encompassing two kebeles(one from each agro-ecology*).* *Tora sadebo* from the low land (*Kola* agro-ecology) and Kindo koyo from the highland (*Woynadega* agro-ecology) were selected for detailed of status of food security and roles of different factors so as to identify the predictions in order of importance.

From the two selected kebels, 10 % households were randomly selected from the lists of the households of the two kebels. Each kebele was shared proportionate sample size (probability proportion) based on number of household. Accordingly, Tora sadebo and Kindo koyo have 460 and 710 household heads respectively; and from each kebele 46 and 71 sample size of household heads were selected.

Table 5: sample size by kebele

Kebeles	Population	Sample size	Percent
Kindo koyo	710	71	60.7%
Tora sadebo	460	46	39.3%

For key informant interviews, six household heads (HHs) were selected (3 HHs from each *kebele*). The purpose of the interview was to explore climate change/variability and its impacts, and their responses. Interview was also held with experts: two government officials from Woreda and one from zone representative in order to get relevant and reliable information.

In addition to these, two group discussions consisting of 20 persons at *kebele* level (one FGD from each agro-ecology) were conducted. One group discussion consisting 10 individuals was conducted at *Kola Kebel* and the second group discussion was conducted at *Woynadega kebele* that also consisting 10 persons. The individuals who were participated in the FGD were knowledgeable, and fairly represent and reflect the opinion of the community at large.

3.2.3 Data source and data collection method

3.2.3.1 Data sources

The required input data for this study were generated from both primary and secondary sources. Primary sources include the administering of questionnaires to three groups of selected interviewees (sample households, key informants and FGD members).

On the other hand, secondary data were generated by reviewing different relevant literature from books, research works, journals, published and unpublished documents, different activity reports of government and non-government institutions, and available rainfall and temperature records of NMA.

3.2.3.2 Data Collection Instruments and Data Collection

Data collection

"Using both qualitative and quantitative approaches together yields more than the sum of two approaches used independently" (Creswell, 2009). The mix of the two research approaches has paramount importance because either of them is not sufficient. Hence, both quantitative and qualitative research methods were integrated for this study for both data collection and analysis.

Structured household survey: household survey is the commonly used approach in various data collection activities. The structured household survey was mainly used to collect quantitative data. The survey was conducted on the selected 10% of households from total population. It was handled by four development agents; two from each kebele of the respective kebeles after taking appropriate training. One day training was organized and orientation also was given for the two enumerators. The preference to use DAs to collect data was based on the fact that:

- they do have a list of households of each category that could be included in the survey;
- they are more familiar with the community hence communication and getting reliable data would be easier;
- they may have rich experience of similar data collection and surveying;
- they do have knowledge and experience on the subject matter and can easily understand the questionnaires and;
- they have training background in area of agriculture;

While the enumerators handling the survey, the researcher was supervising the enumerators, and side-by-side conducting in-depth interviews with the selected households.

Interviews: Individual in-depth interview was used to collect qualitative data and it was conducted on a one-to-one basis between a respondent and the interviewer. Interviews were made on six households (men and women) and three government officials. The purposes of conducting interviews were to triangulate the household survey.

Plate3: Interview Being Conducted with Zone officer

Focus group discussion: It helps to generate data on group dynamics, and allows a small group of respondents guided by a skilled moderator, to focus on key issue of the research topic. The focus group discussions were held with a few knowledgeable elderly individuals of the communities and development agents. At each agro-ecology, one focus group discussion was held with the community. In food security assessments the focus was on all topics related directly or indirectly to availability, access and utilization of food in relation to climate change.

Plate4: FGD Being Conducted at Kindo Koyo (a) and Tora sadebo (b) kebeles

Observation: Observation was made as supportive or supplementary technique to collect data that can complement or set in perspective the data obtained by other means. During the researcher's stay in the study area, he was able to observe various environmental changes. The researcher observed changes in agro-ecology, vegetation covers, and other topographic features.

Document review: various documents available at *zonal* and *wereda* level were reviewed and used to generate secondary data. Census reports, CSA sampled production data for different years; activity progress, climate distribution, and economic information were reviewed and used to supplement the primary data.

3.2.4 Method of data analysis

Household food balance model (HFBM) and Household food insecurity access scale (HFIAS) were used.

3.2.4.1 Household Food Balance Model (HFBM)

The net available food for the households was computed using a modified form of a simple equation known as Household Food Balance Model, originally adapted by Degefa (1996) from FAO Regional Food Balance Model and then used by different researchers. The quantity of food was calculated and converted into dietary calorie equivalent based on Ethiopian Health and Nutrition Research Institute food composition table. Then the food supply at a household level was calculated by dividing a total number of days per year (365) and adult equivalent value for each sampled households was used to calculate calories available per adult equivalent per day for each household.

According to FDRE FSS (1996), 2100 kilo calories per person per day is used as a measure of minimum calories required per adult equivalent per day (i.e., demand) to enable an adult to live a healthy and moderately active life. The output of the HFBM, comparison between calories available and calories demanded by a household was made to determine the food security status of a household.

A household whose daily per capita caloric available (supply) was less than his/her demand was regarded as food insecure and household who did not experience a calorie deficit during the year under study was regarded as food secure.

NGAi = (GPi + GBi + GRi + GPSi) - (HLi+ GSi + MOi +GGi+NSi)

Where, **NGAi**= Net grain available/year/household

GPi= Total grain produced/year/household

GPi= Total grain bought/year/household

GRi= Total Grain obtained from remittance /year/household

GPSi= Total grain obtained through previous stock/year/household

HLi= Post harvest losses/year household

GSi=Quantity of grain reserved for seed/year/household

MOi=Amount of marketed output /year/household

GGi=Grain given to others as a gift within a year/household

NSi=grain planned to be left by a household for next season/year/household

In this model, the index i run from 1, 2………….100

Except post harvest losses, all the data needed for HFBM were collected from the primary data from household survey. However, the rest post harvest losses data was obtained from secondary data. Wolaita zone Agricultural department and from previous study made using HFBM an average post-harvest crop loss during the year under investigation is estimated at an average value of 10% of the total production of each crop.

3.2.4.2. Household Food Insecurity Access Model (HFIAS)

The second model that was used to identify household's food accessibility is HFIAS which was adopted by the researcher from food and technical assistance project (FANTA) of USAID. The information generated by the HFIAS was used to assess the prevalence of household food insecurity (access) (e.g., for geographic targeting) and to identify changes in the household food insecurity (access) situation of a population over time (e.g. for monitoring and evaluation) (Coates et al., 2007).

Each of the nine generic questions was asked with a recall period of four weeks (one month). The first question to the respondent was an occurrence question- that is, whether the condition in the question happened at all in the past four weeks (yes or no). If the respondent answers "yes" to an occurrence question, a frequency-of-occurrence question was asked to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often (more than ten times) in the past four weeks. These questionnaires represent a generally increasing level of severity of food insecurity (access).

Some of the nine occurrence questions inquire about the respondents' perceptions of food vulnerability or stress (e.g., did you worry that your household would not have enough food?) and others ask about the respondents' behavioral responses to insecurity (e.g., did you or any household member have to eat fewer meals in a day because there was not enough food?). The questions address the situation of all household members and do not distinguish adults from children or adolescents. All of the occurrence questions ask whether the respondent or other household members either feel a certain way or perform a particular behavior over the previous four weeks.

Four types of indicators were calculated to help understand the characteristics of and changes in household food insecurity (access) in the surveyed household: Household

Food Insecurity Access-related Conditions, Household Food Insecurity Access-related Domains, Household Food Insecurity Access Scale Score, and Household Food Insecurity Access Prevalence (Coates et al., 2007).

The researcher also used descriptive statistics to analyze household's perception of food security and climate change/variability, and utilization of food in face of climate change. After the necessary information and data were collected and generated, the researcher employed different statistical methods and tools to analyze and present the data collected side by side with qualitative summarization and discussion. The information obtained from key informant interview, focus group discussion and direct observation were analyzed using qualitatively by narrative description. The quantitative data were analyzed by the use of statistical software known as SPSS and Microsoft excel.

Analysis of the rainfall data involved characterizing long-term mean values, and calculation of indices of variability and trends, at seasonal and annual time steps. The Precipitation Concentration Index (PCI) was used as statistical descriptor of rainfall variability and cofficient of variation was also used. The PCI values were calculated as given by Oliver (1980 cited in Woldeamlak , 2009); $PCI = 100*[\Sigma Pi^2 / (\Sigma Pi)^2]$ **:**

Where ***Pi*** is the rainfall amount of the ith month; and ***Σ*** = summation over the 12 months. According to Oliver (1980), PCI values of less than 10 indicate uniform monthly distribution of rainfall, values between 11 and 20 indicate high concentration, and values of 21 and above indicate very high concentration.

Standardized anomalies of rainfall was also calculated and used to assess frequency and severity of droughts in the study area. Temperature anomalies are calculated to examine the year to year temperature differences and the result is displayed using different figures.

The climatic classification of each agro-ecology based on Thorthwaits second classification was made to see the moisture conditions and climate types of study area on different agro-ecology (highland and lowland).

Thornthwaite method of computation of potential evapo-transpiration as a function of temperature alone (Hare. F, 1951):

$$e = 1.6(10t/I)^{a}$$

Where e= 30-day evapo-transpiration (for 12-hour days) in centimeters

t= mean monthly temperature in degree c^0

a= an arbitrary constant varying from place to place

$I = \sum^{12} (t/5)^{1.514'}$ the sigmoid indicates summation over the 12 months

$$\mathbf{a = 0.49239 + (1792 * 10^{-5})\, I - (771 * 10^{-7})\, I^2 - (675 * 10^{-9})\, I^3}$$

The moisture index

1/ at certain times of a year the rainfall r exceeds the water need n; there is hence a surplus of available water and the climate is humid**.** **$s = r - n > 0$**

A humidity index can be defined as follows: **$I_h = 100s/n$** which expresses the surplus as a percentage fraction of the water need.

2/ In the other months the rainfall may very well be less than the water need, and there is a deficit and the climate is arid**.** **$d = n - r > 0$**

An aridity index comparable with the humidity index defined above is **$Ia = 100d/n$**

3/ The moisture index I_m is the difference between I_h and I_a, since, however, deep-rooted perennial plants may be able at times of drought to draw upon subsoil moisture. A surplus at one season may be able to compensate for a somewhat large deficit in others. The moisture index value indicates climatic types as given below:

Table 6: Moisture index value indicating climatic types

Climatic type	Moisture index
A Perhumid	>100
B_4 Humid	80-100
B_2 humid	60-80
B_2 Humid	40-60
B_1 Humid	20-40
C_2 Moist sub-humid	0-20
C_1 Dry sub-humid	-20 to 0
D Semi arid	-40 to -20
E Arid	-60 to -40

3.3 Ethical Considerations

Household questionnaire survey respondents, focus group discussants and key informants were properly asked for their voluntariness to participate in research process. This was done by informing the objectives and outcomes of the study. More than this they were informed as their information is kept confidentially that, unless group summaries, individual's personal information is neither exposed nor given to any third party. This was brightly written on the forward part of household survey questionnaire sheet and forwarded by enumerators. For focus group discussants and key informants the researcher himself has verbally forwarded.

CHAPTER FOUR

4. RESULTS AND DISSCUSION

This chapter presents the findings of the study based on the data obtained on various facet of the sampled households, and historical rainfall and temperature records of the study area. Five main subsections are discussed under the main chapter. The first subsection deals with the pattern of local climate (The annual and seasonal rainfall, and temperature trends) and moisture condition of the study area are discussed in detail. The second sub-section is about the demographic and socio-economic profile of the sampled household that it associated with food security status of respondent. The third sub-section is concerning perception of HHHs on the local impact of climate variability/change (on the production of crops and livestock) and the overall impact of climate variability/change on the food security of the study area is discussed. The fourth sub-section is identifying the HHHs food security status using HFBM and HFIAS, and also food utilization aspect of HHHs is treated under this section. The fifth subsection of the data analysis part discusses about the households' adaptation to climate variability/change and the major constraints of the adaptation strategies in the study area.

4.1. Trends of temperature and rainfall so as to establish the change/variability of climate and moisture conditions in the area.

The researcher planned to detect at climate change (temperature and rainfall) in addition to climate variability. The 31 years rainfall and temperature data was taken from NMA to see the change in rainfall and temperature pattern but the data from 1975-1986 was invalid (no record of rain). Due to this throughout this presentation the researcher detect the variability of rainfall rather than change. The second variable to detect climate change is the temperature data that it is not found in the Beddessa meteorological station. Thus, I took the temperature data of Billate meteorological station, it was part of Damot woyde woreda befor the 2006 administrative readjustment of Wolaita zone and is very close and has similar natural condition, that its data is of 28 years from 1985-2013. And also based on the meteorological data of temperature of Billate station it is impossible to compute climate change (temperature) because the available data is less than 30 years. This also dictates to compute only temperature variability rather than change. Therefore, both rainfall and temperature data were computed to see the variability throughout the discussion.

And the presentation below considers some limitations that the temperature data were taken from Boditi and Billate meteorological station to represent the highlands and lowlands temperature condition of the study area respectively. The elevation of Boditi meteorological station and highlands agro-ecology of study areas are 2043 and 2003 respectively; that is almost the same, and the difference of long term mean annual RF of the Beddesa and Boditi meteorological stations is only about 10cm. Both temperature and RF data to compute climatic condition of lowland agro-ecology were from Billate meteorological station. As it has been mentioned above Billate area is very close to the study woreda and has very similar setting with lowland agro-ecology of Damot Woyde Woreda

Therefore, using the meteorological data of both stations to represent my study area is fitting due to the reason given above of course with some limitations

4.1.1. Rainfall: Amounts, trends, variability and seasonal concentration

The long-term (1987-2013) annual average rainfall at Beddesa Meteorological Station (located in Beddesa *Woreda*) is computed to be about 1116.8mm. The annual total rainfall is somehow increasing over years in the area. The anomalous year is 1999 when the total annual rainfall was only about 711.9 mm. The maximum annual total rainfall occurred in 1997 (i.e. 1462.5mm). Generally, highland parts of the *Woreda* receives sufficient amount of total annual rainfall in view of the characteristics of most Ethiopian highlands. The long term annual average RF at Billate station is 804.1mm; the amount of total RF is also increasing in this station. At this juncture, one can raise a question in relation to rainfall which is the critical problem in this *woreda*. The problem is the amount and variability of rain in lowland areas and not the amount rather the temporal variability in highland areas.

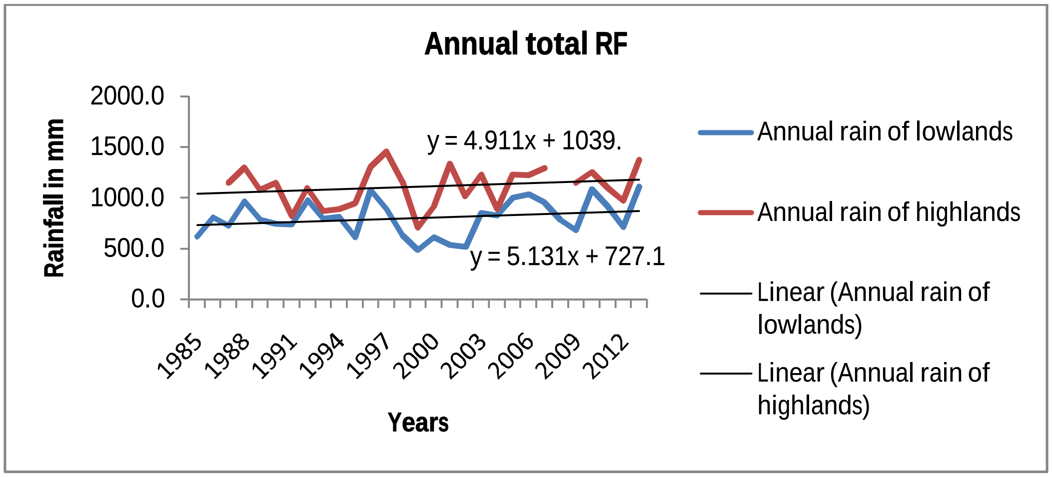

Figure 6: Long-term annual total rainfall

Source: Computed based on the raw data obtained from NMA)

As indicated in Figure 6, the general trend of rainfall in both stations in the study area is increasing over years. The solid linear line in the figure 7 indicates an increasing annual total rainfall. Starting from 1987 up to 2013 rainfall amount increased at about 127.686mm; or it has been increasing 4.911mm per year in Bedddessa meteorological station. The rainfall amount in Billate station also increased at about 143.668mm over the observation years. Since water is one of the crucial resources, this could be an opportunity for the overall agricultural (both crops and livestock sub-sectors) development, and an important input for the existing water resources in the area, whether it is underground or surface water. In fact, one can perceive the increasing trends of rainfall as an adversity so that this may increase the current soil erosion.

One can see from Figure 6 the rainfall condition is slightly affected by annual total rainfall variability. The coefficients of variations of Bedessa and Billate stations are computed to be 0.17 and 0.217 respectively; indicating a slight inter-annual total rainfall variation in Damot Woyde *Woreda*. This indicated that the rainfall is below the average and in other year above the average. As confirmed by FGD and KII participants (held in February 2013), the rainfall variability has been affecting crops and livestock production.

The long-term annual total rainfall is about 1116.8mm of Bedessa station which is an indication of the adequacy of rainfall amounts for agricultural practices. This is more or less better than compared with most areas in Ethiopia. For instance, Messay (2012) has computed the long-term total annual rainfall for the *woredas* in Arsi Zone and found to be around 1000mm. According to Messay (2012), Ziway-Dugda and Sire *Woredas*, in particular, receive very small amount of rainfall over the observation periods as compared to other highland parts of the country. But the long term annual total rainfall of Billate station is 804.1mm, is by far lower than Bedessa station, which shows inadequacy of rainfall for different purposes including agricultural practices.

Table 7: Computation of PCI for Damot Woyde *Woreda of Bedessa and Billate stations*

Bedessa station			**Billate station**	
Months	Long term mean Monthly rainfall in mm (pi)	Pi^2	Long term mean Monthly rainfall in mm (pi)	Pi^2
January	39.8	1586.49	29.62	877.39
February	35.9	1289.362	32.28	1042.177
March	90.8	8248.831	55.5	307987
April	165.8	27503.67	117.28	13754.4
May	164.5	27064.05	104.32	10882.8
June	120.3	14481.35	74.39	5534.3
July	120.1	14415.7	95.26	9074.2
August	118.0	13914.02	75.99	5774.95
September	89.0	7919.631	68.48	4688.9
October	102.6	10530.71	82.96	6865.55
November	45.1	2032.623	43.8	1918.7
December	24.8	614.2772	24.29	589.82

$\sum pi=1116.8$ $(\sum pi^2)$ =129600.7 $\sum pi=804.069$ $(\sum pi^2)$=64083.22

$(\sum Pi)^2$ =1247148 $(\sum Pi)^2$=646526.9

PCI=129600.7/1247148 PCI=64083.22/646526.9

=0.103918(10.4%) 0.099119(0.991192%)

Source: Computed based on the raw data obtained from NMA

The Precipitation Concentration Index (PCI) values for the Beddessa and Billate stations of the study *woreda are* about 0.103918 (10.4 %) and 0.099(0.99%). According to Oliver (1980) as cited in Woldeamlak (2009), values of PCI less than 10 indicate uniform monthly distribution while values between 11 and 20 signify high rainfall concentration. PCI values greater than 20 represent very high concentration of the attribute. Accordingly, rainfall patterns in this area is said to be uniformly distributed. Summer rainfall share of Bedessa station about 32.1% of the total annual rainfall received, and spring rain fall is 37.7%. Only about 21.13% and 9% is received in autumn and winter respectively.

Summer rainfall share of Billate station is about 30.45% of the total annual rainfall received, and spring rain fall is 34.46%. Only about 24.26% and 10.72% is received in autumn and winter respectively (table 8).

Table 8: Seasonal distribution of rainfall at Beddesa and Billate Meteorological Station

	Beddessa ststion		**Billate station**	
Season	Long-term total seasonal rain fall in mm	Percentage distributionof the rainfall	Long-term total seasonal rain fall in mm	Percentage distribution of the rainfall
Summer	358.4	32.1%	245.6	30.54%
Autumn	236.7	21.13%	195.1	24.26%
Winter	100.5	9%	86.2	10.72%
Spring	421.1	37.7%	277.1	34.46%
Total	1116.8	100%	804.1	100%

Source: Computed based on the raw data obtained from NMA

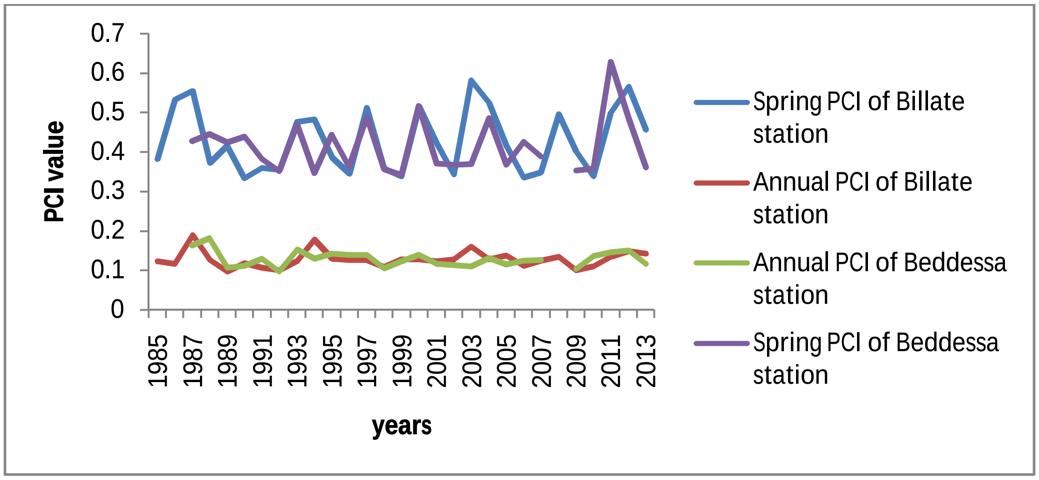

Fig 7: Annual and spring season precipitation concentration index

Source: Own computation using the rainfall data of Woreda from NMA

As illustrated above figure the concentration of spring season rainfall in both stations is increasing over the observation years (1985-2013). And concentration of annual rainfall of Beddessa station is also increasing. This result is similar with the study carried out in Arsi negele Woreda that the annual and seasonal rainfall concentration of the study area is increasing (Abebe, 2013). But the concentration of annual rainfall of Billate station is decreasing.

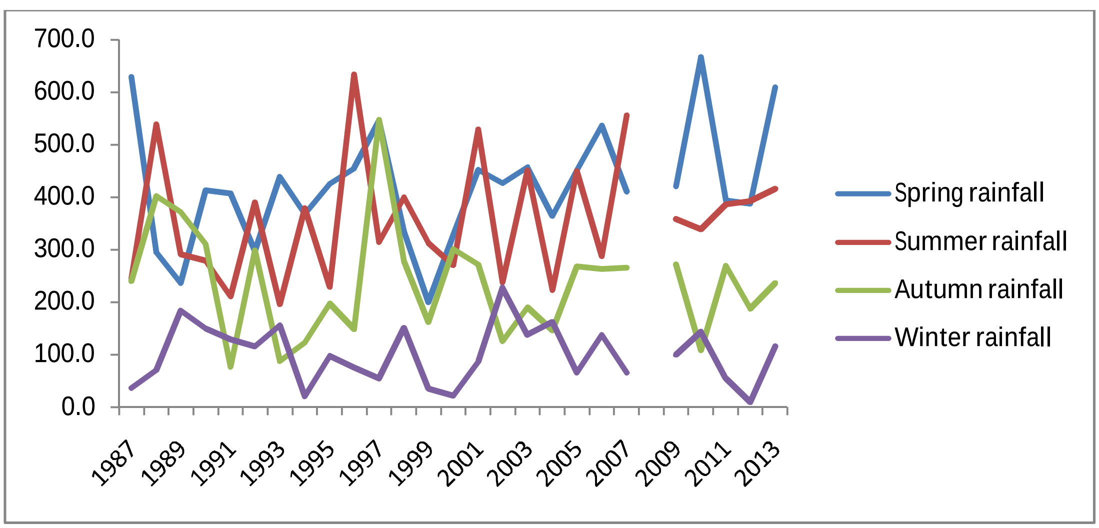

Figure8: Seasonal distribution of rainfall at Beddesa Meteorological Station (1987-2013)

Source: Computed based on the raw data obtained from NMA

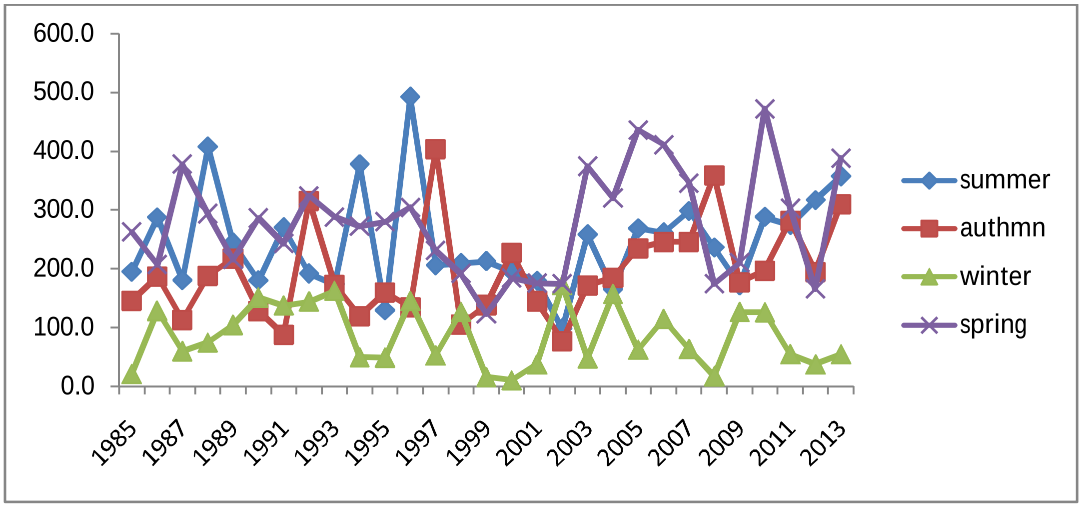

Figure 9: Seasonal distribution of rainfall at Billate Meteorological Station (1985-2013)

Source: Computed based on the raw data obtained from NMA

As illustrated in Figure 8 and 9, the amount of rainfall during all seasons of both stations is variable except winter. Of all the four seasons, spring rain, which is main production season in Wolaita area, is the most variable compared to others. The mean total spring rain of Beddessa and Billate stations ranges between 66.7mm to 209.7mm and 41.1mm to 157.4mm respectively. These indicate variability of spring rain in the study area. This fact has been confirmed by the FGD and KII participants (held in February 2014) in which sometimes the spring rain becomes unnecessarily brings heavy rain and hinder sowing of seeds and also preparation of land for the next important production season (summer season). It occasionally becomes minimal to prepare and plant long-term crops like sorghum and maize. Sometimes, it rains few days and quickly ends after the farmers sow some amount of long-term crops. In this case the farmers may lose their seeds owing to the unpredictable/unreliable nature of the spring rains in the area. Though this fact is true, FGD discussants stressed on the problems of commencement and termination of spring rainfall that mainly affect the agricultural production of the study area.

Standardized anomalies of rainfall was also calculated and used to assess frequency and severity of drought and flood in the study area. The formula that is used to calculate the standardized anomalies of rainfall as in Agnew and Chappel (1999) cited in (Woldeamlak, 2009)

S = [Pt - Pm]/ σ

Where, *S* = standardized rainfall anomaly.

Pt = annual rainfall in year *t*.

Pm = long-term mean annual rainfall, over a given period of observation.

σ = standard deviation of rainfall over the period of observation.

The drought severity classes are ***extreme drought (S < -1.65), severe drought (-1.28 > S > -1.65), moderate drought (-0.84 > S > -1.28), and no drought (S > -0.84).*** Accordingly the standardized rainfall anomaly of the study area was calculated and the result is presented as follow in figure.

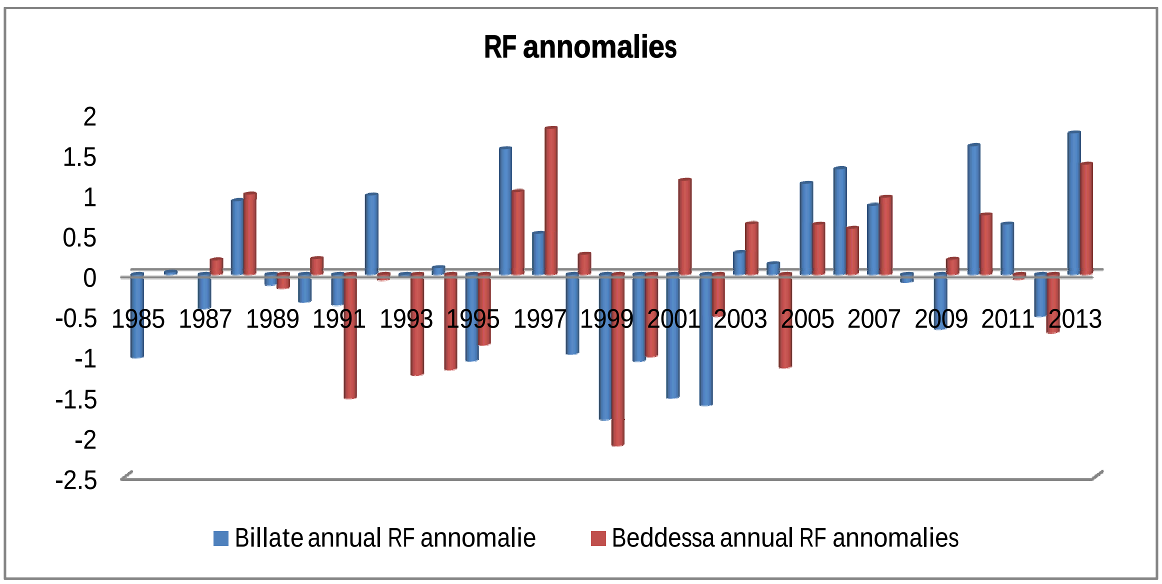

Figure 10: Standardized Rainfall Anomaly of Damot Woyde woreda.

Source: Own computation using the rainfall data of Woreda from NMA

The result of standardized anomalies of rainfall indicated in the above figure of Beddessa station indicates that there was extreme and severe drought in the study area over the observation years. The very wettest years of highlands agro-ecology within the time range indicated were year 1988, 1996,1997,2001,2007 and 2013. The driest years were 1991,1993,1994,1999, 2000, and 2004. The year 1999 is under the category of extreme drought in both agro- ecology and was also mentioned in the FGD that farmers of study area suffered severe food insecurity problem in the Woreda. This anomalies clearly indicates that how it can affect the production of crops and animals.

Standardized anomalies of rainfall of Billate station are also indicating the extreme and severe drought in the lowland agro-ecology. The wettest years were 1988, 1992, 1996, 2005, 2006, 2010 and 2013. The driest years were 1985, 1995, 1998, 1999, 2000, 2001, and 2002. As it can be understood from above figure drought in lowland agro-ecology is frequently happening than highland agro-ecology. The frequent drought together with low amount of rainfall can highly affect the agricultural activities in the lowland agro-ecology.

4.1.2. Temperature: Trends and seasonal variability

Due to climate change/variability, the overall temperature in Ethiopia is showing an increasing trend. At a country level, both the annual minimum and maximum temperature have shown a considerable increase in the last five decades. Between1961-1990, average minimum and maximum temperature has increased by 0.25 ^{0}c and 0.1 ^{0}c at every ten years respectively (NMA, 2001).

As mentioned in NMA (2001) the year to year variation of annual minimum temperatures within Ethiopia for the period 1951 to 2005 was expressed in terms of temperature differences from the mean and averaged over 40 stations. The result showed that, the country has experienced both warm and cool years over the last 54 years. However, the recent years are the warmest compared to the early years. Moreover, the result clearly revealed that there has been a warming trend in the annual minimum temperature over the past 54 years. It has been increasing by about 0.37 0C every ten years.

As indicated in Figure 11, the average annual temperature of both highland and lowland areas is increasing over years similar to the empirical findings in the country (NMA, 2001). Similarly the distribution pattern and trend of temperature of the study area was characterized by general trends of increase and clear inter annual variability.

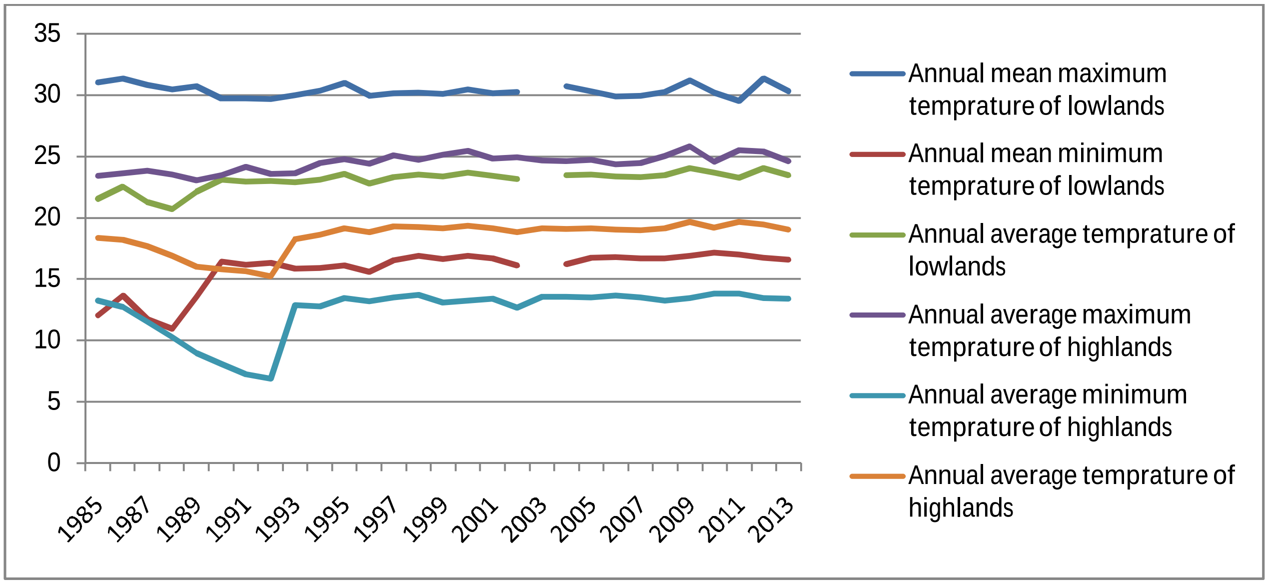

Fig 11: Trends of annual mean maximum and minimum temperature of Damot Woyde Woreda from 1985-2013.

Source: NMA and own computation

The above figure shows that the general trend both the annual average temperature of the study area is increasing with inter-annual variability. The annual average temperature of highlands and lowlands area is increasing and decreasing respectively. However, the trend of the minimum temperature is consistently increasing as compared to the maximum temperature of lowland areas which shows high inter-annual variability. All the three (the maximum, minimum and average temperature) in highland area are increasing. In order to show the deviation of the annual maximum and minimum temperature from their long term mean value; the maximum and minimum temperature anomalies were calculated. A positive temperature anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value. Accordingly the deviation of maximum and minimum temperature of the study area from the mean maximum and mean minimum temperature is calculated and presented in the following figure 11 and 12.

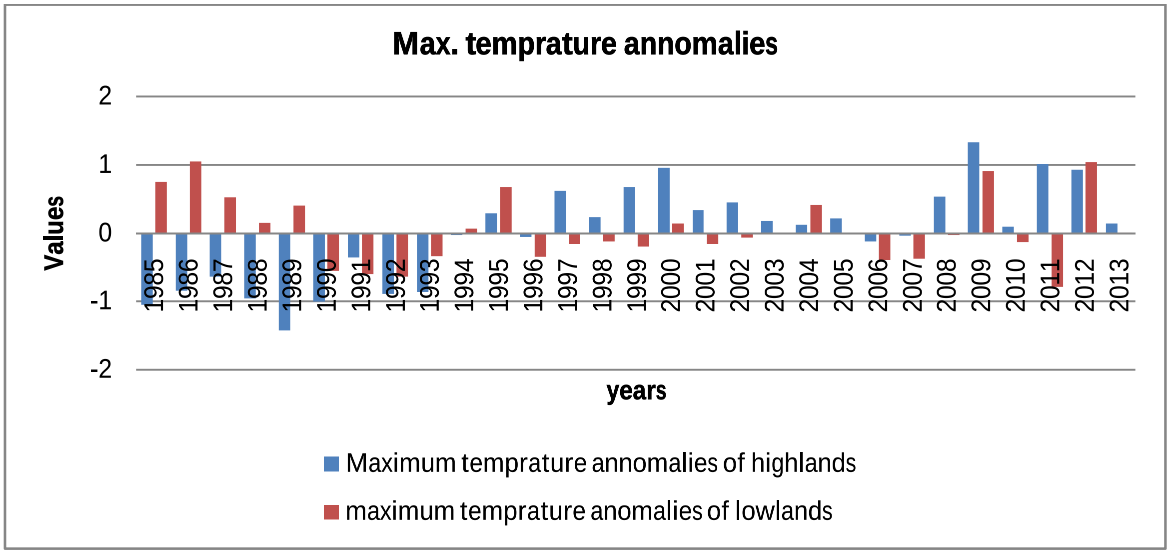

Figure12: Maximum Temperature Anomalies of Damot woyde Woreda.

Source: NMA and own computation

As the above figure shows the maximum temperature of the study area is deviating from the mean and it is rising and falling one year to another. As compared to the minimum temperature deviation, the maximum temperature shows high inter-annual fluctuation from the long term mean value. Except some fluctuation, the maximum temperature of the study area is decreasing and increasing trend of lowlands and highlands respectively from year to year during the observation years.

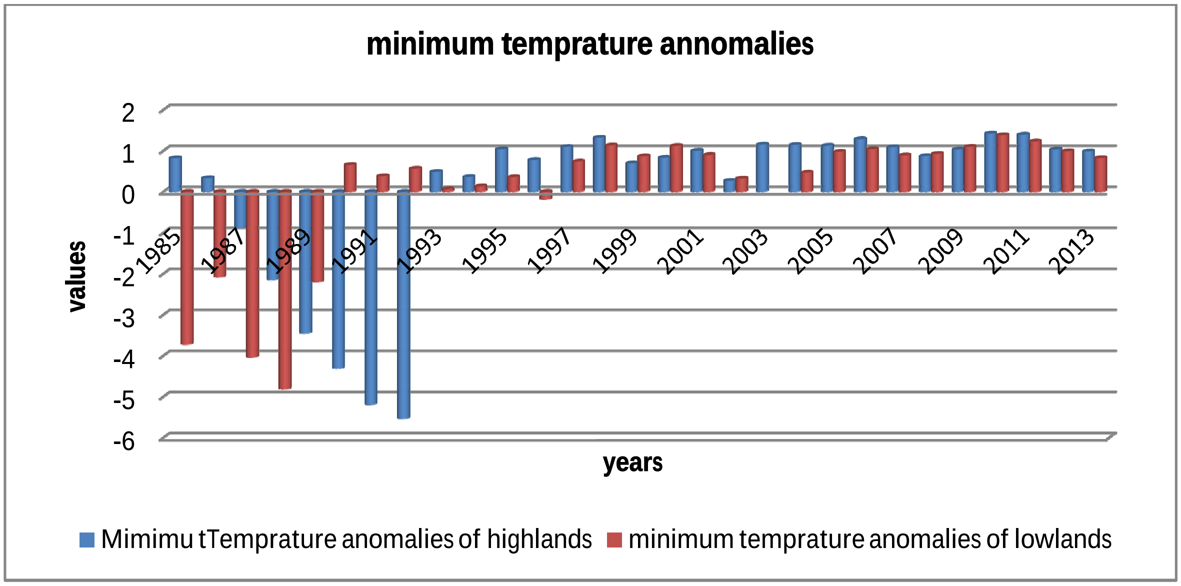

Figure 13: Minimum Temperature Anomalies of Damot woyde Woreda.

Source: NMA and own computation

The figure 13 shows that the minimum temperature of the study area is deviating from the mean minimum temperature over the observation year (increasing trend). In general the maximum and minimum temperature anomalies of the study area indicate that if the temperature is extremely deviate from the long run mean temperature(towards positive or negative side), it has negative impact on food production Activities.

4.1.3. Moisture conditions and climatic types of the study woreda

Hare F. (1951) gave expression on the work of Thornthwaite second climate classification; that it is important and refined way of examining the moisture condition of areas on the surface. And, also it is the best way of classifying climatic type of an area. Thornthwaite method of computation of potential evapo-transpiration as a function of temperature alone:

$$e= 1.6(10t/I)^{a}$$

Where e= 30-day evapo-transpiration (for 12-hour days) in centimeters

t= mean monthly temperature in ^{0}c

a= an arbitrary constant varying from place to place

$I= \sum^{12} (t/5)^{1.514'}$ the sigmoid indicates summation over the 12 months

$$\mathbf{a= 0.49239+ (1792*10^{-5})\, I – (771*10^{-7})\, I^2 – (675*10^{-9})\, I^3}$$

The moisture index

1/ at certain times of a year the rainfall r exceeds the water need n; there is hence a surplus of available water and the climate is humid**.** **s= r-n**

A humidity index can be defined as follows: $\mathbf{I_h=100s/n}$ which expresses the surplus as a percentage fraction of the water need.

2/ In the other months the rainfall my very well be less than the water need, and there is a deficit and the climate is arid**.** **d= n-r**

An aridity index comparable with the humidity index defined above is **Ia =100d/n**

3/ The moisture index I_m is the difference between I_h and I_a, since, however, deep-rooted perennial plants may be able at times of drought to draw upon subsoil moisture. A surplus at one season may be able to compensate for a somewhat large deficit in others. The moisture index indicates different climatic types see (Table 6)

4.1.3.1. Climatic type and moisture condition of highland agro-ecology of study Woreda

TERMS

Ie- Monthly heat index

PET/e- potential evapo-transpiration

CPET- corrected potential evapo-transpiration

C/factor-correction factor

R- rain

SMR- soil moisture recharge

SMU- soil moisture utlisation

SMS- soil moisture status

AET- Actual evapo-transpiration

Table 9: moisture condition of highland areas

Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**SUM**
Temp	19.2	20.1	20.2	19.4	18.7	17.5	16.5	16.7	17.7	18.2	18.5	18.6	
Rain in cm	3.98	3.59	9.08	16.56	16.45	12.03	12.01	11.8	8.9	10.26	4.5	2.58	
Ie	7.7	8.1	8.2	7.8	7.4	6.8	6.1	6.2	6.8	7.1	7.2	7.3	
e/PET	7.3	7.9	7.9	7.4	6.9	6.1	5.4	5.6	6.3	6.6	6.7	6.9	
C/factor	0.97	0.98	1	1.02	1.03	1.04	1.02	1.01	1	0.99	0.98	0.97	
CPET	7.13	7.81	7.99	7.55	7.17	6.35	5.59	5.68	6.27	6.56	6.62	6.7	81.42
R-CPET	-3.2	-4.1	1.09	9.03	9.28	5.68	6.42	6.13	2.63	3.7	-2.11	-4.2	
SMU	3.1	0.52									2.11	4.22	
SMR			1.09	8.91									
SMS	0.52	0.00	1.09	10.00	10	10	10	10	10	10	7.89	3.67	
AET	7.13	4.11	7.99	7.55	7.17	6.35	5.59	5.68	6.27	6.56	6.62	6.7	
S				0.12	9.28	5.68	6.42	6.13	2.63	3.7			33.96
D	3.7												3.7

Source: NMA and own computation

$S=\sum(r-n) = 33.96$ $D=\sum (n-r) = 3.7$

$I_h = 100*s/n = 100*33.96/81.42$ $I_a = 100d/n = 100* 3.7/81.42$

$=42.7$ $=4.54$

Moisture Index (Im) = $I_h - I_a = 42.7 - 4.54 = 38.16$

- ❖ Climate type of highland agro-ecology of the study area is moist Humid B_1 type of Thornthwaites second classification see (Table 9)

4.1.3.2. Climate type and moisture condition of low land agro-ecology of study woreda

Table 10: Moisture conditions of lowland agro-ecology

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
Temp	24.1	24.7	24.7	23.6	22.6	22.1	21.6	21.9	22.3	22.6	22.8	23.5	
RF cm	2.96	3.23	5.6	11.73	10.4	7.45	9.53	7.6	6.85	8.3	4.38	2.43	
ie	10.8	11.2	11.2	10.5	9.84	9.48	9.16	9.35	9.65	9.85	9.98	10.4	
e/RPET	10.1	10.8	10.8	9.6	8.6	8.0	7.5	7.83	8.3	8.6	8.78	9.53	
C/factor	0.97	0.98	1	0.97	0.96	0.95	0.96	0.97	0.98	0.99	0.98	0.97	
CPET	10.21	11.07	11.23	10.11	9.19	8.70	7.96	8.32	8.63	8.82	8.97	9.67	112.9
R-CPET	-7.25	-7.84	-5.68	1.62	1.21	-1.25	1.57	-0.72	-1.78	-0.92	-4.59	-7.24	
SMR				1.62	2.11		1.57						
SMU						1.25		0.72	1.78	0.65			
SMS				1.62	2.83	1.58	3.15	2.43	0.65				
AET	2.96	3.23	5.54	10.11	9.19	8.70	7.96	8.32	8.64	8.55	4.38	2.43	
S													0.00
D	6.98	7.46	5.29									6.25	32.87

Source: NMA and own computation

d=∑ (n – r) = 32.87

n=112.9

I_a =100*D/n =100*32.87/112.9

=29.1%

s= =∑ (r – n) = 0

n= 112.9

I_h=100*s/n=100*0/112.9

=0

Moisture index (Im) = I_h –I_a

=0-29.1

= -29.1%

- Climate type of lowland agro-ecology of the study area is semi-arid D type of Thornthwaits second classification (see table 10).

4.2. Demographic and socio-economic characteristics of respondents

4.2.1 Demographic Characteristics of Sample Households Heads

4.2.1.1 Sex and Age of Household

Out of the sampled households 85.5% of the households are male headed and the remaining 14.5% are female-headed households. Sex of household is important variable for determining food security status of household. It is hypothesized that female headed households are more food insecure than male headed households. This is due to the fact that female headed households are usually constrained by resources. They are mostly deprived in terms of resources endowment like land, capital and labor. Mostly they share crops their land to men farmers due to labor shortage.

However, the chi-square test was made to see if there is significant difference in food (in) security between male and female headed household and the result shows that there is no significant difference in food security situation between female headed and male-headed households that the Chi-Square value 0.097, $P > 0.05$. This may be due to number of male households are by far greater than female headed households.

Age of the household is also regarded as an important variable with an impact on household food security status; i.e. older households are usually better than younger households in terms of resources endowments. Thus it was hypothesized that younger households are more food insecure than older households. The chi-square test was run to test this hypothesis and the result shows that there is a statistical difference between age and food security status; chi-square value 15.22, $p<0.05$. That is younger households are more food insecure than older households due to variation in resource ownership i.e. land.

4.2.1.2. Household's Marital and Educational Status

From the total headed households 89.7% are married, 0.9%, 0.9 % and 8.5% are single, divorce and widowed respectively. And there is no statistical systematic difference between food (in) secured and marital status of households that the chi-square value 2.877, $P>0.05$. This result may be almost all House hold heads are married and the other sections are very few in number.

Concerning education, majority of households included in the study area have not attained basic education (85.5%). However 46.5% of respondents do not write and read. Those who can read and write are about 48.7%.and the remaining 6% and 8.5% of the respondents are attained primary and secondary level education.

Table11: Chi-square test of educational status and food security

Chi-Square Tests				
Kebele of respondents		Value	Df	Asymp. Sig. (2-sided)
Kindo koyo	Pearson Chi-Square	13.796[a]	3	.003
	Likelihood Ratio	13.538	3	.004
	N of Valid Cases	71		
Tora sadebo	Pearson Chi-Square	6.377[b]	3	.095
	Likelihood Ratio	7.882	3	.049
	N of Valid Cases	46		

Source: Own field survey, 2014

Literacy level of the household head is also an important variable mostly assumed to have impact on food security status of the household. Thus, it was hypothesized that households which are headed by relatively more educated households are in better position in terms of food security than whose heads are illiterate. This is because more educated households adopt new technology and farm practices faster, which in turn enhance agricultural productivity. But, when we see the relationship between the status foods security on different agro-ecological base the kolla agro ecology has no statistically systematic difference between food security and education status. This is due to the fact that the extension service is very weak there compared to dega agro-ecology. This idea was reflected by FGD in the sample kebele of kolla agro-ecology that it is Tora sadebo (Table 11).

Chi-Square test was run to know if there is a systematic relationship between educational status and household food security status in the sampled household of Dega-gro-ecology reveals that there is significant statistical difference in food security situation based on their household head educational status (chi-square value 9.326, and $p<0.05$. This may be the fact that extension services enhancing the farmers' insight regarding agricultural practice (Table 11).

4.2.1.3. Family Size

The average family size for the overall sample household is 5.88 with standard deviation of 1.469 and with minimum and maximum family size being 2 and 10 respectively

Family size is another important variable with implication on household food security. It was hypothesized that family size has an impact on household food security status in such a way that large families tend to be more food insecure than those having smaller family size. As it is hypothesized, the result shows that there is a statistical difference in family size between food secured and unsecured households (chi-square value=45.613, $p < 0.05$). The mean family size for food secured and insecured households are 5.11 and 6.88 respectively.

4.2.2. Socio-Economic Characteristics of Sample Households

4.2.2.1. Sources of Livelihood

Agriculture in the area is predominantly crop-livestock mixed systems and also subsistence with very low inputs and outputs. About (96.6%) of sample respondents were engaged in mixed farming in the study area. 3.4% of the total sampled households are involved in crop production.

4.2.2.2 Farm Size and Livestock Holding

Asset ownership or farmers economic status affects the food energy availability for the household. Thus, researcher tried to see the existence of any systematic relationship between asset ownership and food security/insecurity among sample kebeles. In this regard, the relations between food security and land holding size and livestock holding are examined.

According to Degefa (1996), those who have land size of <2, 2-4 and >4 were categorized under small, medium and high land holding size respectively. Sample households(59%) holds farm size >0.5 hectar, and the rest 27.3%, 9.4% ,2.6% and 1.7%

respondents hold 0.6-1, 1.1-2, 2.1-4 and >4 hectars respectively. Thus, almost all of household included under smallest land holding size i.e. < 2 hectare.

Table 12: Distribution of households by land holding size (hectare) with food security status

Kebeles	**<0.5**		**0.6-1**		**1.1-2**		**2.1-4**		**<4**		**Total**	
	No	%	No	%	No	%	No	%	No	%	No	%
Kindo koyo	51	71.8	20	28.2	-	-	-	-	-	-	71	100
Tora sadebo	18	39.1	12	26.1	11	23.9	3	6.5	2	4.3	46	100
FS	42	63.636	21	31.8	3	4.5	-	-	-	-	66	100
FIS	27	52.9	11	21.57	8	15.7	3	5.9	2	3.9	51	100

FIS=Food insecured household, FS= Food secured household

Source: Own field survey, 2014

Land holding size is considered a critical production factor that determines the type of crops grown and the size of crop harvests. According to Degefa (2002), the increase of agricultural output has been attained through the expansion of cultivated land. Therefore, under subsistence agriculture, land holding size is expected to play a significant role in influencing farm households' food security. The result of statistical test shows that, there is a statistical difference between land holding size and food security status at 95% confidence level ($X2=11.932$ *and* $p<0.05$).

With regard to livestock holding, mean value of livestock holding in terms of tropical livestock units for the total sample households is 3.82951TLU and standard deviation of 2.881297. The minimum amount of livestock holding in terms of tropical livestock units is zero and the maximum amount is 12.285TLU. The mean value of livestock in terms of TLU for food secured and insecured household is 5.75771 and 1.33421 respectively. According to Asfaw and Jabar (2008), average TLU in Ethiopia is 4.46. And mean value for sample households are less than this figure. However, the mean value for food secured and food insecured household is higher and lower respectively when compared to the national average. The mean difference between food secured and insecured HHHs shows the role of livestock holding in rural livelihood that impacting the minimum daily calorie of the household

4.3. Perceptions of Respondents on CC & V, and its impact on production

Sample households were asked about years of residence in the study area that it helps respondents to understand the trend of temperature and rainfall over the past years. Accordingly, 93.2% of respondents answered they have lived >15 years in the study area. The remaining 4.3%,1.7% and o.9% of respondents respectively have lived 15 years, 10 years and <10 years. Therefore, respondents have good background to perceive the change/variability of temperature and rainfall of the past years in the area.

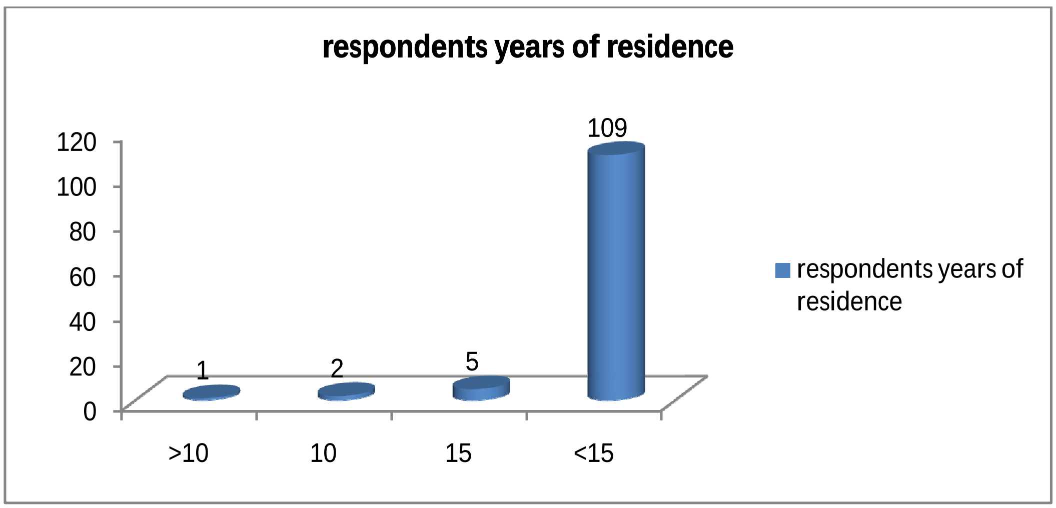

Fig 14: respondents' years of residence in the study area.

Source: Own field survey, 2014

One of the pre requests to adapt to changes/variability occurring in the climate system is recognition of the change or variability taking place. In cases of climate change/variability, farmers must first perceive those changes/variability are in fact taking place. Respondents were asked whether they perceive changes in different climate parameters (temperature, rainfall). Fig.14 shows that 12.7% of the respondents in Kindo koyo and 21.7% of in Tora sadebo perceive that there is significant increase in the temperature over the past 20-25 years. About 80.3% of respondents in Kindo koyo and 54.3% in Tora sadebo 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 2.6% reported that the temperature is decreasing while the rest 10.26% indicated that there is no change in the temperature. In the study district 70.05% of respondents believed that temperature is increasing.

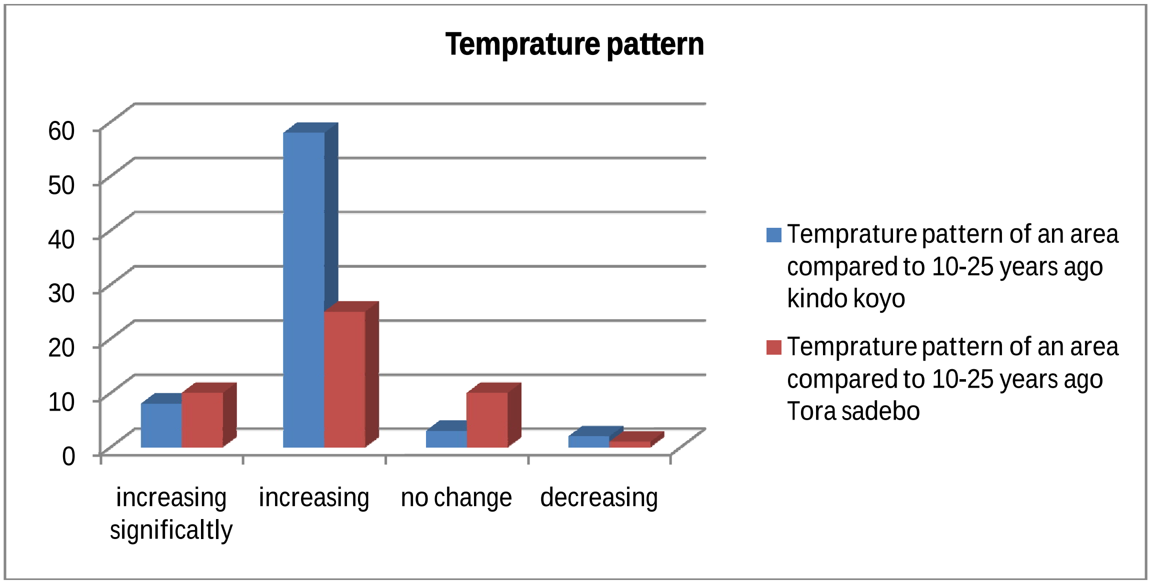

Fig 15: Temperature pattern of the area compared to past years

Source: Own field survey, 2014

Views regarding change of rainfall pattern were also required from the respondents. And 49.3% and 10.9% of respondents respectively, of kindo koyo and Tora-sadebo reported that they have perceived increasing trend in the annual rainfall amount in their village. About 18.3% and 30.4% of respondents respectively in Kindo-koyo and Tora-sadebo reported that they felt rainfall is decreasing but not significantly. In general, in the district, 38.5% of the respondents perceive that the rainfall is increasing, 38.5% of respondents perceived rain fall is decreasing, and the remaining 23.1%reported that no change in trend of rain(Fig.16).

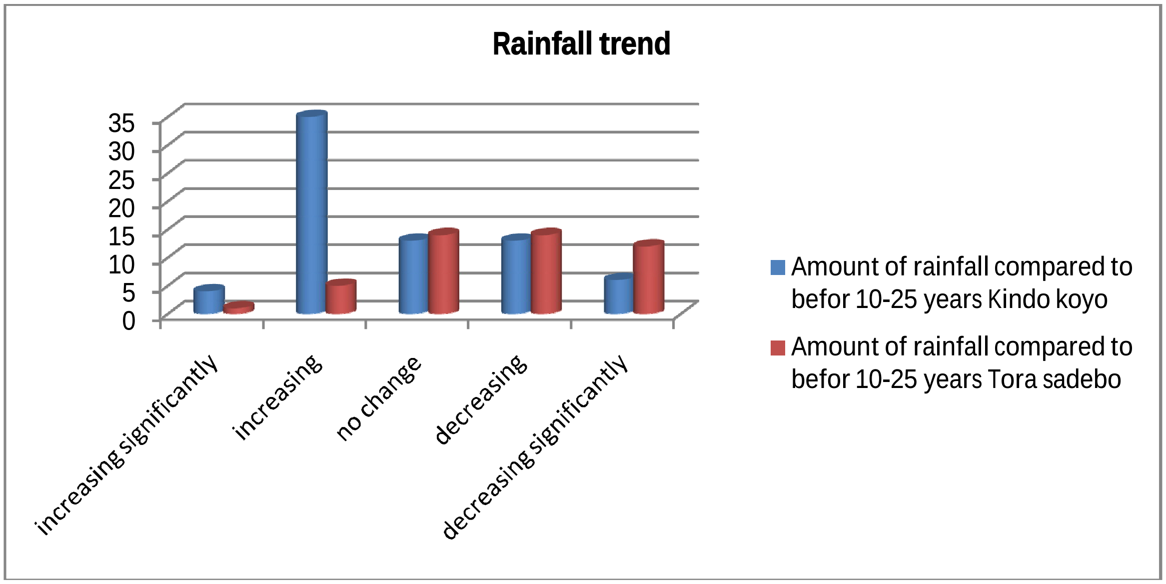

Fig 16: rainfall amount compared to 10-25 years ago

Source: Own field survey, 2014

Table 13: Respondents also asked about change of timing of rain, and they ranked it in the following way.

Items	**1**	**2**	**3**	**4**
Commencement of rain	66	18	20	13
Termination of rain	13	59	24	21
Certainty of continuance without major break	35	32	50	-
Frequency of torrential rain	-	-	-	-

Source: Own field survey, 2014

Commencement of rain= (66x1) + (18x2) + (20x3) + (13x4) = 210

Termination of rain= (13x1) + (59x2) + (24x3) + (21x4) = 287

Certainty of rain= (35x1) + (32x2) + (50x3) + (0x4) = 229

Frequency of torrential rain was not ranked by respondents. Thus, commencement of rainfall with the lowest value (210) is the most impacting factor and it is followed by certainty of rain that these factors are influencing the agricultural activity in the study area.

Respondents were provided with three choices to know if rain fall timing (onset and cessation) had changed and causes a problem. Of the three choices, overwhelming majority of the respondent (84.6%) declared that the rainy season onset late and ends up early. Respondents (15.4%) also reported that the rain comes late and goes late. The third choice i.e. comes early and goes late was not answered by any of respondents. This was assured by FGD and KII that the belg rain was starting in the past 20 years ago in month of January, but it comes now in the mid of March, so our sowing time changed from January to March.

Respondents (69.2%) also associated the change of duration of rain with crop production and that they reflected decreased crop yield. 4.3%, 1.7% and 24.8% of respondents respectively were responded that increase in crop yield, no change in production and decrease of long cycle crops.

Table 14: Rank the major factors affecting declining crop production

Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Unpredictability of rain	104	8	3	-	-	2	-
Increased pest and disease	1	23	17	11	2	7	56
Low soil fertility	-	6	28	14	26	16	26
Lack of modern farm implements	-	2	8	29	42	21	11
High price of farm implements	-	9	31	45	22	6	4
Shortage of labour	-	8	17	8	20	46	17
Lack of modern inputs	12	60	15	9	7	13	1

Source: Own field survey, 2014

(104x1) + (8x2) + (3x3) + (2x6) =137

(1x1) + (23x2) + (17x3) + (11x4) + (2x5) + (7x6) + (56x7) = 586

(6x2) + (28x3) + (14x4) + (26x5) + (16x6) + (26x7) =564

(2x2) + (8x3) + (29x4) + (42x5) + (21x6) + (11x7) =581

(9x2) + (31x3) + (45x4) + (22x5) + (6x6) + (4x7) =465

(8x2)+(17x3)+(8x4)+(20x5)+(46x6)+(17x7) =596

(21x1)+(6-2)+(15x3)+(9x4)+(7x5)+(13x6)+(1x7) =333

Respondents were asked to rank the major factors affecting declining crop production in this area. Totally, 7 factors were given to rank which are listed above. As we can see from Table 11 unpredictability of rain ranked as the first choice of respondents that it is the most impacting crop production in the study area. The next influential factor for crop production in the study area is lack of modern inputs. High price of farm implement, low soil fertility, lack of modern farm implement, increase pest and disease and shortage of labor are the third, fourth, fifth, sixth and seventh choices of respondents as factor of production respectively.

How climate change/variability affects food security status of respondents in the study area was asked and responded as follows. About 89% of the respondents reported that climate change/variability affects food security by shortening of growing season. 8.5%, o.9% and 1.7% of the respondents, respectively, answered climate change/variability affects food security through unpredictability of rain, flood and drought.

How looks like the trend of livestock production in the study area was another question asked. About 73% of the respondents replied the livestock trend is decreasing. And the rest 27.4% of the respondents felt livestock production is increasing. This fact was supported in the FGD and KII; the livestock population is decreasing because of shortage of pasture that it is caused by irregularities of climate of study area. Another reason forwarded by discussants and interviewee was food insecurity problem that they sell live stocks to survive the seasonal food shortage problems. This finding revealed similar result with (Getachew, 2013) that he concluded the variability of climate is influencing the number of livestock in Ziway Dugda, centeral Ethiopia rift valley.

Respondents reported the reason of decreasing trend of livestock number. According to the respondents about 67.5%, 2.6%, 2.6% o.9% are shortage of pasture, shortage of water, others and livestock disease respectively. The remaining 26.5% were not given their reason. Focus group discussants forwarded that climate related shocks affect livestock by two means that directly causing shortage of pasture and indirectly lack of residuals of crops during crop failed.

About 48% of the respondents reported that they lost 1 to 3 numbers of livestock due to climate related shocks. 12.8% of the respondents lost livestock number ranging from 4 to 6. Those who lost livestock number greater than seven were only 1.7%. The rest 37.6 person responded that they lost none.

4.4. Food Security and Food Availability

The result of the HFBM reveals that from the total sample households 56.4% households are food secured who fulfill the minimum recommended daily calorie (2100 Kcal/adul.equ) demanded for their households while 43.6% of them failed to supply this daily minimum requirements.

The chi-square test was computed to show if there is any statistical difference between food secured and food insecured households among two kebeles (different agro-ecology). The result shows that there is a significant difference between food secured and food insecured among the sample kebeles at 95% confidence level ($X2=14.420, P<0.05$). Tora sadebo kebele is more food insecured than Kindo koyo.

4.4.1. HFBM Balance Sheet Result

The balance sheet of HFBM reveals that the mean per adult equivalent kilo calorie of the sampled household is 2431.07kcal/daily/adul.equ., which is above the minimum daily requirement set by the national standard of 2100 kcal/daily/adul.equ. But the distribution of this average energy available in each of the sampled household is further exposed out that it is highly dispersed among the sampled households with a large amount of standard deviation (Std. Dev =1197.665).

These conditions create groups of household that one could achieve in fulfilling the minimum energy requirement in their household while the second groups failed to do so (food insecured). One could also learn that the extent of food security situation among the sample households in line of food availability stretches along at a range of 678 kcal/daily/adul.equ to 9427 kcal/daily/adul.equ. These minimum (678 kcal/daily/ad.equ) and maximum (9427kcal/d/ad.equ) is found in Kindo koyo kebele.

Table 15: Household food balance sheet result

HHFBMItems onkcal/d/ad.equ	Mean		All sample				t-test
	FS	**FIS**	**Min**	**Max**	**Mean**	**STDEV**	
Subtotal of crop gain	3557.358	2022.884	800	14169	2770.309	1733.576	0.000
Subtotal of crop loss	645.3385	374.4702	70.5	3963	527.268	423.910	0.000
Net available crops	2912.02	1648.414	668	10210	2364.11	1525.141	0.000

FIS=Food insecured household, FS= Food secured household

Source: Own field survey, 2014

The result of the food balance sheet of HFBM in table 15 also illustrate that food secured households have greater capacity to produce their own production, a better stock that was left from previous production and have greater capacity to take a food reserve for coming season.

The above table also shows that food secured household have greater capacity to sell products to market, better stock reserved to next season, reserved for seed and providing gift for others in need. And, also mean of net available crops of food secured households is by far greater than food insecured ones that it is why they are food secured.

4.4.2. Food Availability and Agricultural Production

Agricultural production and food availability are just one part of the food security. Agriculture in Ethiopia is important for food security in two ways: it produces the food people eat and it provides the primary source of livelihood for the majority of the working population.

The level of agricultural productivity of a household determines the food security status of a household. This is due to the fact that the greater share of household food energy available is derived from household’s own agricultural production. In fact small holder farmers in the study area and all over the country at large produce for their own consumption and very insignificant part of the household food economy is exchanged. Agriculture in the Damot Woyde woreda is predominantly crop-livestock mixed systems and also subsistence with very low inputs and outputs. However, mixed farming system in the area is highly affected by climate change.

Food production varies spatially and temporally owing to climatic condition. The major agricultural production kebele is characterized by relatively stable climatic conditions, but food insecure kebele from the study area have highly vulnerable climates. Climate change determine the type of crops produced that farmers face problems to make decisions about the type of crops produced in the coming season and the amount of production in different ways.

4.4.3. Crop Production

FGD and KII assured that the main crops produced in the study area are teff, maize, sorghum, yam, taro, false banana, h/bean, potato and s/potato. People give due attention for these crops that farmers food security status highly dependent on their production and productivity in the study area. Therefore, all the discussion here focuse on these crops that are mainly produced in Damot Woyde woreda.

Types of crop produced are different from one Agro-ecology/kebele to the other due to climatic condition and altitudinal difference. As illustrated in Table 16 both kebeles are suitable for producing sorgum but Tora-sadebo best suit for sorgume production (M=122.9773). Tora sadebo/koll is also productive in maize(M=366.0435),and H/beab(M=321.0444), where it have a drier climate with lower rainfall of 804.1 mm per annum is characterized by low and irregular rain fall, extensive land degradation and low soil fertility.

On the contrary, Highland is productive by teff (M=128.2927), taro (1352.754), yam (M=185), false banana (M=175), potato (M=136.5625), and s/potato (M=911.7143). According to the survey result the topography of this kebele is extensive level plain with fertility status of soil. Food security in Kindo koyo was achieved since agricultural productivity is high and has a capacity to do more in this zone even if average temperature increase (fig.16).

Although annual rain fall increases from 1985-2013, production in *kolla* agro ecology is lower than Dega agro ecology. This is due to the fact that, production is highly dependent on climatic condition in *kolla* kebeles than the dega kebeles.

Table 16: Type of crop produced for sampled households in each kebele

Average crops produced/kg/year	Kindo koyo(average kg)	Tora sadebo(average kg)
Teff	128.2927	50.29268
Maize	174.3239	366.0435
Sorgum	102	122.9773
Taro	1352.754	394.3913
Yam	185	37
Fals banana	175	26.75
H/beans	114.2254	321.0444
Potato	136.5625	87.86047
S/potato	911.7143	120.2667

Source: Own field survey, 2014

4.4.3.1. Correlation between climate variability (rainfall) and crop production (2009-2013)

Climate has adverse impact on the agriculture activities ingeneral and rain-fed agriculture inspecific. The five years crop production data was taken from Damot Woyde woreda Agriculture and Rural Development Office (DWWARDO 2009-2013). To examine the relationship between climate variability (rainfall) and crop production the five years rainfall data of the year 2009-2013 was used. As it has been mentioned earlier the types of crops ((maize, sorghum, h/bean, potato s/potato, teff and yam) that are mainly produced in the study area were used to correlate with rainfall. The correlation result indicates that all crops except maize, sorghum and s/potato have statistically no significant association with total annual rain fall of the study area. This results due to the fact that climate affects the study area through rainfall variability rather than annual total amount of rainfall (see appendix 5).

4.4.3.2. Size of Households' Farm Land

Regarding changes that occurred to the farmers' size of land holdings, majority of sample households reported about a decrease in size of land holding starting from the time that they produce in that land. In both kebeles, Kindo koyo and Tora sadebo, the majority of respondents reported decline of land holding size i.e. 71.8% and 76.4% respectively. Thus, the majority of household's land has decreased in the study area under investigation. Some of the households revealed increment and still others told no change of farm size (see Figure 17).

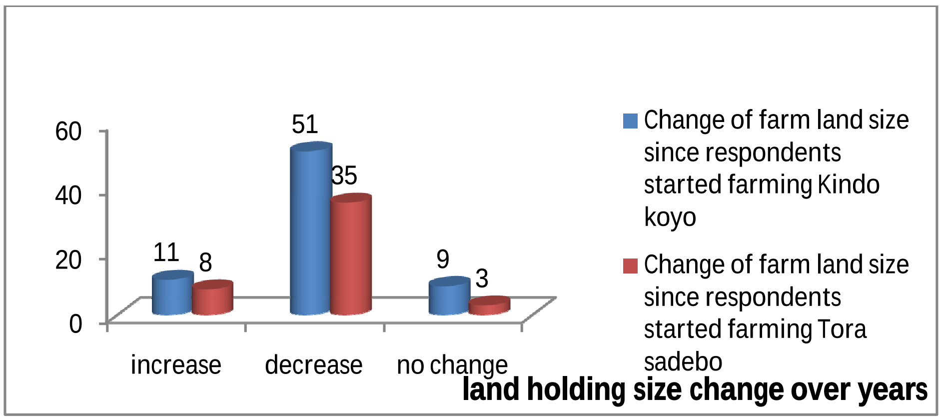

Fig 17: Land size holding change over time

Source: Own field survey, 2014

All respondents were asked about reason for increment, decrement and about no change. The reported reasons for the decline of land holding size includes: land degradation and loss of land to others by redistribution are 74.4% and 51.3% from the entire sample households respectively.

Land degradation in Damot woyde woreda is constraint to agricultural productivity. According to key informant interviewees and focus group discussants of both Kebeles, land degradation occur during rainy season i.e. spring and summer because of soil erosion. On occasion (more frequent than past time) it continues up to Autumn season which is a harvest time and reduces crop productivity. This is due to climate variability and extreme weather events.

Plate5: Photographs taken from the study areas that show problem of land degradation

Tora sadebo kebele (a) Kindo koyo kebele (b)

Kindo koyo kebele (c) Tora sadebo kebele (d)

Source: Own field survey, 2014

Population growth has also led to a high level of fragmentation and diminution of land holding size in the study area. Hence, acquiring a relatively large tract of land for farming is a difficult task thereby size of land degraded. When farm land is fragmented to their family, then piece of land will become more vulnerable to other extreme weather events like flooding.

On the other hand, those who got additional land through different means benefited from farming by clearing shrub land or deforestation (31.6%). Recent land reallocation by government purchasing renting land through share cropping arrangements are also means of increasing land size, according to focus group discussants.

About 15% of total sample households reported, the size of land holding is constant. This may be partly explained by the fact that the size of the land holdings is small.

4.4.3.3. Fertility Status of Farm Land

The farmers were asked to identify the general fertility status of their farm plots. Fertility status of farm plot is determining factor for agricultural productivity and food security status of households.

Food security status of sample household is also determined by fertility status of cultivated land and there is statistical difference between fertility status of cultivated land and food security status of sample households ($X2=9.027$, $P<0.05$).

4.4.3.4. Land Productivity

96.6% of the total sample households revealed that the productivity of land decreased while the remaining 1.7% and 1.7% of them give as land productivity increased and remain the same respectively.

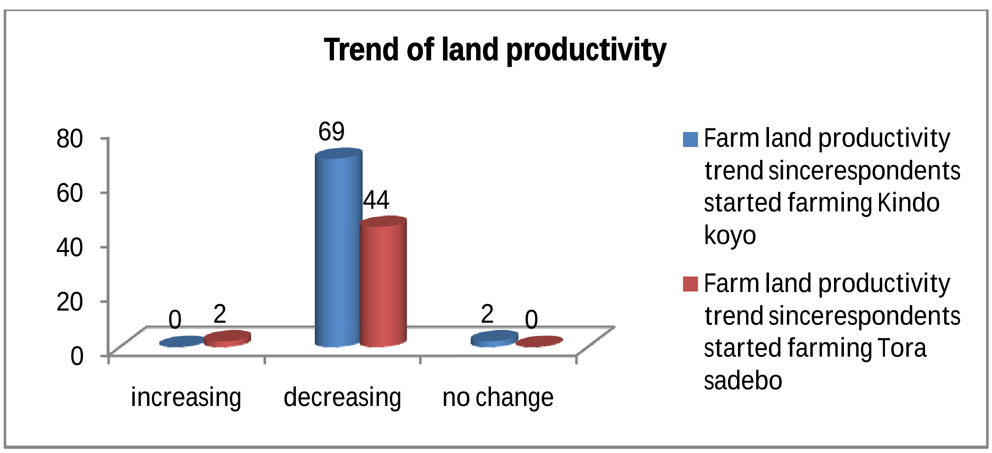

Fig 18: A change in land productivity by kebele

Source: Own field survey, 2014

According to the survey result, 60.7% of total sample respondents put that land productivity decreased due to land degradation. Land degradation, therefore depressing land productivity per unit area and availability of food from domestic harvest and was a major factor affecting household food security.

The second, third and fourth reasons for decreasing of land productivity following land degradation are erratic rain fall patterns (27.4%), drought (1.7%), and pest and diseases (1.7%). The fourth reason for decrease of land productivity is insect pest and weeds. The farmers felt that insect pest and weeds negatively affected agricultural production and were most important problem that lowered the productive potential of production and affected household food security.

Table 17: Crop production for sampled household by food security type

Crops produced/ kg/year	**FS**		**FIS**		**ALL SAMPLE**				**t-test(P value**
	Mean	Stdev	Mean	Stdev	MAX.	MINI.	MEAN	STDEV	
Teff	125.766	96.33	40.3	30.55	400	0	89.29	86.429	0.000
Maize	307.288	250.1	175.2	116.94	1000	20	249.70	212.8	0.001
Sorgume	173.667	146.93	75.4	63.09	500	0	119.09	118.2	0.002
Taro	1399.51	1760.8	410.28	449.7	9000	26	969.41	1438.8	0.000
Yam	111.32	180.2	33.43	40.04	800	0	74	137.4	0.049
False banana	171.189	219.25	35.29	32.54	1400	0	111.91	178.7	0.000
H/bean	241.606	226.9	132.2	90.56	997	20	194.46	188.6	0.002
Potaato	161.35	139.4	60.36	38.08	700	10	116.99	118.2	0.000
S/potato	902.09	1063.6	197.84	188.9	3500	0	602.02	884.6	0.000

Source: Own field survey, 2014

As it is indicated in Table 17 the mean value of crop production of food insecured households is by far lower than food insecured. T-test was also run to see the statistical difference of crop production between food secured and food insecured household heads. The result shows that there is statistically significant difference of crop production between food secured and food insecured household heads.

4.4.4. Cause of Seasonal Food Shortage

The designing of the main instrument for the inquiry on why farm households were unable to produce adequate food at home was largely based on household survey, KII and focus group discussion. There are different constraints that hinder agricultural productivity and then induce food insecurity. Not all constraints have equal magnitude of influence on each household and in each agro-ecology/kebele. Hence, in order to identify the impact of the main perceived cause of food shortage, sample households were asked to respond to each constraint according to their severity to identify and prioritize agricultural problems, which had backed the production and growth of productivity.

The households rated erratic rainfall, lack of cash income, drought and land degradation as most influential factor in the study area. From the household survey of total sample households, 90.6% of the respondents revealed that erratic rainfall was represented as the strongest factor reducing productivity and then resulted in shortage of food. One key informant interviewee from Kindo koyo stated that, ‘rain does not come as it formerly used to. Rains these days do not fall at the usual time. In the past it used to start in mid of January at all but now it goes up to march; and the temperature is now warmer than in the past’. Woldeamlak (2009) also stated that, virtually all food crop agriculture in Ethiopia depends on rainfall that is frequently erratic and unpredictable.

The opportunity to diversify cash income through employment in off farm or non- farm activities appear very limited in Damot woyde area. About 78.4% of the respondents indentified lack of cash income as influential factor. Lack of cash impacts not only farmer’s livelihoods, but also directly reflects a lack of capacity to modernize agricultural systems which in turn impact negatively on households food security. The lack of cash among farmers results in inability to purchase farm inputs and a limited scope to innovate outdated and overused farm implements. Consequently, both labor and land productivity was low. Some of sample households attributed poor productivity and food shortage to the inability to purchase and properly apply modern farm inputs and to unproductive traditional practices.

From the entire households 67.5% of households’ responseded that land degradation has high (29.9%) and very high (37.6%) impact on food production through hindering agricultural productivity. From the total respondents of two kebeles 9 people identified the effect of land degradation as low while all the rest included as high, very high and moderate.

About 87.2% of the total sample households reflected that, drought is a major cause for food shortage severely and more severely. For more than three decades, Ethiopia has experienced recurren deadly droughts including those of the 1972/3, 1984% and 2002/03. Drought has a long term effects in reducing the economic base of households, thereby leading to chronic and acute food insecurity. Household's vulnerability to food insecurity increase during protracted drought through progressive depletion of food stocks and capital assets (Markos, 1997).

The farmers felt that insect, pests and weeds negatively affected agricultural production and were rated as the most important problem following erratic rain fall, lack of cash income, drought and land degradation. Insect, pest and weeds were perceived as a major cause of household food insecurity because they lowered the productive potential of domestic production. About 21.7 % and 1.4% of the sample households from Tora Sadebo and Kindo koyo, respectively, explained that pest as high influential. Accordingly, Tora Sadebo is highly affected by pests than Kindo koyo. About 35.9% of the respondents rated weed infestation as high factor that reduced agricultural production. According to focus group discussants, this pest and weed infestation occured due to climate change particularly drought and they reflect that before this time the temperature was normal but now a day temperature increases from time to time and become cause for insect pest and weed infestation which leads to degradation of productivity.

Dependency on only a single harvest affects production in the study area. About 67.5% of the sample households responded that dependency on single harvest affect food production at low level.

Access to farm credit could compensate for small farmer's cash deficiencies. However, some of the respondents indicated that no such support was provided by the government or government partners. Agricultural extension services were weak due to low resources and poor commitment by the ministry of agriculture towards strengthening the extension services.

Shortage of labor was also indicated as a constraint affecting agricultural production and food security. Post harvest grain loss due to poor storage structures were indicated as one of the constraint to household food security. Considering the already low production, the poor post harvest handling further affected household food security through diminishing the amount of available food from domestic production.

In addition to household survey, different constraints for household food security were explained households during focus group discussion in each kebele. Malaria was identified as the main diseases affecting production in study area through loss of labor for farm operation. The outbreak of an epidemic during critical agricultural operations such as cultivation, weeding and harvesting adversely affected agricultural productivity.

4.5. Food Accessibility and Result of HFIAS Model

4.5.1 Household Food Insecurity Access-related Condition

Household Food Insecurity Access-related Condition provides specific, disaggregated information about the behavior and perception of the surveyed households. The occurrence questions measure the percent of households experiencing the condition at any level of severity. HIFAS could explore that the problem of food insecurity is severe from one to nine. And the percentage of sample household experienced the food insecurity access related problem decrease from worry that their household would not have enough food (69.2%) to its severe condition which is spent whole day and night without eating anything (11.1%) because there was not enough food in the small holder farming households.

Table18: HFIAS generic questions.

In the past four weeks	Yes	%	No	%
Did you worry that your households not have enough food?	81	69.2	36	30.8
Not able to eat the kind of food you preferred?	76	65	41	35
Have to eat limited variety foods?	72	61.5	45	38.5
Have to eat some foods that you really did not want to eat?	60	51.3	57	48.7
Have to eat smaller meal than you felt you needed?	70	59.8	47	40.2
Have to eat fewer meals in a day?	60	51.3	57	48.7
Was there ever no food to eat of any kind in your household?	20	17.1	97	82.9
Go to sleep at night hungry because there was no enough food?	19	16.2	98	83.8
Go whole day and night without eating anything?	13	11.1	102	87.2

Source: Own field survey, 2014

4.5.2. Household Food Insecurity Access-related Domains

These indicators provide summary information on the prevalence of households experiencing one or more behaviors in each of the three domains reflected in the HFIAS - Anxiety and uncertainty (question 1), Insufficient Quality (question 2, 3 and 4) and Insufficient food intake and its physical consequences (from question number 5 up to 9). All sample households which have experienced food shortage or entitlement for access would develop anxiety and uncertainty. When the extent of food shortage developed for the first decision made is supplying the food demand of the household by offsetting quality and preference and the last decision would be taken an amount that would not be enough for the household in quality.

Table19: Household Food insecurity access- related Domain

HFIARD	Yes	%	No	%	total	%
Anxiety and uncertainty	81	69.2	36	30.8	117	100
Insufficient Quality	69	58.97	48	41.0256	117	100
Insufficient food intake	37	31.623	80	68.376	117	100

Source: Own field survey, 2014

The result of the above HFIAS related-Domain reveals that 69.2% of the sample households had experienced some type of anxiety and uncertainty to have enough food for all of their household members. On the other hand, about 59% of the households experienced insufficient quality and preference for poor access to food in their household and finally those who could offset not enough food intakes at least in one of their household members in the one month recall period constitutes 31.623% of total sample households.

4.5.3. Household Food Insecurity Access Scale Score

The HFIAS score is a continuous measure of the degree of food insecurity (access) in the household in the past four weeks (30 days). HFIAS score is calculated by summing the codes for each frequency-of-occurrence question. The maximum score for a household is 27 (the household response to all nine frequency-of-occurrence questions was “often”, coded with response code of 3) and the minimum score is 0 (the household responded “no” to all occurrence questions, frequency-of-occurrence questions coded with 0 value).

The higher the score, the more food insecurity (access) the household experienced. The lower the score, the less food insecurity (access) a household experienced. After summing the scale score for each household, next average HFIAS-score was calculated and presented below.

Table20: Household Food Insecurity Access Scale Score

Kebeles	No_	Minimum	Maximaum	Mean	Std.deviation
All sample	117	0	21	6.6	5.65
Kindo koyo	71	0	21	6.458	5.13
Tora sadebo	46	0	18	6.565217	6.42444

Source: Own field survey, 2014

The result of HFIAS indicates that mean value for all sampled household is 6.6 with a standard deviation of 5.65. The result also shows that the mean value for Kindo koyo is a bit less than Tora sadeebo kebele with lower value of standard deviation; but the maximum score for HFIAS is found in Kindo koyo (21).

4.5.4. Household Food Insecurity Access Prevalence

The Household Food Insecurity Access Prevalence (HFIAP) indicator can be used to report household food insecurity (access) prevalence and make geographic targeting decisions. The HFIAP indicator categorizes households into four levels of household food insecurity (access): food secure and mild food insecure, moderately food insecure and severely food insecure. Households are categorized as increasingly food insecure as they respond affirmatively to more severe conditions and/or experience those conditions more frequently.

A food secure household experiences none of the food insecurity (access) conditions, or just experiences worry, but rarely. A mildly food insecure (access) household worries about not having enough food sometimes or often, and/or is unable to eat preferred foods, and/or eats a more monotonous diet than desired and/or some foods considered undesirable, but only rarely. But it does not cut back on quantity nor experience any of three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating).

A moderately food insecure household sacrifices quality more frequently, by eating a monotonous diet or undesirable foods sometimes or often, and/or has started to cut back on quantity by reducing the size of meals or number of meals, rarely or sometimes. But it does not experience any of the three most severe conditions. A severely food insecure household has graduated to cutting back on meal size or number of meals often, and/or experiences any of the three most severe conditions (running out of food, going to bed hungry, or going a whole day and night without eating), even as infrequently as rarely. In other words, any household that experiences one of these three conditions even once in the last four weeks (30 days) is considered severely food insecure.

Table21: Household food insecurity access prevalence

Kebeles	Number of respondents								
	Food secured	%	Mild food insecure	%	Moderate food insecured	%	Severely food insecured	%	**Total**
Kindo koyo	20	28.169	9	12.676	28	39.437	14	19.72	71
Tora sadebo	14	30.435	3	6.522	14	30.435	15	32.61	46
Total	34	29.06	12	10.256	42	35.897	29	24.79	117

Source: Own field survey, 2014

HFIAS prevalence results for sample households show that about 29.06% of total sample households are food secured. The rest about 10.256%, 35.897% and 24.79% of respondents faced with mild, moderate and severe food insecured respectively. From Table 21, one can conclude that, majority of sample households the constitute moderately food insecured are households from Kindo koyo (N=71, from this, 28 households are included under moderately food insecure). On the contrary, majority of households from Tora sadebo constitute under severely food insecured classification of HFIAS prevalence.

4.5.5. Food Accessibility and livestock ownership status (as a factor)

Like stocks of money or other savings in liquid form; livestock plays an important role in Ethiopian economy ingeneral and food security/insecurity of household inspecific. Almost the entire rural population involves one way another in animal husbandry whose role included the provision of draft power, food, and cash. Of all livestock species, oxen play a very important role in the farm economy of the mixed farming system of rural Ethiopia (Degefa, 2002).

Hence, oxen holding show the wealth status of a farm household and are mostly positively related to food security. T- test was run to test the hypothesis that food secure households have larger oxen holding than the food insecure households. The result of the test shows that the average oxen possession for food insecure households is 0.47TLU and that of the food secure households is found to be 1.48TLU. This difference in mean oxen holding between food secure and insecure households is found to be statistically significant.

Small ruminants are reared by farmers for the purpose of store of asset and for sales in cases of immediate cash need to purchase food grain at times of crop failure or low yield. They also responded that the sheep and goat are sold to settle debts.

The average small ruminants (sheep, goat and chicken) holding for the entire sample size is 0.90003TLU with standard deviation of 1.181215. The minimum small ruminant holding is 0 while the maximum is 6.585 TLU. The t-test also shows that there is significant difference in the mean number of small ruminant possession between food secure and insecure households at 0.05 significance level ($t = 6.249, P < 0.05$). The mean number of small ruminants for the food insecured households is 0.22635TLU, which is lower than the corresponding figure of 1.42029TLU for the food secure households.

Pack animals also sell in time of lack of cash income to purchase food from market. The average value of pack animals for the entire sample household is 0.35897TLU with a standard deviation of 0.437105. The minimum and maximum value of pack animal is zero and 1.400TLU respectively. Now, donkey is the only animal live in the study area. This indicates food insecurity problem is serous in the area because mule and horse owned as a sign of prestige in the culture of the area but from the total sample households none owned even a single of them.

Table22: Average distribution of livestock in terms of TLU

Kebeles	TLU of cattle	TLU of pack animals	TLU of small ruminants	Total
Kindo koyo	3.038732	0.423944	0.990239	1.4843
Tora sadebo	1.847826	0.258696	0.760783	0.9558
Average	2.57	0.36	0.9	1.2

Source: Own field survey, 2014

Households sell different animals during shortage of food. But the price of animals is influenced by the size and condition of the animals, the season of the year and the distance from the main marketing centers. There is seasonal fluctuation in the price of animals coming to the market. In general, animal prices are higher during the rainy season and falls during the dry season. During the dry season animals lose body condition due to shortage of feed and the farmers also desperately need to sell their animals before further loss of weight and die and to buy grain for family consumption.

Respondents also asked about the trends of animals during the past 10 years and 10.3% and 17.1% of the total sample households reveal that trend of animals increase and no change respectively. Majority of households (72.6%) from the entire sample reported that number of animals decrease from time to time.

Table23: Households response about trend of animals the last ten years

Kebeles	Increased	%	Decreased	%	No change	%
Kindo koyo	2	2.8169	53	74.6479	16	22.5352
Tora sadebo	10	21.7391	32	69.565	4	8.6956
Overall	12	10.26	85	72.65	20	17.09

Source: Own field survey, 2014

The deterioration of livestock production and reduction in herd size were asked and households give their response. About 78.35% and 60.5% of total sample households reported that lack of additional fodder and shortage of grazing land, respectively, are the main constraint of rearing animals. Extreme weather events like drought are the main reason for shortage of food, lack of feed of animals and water during the dry and drought season that it is the main constraint affecting livestock production in the area.

In turn shortage of feed and water and the harsh climatic condition of the area seriously affected the health and productivity of animals. Animal diseases as being a further serious constraint on livestock production and productivity in the study area, 60.9% of households from Tora Sadebo stated that prevalence of disease was the major constraints to livestock production. Temperature increase from time to time and create suitable condition for prevalence of animal and crop disease.

According to focus group discussants, veterinary service is available but a good service is not given by workers and it is difficult to go to woreda level with animals by foot. Conflict on grazing land and water is also another reason for decrement of animals and reported by 26.1% from Tora sadebo kebele. In general, all the physical household asset and financial asset (livestock holding) culminates in having easier access to food in the sample kebeles'.

Table24: Households' response causes of decreasing trend of livestock production

Causes		Kindo koyo	%	Tora sadebo	%	Total	%
Shortage of grazing land	yes	69	97.2	11	23.9	80	100
	No	2	2.8	35	76.1	37	100
Lack of additional fodder	yes	70	98.6	27	58.1	97	100
	no	1	1.4	19	41.3	20	100
Disease prevalence	yes	24	33.8	28	60.9	52	100
	No	47	66.2	18	39.1	65	100
Lack of veterinary services	yes	20	28.2	6	13	26	100
	No	51	71.8	40	87	91	100
Shortage of water	yes	1	1.4	28	60.9	29	100
	No	70	98.6	18	39.1	88	100
Conflict(grazing land)	yes	4	5.6	12	26.1	16	100
	No	67	94.4	34	73.9	101	100

Source: Own field survey, 2014

4.6. Food Utilization and its Indicators

4.6.1 Access and Availability of Water Damot Woyde Woreada

Respondents in the study area have to travel long distance for many hours and fetch water. A number of areas experience considerable water stress as a result of insufficient and unreliable rainfall that changes rainfall patterns or causes flooding. Total access coverage of water in Damot woyde Woreda is 27.4% (WZSEP, 2004)

Majority (81.2%) of sample households from the total household replied that, pipeline is the main water sources for drinking. Though majority of respondents fetch pipeline water for drinking, they suffer a lot to get that water because of long distance. Average distance that respondents used to travel to fetch water is 1.4547km. Especially, distance to water sources is very long in Tora Sadebo Kebele that it is about 2.0667km (from Bedessa town) with standard deviation of 1.59844. About 37% of the respondents from Tora Sadebo kebele use river water for drinking and home consumption and the remaining 63% travel to Bedessa town more than 2.0667km, and they get that water by purchasing 40 liter of water by 4 birr. This distance is above the maximum standard according to MOWR (2001). According to MOWR (2001), those who fetch water by traveling more than 0.5km are vulnerable to water stress.

Many respondents replied that the quantity of water changed compared to the past time. Respondents (61.5%) reported that quantity of water decreased comparing to the past availability of water. The remaining 33.3% and 5.1% of the respondents understand water quantity is not changed and increased respectively. Also the reason for water quantity decrement was asked and answered by respondents as follows. About 42.7% of the respondents felt that decrement of water quantity is due to high rate of deforestation in the area. About 16.2% of the respondents are replied water availability/quantity decreased due to reduced amount of rain in the study area.

FAO (2008) stated that, changes in the availability of water will be an essential factor influencing food security effects of climate change. But water is not only relevant for food production and processing; itself is an important good needed for the survival of almost all human activities.

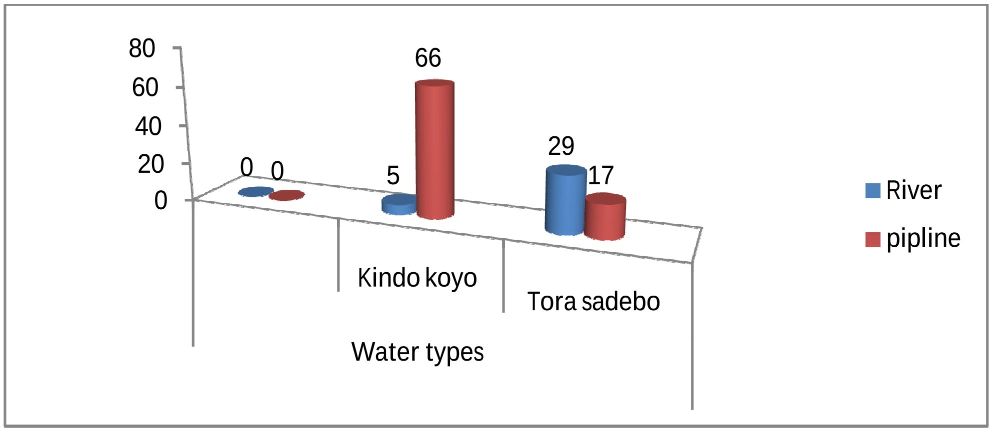

Fig 19: Distribution of water type in each kebele

Source: Own field survey, 2014

4.6.2 Prevalence of Disease

As the study shows malaria, abdominal disease and eye disease are the most prevalent disease in the study area caused by climatic factors. McMichael et al., (2006) also indicated that extreme rainfall events, droughts, and warming temperatures increased the incidence of disease. Out of the total sample households about 73.5%, and 80.4% the respondents from Tora Sadebo kebele, 69% from Kindo koyo replied that, malaria is the most prevalent disease. Tora sadebo is highly vulnerable by malaria in specific and all study area is also vulnerable by malaria disease in general.

Abdominal diseases are the second diseases that occur in the area owing to lack of quality of water and occurrence of water bore disease. About 18% of the total respondents, 15.2% from Tora sadebo, and 19.7% from Kindo koyo reported abdominal disease prevails in their area respectively. Eye infection also reported by some of the respondents: About 7.7% of the total respondents, 11.3% especially in Kindo koyo. In general, ability of human to utilize food is affected by these different diseases in the study area.

4.6.3 Access to Health Post

When we see the access to health services in the study area sample kebeles', majority of respondents about 82.9% from the total sample households have access to health post. Its distance ranges from 0.2km to 8km. The mean distance is about 1.4539km with standard deviation 1.82 in the case of Tora sadebo. The distance to health post in Kindo Koyo kebele is by far shorter that its mean 1.1km with standard deviation of 0.4km. However according to focus group discussants, though there is a health post in each kebele, it does not give all the necessary services. Instead, they might gote adequate health services after traveling long distances up to at a woreda level and in most case up to zonal level.

4.6.4. Women workload

Among the total respondents about 93.2% replied that there is gender based work classification in the area. And also respondents were asked about how looks like the share of work compared to the male and 68.4% reported that the share of women workload is greater than male. About 29.1% and 2.6 of respondents answered women workload is equal to men and less than men respectively.

The quality of food preparation is impacted by women workload. About 59% of respondents answered food preparation is affected by work load of women because cooking food is also the share of women; and women are in hurry during cook to accomplish other responsibilities. And also getting food at right time is influenced due to the fact that women have large share of work that sometimes women are late to begin cook/prepare and get ready for eating. Generally, gender based share of work affects food utilization of the study area.

4.7. Local Adaptation Strategies of Households to Reduce the Impact of Climate Variability/Change on Food Security and Barriers to Local Adaptation Strategies in Damot Woyde Woreda

Climate change posed significant challenges on households, businesses and governments. An effective response will require adaptation as well as mitigation. Measures to cut global greenhouse gas emissions can help to reduce future climate change. In contrast to climate change mitigation, which requires cooperation at a global level, most climate change adaptation occurs at a local level through the actions of individuals, businesses and communities in response to locally specific climate change impacts. Adaptation involves actions to manage the impacts of climate change that are not avoided through climate change mitigation (IPCC, 2007).

In order to achieve food security of households different policies and strategies were practiced and still undergoing currently in Ethiopia. Some of the most important strategies done by the government in this regard, the Ethiopian food security strategy is a good examples. In order to improve the food security situation of the country, successive national Food Security Strategies have been designed in 1996, 2002 and 2003/04. However, in spite of all the effort put by the government and donors to ensure food security of rural household in the country, it continuous to rise and a large proportion of the population faces chronic food insecurity and their livelihoods are at risk (Belayneh, 2005 cited in Abebe, 2013). That is why both chronic and transitory food insecurity perpetuates among the rural poor.

The food security strategy has two major approaches towards achieving food security in Ethiopia: Enhancing agricultural productivity and asset building/productive safety net programmes (PSNP). Ethiopia is recognized as facing the greatest and most intractable problems in addressing food insecurity, poverty and achieving more sustainable livelihoods for its population. Recognizing this fact, the government initiated and formulated a development strategy known as the Agricultural Development-Led Industrialization (ADLI). ADLI is described as focusing on increasing the productivity of smallholder farmers through the diffusion of fertilizers and improved seeds and the establishment of credit schemes as well as the expansion of the road system and improvement of primary health care, primary education and water supply. The other pillar of the Ethiopian food security strategy is Productive Safety Net Programme (PSNP) which is aimed to build the assets of the poorest of the poor to enable them to develop means of living (livelihood). So, here the researcher understands that development strategy of the country is clearly addressing the pillars of food security strategies or the development strategy and food security strategy of the country are strongly linked.

Table25: The most frequently practiced copping strategies to reduce impact of climate variability on food shortage in the study area

Coping strategies	frequency	%
Renting land	48	41
Selling agricultural productive assets(livestock) to purchase food	108	92.3
Borrowing money from merchants and money lenders to purchase food	23	19.6
Petty trade	62	53
Firewood and charcoal selling to purchase food	20	17.09
Selling labour	42	35.9

Source: Own field survey, 2014

From the above table one can understand that the immediate response that the households considered to reduce food shortage problem that results from climate variability in the study area was selling livestock (92.3%). Petty trading, renting land and labour selling are also common in the study area. Others methods sell charcoal and borrow money especially to purchase food.

The sampled household heads practiced these copping strategies when they face different level of food shortage problem (mild, moderate or severe food security problem). The following figure 23 and 24 shows the condition in which the sampled household heads used or practiced petty trading and selling livestock to purchase food or to reduce the impact of climate variability on their food security in the study area.

Selling livestock is commonly practiced by the households as coping strategies to reduce the impact of climate variability and change on food security. Among the sampled household heads 76.9% and 15.4% of them responded that they use or practiced selling livestock as coping strategy in the study area when food shortage is severe and moderate respectively. Therefore, the researcher concluded that even though selling livestock is the common practice in the study area, household heads are forced to sell more livestock to purchase food when they face severe problem of food shortage which is happening due to climate variability (erratic rainfall) that resulting in crop failure or loss.

Similarly the sampled household heads practice petty trading to purchase food when they face food security problem. Most of the time the household heads practice petty trading when they face moderate food shortage problem. The following figure 24 shows this more.

Among the respondents 6%, 39.3% and 13.7 practice petty trading when they face sever moderate and less shortage of food. The households of the study area also used other livelihood strategies or adaptation strategies. Some of the most frequently practiced adaptation strategies in this regard are crop diversification, improved seed varieties, using fertilizer (inorganic and organic fertilizer), soil and water conservation and changing of the or planting dates are the most important strategies commonly practiced in the study area. The following table 26 shows this in detail.

Table26: The most frequently practiced adaptation strategies to reduce impact of climate variability and change on food security in Damot woyde Woreda

Adaptation stratagies	Frequency	Percent
Crop diversification and using fertilizer	48	40.3
Crop diversification, using fertilizer and improved seed varieties	38	31.9
Crop diversification, using fertilizer and soil and water conservation	13	10.9
Using improved seed varieties, fertilizer and changing of the sowing or planting dates	9	7.6
Crop diversification, using fertilizer, changing of sowing or plating dates and soil and water conservation	6	5

Source: Field Survey, 2014

As it shown in the above table, there are different adaptation strategies practiced by the sampled households in the study area to reduce the impact of climate variability and change on the food security. Among the sampled household heads 40.3% (n=48) of them responded that the adaptation strategies that they are frequently practicing to reduce the impact of climate variability and change on their food security is diversifying crops and using fertilizer. In the focus group discussion also they have been discussing the purpose of diversifying crop and using fertilizer. Accordingly they pointed out that crop diversification enable them to reduce risk of crop failure that usually associated with erratic rainfall and using fertilizer enable them to increase production .However, currently they are forced to use minimum amount of fertilizer per acre of land as a result of the rising cost of fertilizer.

As it shown in the above table 31.9%(n=38) of the sampled household heads responded that they are practicing crop diversification, using of fertilizer and improved seeds variety as an adaptation strategies to reduce the impact of climate variability and change on their food security. From above table the researcher also understand that there are only few household heads that are practicing soil and water conservation and changing of the sowing or planting period as an adaptation strategy to reduce the negative impact of climate variability and on food security in the study area.

In order to achieve food security at national level, the Ethiopian ministry of agriculture is practicing different strategies which include supplying of fertilizer and improved seed varieties that tolerate the changing climate and give more yields. For example, the distribution of improved seed varieties of maize (one among important crops that are widely produced in the study area) is increasing in recent year.

Table27: Major Barriers to Farm households Adaptation to climate change in Damot woyde Woreda

Constraining factors	Frequency	Percent
lack of finance and credit	62	53
lack of training	1	0.9
lack of labor and other household problems	23	19.7
lack of information/knowledge	19	16.2

Source: Own field survey, 2014

Farmers' adaptation strategies were constrained by many factors in the study area. As it is illustrated in the above table lack of finance and credit facilities (53%) is the most constraining factor that affected the practice of adaptation strategies. Following lack of finance and credit facilities lack of labor and other household problems, and lack of information/knowledge are the second and third factors respectively. This finding yielded similar result with the research done in Arsi negele woreda by Abebe, (2013). He revealed that lack of finance and poor access to credit facilities constrained local farmers of applying/practicing adaptation strategies.

CHAPTER FIVE

5. CONCLUSSION AND RECOMMENDATION

5.1. Conclusion

Ethiopian agriculture is mostly rain fed, whereas inter-annual and seasonal rainfall variability is high and droughts are frequent in many parts of the country. Rainfall variability has historically been a major cause of food insecurity and famines in the country.

It is important to note two lessons on aspects of climate variability/change at the study site. The first is the state of shortening of growing period; and the second one is extremes and variability aspects that work to accentuate water scarcity – increasing temperature pattern and frequent drought in the area. Especially, lowland agro-ecology that is experiencing frequent drought and highest evapo-transpiration **(**lower moisture condition and dry climatic condition) face serious problem of food insecurity. Unless every activity of rural development, livelihoods improvement, adaptation and coping strategy response is redirected to compromise these imbalances, realization of sustainable rural livelihoods and resilient rural community in changing situations might remained meaningless and the food insecurity problems will continue going on.

The amount of rainfall during all seasons is variable except winter, of all spring RF is the most variable that mean total spring Rain ranges between 66.7mm to 200.9mm and 41mm to 157mm in highland and lowland agro-ecology respectively. Therefore, the seasonal RF variability and both total annual amount and seasonal variability are affecting the highland and lowland agro-ecology of the study area respectively.

Climate variability is causing apparent impacts on rural livelihoods through its implied effects on crop and animal production and resultant food insecurity problems. As per this recurrent droughts and unreliable rainfall pattern is causing frequent crop failures, animal death and low productivity. Recurrent droughts, seasonal rainfall letdown and crop failures are working to put rural poor in a vicious circle of grinding poverty and human impoverished.

In prevalence of climate variability/change impacts, whether it is planned or autonomous, positive or negative in its impact, rural households should undertake coping activities. The results of this study also clearly indicated that coping strategies mostly carried out by surveyed household heads have both unimportant impacts on livelihood welfare of a household after stress season in one way and environmental sustainability in other way. From the coping strategies animal sale especially oxen can be a typical examples for this assertion; which depletes asset endowments and can work to worsen crop production. In addition to this, deforestation activities are very high in the study area that causing tremendous degradation of land resources such as water and soil.

Regarding food availability food insecured sample households are 44% in terms of daily calorie availability per adult equivalent. The result also shows availability of food is not equal across all kebeles/agro-ecology; and food security status of kindo koyo/midland agro-ecology is better than Tora sadebo/low land agro-ecology. Low land agro-ecology is most vulnerable by land degradation and drought that hinder the type of crops a household produce and their productivity. The magnitude of these and other factors are not equal across all kebeles/agro-ecologies. Due to this reason crop production are different from one agro-ecology/kebele to another. Teff, yam, false banana, taro, potato and s/potato are give good production in highland agro-ecology, and in contrary these crop types are less productive and other crops like maize, sorghum, and s/potato yields better in lowland agro-ecology than Highland agro-ecology.

The result of the food balance sheet of HFBM also illustrate that food secured households have greater capacity to produce their own production, a better stock that was left from previous production and have greater capacity to take a food reserve for coming season. Food insecured households are characterized by larger family members, smaller out number of livestock, smaller land holding, lower fertility status of land and low productivity and production.

The study also illustrates agro-ecology/kebele which are food insecured in terms of food availability are also insecured in terms of food accessibility. This means that entitlement to the food or income is considerably related to the daily energy availability of sample households. From HFIAS assessment, HFIAS-prevalence condition shows that most of severely food insecured households are belong to Lowland agro-ecology while major proportion of food secured and mildly food insecured households belong to highland agro-ecology.

Concerning food utilization, climate change/variability affects food utilization of sample households through reducing the availability and quantity of water and prevalence of disease. River and pipeline are the major sources of water for all study areas. Malaria is most prevalence disease in the whole study area but kolla kebele is highly vulnerable by malaria.

There are different adaptation strategies practiced by the sampled households in the study area to reduce the impact of climate variability and change on the food security. Among the adaptation strategies that they are frequently practicing to reduce the impact of climate variability/change on their food security is diversifying crops and using fertilizer. Selling livestock, petty trading and renting land are also commonly practiced by the households as coping strategies to reduce the impact of climate variability change on food security. Regarding barrier to adaptation lack of finance and credit, lack of labour and other household problems, and lack of information are rated the 1^{st}, 2^{nd} and 3^{rd} factors that are identified as major Barriers to Farm households Adaptation to climate change/variability.

5.2. RECOMMENDATION

Based on the result of the household survey, interview and focus group discussion the following issues need to be considered to address the food security problem and to reduce the adverse impacts of climate change/variability in the study area:

Introducing new crop varieties that can tolerate drought (moisture stress) and high temperature will help to cover production gap of the study area.

Adoption of short maturing crops is very important that reduce the impact of shrinking of rainy season due to climate variability.

Researcher wants to recommend that households have to harvest water in the rainy season to use it for production of vegetation in their gardens during the dry seasons. Because if they do so they can produce food in addition to what they produce during the rainy season and they also get additional income that helps them to purchase food in time of food shortage.

Financing of the local farmers especially kolla/lowland agro-ecology by developing suitable financial systems that will allow farmers to have access to affordable credit which will play a role in promoting adaptation.

Intervention should be done in the creation of non-farm activities (livelihood).

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.

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Addis Ababa University College of social science Department of geography and Environmental studies

Introduction

This questionnaire is prepared for acquiring information to conduct research for Partial fulfillment of Master of Arts in geography and environmental studies (Climate change and adaptation).

The study is very important to examine the existing situations of climate variability and change impacts on food security and the local strategies used by the farmers to reduce the adverse effect climate variability/change on food security and those factors hindering the appropriate implementation of those local adaptation strategies.

The result of this study is entirely dependent on your response .Therefore, try to answer all questions correctly as much as possible .Your name will not be included in the study report and information that you give for this study will be kept confidential.

Appendix 1: Household survey question

A. Socioeconomic and demographic profile of sample household heads:

1. House Code____________________

2. Sex: 1= Male 2= Female

3. Age: 1= 15-30 2= 31-65 3=>65

4. Marital Status: 1=Married 2= Not married 3= Divorce 4=Widowed

5. Educational Status: 1= Illiterate 2= Capable of reading and writing 3= primary School 4= Secondary school 5= Higher education

6. Livelihood source 1= Crop production 2= Livestock production

3= Mixed agriculture 4=Government civil servant

5= other, please specify_________________________________.

7. Family size including the HHH: --

8. Number of years of residence of your family at the present site?

1. <10 years 2. 10 years 3. 15 years 4. > 15 years

B. Perception of people of impacts of changing climate or variability on crop and livestock production

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

1. Increasing significantly 2. Increasing
3. Neither of the two (no change) 4.Decreasing
5. Decreasing significantly

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

1. Increasing significantly 2. Increasing
3. Neither increasing nor decreasing 4. Decreasing
5. Decreasing significantly

3. Is there change in the time of the rain? rank the choices below

No	Change in the time of the rain?	rank 1 the most impacting one and last rank the least impacting)?
1	Commencement of rainy season	
2	termination of rainy season	
3	certainty of continuance without major break	
4	frequency of torrential rain	

4. How do you characterize the change in the timing (duration) of the rain?

A. Comes early and goes late B. Comes late and goes late C. Comes late and goes early

6. If your answer to **Q4** is comes late and goes early, what changes you have seen in your crop production?

1. Decrease in crop yield
2. Increase in crop yield
3. No change in production
4. Decrease of long cycle crops
5. Others

7. What are the major factors affecting declining crop production in this area; rank the choices below as per their negative impact on agricultural products?

Factors affecting declining crop production in this area	Rank 1 the most impacting one and last rank the least impacting?
1. Unpredictable rain fall	
2. Increased pest and disease	
3. Low soil fertility	
4. Lack of modern farm implements (fertilizer, improver seeds, pesticides etc	
5. High price/charges of farm implements	
6. Shortage of laboure	
7. Lack of modern inputs	

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

1. By causing drought when shortage of rain
2. Flood when excess of rain
3. Shortening of growing seasons with late commencement and early termination

4. Unpredictability of rain fall amount and duration 5. Others?

9. How do you perceive the livestock production in your village?

1. Increased 2. Decreased

10. If your answer is decreased please specify the reasons;

A. Livestock disease B. Shortage of pasture (animal feed)

C. Shortage of water D. Others (specify)

11. How many livestock you have lost because of climate change related shocks in the past 10 years. A. none B. 1-3 C.4-6 D. 7+

C. Household's food Availability

Land:

1. Do you have your own farm land? 1. Yes 2. No

2. If 'yes' for question no 1, how did you get access to it?

1. Inherited from parents 2. From *kebele* or peasant association

3. If your answer to question 1 is yes, what is its size in hectare?

1/ <0.5hectar 2/ 0.6-1 hectares 3/ 1.1-2 hectares 4/ 2.1-4 hectares 5/ >4 hectares

4. Has your farm land size decreased or increased since you have started farming?

1. Increased 2. Decreased 3. No change

5. If you say increased, do you think that deforestation is the reason for increment?

1. Yes 2. No

6. If your answer for **Q5** is decrease, do you think degradation of land is the reason?

1. Yes 2. No

7. Do you think that distribution of cultivated land in the expanding family is the reasons for the decrease of your cultivated land? 1. Yes 2. Yes

8. Is your farm land productivity decreasing or increasing since you have started farming in this cultivated land? 1. Increasing 2. Decreasing 3. No change

9. If you say increased, do you attribute it to increased soil fertility? 1. Yes 2. No

10. Do you think that strong extension services are the reasons for the increment?

1.Yes 2.No

11. Do you think that suitable weather conditions are the reasons? 1. Yes 2. No

12. If your answer is decreased, which one of the following do you think the reason?

1. Land degradation 2.rainfall variability 3.drought 4.pest and crop disease

13. How do you rate your cultivated land with regard to fertility?

1. Less fertile 2. Somehow fertile 3.fertile 4.highly fertile

Crops:

1. For how long your annual production can feed your family?

1. Below six month
2. Six month -one year
3. one year-two years
4. Above two years

2. If your production is not enough to feed your household year round, please specify the main reason by severity level as: 1- low, 2- moderate, 3-high and 4-very high.

Items	1= low	2= moderate	3= high	4= very high
Erratic rainfall				
Drought				
Shortage of labor				
Erratic rainfall				
Lack of agricultural credit facilities				
Pest damage				
Weed infestation				
Land degradation				
Dependency on single harvest				
Lack of cash income for investment in modern inputs				
Post harvest losses				
Health problem/ effecting labor requirements				
Others, specify				

3. Pleas estimate the different sources of household food consumption during 2012 to 2013.

Name of crops	Total grain produced	Total grain purchased	Total grain obtained from remittance	Total grain obtained from previous stock	Post harvest losses	Total grain utilized for seed	Total marketed output	Grain planned to next season	Total grain given to others	Net grain available
Teff										
Wheat										
Barley										
Maize										
Sorgum										
Taro										
Yam										
False banan										
Cassaba										
H/beans										
Potato										
S/potato										
Cheeck pea										
Beans										
Pea										

Banan										
Cabbage										
Avocado										
Tomato										
Carrot										

Livestock

4. Mention the number of livestock owned by your family currently?

Types of livestock	**Number**
Cattle	
Cows	
Calves	
Heifers	
Bulls	
Pack animals	
Donkey	
Horse	
Mule	
Small ruminant	
Chicken	
Sheep	
Goat	

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

1. Increasing 2. Decreasing 3. No change

6. For what purpose do you mainly use livestock and their products?

1. For cash income 2. For food 3. Both for food and cash equally

7. Which of the following are the constraints to rearing livestock in your community in your opinion?

Constraints	Yes	No
Shortage of grazing land		
Lack of additional fodder		
Disease prevalence		
Lack of sufficient veterinary services		
Shortage of water		
Conflict on grazing land and water		
Specify other		

D. Household Food Insecurity Access Scale (HFIAS)

1.Occurrence and frequency occurrence question for households

No	**Questions**	**Response options**
1	In the past four weeks, did you worry that tour household would not have enough food?	0= No(skip to Q2 1= Yes
1a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
2	In the past for weeks, were you or any households' member not able to feed the kinds of foods you	0= No(skip to Q3 1= Yes

	preferred?	
2a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
3	In the past four weeks, did you or any household member have to eat a limited variety of foods?	0= No(skip to Q4) 1= Yes
3a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
4	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat?	0= No(skip to Q5) 1= Yes
4a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
5	In the past four weeks, did you or any household member have to	0= No(skip to Q6) 1= Yes

	eat a smaller meal than you felt you needed?	
5a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
6	In the past four weeks, did you or any household member have to eat fewer meals in a day?	0= No(skip to Q7) 1= Yes
6a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
7	In the past four weeks, was there ever no any food to eat of any kind in your household?	0= No(skip to Q8) 1= Yes
7a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
8	In the past four weeks, did you or any household member go to	0= No(skip to Q9) 1= Yes

	sleep at night hungry?	
8a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks
9	In the past four weeks, did you or any household member go a whole day and night without eating anything?	0= No(skip) 1= Yes
9a	How often did this happen?	1= rarely(once or twice the past four weeks 2=sometimes(3 to 10 times in the past four weeks 3=often(more than 10 times in the past four weeks

E. Food Utilization situation of Households

Water:

1. Is there any water source in your locality/surrounding? 1. Yes 2. No

2. If your answer is yes please fill the following table?

Types of water sources	Distance from home/farm	Adequate and pure water			
		For agriculture	For drinking	For animal	For house consumption
River					
Spring					
Borehole					
Pipeline					
Other					

3. Is quantity of water changed? 1. Decreased 2. Increased 3. No change

4. If your answer to question 2 is decreased, what do think the reason?

1. No rain 2. Deforestation 3. Other, specify--------------------------------

Health:

5. Is there any health post in your locality? 1. Yes 2. No

6. How much distance and time it takes to reach the nearby health centre? ____________?

7. What is the most prevalent disease in your family?

1. Malaria 2. Eye 3. Abdominal

4. Cardiac problem 5. Other, specify 6. There is no disease

8. What do you think about the cause for the prevalence of these diseases____
____?

Woman work load

11. Is there gender based work classification in your culture? 1. Yes 2. No

12. If your answer for above question is yes, how looks like women's share of work?

1. More work load 2. Less work load than male 3. Equal

13. If your answer for above question is more work load of women, Do you think it has impact on quality of food preparation? 1. Yes 2. No

14. Does work load of women influence getting food at right time? 1. Yes 2. No

F. Questions concerning the Household coping/Survival and Adaptation strategies to food insecurity Problem caused by climatic variability and change

1. Among the following coping strategies listed in table below, which coping strategy do you use most frequently to reduce the impact of climate variability (rainfall variability) on your households food security?

	Coping strategies	**Write** '1' **if it is** 'Yes' **and** '2' **if it is** 'No'	If 'yes' you use a strategy when food shortage is: **1. Less 2. Moderate 3. severe**
1.	Renting land		
2.	Selling agricultural productive assets(livestock) to purchase food		
3.	Borrowing money from merchants and money lenders to purchase food		
4	Petty trade		
5	Firewood and charcoal selling to purchase food		
6	Selling labour		

2. Among the following adaptation strategies listed in table below, which adaptation strategies do you practice to reduce the impact of climate variability and change on your household's food security?

No	Adaptation Strategies	Write '1' if it is 'Yes' and '2' if it is 'No'
1	Crop diversification and using fertilizer	
2	Crop diversification, using fertilizer and improved seed varieties	
3	Crop diversification, using fertilizer and soil and water conservation	
4	Using improved seed varieties, fertilizer and changing of the sowing or planting dates	
5	Crop diversification, using fertilizer, changing of sowing or plating dates and soil and water conservation	

3. For effective implementation of strategies mentioned at Question 3, what are constraining factors?

1. Lack of finance and credit services 2. Lack of access for extension services

3. Lack of access for training 4. Lack of labor and other household problems

5. Lack of information/knowledge 6. All the problems were challenges

Appendix 2: Interview Guide(KII) to be administered to officers and community ealders

1. What is the current condition of food security in the Woreda?

2. What is the status of availability and productivity of land?

4. What is the quality and availability of water?

5. What are the major reasons of food insecurity in your Woreda?

6. Which growing season is more important/major one for agricultural production in your area; belg or meher?

7. What are the major types of crops grown and livestock's in the Woreda?

8. What are the major limiting factors of crop production? Is there any crop type the farmers switched off or less frequently used than before (20-25 ago)? What is the reason for this?

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

10. 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?

11. What methods the farmers use to cope with the existing changes ofcroppingcalendar?

12. What are people's major coping mechanisms to food insecurity caused by climate variability/change?

13. What adaptation strategies are implemented in the Woreda to reduce the problem of Food insecurity that is happening due to climate variability and change on sustainable manner?

14. Which agroclimate zone of the Woreda is frequently affected by the climate change/variability induced food security problem?

15. To effectively cope with and adapt for climate variability, what should be done for the community there: what were the urgent needs of the people: what is expected from stockholders of the Woreda?

16. Is there any year that you recall the late/early onset and offset brings high crises on the *woreda* within the last 20 years? What measurements you took for the crises?

Appendix 3: Interview guide for Focus group disscussion

1. How is the general trend of food security situation of the area?

2. Did you get the type of food that you preferred to eat?

3. What looks like the productivity of crops/lands?

4. What is the general health condition of the area?

5. Which growing season is more important/major one for agricultural production in your area; belg or meher?

6. What are the major types of crops grown and livestock's in the Woreda?

7. 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?

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

9. Which agro ecological zone of the *wereda* is most vulnerable to food insecurity as a result of climate variability/change? *Kebele*s/areas severely affected

10. 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?

11. What methods the farmers use to cope with the existing changes of croppingcalendar?

12. An Average number of months/days in which you are able to feed your households   from own production has increased or decreased?

13. What are your survival/coping strategies when you face food shortage as a result climate variability?

14. Is there any year that you recall the late/early onset and offset brings high crises on the *woreda* within the last 20 years? What measurements you took for the crises?

Appendix4: List of conversion factors used for the research

1. Conversion factor used to estimate tropical livestock unit

Animals	TLU	Animals	TLU
Cow/ox	1.00	Horse	1.10
Calf	o.25	Chicken	0.013
Heifers	0.75	Sheep and goat(young)	0.13
Donkey	0.7	Sheep and goat(adult)	0.06

Appendix5: Correlations of crop production and annual rainfall

Correlations						
		Rain	Teff	Yam	taro	potato
Rain	Pearson Correlation	1	.586	.186	.352	.157
	Sig. (2-tailed)		.299	.764	.561	.801
	N	5	5	5	5	5
Teff	Pearson Correlation	.586	1	.521	.667	.227
	Sig. (2-tailed)	.299		.368	.219	.713
	N	5	5	5	5	5
yam	Pearson Correlation	.186	.521	1	.792	-.326
	Sig. (2-tailed)	.764	.368		.110	.593
	N	5	5	5	5	5
taro	Pearson Correlation	.352	.667	.792	1	.314
	Sig. (2-tailed)	.561	.219	.110		.607
	N	5	5	5	5	5
potato	Pearson Correlation	.157	.227	-.326	.314	1
	Sig. (2-tailed)	.801	.713	.593	.607	
	N	5	5	5	5	5

Correlations					
		Rain	Maize	s/potato	sorgume
Rain	Pearson Correlation	1	.895*	.939*	.931*
	Sig. (2-tailed)		.040	.018	.022
	N	5	5	5	5
maize	Pearson Correlation	.895*	1	.789	.913*
	Sig. (2-tailed)	.040		.113	.031
	N	5	5	5	5
s/potat	Pearson	.939*	.789	1	.852

o	Correlation				
	Sig. (2-tailed)	.018	.113		.067
	N	5	5	5	5
sorgu me	Pearson Correlation	.931*	.913*	.852	1
	Sig. (2-tailed)	.022	.031	.067	
	N	5	5	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix6: Crops productivity in Damot Woyde Woreda

Years		2009	2010	2011	2012	2013
Maize	Land in hectare	4269	4269	4269	4269	4269
	Production in quintal	113925	125357	111320	99388	154678
Sorgume	Land in hectare	51	51	51	51	51
	Production in quintal	1326	1411	1326	1132	1530
Teff	Land in hectare	650	650	650	650	650
	Production in quintal	4964	5020	4723	4073	7087
Yam	Land in hectare	2760	2760	2760	2760	2760
	Production in quintal	248120	473600	24200	23400	489123
S/potato	Land in hectare	3657	3657	3657	3657	3657
	Production in quintal	332014	991730	604287	242498	1148259
Taro	Land in hectare	431	431	431	431	431
	Production in quintal	41718	86826	43200	40100	142094
Potato	Land in hectare	315	315	315	315	315
		35916	60163	34900	33103	93037

Appendix7: Monthly mean precipitation of Beddessa (Wadu) meteorological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975		9.5	105.2									
1976	0.0	31.0	71.8	106.5								
1977				222.8	172.0	141.3	233.5	188.1				
1979							213.0	296.5	283.5	434.0	0.0	0.0
1986												65.0
1987	2.5	33.6	118.6	144.0	366.4	108.2	42.6	94.0	88.4	121.4	30.8	0.6
1988		27.5	39.0	175.7	80.1	115.1	244.4	179.1	0.0	402.8	0.0	3.4
1989	56.7	102.1	24.3	124.1	88.9	115.2	108.7	67.4	209.6	103.9	58.0	
1990		79.4	246.3	67.2	100.3	144.4	44.9	89.6	139.4		69.1	31.0
1991		64.8	118.3	82.6	205.9	81.7	84.4	44.0	45.7	20.4	10.6	
1992	48.7		67.1	121.8	108.2	101.4	150.6	138.4	80.5	127.6	91.2	31.9
1993	77.0	68.1	14.4	204.8	220.0	78.3	56.0	61.7	20.5	48.9	17.9	10.6
1994	1.8	15.9	95.2	154.6	117.9	95.5	167.5	116.4	48.9	24.5	50.0	3.1
1995	0.0	65.2	104.7	255.6	65.6	115.3	82.1	31.2	132.0	58.0	8.1	32.1
1996	55.7	13.9	208.5	98.0	148.1	301.8	152.8	179.6	116.0	15.6	16.8	6.2
1997	4.2	0.6	38.7	341.7		129.1	80.3	104.9	85.8	210.5	251.4	50.5
1998	99.0	45.9	72.9	145.8	115.4	152.5	98.3	149.4	103.5	160.8	14.3	6.2
1999	26.2	0.0	65.9	53.8	80.5	64.2	131.1	118.0	44.8	103.6	13.3	10.1
2000	4.6	0.0	21.8	88.8	217.7	115.8	86.2	68.1	67.3	165.1	68.4	18.5
2001	6.9	59.7		144.8	216.1	152.4	159.1	218.0	146.0	109.6	16.5	19.8
2002	87.2	17.9	83.7	146.9	196.1	49.2	80.8	107.5	47.1	62.9	15.6	122.6
2003	81.2	9.5	177.5	196.6	82.6	156.5	151.6	143.6	30.5	114.3	45.4	47.6
2004	111.8	28.7	26.0	227.0	111.6	49.3	69.7	103.8	67.4	60.4	19.0	21.1
2005	42.7	16.4	100.3	216.0	134.7	119.0	213.1		111.6	105.8	51.2	6.6
2006	5.1	49.3	85.4	308.6	142.3	80.9	89.1		81.2	137.6		83.4
2007	32.5	34.2	79.2	119.5	212.2	212.9		223.1	183.6	36.6		0.0
2009									96.4	130.6		
2010	49.7	81.9	201.1	160.8	304.5	118.4	132.9	87.3	75.1	13.7	19.3	12.9
2011	3.1	27.5	22.8	66.9	304.2	110.8	96.0	179.3	98.8	88.4	82.3	
2012	0.0	8.2	9.1	214.6			182.0	90.5	104.7	39.9	42.6	2.2
2013	79.8	11.5	159.0	285.9			177.3					

Appendix8: Monthly mean precipitation of Billate meteorological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	12.0	4.3	59.0	134.4	69.2	86.5	59.6	48.5	49.5	66.9	29.2	4.8
1986	0.0	60.0	0.0	78.0	129.0	X	108.7	105.3	119.2	44.1	23.5	68.1
1987	5.4	48.1	127.4	0.0	250.5	60.9	21.2	98.2	29.8	70.7	11.9	6.1
1988	20.3	43.0	52.3	133.5	108.0	72.0	208.4	127.4	81.4	105.9	0.0	11.2
1989	41.0	39.0	64.6	119.1	32.0	X	X	x	X	X	65.5	x
1990	8.7	134.3	99.0	97.1	90.1	74.8	75.0	30.1	22.5	X	22.1	7.8
1991	29.7	64.4	81.3	52.8	x	X	71.9	125.1	55.3	32.5	0.0	43.2
1992	24.2	94.5	73.9	141.7	x	54.7	60.9		84.2	138.8	92.5	25.3
1993	88.1	71.2	10.9	116.6	160.6	103.7	33.2	36.8	57.7	93.5	21.5	2.9
1994	0.0	14.5	45.8	176.4	50.2	88.1	263.1	26.3	36.3	42.1	40.8	35.0
1995	0.0	11.0	101.1	133.9	44.8	42.8	64.4	21.8	92.0	51.7	15.7	38.0
1996	118.3	1.3	96.8	126.5	80.9	252.5	133.0	106.7	76.3	39.4	18.7	25.4
1997	11.3	0.0	8.5	146.5	76.2	57.4	72.0	x	89.2	164.3	150.0	41.3
1998	88.2	38.2	41.5	66.1	84.4	59.6	61.6	87.8	33.2	70.0	1.8	0.0
1999	8.6	0.0	37.0	37.5	48.7	32.5	X	84.9	42.1	76.1	19.8	7.3
2000	0.0	0.0	7.4	58.7	117.8	69.4	74.0	51.9	99.7	76.8	50.1	10.6
2001	10.9	17.4	34.9	39.4	101.3	80.0	53.5	45.9	48.7	91.3	4.6	9.0
2002	47.1	1.2	52.7	72.5	49.0	17.2	33.3	47.6	27.9	48.6	0.0	123.5
2003	12.0	16.0	39.3	276.6	58.7	75.9	66.7	115.5	72.8	53.1	45.1	19.3
2004	89.0	43.5	15.9	212.5	91.9	27.2	71.1	66.7	86.4	59.3	39.0	x
2005	37.6	9.7	58.3	141.8	235.6	41.6	185.8	41.1	91.4	71.7	71.3	14.8
2006	4.7	41.9	147.8	126.5	136.7	38.8	86.5	136.3	82.1	144.4	18.8	67.9
2007	40.2	23.0	82.3	120.5	143.3	174.1	58.5	65.6	169.0	47.7	29.1	0.0
2008	10.4	4.3	0.9	86.3	87.4	38.4	109.9	87.6	69.9	161.2	127.9	2.8
2009	52.2	19.9	26.1	99.2	85.3	61.4	47.8	62.7	42.4	100.1	34.6	54.0
2010	37.0	81.4	141.6	187.5	143.0	133.2	73.1	81.7	113.8	40.8	41.9	7.3
2010	X	x	X	187.5	143.0	X	X	81.7	X	X	X	x
2011	13.4	16.8	38.7	63.5	200.4	36.1	X	x	X	X	X	x
2011	13.4	16.8	38.7	63.5	200.4	36.1	93.0	145.3	36.1		162.4	
2012	0.0	x	9.5	X	38.0	67.1	196.8	52.8	82.9	41.1	70.0	5.8
2013	48.7	5.8		238.2	94.9	92.2	188.9		25.5	222.1	62.5	0.0

Appendix9: Monthly mean temperature of Boditi meteorological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	19.3	19.85	20.35	18.6	18.45	17.45	16.15	16.25	17.65	18.45	18.7	18.75
1986	19.25	19.85	20.2	18.95	18.5	16.8	16.1	16.6	17.87	17.75	18.5	17.9
1987	18.2	18.95	18.6	18.5	17.6	16.75	16.5	16.5	17.4	17.55	17.55	18.05
1988	18.35	18.85	19.7	18.4	17.35	16.15	14.4	15.1	15.7	16.15	16.1	16.4
1989	16.35	17	17.45	16.3	16.7	15.15	14.45	14.9	15.5	15.85	16.45	15.95
1990	15.95	16.8	16.7	16.7	16.4	15.1	14.1	14.25	15.35	15.65	16.45	15.95
1991	17.35	17.35	16.7	16.85	16.15	15.3	13.2	13.9	15.2	15.3	15.65	15.05
1992	15.9	15.75	17.1	16.75	15.8	14.35	13.1	12.55	13.85	14.45	14.55	18.6
1993	18.25	18.5	20.15	18.95	18.55	17.45	16.4	16.85	17.6	18.55	18.65	19.15
1994	19.6	20.65	20.15	19.65	18.75	17.2	16.05	16.6	18.1	18.85	18.9	18.8
1995	20	20.5	19.6	19.2	19.55	18.75	17.25	17.25	18.25	19.25	19.5	20.15
1996	19.45	20.95	20.5	19.45	19.1	17.15	16.8	17.1	18.05	18.75	19.2	19.15
1997	20.3	20.75	21.75	18.9	19.1	18.65	17.2	18.3	19.55	19.05	18.75	19.3
1998	19.8	20.65	21.05	21.05	20	18.35	17.35	17.2	18.65	18.4	18.75	19.4
1999	20.1	21.35	20.05	20.65	19.6	18.6	16.8	17.5	18.75	18	18.7	19.4
2000	20.45	21.6	22.1	20.45	19.1	18.15	17.3	17.4	18.35	18.5	19.2	19.45
2001	19.6	20.55	20.1	20.45	19.2	18.1	17.3	17.3	18.7	18.95	19.3	19.8
2002	19.8	21.05	19.5	19.6	18.95	17.9	17.7	16.9	17.6	18.75	19.35	18.55
2003	18.2	21.05	21.1	19.95	19.95	18.2	17.25	17.05	18.65	19.5	19.85	18.55
2004	19.9	19.9	20.7	19.6	20	17.8	17.35	17.7	18.2	18.6	19.55	19.6
2005	19.65	21.65	20.7	20.8	18.65	18.25	17.15	17.8	18.1	18.85	18.85	18.9
2006	20.35	21	20.05	19.3	19.35	18.1	16.9	17.4	18.35	19.2	19.1	19.2
2007	19.25	20.4	21.2	19.8	19.8	17.55	17.1	17.25	17.95	18.75	19.3	19.25
2008	20.35	20.65	21.95	20.55	19.05	17.85	16.8	17.45	18.65	18.8	18.3	19.3
2009	19.8	20.95	22.25	20.7	20.3	19.8	17.9	18.2	19.4	19.05	18.46	18.64
2010	19.8	20.2	19.95	20.35	19.25	18.5	17.05	17.75	18.35	19.85	19.8	19.55
2011	20.3	21.4	21.5	22	19.7	18.45	17.8	17.9	18.55	19.65	19.35	19.15
2012	20.4	21.8	22.4	19.35	18.71	17.5	17.3	17.5	18.15	19.85	20.05	20.05

Appendix10: Monthly mean temperature of Billate meteorological station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	24.35	22.05	22.3	21.85	20.15	19.6	21.75	20.25	20.55	21.1	22.4	22.15
1986	22.2	22.35	22.4	21.6	20.55	21.9	21.85	22.35	22.75	23.65	24.1	24.5
1987	25.4	21.9	22.8	21.15	20.9	20	20.05	19.9	20.8	20.85	20.5	21.05
1988	22.65	23	23.05	23.05	20.9	19.95	18.6	18.7	19.45	19.4	19.2	20.4
1989	21.3	21.6	22.85	21.45	20.85	22.1	21.6	21.9	22.3	23.05	23.1	23.5
1990	23.05	23.95	23.15	23.7	22.8	22.25	21.8	22.35	23.15	23.05	23.8	23.95
1991	24.85	24.55	24.5	23.65	22	22.6	20.85	21.6	22	21.85	23.35	23.3
1992	24.65	24.85	24.9	24	22	22.4	21.6	21.75	22.15	22.25	22.25	23.15
1993	23.35	22.9	23.8	23.95	22.85	21.65	21.8	22.25	22.5	22.65	22.95	24.1
1994	25.15	25.35	24.95	23.3	22.8	21.95	21	21.6	22.8	22.3	22.8	23.55
1995	24.75	25.55	23.9	23.85	23.55	23.1	22	22.35	22.65	23.65	22.75	24.5
1996	24.45	25	24.55	24.15	24	21.65	21.05	21.4	21.8	21.35	21.35	22.45
1997	24.25	25.35	25.9	23.05	22.95	21.95	21.9	22.85	23.4	23.2	22.6	22.5
1998	23.4	24.45	24.75	25.3	23.85	22.9	22.65	22.15	23.1	22.95	23	23.95
1999	24.45	25.25	24.85	24	22.9	23.2	21.85	22.25	21.9	22.5	23.3	23.95
2000	25.05	25.95	26.5	25.1	22.7	22.2	22	22.1	22.8	22.75	22.65	24.15
2001	24.6	25.05	24.9	24.05	23.15	21.7	21.85	22.2	22.6	23.3	22.85	24.6
2002	24.75	25.15	24.7	23.75	22.7	22.1	21.6	21.9	22.3	22.65	22.85	23.5
2003												
2004	24.05	24.85	25.25	24.2	22.6	22.1	22.3	22.85	22.8	23.25	23.9	23.5
2005	24.75	26.4	25.5	25.05	22.3	22.45	21.75	22.55	22.15	22.75	22.9	23.65
2006	25.35	25.1	24.4	23.2	23.25	22.5	21.95	21.9	22.7	23.15	22.75	24
2007	24.7	25.9	25.35	23.9	23.4	21.75	21.55	21.35	22.15	21.95	23.35	24.15
2008	25.1	25.7	25.7	24	22.95	22.8	21.75	22.05	22.7	22.75	22.4	23.85
2009	24.4	25.35	26.1	24.05	23.6	23.25	22.6	23.3	23.75	23.45	24.25	24.35
2010	24.6	25.95	25.4	23.75	23.3	22.5	21.95	22.35	22.75	23.55	23.45	24.35
2011	17.7	25.45	26.35	25.75	23.8	22.35	21.65	22	22.95	23.6	24	23.45
2012	25.35	25.65	27	23.75	23.95	23.5	21.9	22.2	22.45	23.8	24.2	24.8
2013	25.6	26.85	24.7	23.85	22.6	22.4	21.45	21.9	22.55	22.95	22.85	23.7