COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR FOOD SECURITY STUDIES

CLIMATE VARIABILITY, ADAPTATION STRATEGIES AND DETERMINANTS OF HOUSE HOLD FOOD SECURITY IN HUMBO WOREDA, WOLAIT AZONE, ETHIOPIA

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JANUARY, 2022
ADDIS ABABA

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THESIS SUBMITTED TO CENTER FOR FOOD SECURITY STUDIES, COLLEGE OF DEVELOPMENT STUDIES ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR MSC DEGREE IN FOOD SECURITY AND DEVELOPMENT

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DECLARATION

I, Blen Mezegbu Alemayehu, do here by declare to Addis Ababa University School of Graduate Studies that this my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than my own are dually acknowledged.

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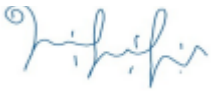
This is to certify that the above declaration made by the candidate is correct to the best of my knowledge as an advisor.



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This is to certify that the thesis prepared by Blen Mezegbu "**climate variability, adaptation strategies and determinants of hose hold food security in humbo woreda, wolait azone, ethiopia**" and submitted in partial fulfillment of the requirement for the degree of master of science in food security and development complies with the regulations of Addis Ababa University and meets the accepted standards with respect to originality and quality.

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List of abbreviation and acronyms

CEEPA	Center for Environmental Economics and Policy in Africa
CSA	Central Statistical Agency
DDC	Data Distribution Center
GDP	Gross Domestic Product
GHGs	Green House Gases
HH	Household
HHH	Household Head
HA	Hectares
MDG	Millennium Development Goal
MoFED	Ministry of Finance and Economic Development
NGO	Non-governmental Organization
SNNPR	Southern Nations Nationalities and People Region
IPCC	Intergovernmental Panel on Climate Change
NAPA	National Adaptation Program of Action
NOAA	National Oceanic and Atmospheric Administration (US Doc)
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program

ABSTRACT

Climate variability is predicted to adversely affect agricultural yields, particularly in African countries such as Ethiopia, where crop production relies heavily on environmental factors. This study was designed to understand local rainfall and temperature situations and its perceived impact on household food security. Accordingly, relevant data were collected from 200 sample households using simple random sampling and interviewed, together with focus groups supplemented. Both quantitative and qualitative data were collected concurrently. The quantitative data includes long-term climatic data (1981-2018. Data were analyzed using the descriptive and inferential statistics such as mean, percentage and standard deviation together with the logit regression model. Climate change over the last three decades was found to have a negative impact on the food security status of households. The unpredictability of rainfall, pests, and diseases were also contributing factors. The unpredictability of rainfall, pests, and diseases were also contributing factors. The study shows that more than eighty percent of farmers perceived the various manifestations and effects of climate variability on their food security status. Using HFIAS, 69% of sampled respondents were found to be food insecure. Analysis using the logistic regression model showed that sex and family size, as well as the amount of cultivated land and total livestock holding and occurrence of crop failure were the significant ($p < .05$) factors influencing household food security status. A large proportion (69.8%) of farmers were incorporating adapting strategies into farm management including improved use of crop varieties and livestock production, in addition to income diversification.

Key words: Food security, adaptation, households, climate variability

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the coming decades, global climate 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. Due to the current negative effect of climate change most areas are currently suffering from food insecurity. 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 (Schlenker and Lobell, 2010).

Due to the recently emerging climate change-induced phenomena, food insecurity is threatening everywhere (Nelson et al., 2009). Global environmental changes and increased climatic variability could demand the adaptation options and ways to minimize its risks (Getachew, 2010). Up to date, the links of climate change impacts and food security is largely been explored in relation to crop productivity and, hence, food production. (Gregory et al. (2002) summarized experimental findings on wheat and rice that decreased in yield as a consequence of warming about 5% per °C rise above 32°C (Gregory et al., 2008). Cline (2007) also estimates that global agricultural productivity will be reduced by 15.9% and developing country experiencing a disproportionally larger decline of 19.7%. Similarly, simulation of maize production in Africa and Latin America for 2055 predicted an overall reduction of 10% (Jones & Thornton, 2003). Increased impacts of climate change make the agricultural dependent people practice various adaptation and coping strategies (Akinnagbe & Irohibe, 2014). This mainly includes indigenous knowledge and skills outside the formal education over a long period of time in the rural communities (Mongi et al., 2010).

Developing countries are highly vulnerable 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 , although with special variations (Thobei et al. 2014).

Developing countries cover over nine tenths of the climate burden and represents 98% of those countries rigorously affected by climate change, over 99% of deaths are due to climate change related disasters and over 90% of the total economic losses caused by climate change occur in developing. Climate change impacts on developing countries as the extremely vulnerable people are typically poor and live in least developed countries that are prone to more than one type of climate disaster (Simane et al., 2016).

Climate change has implications for Africa which are highly distinctive. Comparing to the present atypically severe exposure to effects on production, African countries contribution in emissions of carbon is minor. Its past economic activity has not contributed to the accumulated global stock of carbon, its current activity accounts for less than a trivial proportion of worldwide emissions, and it will continue to be marginal. In Africa the major concern is adaptation of production, whereas in other countries the key issues concern how to decrease carbon emissions (Mota et al., 2019).

Ethiopia is the most vulnerable countries to climate change/variability in the world because of High dependence on natural resource and climate sensitive livelihoods together with existing poverty. The backbone of the country‘s economy is agriculture and natural resources including water and forest resources as well as main socio-economic sectors are highly affected by climate change (Mekuriaw et al., 2014).

Climate variability has creating challenge to Ethiopia, affecting agricultural productivity, economic growth, and food security. Subsistence farmers are particularly vulnerable to climate variability due to their low adaptive capacity; and dependence on consistent year-to-year agricultural production. Climate change/variability is expected to exacerbate variability in rainfall and temperature in Ethiopia, potentially increasing farmer exposure to climate-related hazards and associated food insecurity (Asfaw et al., 2018).

Understanding local perceptions and adaptive behavior provides better insights and information relevant to a policy that helps to address the challenge of sustainable agricultural development in the face of variable and uncertain environments (Simane et al. 2016). This study, therefore, will respond to a paucity of empirical information regarding the indicated gaps of knowledge addressing threefold purpose.

Wolaita is one zone in the South Nations Nationalities and peoples region (SNNPR) of Ethiopia. Like other parts of Ethiopia the area is being affected by climate related change. The food security of local peoples are extremely dependent on rain-fed subsistence agriculture: mixed crop-livestock production (Ayele, 2008). Drought induced famine, loss of crop productivity, declining of livestock production and livestock numbers and loss of biodiversity particularly indigenous crop varieties are frequently occurred challenges due climate change. Because of agricultural production, human and livestock health environmental resources and sociocultural system are fundamentally linked to climate Loss of agricultural outputs and deteriorating conditions in rural areas caused by climate variations will directly increase poverty of households in poor areas like Wolaita (UNEP 2006, Diao et al., 2005). Frequent failure in crop production and coping with seasonal food shortage through asset sales, renting out agricultural land and borrowing are found to ease food insecurity and poverty in areas like Humbo woreda (Mota et al., 2019).

Even recent studies in Wolaita and its surroundings by other researchers (Wedaje, et,al. 2016) assessed only trends in extreme and mean climate and adaptation strategies to climate change, respectively. Others have examined the link between farmers’ perception of climate change and trends of change in the meteorological data using station-based data and household surveys at national and subnational levels, which may not fully explain the situation at the local level. Crosssectional data from farm households located at different AEZs have also been used for exploring factors affecting farmers’ perception of climate

change and linking recently promoted gridded time series data for analyzing trends in the climate parameters. 'ere is a paucity of studies that use gridded data set s to analyze climate trends relating to the household perception of climate change in Ethiopia (Bedek. W et, al. 2019).

1.2 Statement of the Problem

Food security is that the most acute challenge in Africa. These challenges are compounded by effects of temperature change that result either in heavy flooding or drought that destroy farm produce and causes failure respectively(Negatu, 2016). Agricultural productivity is extremely obsessed on weather, climate and water availability, and is adversely stricken by weather and climate related disasters. Failure and food shortage may end up from what appears to be a minor and far localized decrease in annual precipitation (Mota et al., 2019).

In spite of the advance of main macro-economic indicators in recent years, food security remains one in every of the foremost important issues in Ethiopia's development agenda thanks to high dependence on climate sensitive agriculture. This dependency on the climate greatly affects food security of countless people. Within the past three or four decade, the country has been hit by repeated drought, flooding, famine and epidemics that relate to changing weather conditions. Indeed, food insecurity in some vulnerable regions is one in every of the foremost obstacles to poverty reduction (Mekasha et al., 2014).

Wolaita zone, like other parts of Ethiopia, is stricken by temperature change. In Wolaita, the livelihoods of the foremost people are supported agriculture: mixed crop-livestock production. This sector is greatly climate sensitive in its nature and little changes in climate conditions adversely affect agriculture generally and also the food security of households specifically. Some signs of this effect are drought, food insecurity, failure of crop production, death of livestock, loss of biodiversity (indigenous crop varieties) and even famine. Loss of agricultural productivity caused by climate variations will directly increase poverty of households, because agricultural production fundamentally linked to climate (UNEP 2006, Diao et al., 2005). The matter is further complex with existing poverty, increase and resource degradations.

Humbo woreda is one amongst the chronically food insecure and vulnerable area of Wolaita Zone. Humbo Woreda is also known to be one of the areas with highest level of environmental degradation in the region. The rate of soil erosion has generally increased through time while the intensity of deforestation has shifted towards lowlands in recent times and the area is experiencing erratic rainfall. Rural households in the study area face continuous food shortage and from the total population of the woreda about 44.1% have been benefited from safety net program since 2004 (HWAO, 2014).

According to Humbo Woreda Agricultural Office (2015) report food productions of major food item in the area have not been sufficient to satisfy the food demand of the increasing population and currently 15,550

people were benefited food aid due to climate change and 46,765 people benefited from safety net programme. These indicate that the rural poor to depend on food aid for their survival. These problems exposed many people to vulnerable condition. Therefore, relief assistance is common and provided frequently in the area from government and non-government organizations. Furthermore, the SNNPRS food security department in 2012 categorized Humbo woreda as primary hot spot woreda affected by climate variability related food security problem in the zone.

Limited research conducted during this area concerning global climate change and its impacts in Humbo woreda. Therefore, this research was aimed to come up with research based knowledge about climate change/variability and its impacts, by assessing the present situation associated with food security of local people within the study area and thus to fill the research gap within the area.

Although the area people, government bodies and other stakeholder recognize the matter within the area, without research-based knowledge the trouble to cope and adapt climate related impacts become very difficult. Limited research conducted during this area concerning global climate change and its impacts in humbo woreda. Therefore, this research is aimed to come up with research based knowledge about the global climate change and its impacts, by assessing the prevailing situation associated with the livelihoods of local people within the study area and thus to fill the research gap within the area.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of this study is to assess climate variability, adaptation responses and determinants of household food security in Humbo woreda,Wolaita zone.

1.3.2 Specific objective

More specifically the study is designed to:

- Examine trends and variability of temperature and rainfall in the area.
- Explore households perceptions of rainfall and temperatures and its impact on food security,
- Analyze determinants of household food security in the study area
- Describe climate variability adaptation strategies in the study area.

1.4 Research Questions

- What is the climate trend of the area?
- To what extent does climate variability affect the agricultural productivity and foodsecurity?
- How climate change affect household food security
- What are the local adaptation and copping strategies to impacts in the study area?

1.5 Significance of the Study

The local people awareness towards climate variability impacts is extremely limited. People don`t understand the science of human- induced climate variability but they understand how climate affect their food security. This study is important because it'll raise awareness among the local communities about global climate change and it'll provide valuable information to share with other communities including government bodies on the mechanisms that enable local communities to adapt to climate changes like short or lack of season, extremes of rainfall and runoff and drought. The study also will be helpful to spot the various stages of adaptation strategies so as to form interventions appropriate to the realm. Results of the study are going to be did and documented at district level in order that it'll function source material for further research development strategy.

Besides, this study provides necessary information for the regional government commissions of development planning program. Domestic in addition as international NGOs curious about promoting rural development within the study area would have the benefit of the findings of the study. The study gives insight to researchers and students inquisitive about the subject to stimulate further investigations of the issues in other areas.

1.6 Scope and Limitations of the Study

The scope of the study will be one woreda, and purposively selected two kebeles. The data of the study will be based on a cross sectional survey. The objective of this study is to assess the climate variability impact on household food security and their adaptation strategies. The data collection might be difficult as the study will conducted in rural area infrastructure and the willingness of the respondents may bother the data collection.

CHAPTER TWO

LITERATURE REVIEW

2.1 Concept of Climate Variability and Food Security

Climate variability is occurring since long and threaten the stability of societies as well as natural and managed ecosystems. Increases in ambient temperature and changes in related processes are directly linked to rising anthropogenic greenhouse emission (GHG) concentrations within the atmosphere. The impacts of climate change on the ability of agricultural systems, which include soil and water resources, to supply food, fuel, and maintenance of the existing ecosystem services (e.g., water system and habitat for crop landraces, wild relatives, and pollinators) also because the integrity of the environment, are major concerns. (Mekasha et al., 2014).

The word Climate variability implies any change in dimensions of climate –including average temperature and wind and rainfall patterns –over a long period. As free encyclopedia it's a change within the distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to many years). Climate change may ask a change in average weather, or within the time variation of weather around longer-term average conditions. (IPCC, 2014).

Climate variability considerations involve such major policies because the reduction of GHG emissions , including lowering carbon intensity of economies with less fuel (such as oil and coal) mined, burned, traded, introducing cleaner technologies, global climate change mitigation and adaptation. Global climate variability is becoming serious threats to the region's environment, ecological and socio-economic systems. Agricultural production has already decreased in some commodity groups and quantities and qualities of water resources are in danger of severe effects of global climate change. (Thobei et al. (2014)).

Shifting weather patterns, for instance, threaten food production through increased unpredictability of precipitation, rising sea levels contaminate coastal freshwater reserves and increase the danger of catastrophic flooding, and a warming atmosphere aids the pole-ward spread of pests and diseases once limited to the tropics. (Mengistu et al, 2011).

2.1.1 Climate variability in Ethiopia

Ethiopia is one among highly vulnerable countries to the impacts of climate variability due to heavily hooked in to natural rainfall agricultural system, with irrigation agriculture accounting for less than 1% of the whole farmland. Thus, key determinants to the crop yields and, in turn, food shortages, malnutrition and famine are temperature, the quantity and temporal distribution of rainfall and other climatic factors during the season. Small scale farmers and pastoralists are already conscious of these impacts in their food security status and livelihood opportunities (Oxfam, 2008).

Ethiopia ranks 10th within the list of countries most in peril of worldwide global climate change in 2014, according to the worldwide global climate change Vulnerability Index, prepared. The low-level of development and dependence on agriculture are the foremost reasons for this vulnerability. Climate variability and extreme events (drought and heavy rains) are causing significant damage to life, property, natural resources and economy in Ethiopia; making the foremost important economic systems highly vulnerable (EPCC, 2015). Food security is very sensitive to climate risks in Ethiopia. Compared to the 1961-1990 normal, mean annual temperature will increase within the range of 0.9–1.1°C by 2030, 1.7–2.1°C by 2050 and a couple of .7– 3.4°C by 2080, and a little increase in annual precipitation will occur over the country, with a rise of 1.3–6.1% by 2030, 2.4– 11.6% by 2050 and three .9–18.9% by 2080 (Weldegebriel, 2014).

Climate variability and its impacts have also been perceived by local people, who express (from their indigenous knowledge and experiences) climate variability and alter in this generally the temperature is increasing and therefore the rainfall is decreasing the bulk of local people in many areas have the perception that rainfall is simply decreasing, but scientific evidence (analysis of rainfall data obtained from the meteorological stations) shows rainfall variability (decreasing; increasing; unpredictable frequency, distribution, duration and timing) reckoning on location and time (season, year). On the opposite hand, the bulk of individuals believe that global climate change is caused by human activities like deforestation, while some link it to supernatural wrath and punishment from God to the bad activities being done by individuals (Chalachew et al., 2014).

2.1.2 Climate variability Impacts in Ethiopia

Ethiopia has experienced a minimum of five major national droughts since 1980, alongside literally dozens of local droughts. Frequently occurring drought creates a situation for several households, constantly upsetting the livelihoods of the many small hold farmers. (World Bank, 2008). Drought is widely known as a serious climate hazard and a key development challenge in Ethiopia. Recent reports also show that droughts have

increased in frequency and intensity in recent times. For instance, International Bank for Reconstruction and Development 2009, Ethiopia features a long history of recurring drought; however, since the 1970s, the magnitude, frequency, and impacts of droughts became more severe.

2.1.3 Climate Variability Impact on Agriculture

Agriculture is that the base for the livelihoods of various people within the developing world. Most of nations economy depends on that. Agricultural production is extremely addicted to weather, climate and water availability, and is adversely plagued by weather and climate related disasters (Hanse J. and Sivakumar M.V. K 2007). Similar explanation given by Akililu and Alebachew 2009) also indicates variations within the normal pattern of climate affects agricultural production by reducing productivity, the length of growing periods and forcing marginal area out of production.

The impacts of global climate change on agriculture are significant in Africa where agriculture is truly important for subsistence and where adaptive capacity is low ((Mekuriaw et al., 2014). Many research findings indicate that agriculture remains far and away the foremost important sector within the developing countries 'economy like Africa. as an example, World Bank, 2010 within the research conducted on social dimensions of adaptation to global climate change in Africa indicates that temperature change effects are seen in Africa over an extended period of your time through changes within the environment and natural resources and influences on livelihood activities and also the financial set-up at large; the later basically depends on agriculture, which is especially susceptible to natural disasters (World Bank, 2010).

In Ethiopia Agriculture directly supports about 85% of the population in terms of employment and livelihoods, contributes about 50% of the country's gross domestic product (GDP), produce about 88% of the export earnings, and supplies around 73% of the stuff requirement of agro-based domestic industries. Rosegrant et al., (2005) states that currently agriculture dominates the Ethiopian economy and accounting for nearly half the GDP and for the overwhelming majority of employment. While the country is greatly obsessed with the agricultural sector for income, foreign currency, and food security, small-scale farmers use largely rain-fed and traditional practices (Asfaw et. al., 2018).

Agriculture is also the major source of food for the population and hence the prime contributing sector to food security. It is also expected to play a key role in generating surplus capital to speed up the country's overall socioeconomic development. Due to climate change, it is projected that agricultural production could be reduced by 50% by 2020 (IPCC, 2014). This would impose great burdens on the livelihoods of millions of people in the world and aggravate poverty particularly in developing countries like Ethiopia.

2.2 The Concept of Food Security

Food security is defined in several ways by international organizations and researchers without much change in basic concept. According to FAO (2014), food security is defined as situation when people, in the least times, have physical and economic access, safe and nutrition food to satisfy their dietary needs and food preferences for a lively and healthy life. According to this definition, there are four important interlinked components of food security: availability, access, utilization and stability.

Food Availability: means food is physically present because it's been grown, processed, manufactured, and/or imported. For example, food is out there because it are often found in markets and shops; it's been produced on local farms or in home gardens; or it's arrived aspart of food aid. This refers to all or any available food within the area, and includes fresh, also as packaged food.

Food Access: refers to the way during which different people obtain available food. Normally, we access food through a mixture of means. This may include: home production, use of leftover stocks, purchase, barter, borrowing, sharing, gifts from relatives, and provisions by welfare systems or food aid. Food access is ensured when everyone within a community has adequate financial or other resources to get the food necessary for a nutritious diet.

Food Utilization: is that the way during which people use food. It is dependent upon variety of interrelated factors: the standard of the food and its method of preparation, storage facilities, and therefore the nutritional knowledge and health status of the individual consuming the food. For example, some diseases don't leave optimal absorption of nutrients, whereas growth requires increased intake of certain nutrients.

Food Stability: refers to be food secure, a population, household or individual must have access to adequate food within the least times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore ask both the supply and access dimensions of food security.

2.2.1 Climate Variability and Food Security

Climate variability and food availability are highly interlinked being climate variability may be a primary

controlling factor of agricultural productivity. It's expected to negatively influence crop production, livestock rearing and water cycle. It also affects food security along with overpopulation, poor land and poor water management causing hunger and malnutrition. A big proportion of individuals within the crop dependent highlands are chronically food insecure. Moreover, global climate change places more pressure on the food security of millions by reducing crop yields, increasing land degradation, and lowering water availability (EPCC, 2015).

Over 45million people affected worldwide as a results of reduced yield of cereals, fruits, vegetables, cash crops and livestock‟s (GHF, 2009). So ,climate change make shrinking of yield rates, arable land shocks to natural calamity creating less favorable growth conditions. Extreme weather events under global climate change, the frequency and intensity of some disasters like droughts, floods and storms could increase, with an adverse impact on livelihoods and food security.

Understanding the precise impacts of temperature change on food security is challenging because vulnerabilities are unevenly spread across the planet and ultimately rely on the flexibility of communities and countries to address risks. Within the context of food security, some regions of the globe might experience gains under temperature change, but developing countries are likely to be negatively affected. Changes in weather conditions have already affected the assembly of some staple crops, and future global climate change threatens to exacerbate this (Asfaw et. al, 2018).

2.3 Climate variability Adaptation

Adaptation to global climate change refers to adjustments in environmental, social and economic systems in response to the particular and expected impacts of temperature variability. Adaptation moderates vulnerability to temperature change. An efficient temperature change adaptation policy must be alert to a large form of environmental, social, economic, cultural and political circumstances. Adaptation to global climate change needs to be localized, only if adaptation to global climate change is inevitably and unavoidably local (Blaikie et al., 1994; Ribot, 1995). As such, adaptation should be a national priority and requires committed local action (Bewket, 2011). Adaptation strategies must be diverse and specific to a specific location supported traditional roots and may like modern science (Thobei et al. (2014)).

Adaptation to global climate change requires combining knowledge base with indigenous knowledge and practices. Moreover, adaptation to global climate change has to be endless endeavour. In Ethiopia, communities have important indigenous knowledge, skills and technologies that are 10 essential for tackling

hazardous 10 environmental conditions including climate variability and alter. In fact, they employ variety of short- and long-term global climate change mitigation and adaptation strategies to address and overcome the impacts of climate variability and alter. Thus, the utilization of indigenous knowledge and native coping strategies should be promoted as a place to begin for planning global climate change mitigation and adaptation (Mihretu et al, 2019). However, the power of communities to adapt to the impacts of climate variability and alter is constrained by variety of factors/barriers. Thus, the constraints to temperature variability adaptation are biophysical, human, financial, technical, technological, institutional, infrastructural, informational and political.

Coping Mechanisms to Climate Variability Experience with how society copes with current climate variability and extreme events provides a valuable foundation for longer-term adaptation, as it offers familiarity with climate and its socioeconomic impacts. Decision support tools and methods that are used for addressing today's challenges could also be used under a changing climate. In this regard strengthening capacity in terms of developing methods, tools, institutions and individuals to produce, disseminate and apply climate information is highly essential (Thobei et al. 2014).

Traditional and contemporary coping mechanisms to climate variability and extreme in Ethiopia include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid, etc. Therefore, communities have to be assisted to make their resilience against current and future climate stresses using indigenous knowledge and native coping/adaptation strategies and adopting appropriate technologies that are harmonized with government plans and research directions (Mihretu et al, 2019).

2.3.1 Adaptation Practices

Adaptations to global global climate variability and weather variability are extremely varied and will occur at varying scales. Consistent with Pearce (2009), adaptation measures may occur at organizational level through technological advances like crop development, machinery improvements and meteorology. Adaptation also occurs at the farm level through tactical and strategic adaptations. Tactical adaptation would come with practices like 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 (Meles et al, 2016).

The primary technological development which is that the foremost often advocated strategies for adaptation to global global 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 global global climate change. Farm production practices are third category which involves changes within the particular operation of the farm. This category ultimately describes farm level decisions with regard to farm production like land use, irrigation and operational timings the ultimate category is farm financial management highly influenced by government agricultural support. It is a farm level response using farm income strategies to scale back the danger of climate related income loss. Few researchers have addressed adaptation in analyzing the choice making process at farm level (Mulatu 2014).

2.3 Empirical Studies/literatures

Climate variability studies are becoming attention of most researchers from different discipline. Most studies are that specialize in the impacts of global climate change and variability on different sectors and adaptation strategies of systems to the change. Empirical studies on global 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 global climate change impacts, adaption on agriculture and food security.

The study reviewed was conducted in Tanzania by Mary and Majulle, (2009), the impact of global climate change variability and adaptation strategies on agriculture in Manyoni district. The study was aimed toward 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, consistent with the perception of local peoples and statistical climate data, showed that the temperature and rainfall has changed. The study reported that global climate change and variability is that the major challenge of crop production. In response to the impacts related to global climate change and variability, communities in study villagers are implementing different adaptation measures like Soil fertility improvement management, practices soils tillage practices, and staggered seed crop planting.

The second study, the impact of global 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 shown variability and successively this global 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 main ones. To minimize the impacts of global 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 costly foods. Beles feeding for livestock, migration, early maturing crop varieties, water and conservation, rehabilitation of gullies and area closure were future 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 global 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 within the study area perceived climate variability and change-induced hazards like 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 global climate change. The foremost common adaptation options include: reforestation, terracing, rain water harvest, change in cropping pattern, growing short maturing crops, birth control and diversification of income. But, poverty, water scarcity, land scarcity, market problem, lack of data about the weather or long-term global climate change, forage and feed scarcity, lack of agricultural technologies and appropriate seed and lack of health service were major limitation of adaptation within the study area

The study administered in Konso by Meron (2012), how the impact of global 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 suffering from the impact of global climate change not due to the working culture of the society rather there are factors which may affect or reduce the resilience of the society and their adaptation of agro ecological farming practices.

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

Empirical Evidences on Climate Variability and Adaptation Strategies

Different studies present a range of various coping strategies that the households are likely to adopt when faced with food shortage. Households aren't passive victims of food insecurity or drought. But, supported their

capacity, every household undertakes different activities to deal with crisis and to attenuate it. Cutler and Stephenson (1984) argue that the pattern of coping is basically determined by the precrisis characteristics of individual households that involve a succession of responses to increasingly severe conditions. Webb and Wernher Magnus Maximilian von Braun (1994), elaborate that these responses do not signify an overnight awakening to danger, rather a progressive narrowing of options that leads from broad attempts to attenuate risk in long-term through actions designed to limit damage caused by a crisis, to extreme measures geared toward saving individual lives, even at the expense of household dissolution. A study made in northern a part of Ethiopia identified the foremost common coping practice that's sequentially used during food crisis. It includes reducing number and size of meals, sell of small ruminants and draft oxen, consuming wild food, borrowing of money and/ or food from comfortable neighbors and/or relatives. Another less frequently used strategies were postponing wedding, sell of firewood, withdrawing children from school and eating toxic or taboo food (Eshetu, 2000).

Asfaw (2018) considers coping strategy as a shift between or within the assembly, consumption, income, assets and migration paths. The assembly path is indeed related to risk management that the farm households employ to scale back crop loss through diversification of crop varieties (Hardaker et al., 2004). It could also see the coping mechanism through diversification of the income sources as they promptly react to the food scarcity. However, such measures adopted by the households to attenuate risks remain effective for under limited periods of some time.

Mengestu (2011) reported that the coping mechanisms are sequentially adopted in an exceedingly way that the actions taken would, the utmost amount as possible, save life today without risking the end of the day food production or entitlement capacity of the household. At early stage, so on crop the extent of food insecurity, households adjust their production decisions similarly as labor location and commit non-(or less) productive assets.

2.4 Conceptual Framework of Household Food Security and Climate variability

Climate variability and food security are highly interlinked being climate variability could be a primary controlling factor of agricultural productivity. Moreover, global climate change places more pressure on the food security of millions by reducing crop yields and increasing land degradation (EPCC, 2015). So, climate change make shrinking of yield rates, arable land shocks to natural calamity creating less favorable growth conditions. Extreme weather events under temperature change, the frequency and intensity of some disasters like droughts, floods and storms could increase, with an adverse impact on livelihoods and food security.

As clearly discussed in literature review section and as revealed in figure 1 below, that household food security were affected by different factors. The analytical frame work shows that the linkage between household food security and variables assumed that affect household food security in study area. According to their nature, these variables are categorized under four categories. Demographic characteristics which include age, sex, educational level of the household head, family Size. Institutional factors category includes access to credit, Farm Technology and contact with development agent. Socio-economic factors involves, farm size, livestock size and non-farm income activity and also Climate and rain fall variability and adaptation strategies

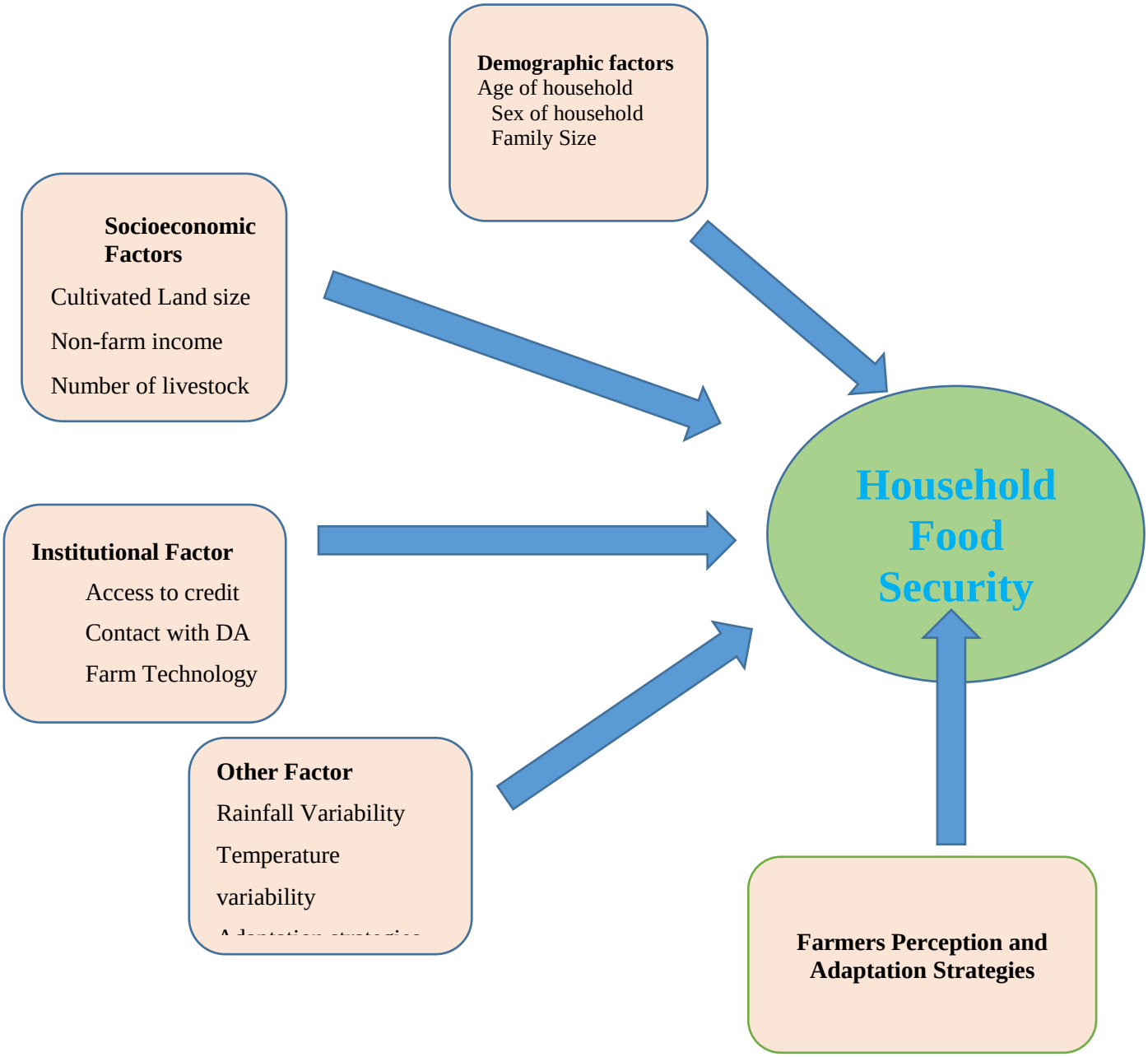

Fig 1: Conceptual Framework: Climate variability, socio-economic and institutional determinants of Food Security

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Descriptions of the Study Area

Location

Humbo Woreda is one of 12 Woreda in the Wolaita zone (135 in SNNRP). The Woreda is located at a distance of 408 km (to the south) from Addis Ababa. It is 18 km to the Southern of Sodo town, the seat of Wolaita zone administration. The woreda has 22 rural kebele administrative. The total land coverage of the Woreda is 86,646 hector out of which 38,488.15 h/r (44.42%) is used to crops production, and the rest 48,157.85 h/r (55.58%) of the land is used for grazing, forest, degraded and small portion of land for other communal purposes (HWAO, 2014).

Socio- Economic Condition

This woreda has a total population of 161,792, of whom 81,151 are men and 80,641 women; 6,247 or 4.98% of its population are urban dwellers. The total number of household heads in the Woreda is 32,682 out of which 28,812 (88.16%) are men and 3,870 (11.84%) are women. The average household size is 4.88 (WZFED, 2014). The Woreda is classified into two agro ecological zones, among them large proportion is Kola (low altitude) which is about 70% of the area; the rest 30% is described as Waina-Dega (mid-altitude). Agriculture is the main source of livelihoods of the people. However, the agricultural system is still traditional and is often characterized by low productivity. Farmers grow a variety of crops in the two seasons. Major crops grown in the Woreda include cereals, pulses and cash crops like, fruits, and root crops. Maize is the dominant cereal crops grown in the area (HWAO, 2014).

Climate Condition

There are two agricultural production seasons; meher (long rainy season) and belg (short rainy season). The meher rains start in June and extends up to Mid-September, while the belg rainy season lasts from March to May. The belg season contributes the highest share to the annual crop production; and above 90% of the farmers operates in this season. However, the area is known for its low productivity due to erratic rainfall and prevalence of pests. As a result, income from non-farm and off-farm activities is the second most important source of livelihood in the Woreda. Especially, trading plays an important role in generating income for both non-farm and off-farm activities. Apart from trading, income from daily labor and seasonal workforce movement during harvest time is another source of income (HWAO, 2014). Above 35% of the

farmers operated in the Maher season it is from March to May .the belg season contributes the highst share to the annual crop production.

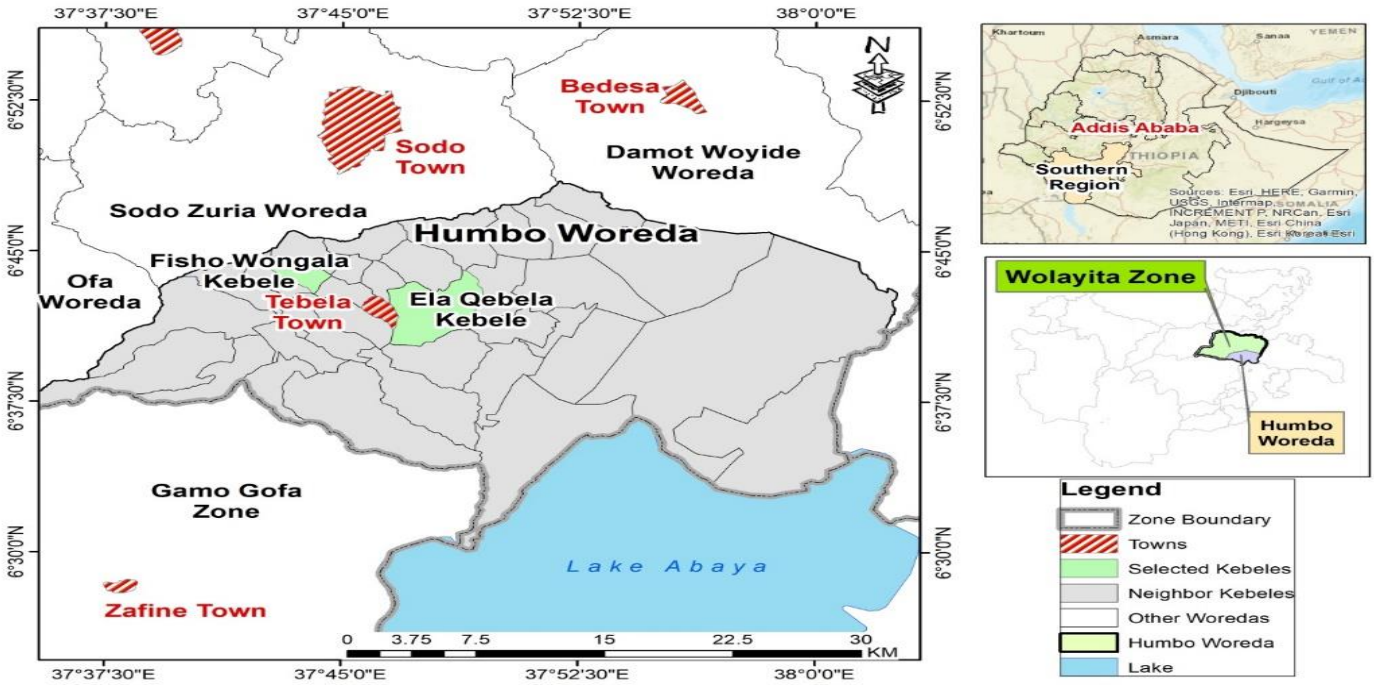

Figure 2. Map of the Study Area

3.2 Research Design

In this study, descriptive and explanatory research approach was applied for collecting the essential data used to assess the effect of climate variability on household food security in Humbo woreda. Because in order to address the stated objectives the study needs the collection of statistical (numerical) data for the quantitative approach and to describe existing conditions of the woreda by using qualitative data.

3.3 Research Methods

This research was employ both qualitative and quantitative research approaches. Also, the study used both primary and secondary data sources; which complement to each other. quantitative method was used to capture relevant information related with socioeconomic and demographic characteristics of respondents, rainfall and temperature situations, perceptions, food security status and food coping response) and likewise qualitative method was mainly applied to support the quantitative data and hence it encompasses).

3.3.1 Sampling Techniques and Sample Size Determination

In this research a set of sampling methods were applied to select research sites and respondents from different

segment of the community. Accordingly, Humbo woredas was selected purposely due to its exposure to climate variables and pervasive food insecurity problem and kebeles from woinadega and kola agro-ecology were selected purposely.

Humbo Woreda is divided into 22 kebeles. Two kebeles were stratified from the two agro climatic zones highland; weynadega, and low land; Kola. Ela Qebela from the low land (Kola agro-ecology) and Fisho Wongela 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. The target population for the study comprised households living in selected Kebeles households were selected random sampling from kebele administration registration lists depending on their population size by applying the formula suggested by (Yeman, 1967)

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

Where n= sample sizeN= the population size
e = the level of precision (+7)

Currently records show that there is a total 6357 (3113 male and 3244 female) population in the selected two kebeles (Finance and Economic development of Wolaita Zone2016). Therefore, the sample size was calculated as

$$n = N\frac{N}{1+(e)7} = \frac{6357}{1+6357(0.07)2} = \frac{6357}{} = 200$$

Samples from each kebele were selected based on proportional sampling and the sample selected from each kebeles were proportional to the population in each kebele and was determined using the following formula:

$$ni = \frac{(Ni)(n)}{\sum Ni}$$

Where ni - the sample to be selected from i^{th} kebele

Ni - the total population living in i^{th} kebele.

ΣNi - the summation of population living in selected four kebeles

n - total sample size for the district

Table 1. Sample Size

Kebeles	Male	Female	Total	Percentage	Sample Size
Ela Qebela	1499	1560	3059	31.84	94
Fisho Wongala	1614	1684	3298	34.3	106
Key informants					6
Grand total of sample size	3113	3244	6357		206

3.3.2 Data Sources and Data Collection Tools

The two major sources of data for this particular study are primary and secondary sources. As primary sources, some relevant data were obtained by making use of semi structured interviews, observation supported with photographs, and key informant interviews; while as secondary sources existing documents (published and unpublished) on the theoretical and empirical aspects of the issue under the study were collected, reviewed and analyzed. Furthermore, meteorological data (rainfall and temperature monthly means) for last 20 to 30 years and crop yield data of the last 5 years will be obtained and analyzed.

The primary data were collected using both quantitative and qualitative data collection methods. The quantitative data collection method were HHs survey. The qualitative data sources were gathered by employing FGDs, Key Informant Interviews and field observation. The tools of data collection were prepared such as questionnaires and checklist/guideline respectively.

Secondary data sources were collected from journal articles, books, legal documents (proclamations, regulation and directives), statistical abstracts, study reports, thesis and dissertations among others.

These sources of secondary information were accessed from the internet, university libraries, institutions and organizations. Historical data on demographic and socio-economic variables were obtained from various statistical abstract.

Household Survey

A household survey were conducted using structured questionnaires designed in line with stated research objectives and research questions. As determined in sample size, in this study 200 HHs were participated in structured interview. The data to be collected using this method included personal background information of respondents.

Focus Group Discussions (FGDs)

One focus group discussions at each study areas were conducted and each focus group comprised six to eight individuals. The output of the discussion was used as a guide the design of household questionnaire and to get additional supporting qualitative evidence of the on current situation of household food security and challenges that farmers have been faced due to climate variability.

Interviews

Two community elders were interviewed. Community elders'interviews were held to get more information about the climate trends, climate variability, and impacts on their food security and coping mechanisms in the area as well as to confirm the ideas collected in households'response.

Field Observations

Field observations were conducted unsystematically during field data collection in the selected kebeles and photographs were taken to illustrate some of the current environmental and socio- economic challenges in the area, and the existing adapting mechanisms of the local communities.

3.3.3 Data Analysis

After data collection and editing and coding were completed, it was entered into computer using statistical package for social science (SPSS) version23 software. For the purpose of this particular study, the collected data was analyzed in different ways. Based on objectives of the study, both descriptive and inferential statistics and econometric model was adopted.

As descriptive statistics, frequency distribution, charts, mean, maximum and minimum, percentage distribution and standard deviation was employed to analyze the quantitative data. As inferential statistics, chi square was used to identify the associations between categorical variables and independent t- test was also used to compare mean differences between two groups across the study variable, while

taking the research objective into consideration. Data that was obtained from key informant discussion and other qualitative data were analyzed in qualitative way. Household Food Insecurity Access Scale (HFIAS) and examines the food security status of households. The HFIAS score was calculated using the answers based on the nine frequency-of-occurrence questions. Determinants of household food security were identified using logistic regression model.

Household Food Insecurity Access Scale (HFIAS)

Food and Nutrition Technical Assistance (FANTA) Project and its partners have identified a set of questions. Household food insecurity access scale generic questions that will be used to distinguish the food secure from food insecure households. The HFIAS consists of two types of related questions. The first question type was called an occurrence question.

There will be nine occurrence questions that ask whether a specific condition associated with the experience of food insecurity ever occurred during the previous four weeks (30 days). Each of the questions in table 3 will be asked with a recall period of four weeks (30 days). Therespondents will first asked 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 30 occurrence question, a frequency-of-occurrence question is asked to determine whether the condition happened rarely (once or twice), sometimes (three to ten times) or often (more than tentimes) in the past four weeks, (FANTA, 2007).

As it discussed in detail by Coates *et al.* (2007), the HFIAS module allows calculating the four types of indicators that capture Household Food Insecurity Access-related. These are: Conditions, Domains, Scale Score and Prevalence. The Conditions indicator measures the percentage of the households experiencing a specific condition at any time during the four week recall period, and informing about the behaviors and perceptions of the interviewees. It can be computed with respect to a certain question or to the related frequency sub-question.

Table 2: Formula of Household Food Insecurity Access-related Conditions

Household Food Insecurity Access-related Conditions Households experiencing condition at any time during the recall period.	Percent of households that responded, "yes" to a specific occurrence question. For example: "Percent of households that ran out of food." Example: $\frac{\text{Number of households with response } = \text{ 1 to Q7}}{\text{Total number of households responding to Q7}} \; x \; 100$

Households experiencing condition at a given frequency	Percent of households that responded "often" to a specific frequency-of-occurrence question. For example: "Percent of households that ran out of food often." Example: $\frac{\text{Number of households with response } = \text{ 3 to Q7a}}{\text{Total number of households responding to Q7}} \; x \; 100$

Source: Coates et al. (2007)

Information on the prevalence of households experiencing one or more behaviours in each dimension is summarised by the Domains indicator, which considers the experiences which households getting any of the conditions, at any level of severity.

Table 3: Formula of Household Food Insecurity Access-related Domains

Household Food Insecurity Access-related Domains Households experiencing any of the conditions at any level of severity in each domain	Percent of households that responded "yes" to any of the conditions in a specific domain. For example: "Percent of households with insufficient food quality." Example: $\frac{\text{Number of households with response } = \text{ 1 to Q2 OR 1 to Q3 OR 1 to Q4}}{\text{Total number of households responding to Q2 OR Q3 OR Q4}} \; x \; 100$

Source: Coates et al. (2007)

The Scale Score indicates the severity level of household's food insecurity. The score variable is calculated by summing the codes for each frequency question: the score ranges from a minimum of zero (households never experiencing any of the situations presented in the questionnaire) to a maximum of 27 (households often reporting such situations). Hence, the higher the score, the more severe the food insecurity status is. The score indicator uses the score variable and was expressed as the average HFIAS score (see the calculation on Table 4 and 5).

Table 4: Formula of HFIA Score

HFIAS Score (0-27)	Sum of the frequency-of-occurrence during the past four weeks for the 9 food insecurity-related conditions Sum frequency-of-occurrence question response code (Q1a +Q2a + Q3a + Q4a + Q5a + Q6a + Q7a + Q8a + Q9a)

Source: Coates et al. (2007)

Next, the ***indicator***, average Household Food Insecurity Access Scale Score, is calculated using the household scores calculated above.

Table 5: Formula of Average HFIA Score

Average HFIAS Score	Calculate the average of the Household Food Insecurity Access Scale Scores xi $\frac{Sum\ of\ HFIAS\ Scores\ in\ the\ sample}{\text{Number of HFIAS Scores (i.e., households) in the sample}}$

Source: Coates et al. (2007)

The Household Food Insecurity Access Prevalence indicator categorizes households into four levels of household food insecurity (access): food secures, mild food insecure, moderately food insecure and severely food insecure (see the calculation on Table 5 and 6). Households were categorized as increasingly food insecure as they responded affirmatively to more severe conditions and/or had experiences to those conditions frequently. On the other hand, a food secure household experiences none of the food insecurity (access) conditions; or it rarely experiences worry.

A mildly food insecure (access) household sometimes or often worried about not having enough food. Besides, it is unable to eat the foods they preferred, and/or some foods considered undesirable. This only rarely happened. It did not cutback either the quantity nor the experience any of the three most sever conditions such as running out of food, going to bed hungry and going a whole day and night without eating (in questions 7, 8 and 9).

A moderately food insecure households sacrifices quality more frequently, by habitually eating a monotone or similar diet or undesirable foods sometimes or often, and/or had started to cut back the quantity of the food by reducing the size of meals or number of meals, rarely or sometimes. But, the moderately food insecure households did not experienced any of the three most sever conditions.

A severely food insecure household was experienced any of the three most sever conditions (running out of food, going to bed hungry and going a whole day and night without eating). In other words, any household which experienced one of the three conditions; even ones in the last four weeks (30 days) were considered as severely food insecure.

Table 6: Formula of HFIA Category

	First, the Household Food Insecurity Access category for each household should Calculate. 1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure Access

HFIA category	HFIA category = 1 if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]
	HFIA category = 2 if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]
	HFIA category = 3 if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]
	HFIA category = 4 if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]

Source: Coates *et al* (2007)

Next, the prevalence of different levels of household food insecurity (access) is calculated.

Table 7: Calculation of HFIA Prevalence

HFIA Prevalence	Percentage of households that fall in each food insecurity (access) category. For example: "Percentage of severely food insecure (access) households." Example: $\frac{\text{Number of households with HFIA category } = 4}{\text{Total number of households with a HFIA category}} x\ 100$

Source: Coates *et al.* (2007)

The analysis of rainfall and temperature involved characterizing long-term mean values, calculations of indices of variability and trend at annual and seasonal time steps. Standard anomaly was calculated to assess rainfall and temperature variability.

Food Consumption Score

To estimate the FCS, foods will be regrouped into eight standard food groups (Table 2 below). The Food Consumption Score (FCS), a tool developed by WFP, is commonly used as a proxy indicator for access to food. It is a weighted score based on food frequency and the nutritional importance of food groups consumed. Data will be collected on the number of days in the last 7 days before the survey a household ate specific food items.

Table 8: Food Items, Food Groups and Weights for Calculation of the FCS

Food items	Food group	Weight
Cereals: Corn, Wheat,	Staples	2
Sorghum, Rice, Bread		

Roots and Tubers:		
Pulses/Beans/ Nuts Pulses	Pulses	3
Milk/ Milk Products Milk	Milk	4
Animal Proteins: Fish, Meat, Eggs	Meat and fish	4
Vegetables (including green, leafy vegetables)	Vegetables	1
Sugar/ Honey	Sugar	0.5
Fruits	Fruits	1
Oil and Fats	Oil	0.5

Source: World Food Program (2007).

The Household food consumption score (FCS) will calculated by multiplying each food group frequency by each food group weight, and then summing these scores into one composite score. The weighting of food groups has been determined by (WFP, 2007) according to the nutrition density of the food group. In line with the explanations given above, the most basic estimation equation for the Food Consumption Score use for this study is:

FCS=$a\times f$(staple)+β×f(pulse)+γ×f(vegetables)+γ×f(fruit)+δ×f(animal)+×f(sugar)+$\delta\times f$(dai
ry)+×f(oil)

Where FCS = food consumption score,

f= frequencies of food consumption = number of days for which each food group was consumed during the past 7 days,, β, γ, δ and = weight/nutritional value of each food group.

According to (WFP, 2007; IFPRI, 2008), households with poor food consumption have a food score of 0-28, households with borderline food consumption have a food score of 28.542 and households with adequate food consumption have a food score of above 42 which is viewed as acceptable.

Econometric Model Specification

According to Gujarati (1995), three types of models have been proposed in the econometric literature for estimating binary choice models: the linear probability, logit and probit models represented by linear probability function, logistic distribution function and normal distribution function, respectively. These functions were used to approximate the mathematical relationships between explanatory variables and the food security situation that is always assigned qualitative response variables.

According to Hosmer and Lemeshow, (1989) the major point that distinguishes these functions from the linear regression model is that the outcome variable in these functions is dichotomous. Besides, the difference between logistic and linear regression is reflected both in the choice of a parametric model and in the assumptions. Once this difference is accounted for, the methods employed in analysis using logistic regression follow the same general principles used in linear regression.

Available evidence shows that the logistic function is the most frequently used function in food security studies. According to Hosmer and Lemeshow (1989), there are two primary reasons for choosing the logistic distributions: from mathematical point of view; it is an extremely flexible and easily used function; and it lends itself to a meaningful interpretation. The interest of the study with regard to this objective is to analyze the determinant factors that affect the household food security. For this study, analytical model selected is binary logit model which significantly identifies the food security situation of households.

Binary choice models are appropriate when the decision making choice between two alternatives (food secure and food insecure). Household food security is a dependent variable, which takes a value of zero or one depending on whether or not a household was food secure or not (i.e. Food secure=1 and Food insecure=0).

Following (Gujarati, 1995) the logistic distribution for the food security situation can be specified as:

Pi= $e\ zi\ 1+e\ zi$….....1

Where pi =was the probability that an individual is being food secure for the ith household and ranges from 0 to 1.e = Represents the base of natural logarithms and

Zi= is the function of a vector of n- explanatory variables(x) and expressed as

$Zi=\beta 0+\sum \beta iXi+ ui$……2

Where β0= is the intercept

Bi = is regression coefficients to be estimated,

Xi= is Variables and ui = is a disturbance term 1-Pi was represents the probability of not being food secured group and can be written as:

$1\text{-}Pi=11+e\ zi$……....3

Then odds ratio can be written as:

$pi1-Pi=1+ezi1+e-zi=e\ zi$….....4

Equation (4) was indicates simply the odds ratio. It was the ratio of the probability that the household was food secure (Pi) to the probability that he/she was food insecure. Finally, by taking the natural logarism of equation (4) the log of odds ratio could be written as:

$Li=Ln\ (\ pi\ 1-Pi\ )=Ln\ (e\ \beta 0+\sum \beta\ n\ j=1\ jxij) = Zi=\beta o+\sum \beta jxij\ n\ j=1\ +ui$……..5

Where Li was log of the odds ratio, which was not only linear in X ji but also linear in the parameters.

3.3.4 Measurement and Definition of Variables used in the Models

Dependent Variable: The household food security status, which is the dependent variable for the logit analysis is a dichotomous variable representing the status of the household food security. It is represented in the model by 1 if the household is food insecure and 0 otherwise.

Age of Household Head: is a continuous explanatory variable measured by year. Older people have relatively richer experiences of the social and physical environments and greater experience of farming activities. Older household heads are expected to have better access to land than younger heads, because younger men either have to wait for land redistribution, or have to share land with their families (Haile et al., 2005). Thus, it is hypothesized that age of the household heads and household food security would be positively correlated.

Sex of Household Head: It is dummy variable and household head is a person who economically supports or manages the household. It could be male or female. Male headed households have more access to agricultural technologies, more labor power and farm land as compared to female headed households. Whereas, women farmers may need a long adjustment period to diversify their income sources fully and become food secure (Christina et al., 2001). Hence, it is hypothesize that male headed households are more likely to be food secured than female headed households.

Educational Status of Household Head: is dummy variable and an important determinant of household food security status in that; educated households have a better chance of adopting soil conservation measures which in turn increases crop production (Million and Kassa, 2004). Moreover, educated household head has the capacity to innovate and to adopt timely technology and has better understanding of the cash crops that can help them to have a better income than the non-educated households (Fekadu, 2008). Thus, education status is hypothesized to have a positive effect on household food security.

Family Size: is a continuous variable; it refers to the total number of household members who lived and eat with household at least for six months. It is an important variable which determines the state of household food security and expected to have negative effect on household food security (Mequanent, 2009). According to reviewed literatures, increasing family size tends to exert more pressure on consumption than the labor it contributes to production (Tsegay, 2009). Thus, family size is hypothesized to have a negative effect on household food security.

Total farm size: is a continuous explanatory variable and an important determinant of household food security. Farm size is the total area of land cultivated to food and cash crop by households, measured in hectares. Positive relationship has been established between farm size and improvement in households' income and food security (Jayne et al., 2005). Therefore, expected of a household with a larger farm size to be more food secure

than a household with a smaller farm size.

Off-farm Activity: A dummy variable whether the household head works in off farm income or not. According to the data this study uses, off farm income is a situation by which the household earns income through participating in an activity out of his own farm. This could be in food for work or in a farm other than own farm. Holden et.al (2004) found that off farm activity has positive welfare implications. Hence, it is anticipated that households participate in off-farm activities have positive effect on food security than Non participant households.

Total Livestock Owned (TLU): is a continuous variable and is important source of livelihood. It contributes as source of transport, nutrition, and income. It also serves as a means of coping mechanism during shortage of food (Almaz et al., 2015). The types of animal reared in the study area include cattle, sheep, goat, donkey and chicken. Therefore, it is expected a household with a larger number of livestock owned to be more food secure than a household with a smaller number of livestock owned.

Use of Inputs: is dummy variable and refers to use of chemical fertilizer, improved seed, pesticide and herbicide. A household who could have used farm inputs hypothesized to have positive relation with food security status because he/she produce more (Mequanent et al., 2014). Thus, it is hypothesized that household who used farm inputs would have a positive relation with household food security than non users.

Access to Credit: was a dummy variable that takes the value 1 when the household takes loan and 0 otherwise. Credit is very much useful to purchase inputs such as improved seeds, other important inputs due to use of agricultural inputs which enhance food production and ultimately increase household food security status. Moreover, households with access to credit may purchase food when the need arises. Both pathways indicate that a direct relationship of credit access and household food security. Including staple food. Hence, farmers who have access to credit would have positive effect on crop production

Extension Service: is continuous variable and the effort to disseminate new agricultural technologies are mainly successful if there is smooth and frequent contact between development agent and the rural household. Here, the extension contact between a farmer and development agent has the potential force to accelerate effective dissemination of adequate agricultural information that, in turn, enhances farmers' decision to adopt agricultural technologies (Kidane et al, 2005). Therefore, it is hypothesized that households having frequent extension contact would have positive relation with household food security than have no frequent extension contact.

Table 9: Variable Definitions, Measurement and Hypothesis

Variable code	**Description and measurements**	**Hypothesized sign**

AGEHHH	Age of the household head (in years)	+
SEXHHH	Is a dummy variable taking the value 1 if the house hold head is male, 0 otherwise	+
FAMILYSIZE	Is the number of the households members	-
EDUCATIONSHHH	Is a dummy variable taking the value of 1 if the household is literate, 0 otherwise	+
FRQEXNCONT	Number of time extension agent visited/advised farmer (number) per a year.	+
OFFARMINCOME	Is dummy variable taking the value 1 if the household participate on off farm income, 0 otherwise	+
TOTALLIVESTOCK	Total livestock owned by the farm household (TLU).	+
FARMSIZE	Total farm size of household (in hectare).	+
USEOFINOUT	Is dummy variable taking the value 1 if the household uses inputs, 0 otherwise	+
ACCESSTOCREDIT	Is dummy variable taking the value 1 if the household uses inputs, 0 otherwise	+

CHAPTER FOUR

RESULT AND DISCUSSION

4.3 Demographic Characteristics of the Sampled Households

Sex: The study sample comprised of 200 household heads, of which 119 were male household heads and 81 were female household heads. The table (8) below and its discussions explained the demographic characteristics of the households from various perspectives. According to the study result, 59.5% of the sample household heads were males and the reminding 40.5% were females.

Age: Table 8 portrays the age distribution of the sampled population. The mean age of the sample household heads was found 45.82 with standard deviation of 12.14. The mean age of food insecure households was 43.3. Years and that of food secure households was 51.33 years. The statistical analysis revealed that there is significant difference in the mean age of the household head between food secure and food insecure households.

Educational status: As it is displayed on the same Table, the highest percentage of educational status of household members categorized on illiterate (unable to read and write) at 73%, 20.5% respondents attend primary school and the remaining 6.5 % attend high school.

Family Size: The study revealed that family sizes vary from 2 people per household to a maximum of 10 family members. The table 14 also shows that, 11 % of the households had family sizes ranging from 1 to 3 members, 68.5% had household sizes ranges from 3-7 family members while 20.5% had family sizes 7-10 members. The average family size for the overall sample household is 6.94 with standard deviation of 2.36 and with minimum and maximum family size being 2 and 12 respectively.

Table 10: Demographic Characteristics of Household Heads

		Frequency	%
Sex	**Male**	119	59.5
	Female	81	40.5
Total		200	100
Educational status	**Unable to read and write**	146	73
	Primary level	41	20.5
	Secondary level	13	6.5
Total		200	100
Age	**20-40**	13	7.80

	40-60	64	39.46
	> **60**	86	52.74
Total		200	100
Family size	**1-3**	22	11
	3-7	137	68.5
	≥ **8**	41	20.5
	Total	200	100

4.1 Trend and Variability of Rainfall and Temperature

The computed summary statistics of rainfall including mean, standard deviation (SD) and CV over the study area for the period 1981–2018 are presented in Table 10. The mean annual rainfall was recorded as 807.96mm with a standard deviation of 175mm. The long-term average of main rainy season and small rainy season are 286.28 and 276.91 with coefficient of variation 92.63 and 98.64 respectively. The coefficient of variation (CV) of the seasonal rainfall revealed 32.36% and 35.62%) rainfall variability Main and small rain seasons respectively. The main and small rain season received 35.4% and 34.2% of annual rainfall respectively.

Table 11 Annual and Seasonal Rainfall long-term Average, Standard deviation and Coefficient of Variation in the Study Area (1981-2018)

	Season		
Rainfall	**Annual**	**Main rainy season**	**Small rainy season**
Long-term Average	807.96	286.28	276.91
Standard Deviation	175.75	92.63	98.64
Coefficient of Variation (%)	21.7	32.36	35.62

According to the data obtained from Ethiopia Metrological Agency, the coefficient of variation of long-term average rainfall in the study area was 21%, 32.36%, and 35.62% for annual, main and small rain season, respectively. This indicates that there was a high inter-annual variability of rainfall between 1983 and 2016. It further explained that the degree of variation in the amount of rainfall was higher for small rain season than main rain season.

Majority (83.8%) of the respondents in the study area had heard about climate change and its impacts. The also

perceived that there was a decrease in the amount of annual rainfall, whereas 50.8% of them responded that rainfall is late during the onsets and ends up early, and 84.3% of the respondents perceived that there was a significant increase in temperature. The percentage of evidence in the data confirmed that there was a change in climate. The proportion of people having heard about climate change and its impact on people was significantly higher in the study area. Among those who had heard about climate change in study areas, more than two thirds were aware of the term "climate change" and interpreted it as soil drying, high temperature and long heat waves. The impact of climate change most often mentioned by the respondent was the impact on crop and live stalk production.

The long term (1981 to 2018) totally 38 years total annual rainfall is 1261.4mm. The annual total rainfall is decreasing over the years; mostly1984, 2009 and 2015 was the anomalous year with a total amount rainfall only 419mm, 554.9mm and 491.4mm respectively. The maximum annual amount of rain fall received in1996 and1997 accounting for 1248.3mm and 1089mm respectively. Humbo Woreda receives insufficient total amount of rainfall. The other problem of rainfall distribution was more related to the temporal variability or concentration within a few seasons. In other words, the inconsistency in onset and termination of rainfall should be given a due attention. The annual total rainfall of Humbo Woreda ranges between the year 1981 and 2018 for 38 years is between 419 mm in 1984 to 1248.3mm in 1996.

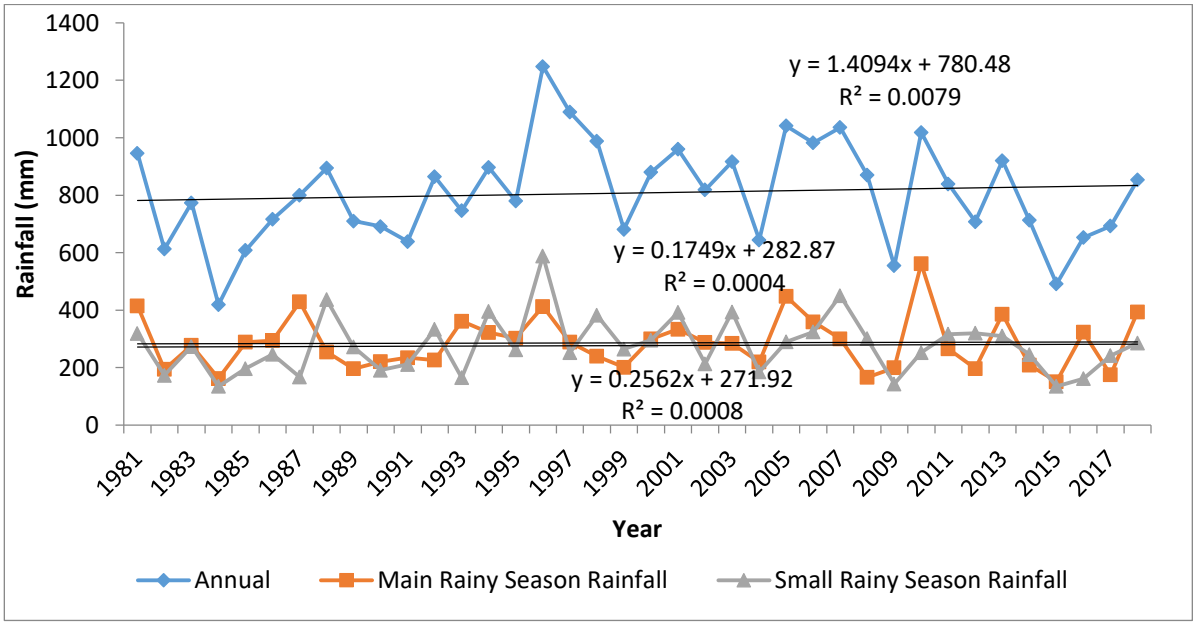

Figure 3. Trends of Annual and Seasonal Rainfall in the Study Area (1981-2018)

As indicated in the figure 3 the assessed rainfall trend value (curve) shows slightly increasing between 1996, 1997 and 2010. It drops in years between 1994and 2009 and 2015. Hence, the objective of the study is to assess the trend of temperature and rainfall, overall annual rain fall trend reveals decreasing on average except 1996,

1997, 2005 and 2010. In general rainfall is one of the vital resources to carry out the overall agricultural output and other developmental activities. Thus, one can infer that, an increasing trend of rainfall tend to have the potential to devastate the soil in a form of soil erosion, which eventually will result in deterioration of agricultural productivity. Effects of rainfall such as drought and flood were damaging both crop production and livestock raring resulting in food insecurity. Thus, it has a vital risk and impacts on the livelihoods of the rural population. On figure 6 one can infer that, rainfall condition is slightly affected by the annual rainfall variability.

One can see from Figure 6 the rainfall condition is slightly affected by annual total rainfall variability. The coefficients of variation is computed to be 21.7%; indicating a slight inter-annual total rainfall variation Humbo Woreda. This indicated that the rainfall is below the average and in other year above the average. As confirmed by FGD and KII participants, the rainfall variability has been affecting crops and livestock production. The long-term annual total rainfall is about 807.96mm, which is an indication of the inadequacy of rainfall amounts for agricultural practices. This is more or less better than compared with most areas in Ethiopia.

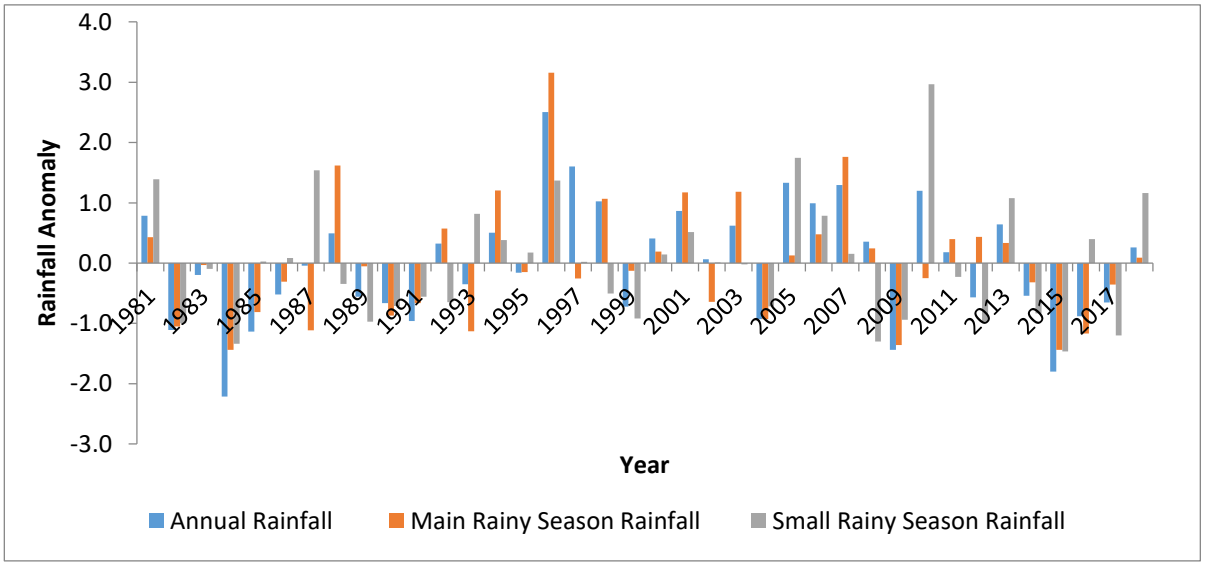

Figure 4. Annual and Seasonal Rainfall Variability of the Study Site (1981-2018)

Short Rainy season (spring) rain, which is main production season in Wolaita area, is the most variable compared to others. The mean total spring rain of Humbo woreda ranges between 166mm to 561mm. These indicate variability of spring rain in the study area. This fact has been confirmed by the FGD and KII participant 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.

Figure 4. Shows annual rainfall, main rainy season of Humbo woreda have been increasing by 14.09 mm, 1.74 mm, and 2.56 mm per decade from 1981 to 2018. The mean total spring rain of Humbo woreda ranges between 148mm to 588mm. As indicated in the figure 4 the main rainy season rainfall trend value (curve) shows slightly increasing between 1987, 2005 and 2010. It drops in years between 1984 and 1999 and 2008.

The dominant crops grown in the study area are maize, wheat and Cassava. Trends of maize production were used as an indicator on the impact of climate change on the food security of the households given that it is a major food security crop in the study area. The changes in yield were highly correlated with rainfall. The descriptive analysis also confirms that, with keeping other agricultural inputs constant, productivity of maize is changed from year to year due to climate change and variability. The average productivity of maize was 40.10 quintal/ha from the year of 2007–2016 with the standard deviation of 42.1 quintal/ha

The study site has been experiencing a mix of increasing and decreasing maximum temperature. Figure 5. Shows annual maximum temperature, main rainy maximum temperature shows statically significant increasing trend whereas small rainy season maximum temperature has been decreasing for the last thrifty-seven years. Annual maximum temperature and main rainy maximum temperature shows increasing trend by 0.32^{o} C and 0.63^{o} C per decade respectively. However, small rainy season maximum temperature shows a decreasing trend by 0.11^{o} C.

Table 12. Annual and Seasonal Temperature Maximum long-term Average, Standard deviation and Coefficient of Variation in the Study Area (1981-2018)

	Season		
Temperature Maximum	**Annual**	**Main rainy season**	**Small rainy season**
Long-term Average	29.1	28	28.4
Standard Deviation	0.6	1.2	1
Coefficient of Variation (%)	2.06	4.3	3.5

The mean annual temperature in the study area for the period was 21.3 ◦C and the mean maximum and mean

minimum temperature were 28.9 ◦C and 13.7◦C respectively. Decadal analysis of the mean maximum temperatures from 1989 to 1998, 1999 to 2008, and 2009 to 2018 was as 28.6 ◦C, 29.4 ◦C, and 29.5 ◦C while the mean minimum temperatures were 13.02 ◦C, 13.51 ◦C, and 12.92 ◦C respectively. This analysis showed significant ($p < 0.05$) increasing trends for both mean maximum and minimum temperature in the study area.

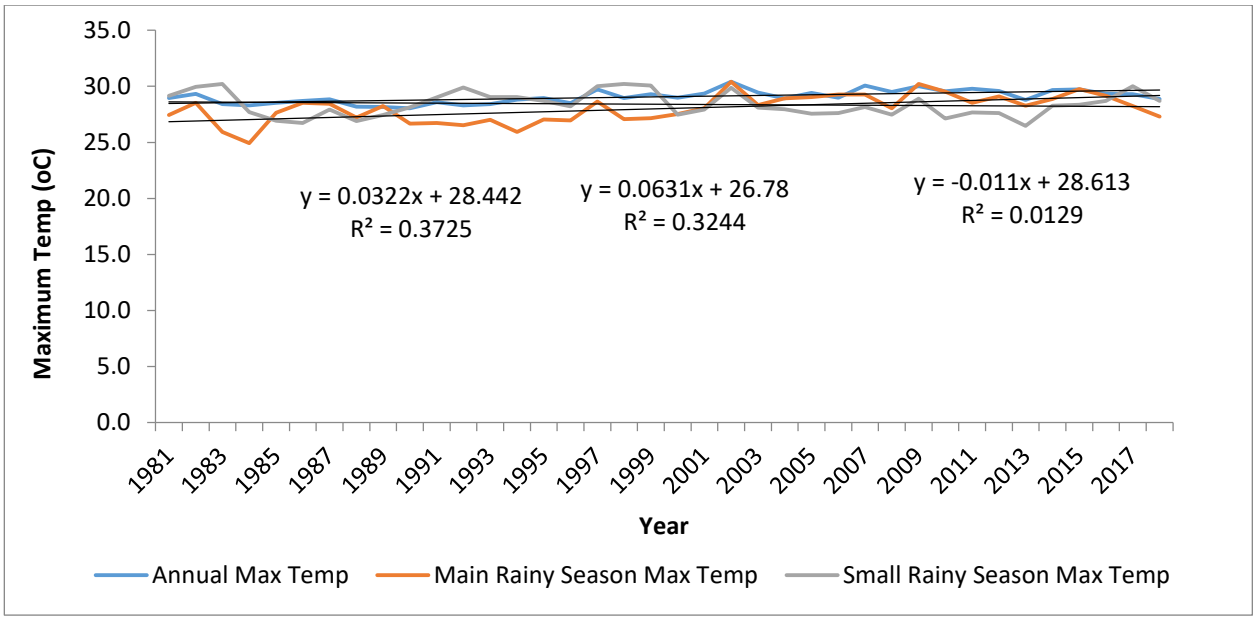

Figure 5. Trends of annual and seasonal Maximum temperature in the study area (1981-2018)

The minimum temperature increase trend was greater than max temperature trend of the study area for the last 38 years (Figure 5). These findings are similar to studies in the region that, have showed that there has been an increasing trend in the average annual temperature, and annual maximum and minimum temperature in Ethiopia. The increasing temperature and decreasing precipitation in the country has devastating effects on crop farmers because 80% of the country's population is farmers who are depending on rain fed agriculture. Additionally, climate projections suggest that the annual temperature trends would be higher in the future. Thus there is need to develop adaptation and mitigation measures in the various sectors of the economy specifically agriculture, water, energy and health.

Table 13. Annual and seasonal Temperature minimum long-term average, standard deviation and coefficient of variation in the study area (1981-2018)

	Season		
Temperature Minimum	**Annual**	**Main rainy season**	**Small rainy season**

Long-term Average	13.8	13.9	14.3
Standard Deviation	1.2	1.6	1.3
Coefficient of Variation (%)	8.7	11.5	9.1

The study site has been experiencing a mix of increasing and decreasing minimum temperature. Figure xxx. Shows statically significant increasing trend of main rain season minimum temperature whereas small rainy season maximum temperature has been decreasing for the last thrifty-seven years. Annual maximum temperature and main rainy maximum temperature shows increasing trend by 0.06^{o} C and 0.63^{o} C per decade respectively. However, small rainy season minimum temperature shows a decreasing trend by 0.06^{o} C.

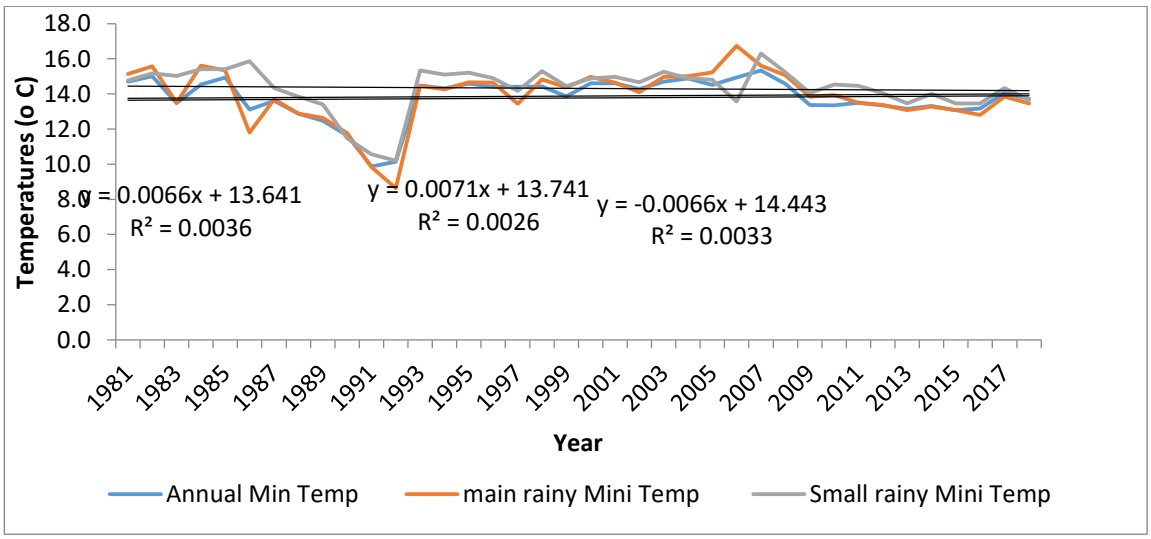

Figure 6. Trends of annual and seasonal minimum temperature in the study area (1981-2018

4.2 Farmers Perception about Rainfall and Temperature Variability

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).

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, 79.5% of respondents answered they have lived lifetime in the study area. The remaining 20.5% of respondents have lived 21-30 years. Therefore, respondents have good background to perceive the change/variability of temperature and rainfall of the past years in the area.

4.2.1 Perception about Temperature Variability

Out of the total sampled respondents 21.7% of respondents perceive that there is significant increase in the temperature over the past 20-25 years. About 73% of respondents 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 6.5% reported that the temperature is decreasing while the rest 20.5% indicated that there is no change in the temperature. In the study district 70.05% of respondents believed that temperature is increasing.

Furthermore, 78 percent of households perceived an increase in hot days, while 7 percent noted the decrease of coldness in cold seasons, respectively. Generally, the majority of households are aware about the presence of climate change and variability. They revealed their local experience of climate change and variability using variability in onset and cessation time of the rainy season, the decreased number of rainy days, a raise of drought severity, and the increased number of hot days.

Their perceptions of increasing temperature tally with the meteorological records of mean temperature. Moreover, farmers' perception is consistent with scientific claims about the increasing trend of temperature in Ethiopia and globally.

“As the one FGD member informed in bega season rain fall is scanty. The quality of animals was decreasing. This is due to the lack of forage and the scarcity of water and the prevalence of animal diseases resulted from high temperature variability. Thus, the quality and the quantity of animal product also deteriorated, even in the year 2018 more than 200 cattle‟s died, particularly larger animals are highly affected (KII &FGD,2021).

According to the metrological data of the study area, annual average temperature distribution of the study area characterized by a general trend of increasing annual variability. Annual maximum temperature and main rainy maximum temperature shows increasing trend by 0.06^{o} C and 0.63^{o} C per decade respectively. However, small rainy season minimum temperature shows a decreasing trend by 0.06^{o} C.

Figure 13.Pattern of belg temperature as shown in Figure 4 above in short rain season, general trend of temperature was increased but relatively with decreasing rate. Specifically, the highest temperature recorded was 33.4 c in 2011, 2012 and 2016 in the December month. And the lowest temperature was recorded as 8.1 c in October 1992.

As it computed the highest average temperature 26.50 c in 2015 recorded and minimum average temperature was 17.60 c in 1993 observed within 22 years. So, belg average temperature difference with in 22 years in the study area reveals 8.60 c. This season is the main production months particularly maize to the households as well as a time of good access to livestock fodder in Humbo Woreda but it is drying up with the average

increasing of annual and seasonal temperature.

4.2.2 Perceptions about Rainfall Situations

Views regarding change of rainfall pattern were also required from the respondents. And 58.5% of respondents reported that they have perceived increasing trend in the annual rainfall amount in their village. About 38.5% of respondents reported that they felt rainfall is decreasing but not significantly, and the remaining 3%reported that no change in trend of rain (Fig.16).

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 25 years ago in month of January, but it comes now in the mid of March, so our sowing time changed from January to March.

Majority of respondents perceived that the main rainy season and belg season rain are starting later and ending earlier. According to participants, two decades ago the amount and number of rainy days varied significantly, with rainfall occurring from April to October (the belg rain starts and the tsedy rain ends); nowadays however, participants stated that it usually starts in the middle of June and ends in the middle September. Farmers' perceptions that the annual and main rainy season are highly variable negates from meteorological analysis since the recorded data shows consistent rainfall distribution.

Moreover, During FGD participants mentioned that the variability of belg and mehar rainfall and the presence of crop disease that caused the average low production of wheat production. The shortage of belg rainfall during its growing period and, the more excess summer rainfall during its harvesting period caused for the low production of potatoes crop, the fluctuation (the late onset of belg rainfall and the early secession of tseday rainfall) leads to the significance deterioration of crop production. For instance, the late onset of belg rainfall is the causes for low production of maize and groundnut crops. Hence, these two crops planted or sow during this season.

Out of the total sampled households, 88% respondents also associated the change of duration of rain with crop production and that they reflected decreased crop yield. 7.3%, 4.7% and 24.8% of respondents respectively were responded that increase in crop yield, no change in production.

Respondents were asked to rank the major factors affecting declining crop production in this area. Totally, 7 factors were given, 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.

4.2.3 Perceptions of Climate Variability and its Impact on Food Security

Climate has adverse impact on the agriculture activities in general and rain-fed agriculture in specific. 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.

Depending of the research contexts, different studies have been carried out to examine how farmers perceive changes in the climate system. Understanding farmers' perception levels and the various adaptation strategies individual households employ would benefit to gather supplementary information relevant to policy and intervention to tackle the challenges of climate change. 'e descriptive analysis show that about 61.54% of the farmers perceived changes in the climate parameters (i.e., increased temperature and decreased rainfall) in the aggregate sample. In our case, the proportion of farmers who perceived increasing temperature and decreasing rainfall is slightly different compared to studies in Ethiopia and other countries, being influenced by factors affecting their level of perception in general and the type of meteorological data (station vs. gridded data) and climate data availability (longer vs. shorter time period) in particular. Moreover, (Schwartz, 2010) pointed that people believe climate may change owing to fresh climate experiences, such as the recent 2015/2016 El Niño events prior to the data collection period may contribute to their perception in the study area context. 'e data on the temperature indicators also revealed that farmers perceived an increase in dry season temperature and hot days' temperature, which are consistently increased. In addition, over 60% of farmers perceived an increase in rainy season temperature while a comparable proportion of farm households perceived increased temperature in the rainy season. Farmers' perception results are in line with a recent study (Esayas, et, al. 2018). Others studies observed similar patterns in different parts of Ethiopia (weldegbreal. B 2017). Farmers also perceived that rainfall comes late and goes early and observed decreasing trend in the short rains. In general, farmers perceived declining trends both for the belg/short-rains and meher/long-rains over the last two decades, which makes rainfall erratic. This result agrees with empirical studies (weldegbreal, Tadesse and Tesso), which reported that farmers perceived declining trend in the rainfall amount over years in Ethiopia. Similarly, a study by (Mkonda et al) reported that a significant increasing temperature was observed in Tanzania. Regarding the perceived impacts of climate change, farm households witnessed impacts, including, crop productivity decline (98.26%), food price inflation (98.01%), increased frequency of drought (94.79%), increased crop pest

(70.72%), increased frequency of floods (68.73%), shortage of water for human use (63.03%), emergence of new pests (61.79%), shortage of water for irrigation (61.04%), increased livestock disease (58.81%), and conflict over diminishing resources (55.83%) in order of severity. Similarly, (Tesso et al. 32) documented perceived impacts of climate change in North Shewa, Ethiopia. Hence, farmers' perception of the climate-induced impacts over years is indicative of Ethiopia's vulnerability to climate change and variability. 'us, studies recognized that Ethiopia suffers from problems associated with high rainfall

Majority of farmers perceived the changes of climate variability in their localities in the last two decades with. Although this study has similar finding about the perceptions of farmers' temperature increment and decrement of rainfall amount, it does not neatly fit with the actual behavior of climate variability.

The most perceived aspects of climate variability is increase of temperature, increment of erratic rainfall cessation and onset time, increase of the number of hot days and hot nights, increment of rainfall intensity, increase of the degree of coldness of cold season, reduction of rainfall amount, increment of untimely rainfall occurrence and increase of drought frequency.

The main challenges of climate variability in the study areas are related to increment of temperature and extremes, more erratic rainfall and increment of rainfall intensity in there order of importance to agricultural production and activities. The problem of water deficiency (the resultant effect of perceived rainfall amount reduction, more frequent drought and depletion of surface and underground water), however, can easily be understood if looked from the point of view of 'agricultural drought' rather than absolute decrease in seasonal and annual rainfall amount. The main problem is rising temperature and bad rainfall distribution that affect agricultural production

How climate change/variability affects food security status of respondents in the study area was asked and responded as follows. About 79% of the respondents reported that climate change/variability affects food security through unpredictability of rain and the remaining 21% of the respondents, answered climate change/variability affects food security through flood and drought.

regarding the perceived impacts of climate change, farm households witnessed impacts, including, crop productivity decline (98.26%), food price inflation (98.01%), increased frequency of drought (94.79%), increased crop pest (70.72%), increased frequency of floods (68.73%), shortage of water for human use (63.03%), emergence of new pests (61.79%) and increased livestock disease (58.81%).

The farmers also perceived that among the factors that affect their food security, rainfall fluctuation is serious than others. Generally, when rainfall became scanty, onset and late or early affected crop production and animals raising of the farmers in the study community rather than other factors. In addition to survey, woreda disaster and risk management also mentioned that the shortage and erratic rainfall is the prominent physical factor that causes the failure of crop production which ultimately results in the chronic food security. Rainfall

starts at the beginning of March (belg) rain and continue till the end of September (tseday). However, in the last 20 years erratic belg rain and the secession of summer (keremt) rainfall negatively influenced crop production in the woreda.

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. They perceived that climate variability highly affect livestock stock. The absence of rainfall during bega season and the unreliable rainfall in belg season makes limited quantity of animals‟ pasture and drinking water. Moreover, during these seasons animal‟ diseases also highly affect livestock production.
Livestock disease highly devastates in dry agro-climatic zone. 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.
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.

4.2.4 Perception about Climate Variability and 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 81 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, and 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 Humbo woreda 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.

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 recurrent 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).

4.4 Food Insecurity Status of the Household

Household Food Insecurity Access Scale (HFIAS) results of analysis were investigated using access-related, condition, and prevalence.

The analysis of the *Access-related condition* based on the 9 generic questions (Table 15) indicated that 88.8% of the surveyed households faced problems of both economic and physical access to food while 11.2% of them had never faced it. With regards to the average severity level, 36.7% of households faced access problems "rarely", 28.1% "sometimes" and 24%"often" during the study period.

The nine generic questions of households' food insecurity access were also designed to represent the varying levels of food insecurity and reflect the three domains. These domains are *anxiety and uncertainty, insufficient quality* and *insufficient quantity*.

In the first domain (anxiety and uncertainty) matched with the proportion of the households answered "yes" to the first question only. The result indicated that all (100%) of surveyed households were uncertain and anxiety about their access to enough food at any severity levels. Out of this, 34%, 38.5% and 27.5% of surveyed households anxious and uncertain about access to food were rarely, sometimes and often, respectively (Table 17). Considering the most severity levels of condition (as sometimes and often), significant proportion (66%) was anxious and uncertain about their access to enough food.

		No. and % of Households by Frequency	HH condition

Table 14: Households Food Insecurity Condition

			Rarely	Sometimes	Often	Total	
1.	Worry about food	No.	68	77	55	200	200
		%	34	38.5	27.5	100	11.11
2.	Unable to eat preferred Food	No.	79	67	54	200	200
		%	39.5	33.5	27	100	11.11
3.	Eat just a few kinds of foods	No.	12	94	94	200	200
		%	6	47	47	100	11.11
4.	Eat foods they really do not want to eat	No.	20	90	90	200	200
		%	10	45	45	100	11.11
5.	Eat a smaller meal	No.	94	70	36	200	200
		%	47	35	18	100	11.11
6.	Eat fewer meals in a day	No.	53	59	88	200	200
		%	26.5	29.5	44	100	11.11
7.	No food of any kind in the household	No.	153	33	15	200	200
		%	73.6	17.17	9.67	100	11.11
8.	Go to sleep hungry	No.	183	17	0	200	200
		%	91.5	8.5	0	100	11.11
9.	Go a whole day and night without eating any food	No.	0	0	0	200	0.0
		%	0	0	0	100	0.0
Total Score is 200*9=1800		No.	662	507	432	1800	1304
		%	36.7	28.1	24	100	88.8

The second domain shows that the food quality in terms of variety preference was measured based on the three next questions (2, 3 and 4). The result revealed that 39.5%, 33.5% and 27% of the households reported that they could not eat the food they prefer as rarely, sometimes and often correspondingly. Similarly, 6%, 47% and 47% of surveyed households ate limited variety of meal rarely, sometimes and often respectively. On the other hand, 10%, 45% and 45% of households depended on the food type they really did not want to eat rarely, sometimes and often correspondingly. In terms of the most severity levels of condition as (sometimes and often), 83.2% of households were taking insufficient quality food.

The last domain representing the access to sufficient quantity and its consequences was also investigated based on the last five questions (5, 6, 7, 8 and 9) that indicated the most severe behaviours as reflected by the households. Among these severe conditions the household of the study fall under all, except went hungry the

whole day without eating any food (question 9). As it is shown in table 17, 47%, 35% and 18% of households were rarely, sometimes and often ate smaller meal respectively.

The second severe condition under this domain is whether a household ate fewer meals per day, which was reported about 26.5%, 29.5% and 44% of households were rarely, sometimes and often ate smaller meals per day in that order. The next severe condition that stated by the households was rarely (73.6%), sometimes (17.17%) and often (9.67%) no food of any kind in the household respectively.

The fourth severe condition was sleeping hungry at night, which were reported rarely (91.5%), sometimes (8.5%) and often (0.0%) correspondingly. Regarding with the most severity levels of condition as (sometimes and often), 49.0% of households are taking insufficient quantity food.

As discussed in the previous chapter, the households' food insecurity score ranged from 0 to 27, with a high score indicating greater vulnerability to food insecurity. In this study, as presented in Table 10, the average score measuring vulnerability to food insecurity was 11.9, the minimum score was 8 and the maximum score was 17. The standard deviation of 2.85 implied that there was a high variation between the individual scores ranging from 8 to 17. There also existed a difference between the mean HFIAS Score of food secure (9.0) and food insecure (13.3) households. Furthermore, the mean difference was statistically significant at 1% probability level.

Of course, the HFIAS is better interpreted when it used to assess Household Food Insecurity Access Prevalence (Guyu, 2015). Accordingly, the Household Food Insecurity Access Prevalence (HFIAP) indicator was used to observe households food insecurity prevalence, HFIAP indicator categorized households into four main levels of food security status depending on how they respond to the nine-frequency occurrence questions (Table 11).

From the total sample collected, it was found that the number of people who were food secure were only 62 (31%), while others fall under different food insecurity status categories. 43 (21.5%) of the respondents were mildly food insecure, 71 (35.5%) moderately food insecure while 24 (12%) of the sample was under severe food insecure condition. This finding agrees with the research conducted by (Fumane, 2013; Palanivel *et al.*, 2014; Zeid *et. al*, 2016; L.valesova *et al.*, 2017).

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 86 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.

Table 15: Household Food Insecurity Access Prevalence (HFIAP)

	Frequency	Percent (%)
Food Secure	62	31
Mildly Food Insecure	43	21.5
Moderately food Insecure	71	35.5
Severely Food Insecure	24	12
Total	200	100.0

HFIAS prevalence results for sample households show that about 31% of total sample households are food secured. The rest about 21.5%, 35.5% and 12% of respondents faced with mild, moderate and severe food insecure respectively. From Table 21, one can conclude that, majority of sample households constitute moderately food insecure.

4.5 Household Food Consumption Score

According to the Food Consumption Score, households with poor consumption are regarded as food insecure,

while households with borderline consumption are categorized as moderately food insecure and the households with acceptable food consumption were categorized as food secure. Out of the total 200 households the mean Food Consumption Score were 1.67 with standard deviation of 0.803.

Table 16. Household Food Consumption Score

	Frequency	**Percent%**
< 28 (poor)	108	54
28.5 - 42 (Moderate)	50	25
42 and above (Adequate)	42	21
Total	200	100.0
Mean	1.67	
Standard deviation	0.803	

4.6 Demographic Factors and Food Security

Sex of the Household

Sex of the household was one of the demographic characteristics hypothesized to influence food insecurity status of households. Male headed Households were expected to be more likely food secure when compared to the female headed households. The possible reasons might be due to physical, socio-cultural and time constraints that females are facing as compared to males, and these contributed to food insecurity status of female headed households.

From the total food secure households 62.9% were males while 37.1% were female headed. It shows that majority of the respondents in tis areas are male headed. Based on the result of Pearson Chi-Square test male household heads were more food secures than female household heads and the association was significant at 5% probability level.

Table 17: Sex of Respondents and Food Insecurity Scale

			Household Food Insecurity Scale				
			Food Secure	Mildly Food Insecure	Moderately food Insecure	Severely Food Insecure	Total
Sex of respondents	Male	Frequency	39	32	38	10	119
		Percent	32.8%	26.9%	31.9%	8.4%	100.0%

	Female	Frequency	23	11	33	14	81
		Percent	28.4%	13.6%	40.7%	17.3%	100.0%
	Total	Frequency	62	43	71	24	200
		Percent	31.0%	21.5%	35.5%	12.0%	100.0%

Pearson Chi-Square= 8.490, df = 3 and P=0.037
Source: Authors' survey, 2021

Educational Status

Since education plays a major role in improving the farmers' way of life, educational status was one of the potential explanatory variables that affect food insecurity. In this study, it was hypothesized that education negatively influences the food insecurity status of the households. As it is depicted in the Chi-square test result, Table 14, among the total respondents, those who were unable to read and write households were accounted 73 %. While the rest of the respondents, 20.5 and 6.5 attend Primary and high school. The proportion of food insecure households was high within unable to read and write which is 68.49%, 19.2 mildly food insecure, 34.2 moderately food insecure and the remaining 15.1 severely food insecure. The result of Pearson Chi-Square revealed that more households turn out to be illiterate and food insecure and the difference was significant at 1% probability level.

Table 18: Education Status of Respondents and Food Insecurity Scale

			Household Food Insecurity Scale				
			Food Secure	Mildly Food Insecure	Moderately food Insecure	Severely Food Insecure	Total
Educational Status	Illiterate	Frequency	46	28	50	22	146
		Percent	31.5%	19.2%	34.2%	15.1%	100.0%
	Primary	Frequency	12	9	18	2	41
		Percent	29.3%	22.0%	43.9%	4.9%	100.0%
	High School	Frequency	4	6	3	0	13
		Percent	30.8%	46.2%	23.1%	0.0%	100.0%
Total		Frequency	62	43	71	24	200
		Percent	31.0%	21.5%	35.5%	12.0%	100.0%

Pearson Chi-Square= 21.448, df = 3 and P=0.011
Source: Authors' survey, 2021

Age of the Household

The age structure of the sampled household indicates that the youngest average age of the household was 21 years and the oldest was 67 years. The average age of sampled households was 45.8 years with standard deviation of 12.14. The mean age difference between the food secure and food insecure groups was statistically significant at 1% probability level (Table 13). The average age of the food secure households was higher than that of the food insecure with average ages of 51.3 and 43.3 years respectively. This shows that, as age of the household members being younger the likelihood of being food insecure increases. The result showed that the average age for food secure and insecure households were 51.33 and 43.34 years with standard deviations of 11.28 and 11.72 respectively. From the result, the mean age of food secure households was higher than that of food insecure. This is to mean that age is positively related to household food security status. The t-test also showed that the mean difference was statistically significant at 5 percent.

Family Size

The family construction of the sampled household indicates that the smallest average size of the household was 2 and the largest was 12. Based on the T- test result the mean size of the sample households was 6.94 persons with standard deviation of 2.36 which was larger than the national average family size of 4.9 persons per household (CSA, 2008). The mean family size for food secure and insecure households were 4.6 and 7.9 with standard deviations of 1.5 and 1.8 respectively. From the result, the mean family size for food secure households was lower than that of food insecure. This is to mean that family size is negatively related to household food security. The t-test result also showed the mean difference was statistically significant at 10 percent.

4.6 Socio-economic and Institutional Factors of Household Food Security

Engagement in Off-Farm Activities

According to the elaboration of documents, in Ethiopia, agriculture accounts about 42.5% of the total GDP, employing and supporting about 84% of the total population and accounts for about 90% of the exports (CSA, 2011). In spite of all these, it is increasingly evident that access to the off-farm sources of income is critical to the survival of the rural poor (Nolte and Ostermeier, 2017). Participating in off-farm activities is one of the sources of income diversification and has a decisive role in reducing food insecurity through providing additional access to food.

Chi-square test was used (Table 17) to examine the relationship between off-farm activities and food security status. Out of the total sample households, 85% were not engaged on off- farm activities. In terms of food security status, households engaged in off-farm activities 10.3%, 62.1% and 3.4% were mild, moderate and severely food insecure respectively, while 24.1 % were food secure. Food insecurity was mostly prevalent on

those households were not participated on off-farm activities; with mildly (23.4%), moderately (31.0%), and severely (13.5%). Likewise, the result of Pearson Chi-Square revealed significant relationship at 5% probability level.

Table 19: Off- Farm Activity and Food Insecurity Scale

			Household Food Insecurity Scale				
			Food Secure	**Mildly Food Insecure**	**Moderately food Insecure**	**Severely Food Insecure**	**Total**
Off-farm Activity	Yes	Frequency	7	3	18	1	29
		Percent	24.1%	10.3%	62.1%	3.4%	100.0%
	No	Frequency	55	40	53	23	171
		Percent	32.2%	23.4%	31.0%	13.5%	100.0%
	Total	Frequency	62	43	71	24	200
		Percent	31.0%	21.5%	35.5%	12.0%	100.0%

Pearson Chi-Square= 11.290, df = 3 and P=0.010
Source: Authors' survey, 2021

Crop Failure

On farm activities are the main activities, in most cases the only activities that farmers use to generate production for self-consumption or sale. Even though in the study kebele production of Maize, wheat and teff are the most common on-farm activities. The responses of the key informants the farmers are facing a serious crop failure high fluctuation of onset and cession rainfall.

According to the chi-square outcome, from the total sample households, more than 92% were replied the lessening of on-farm activities; out of this figure more than 67.5% were food insecure (mild food insecure 23.4%, moderate food insecure 37.5%, severely food insecure 12.5%). The remaining less than 8% of the households were stated that the on-farm activities are on the normal status; among this group 81.2% of the respondents where food secure, while, the rest where under different level of food insecurity. Likewise, the result of Pearson Chi-Square revealed significant relationship at less than 10% level (Table 18). This statistics shows that the declining of on-farm activities had a contribution to the increment of the study area food insecurity status.

Table 20: Crop Failure and Food Insecurity Scale

			Household Food Insecurity Scale				
			Food Secure	**Mildly Food Insecure**	**Moderately food Insecure**	**Severely Food Insecure**	**Total**
Crop Failure	Yes	Frequency	49	43	69	23	184
		Percent	26.6%	23.4%	37.5%	12.5%	100.0%
	No	Frequency	13	0	2	1	16
		Percent	81.2%	0.0%	12.5%	6.2%	100.0%
	Total	Frequency	62	43	71	24	200
		Percent	31.0%	21.5%	35.5%	12.0%	100.0%

Pearson Chi-Square= 50.994, df = 6 and P=0.000

Source: Authors' survey, 2021

Access to Credit

Credit is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. However, some farmers have access to credit while others may not have due to problems related to high interest rate. As indicated in Table 6, out of the 4total household sampled only 37% of households had access to credit. The majority of sample households (63%) had no access to credit service. From the total sampled households, 62.2% of the food secure households and 12.7% of the food insecure households had received credit in the last three years. The result indicates that food secure households received more credit than food insecure households. The Chi-square test indicated that there was 10% significant difference in access to credit between food secure and food insecure households.

Table 21: Credit Access and Food Insecurity Scale

			Household Food Insecurity Scale				
			Food Secure	**Mildly Food Insecure**	**Moderately food Insecure**	**Severely Food Insecure**	**Total**
Credit Access	Yes	Frequency	46	9	15	4	74
		Percent	62.2%	12.2%	20.3%	5.4%	100.0%
	No	Frequency	16	34	56	20	126
		Percent	12.7%	27.0%	44.4%	15.9%	100.0%
	Total	Frequency	62	43	71	24	200

		Percent	31.0%	21.5%	35.5%	12.0%	100.0%

Pearson Chi-Square= 53.490, df = 3 and P=0.000
Source: Authors' survey, 2021

Livestock Production

Livestock plays an important role in Ethiopian economy in general and food security/insecurity of household in specific. 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). Among the total household respondents 62.5%, 29% and 8.5% revealed that there is a decrease, no change and increase of livestock number respectively.

Table 22: Livestock Production and Food Insecurity Scale

			Household Food Insecurity Scale				
			Food Secure	**Mildly Food Insecure**	**Moderately food Insecure**	**Severely Food Insecure**	**Total**
Livestock production	**Decrease**	**Frequency**	18	29	56	22	125
		Percent	14.4%	23.2%	44.8%	17.6%	100.0%
	Normal	**Frequency**	31	13	12	2	58
		Percent	53.4%	22.4%	20.7%	3.4%	100.0%
	Increase	**Frequency**	13	1	3	0	17
		Percent	76.5%	5.9%	17.6%	0.0%	100.0%
Total		**Frequency**	62	43	71	24	200
		Percent	31.0%	21.5%	35.5%	12.0%	100.0%

Pearson Chi-Square= 20.976, df = 3 and P=0.000
Source: Authors' survey, 2021

Farm Size

Landholding size under subsistence agriculture plays a significant role in the household food security situation. According to FAO (2009), the size of the land in agriculture influences household food security. As reported in Table 10, the average mean land holding in the study area was 1.13 hectares (ha) with standard deviation of 0.98.

The result showed that the mean land holding for food secure and insecure households were 2.09 and 0.69 with standard deviations of 1.08 and 0.52 respectively. This shows that in the study area food secure households had

larger land size as compared to food insecure households. The t-value shows that there is significant mean difference in land holding between food secure and food insecure households at 5% significant level.

According to the report of WFP (2019), the average land holding size of the Ethiopian agricultural households' is estimated to be 0.9 hectares while about one third of the Ethiopian farm households possess farmland less than 0.5 hectares, mainly for subsistence farming. Similarly, the mean farm size of the study and the mean farm size of food insecure households are closer to the estimation of the average land size of the national standards.

Livestock Holding

Livestock production plays an important role in the study area. Farmers rear livestock for various purposes such as for food (source of egg, milk and meat), means of transport, animal dung for fuel wood and organic fertilizer, and means of transport and source of cash for urgent needs Livestock is also considered as a measure of wealth in the rural area. Farm households having a number of livestock are considered as wealthy farmer in the farm community.

Livestock holding widely varied among the sampled households (Table 7). The average size of livestock holding in tropical livestock unit (TLU) for the total sampled households was found to be 2.87 with standard deviation 1.76. Average holdings for food secure and food insecure households were 4.52 and 2.13 TLU with standard deviation of 1.18 and 1.45respectively. 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 insecure household is higher and lower respectively when compared to the national average. The mean difference between food secured and insecure HHHs shows the role of livestock holding in rural livelihood that impacting the minimum daily calorie of the household. This is to mean that livestock holding is positively related to household food security. The t-test result also showed the mean difference was statistically significant at 5 percent.

Extension service

Table 6 showed that the number of contacts per months that the respondents made with extension (a.k.a. agricultural development) agents. 55.5 % food households made contact with agricultural development agents one time, 25.6 % two times, 7% more than three times and the remaining 12.55 have no contact with agricultural development agent. The mean contact of total household were 1.6 with 0.94 standard deviation. The mean contact of food secure households with agricultural development agents was 1.83 times per month while that of food insecure households was 1.73 time per month. The t-value indicated that there was no significant mean difference of number of contacts with agricultural development agents between food secure and food insecure households.

Table 23: T test Result for Continuous Variables

	Food Security status of the household	N	Mean	Std. Deviation	t-test	p-value
Age of Respondents	Food Secure	62	51.3387	11.28606	4.510	0.000
	Food Insecure	138	43.3478	11.72287		
Family Size of the Household	Food Secure	62	4.6774	1.58656	-11.897	0.000
	Food Insecure	138	7.9638	1.89663		
Farm Land Size	Food Secure	62	2.0927	1.08098	12.337	0.000
	Food Insecure	138	.6957	.52208		
Total livestock Holding	Food Secure	62	4.5210	1.18088	11.347	0.000
	Food Insecure	138	2.1341	1.45434		
How frequent do you get Extension service in a month	Food Secure	62	1.8387	.87203	0.673	0.502
	Food Insecure	138	1.7319	1.10434		

4.7 Econometric Results

The result of logistic regression presented in Table 26revealed that, out of twelve independent variables included in the model, seven independent variables (sex of the household head, family size, livestock holding, land owned, Off-farm engagement, crop failure and access to credit services) were the variables that significantly affected food security status of households in the study area.

Sex of the household head: As expected, sex of the household head affected household food security positively and significantly at 5 percent probability level. This means male headed households are more likely to be food secure than female headed households. Male farmers are more (75.7%) likely to apply adaptation choices to recruit the climate change effects. Female-headed households were more susceptible for the climate change. This can be due to the fact that women are culturally assigned for domestic activities and have limited access to critical resources (land, cash, and labor), which often undercuts their ability to carry out labor-intensive activities that make them economical subordinate to their husbands. In addition, even a little change in climate adversely influences the livelihoods of female-headed compared with their counterparts due to less mobility from place to place for the search of non-farm income-generating opportunities This result is consistent with the findings of Ahmed (2015), Mustapha et al. (2018) and Sani and Kemaw (2019). The

household size of this study was significant at less than 5% probability level and shows a positive relationship in explaining the status of household food insecurity.

Family size: In contrary to the hypothesis, the household size of this study was significant at less than 5% probability level and shows a negative relationship in explaining the status of household food security. This result is indicating that the households with larger family size are less likely to be food secure compared to the households with smaller family size. This might be because of adding additional family member to limited resources may cause scarcity and lead the family to food insecurity status. This result is consistent with the findings of Mesele et al. (2018), Mustapha et al. (2018) and Temesgen (2019).

Off- Farm Activity: The variable represents the participation of the respondents in other income generating activities aside farming. Off-farm income generating activities are critical to raise household's income in the study area. Households who did not participate in off-farm activities and mainly rely on the farm had inadequate sources of income to enable them afford inputs and also fulfil their family needs, hence were likely to be food insecure. Since the money that they earn from nonfarm activity would increase the household's liquidity to make on-farm investments or increase its income to purchase food and, thereby, improve household food security. This variable is significant at a probability level of 1% and has positive relation with household food security status. The positive sign showed that the probability that the household was food secure increases as off-farm activities increase. This finding is consistent with studies such as (Indris, 2012; Zerihun and Getachew, 2012; Maru, 2016; Girum, 2016; Ermias and Ayana, 2017; FAO, 2019) who explained that off-farm activities has the tendency to increase farming household's portfolio as they do not only source their income from the farm.

Livestock holding in TLU: As hypothesized, livestock holding affected household food security positively and significantly at 5 percent significance level. From this result, the households having more livestock are more likely to be food secure compared to those households holding lesser numbers of livestock. The reason for this was the multi-dimensional contributions of livestock products and byproducts in combating household food insecurity. Livestock serves as source of food as well as source of income to purchase food during the time of food shortage. This result is consistent with the findings reported by Haileyesus (2019), Mesele et al. (2018), Habtewold (2018)

Land owned: As expected, cultivated land size owned by households positively affected households food security at significant level of 1%.The result of focus group discussion highlighted that land is the most important determinant of crop and livestock production. Households having larger land size easily perform crop

production and livestock rearing compared to the households owning smaller land size or not owning land at all. This is because of high land rental price for crop production and for grazing. This result is similar with the result of Beyena and Muche (2010).

Crop Failure: This variable was found statistically significant at 5% probability level and had a negative relationship with the household food security status. The negative sign showed that the probability that the household was food security decreases in relation to the existence of crop failure due to many reasons, mostly erratic rainfall in the study area.

Access to credit services: As expected, this variable also affected household food security positively and significantly at 10 percent significance level. The households having access to credit services are more likely to be food secure than household without the services. This is because of those households having access to credit services can easily buy agricultural inputs like improved seed, fertilizer, labor, rent farm land, and etc. and improve their production and productivity which improves their food security status. This result is also consistent with the findings reported by Mustapha et al. (2018), Habtewold (2018) and Sami and Kemaw (2019).

Table 24: Logistic Regression Estimates for Determinants of Food Security Status

Variables	Coif	Wald	P- value	Odd ratio
Age	-0.044	1.308	0.253	.957
Farm Size	0.752	6.176	0.013**	2.121
Educational Status	-0.252	.089	0.766	.777
Family Size	-1.954	5.870	0.015**	.142
Off Farm Activity	2.043	3.778	0.051***	7.716
Use of Input	0.001	.000	0.999	1.001
Livestock Holding (TLU)	0.753	4.383	0.036*	2.471
Extension Service	-1.568	1.570	0.210	.208
Livestock production decline	-0.614	1.515	0.218	.541
Sex	4.468	7.788	0.005**	87.216

Crop Failure	3.289	7.767	0.005**	7.037
Access to credit	2.614	9.2	0.02***	6.01
Constant	-1.257	0.067	0.796	0.285

4.8 Major climate variability Coping Mechanisms to Food Insecurity

Coping strategies refers to adjustments in behavior and activities made by household during periods of food insecurity. During food insecurity periods these households use a wide range of mechanisms and social networks to cope with the situation.

Households in the study area have various coping mechanisms during food shortage months. This included: sealing livestock, consumption less preferable food, reduction in the number of meals, reduction in the quantity of food at each meal, skipping meals, skipping meals for a whole day, reduction in the quality of food taken and reduction in complementary food to children (reduction in the additional food for children) were the major ones.

As indicated in Table 11, selling agricultural asset like livestock was adopted by 17.5% to cope with food insecurity. Reduction in the quality of food taken was adopted by 9.5% and consumed less preferred food was adopted by 13.5%. Reduction in number of meals was adopted by 6% to cope with food insecurity and it consists of to reduce the meals frequency per day. Renting land also adopted by 4.5%.

4.9 Climate variability Adaptation Response

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 Majority 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.

Table 25. Adaptation Strategies

Adaptation strategies	Frequency	Percent
Crop Diversification	162	81

Using Fertilizer	154	77
Use of improved crop variety(yes)	134	67
Livestock diversification (yes)	34	17
Changing the planting and harvesting date (yes)	23	11.5
Income source diversification (yes)	18	7.5

As it shown in the above table 81%, 77% and 67% 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 respectively. From above table the researcher also understand that there are only few household heads that are changing the planting and harvesting date 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.

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 (65.5%) is the most constraining factor that affected the practice of adaptation strategies. Following lack of finance and credit facilities lack of training 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

CONCLUSION AND RECOMMENDATION

CONCLUSTION

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.

One of the objective of the study is to assess the rainfall and temperature trend in the study area, as long- term meteorological data shows there is high concentration of rainfall that is erratic in nature and there is high fluctuation of temperature with increasing trend.

Short Rainy season (spring) rain, which is main production season in the study area, is the most variable compared to others. The mean total spring rain ranges between 166mm to 561mm. These indicate high variability of spring rain in the study area, it becomes unnecessarily brings heavy rain and hinder sowing of seeds and also preparation of land for the next important production season (summer season).

As the study objective to examine climate variability impacts on agricultural productivity and food security. Food security challenges have been compounded by effects of erratic rain fall and temperature fluctuation that resulted either in heavy flooding or drought that destroyed farm produce and caused crop failure respectively. As a discussion, the impact of climate change on food security would be mainly through variability in rainfall cause complete crop failure.

Farmers are not only victims of climate variability and extremes but also perceived the manifestations of climate variability and its effect on crop and livestock sector in their locality. Moreover, farmers' perception is consistent with scientific claims about the increasing trend of temperature in Ethiopia and globally. The farmers also perceived that among the factors that affect their food security, rainfall fluctuation is serious than others. .

They perceived that climate variability highly affect livestock stock through the absence of rainfall during bega season and the unreliable rainfall in belg season makes limited quantity of animals‟ pasture and drinking water. Moreover, during these seasons animal‟ diseases also highly affect livestock production. Their perceptions tally with the meteorological records of mean temperature and rainfall it shows that farmers are well aware of the change/ variability of rainfall and temperature in their locality.

Food security was measured using a commonly known measure of food security status known as household food insecurity and access scale and food consumption score. The results based on HFIAS measurement revealed that only 31% of the households in the study area were food secure while 69 % were food insecure in different level of insecurity, about 21.5%, 35.5% and 12% of respondents faced with mild, moderate and severe food insecure respectively.

Results of sample households' food security status using Food Consumption Score. By using the Food Consumption Score cut-off, Out of the total households with acceptable food consumption were 21% while 25% the households had borderline consumption and 54% with poor food consumption score.

The econometric result of food that Sex of household, cultivated land holding, Livestock Production, access to credit, family size, Crop Failure, Livestock Holding and Off-farm activity were the major factors that significantly influence on households household food security. Sex, cultivated land holding, access to Credit, Livestock Holding (TLU), Off-farm activity positively affected the household food security in the study area. Crop Failure and Family size negatively affected household food security.

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 Training and lack of information are rated the 1st, 2nd and 3rd factors that are identified as major Barriers to Farm households Adaptation to climate change/variability.

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:

- The government should design new production oriented and commercialization policies that are focused on improved agricultural system, provision of timely climate information, widening the income sources and adopting improved varieties are the most important ones that should be taken in to account to reduce the food security risks of the area in the time of climate change. 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.

- Educating the households and strengthen female-headed household's participation in income-generating activities are also the other most important mechanisms for climate change adaptation in the area. Women have numerous roles in household nutrition, family planning, and other productive activities. Therefore, special needs of women/female-headed households (like access to land, technology, women extension services and basic survival support) should also be clearly identified and addressed in all development policies and interventions.

- Rainfall seasonal variability and temperature fluctuation was influencing agricultural productivity and food insecurity. Therefore, government with the experts from disaster prevention and preparedness, crop and animal production offices and farmers have to integrate in the update information of weather and climate conditions and there should be established well organized weather forecasting and meteorological stations

- Households with large family size are more food insecure than that of small family size. Therefore, government policies and strategies promoting family planning should be implemented and health extension workers should improve the awareness of the households towards family planning.

- Households getting access to credit services were more likely to be food secure than those households not getting access to credit services. This is because of those households having access to credit services can easily buy agricultural inputs like improved seed, fertilizer, labor, rent farm land, and etc. and improve their production and productivity which improves their food security status. Microfinances giving credit services to small-holder farmers should check their interest rate, credit system and the amount they are giving.

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Appendixes

Appendix I: Questionnaires Used for Data Collection

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

Basic Information of the Sample Households

1. Household Head name
2. Sex of the household‘s head: Male____ Female_____
3. Age _____
4. Duration of stay in the kebele _____
5. Family size:

Male___ Female_____ Total_____

6. Educational status:_____

Livelihoods of the households

7. What are the main sources of income for the house hold?

1. Crop production 2. Cattle rearing
3. Petty trade 4. Weaving
5. Daily laborer 6.Others specify _____

8. On farm Income

1 Decrease 2 Increase 3. Normal

9. Farm land in Hectare _____

10. Do you have livestock 1 Yes 2 No

11 If yes

Types of livestock	**Number**
Cattle	
Cow	
Goat	
Calf	
Sheep	
Chicken	
Donkey	

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

Constraints Yes No

1. Shortage of grazing land 2. Lack of additional fodder

3. Disease prevalence 4. Lack of sufficient veterinary services

5. Shortage of water C 6. Conflict on grazing land and water Specify other

12. Do you get extension service 1. Yes 2. No

13. Do you have access to credit service 1. Yes 2. No

14 If yes, how many times per month

1. 1times 2. 2 Times 3. 3 times 4. More than 3 Times

15. Have you ever faced Crop failure due to rainfall?

1. Yes 2. No

General perceptions about climate change and vulnerability in the area

1. Have you heard about the issue of climate change?

1. Yes 2. No

1. If yes, what problems you have faced due to the change of climate? (More than one choice is possible).

1. Fluctuation of rainfall 4. Disease incidence like malaria

2. Increased temperature 5. Deforestation 7. Cold temperature

3. More flooding 6. Hail storm 8. Drought

36. Did you notice changes in the amount of rain fall in your area in last 20 years?

1. Yes 2. No

37. Did you notice changes in the amount of temperature in the last 22 years?

1. Yes 2. No

This section seeks to assess the perception of farmers on climate variability and its impact on agricultural production. The section encompasses three parts; i.e. farmers' perception on temperature, rainfall and accesses. Accordingly, some possible statements are listed in the table below. Please read each item separately and indicate your opinion by putting a tick (√) mark under one of these alternatives. Your response could range from strongly agree (1) to strongly disagree (5).

1. Strongly disagree
2. Disagree
3. Neutral (undecided)
4. Agree
5. Strongly agree

6.1. Farmers perception on temperature, rainfall, impact

No.	Statements	1	2	3	4	5
1.	m well aware that the temperature in this area increases from time to time					
2.	m aware that the rise of temperature can negatively affects agricultural production					
3.	hen temperature is high the incidence of crop pests and diseases and					

	livestock diseases would increase					
4.	my opinion the temperature is highest during *belg*, are lower in *bega*, *tsedey* and *kiremt* in this order					
5.	m of the opinion that the frequency of drought occurrence increases with an increase in temperature					
6.	am of the opinion that land use patterns change due to increasing temperature					
7.	think a rise of temperature would decrease the water reservoirs in our locality					
8.	m well aware that when temperature increases not only scarcity but the quality of grazing land would decrease in my locality					
9.	now that changes in temperature could result in a change in my cropping pattern, livestock size and variety					
10.	do not think that changes temperature would cause changes in livelihood strategies					
11.	m aware that there is direct association between temperature and amount of crop & livestock production					
12.	m of the opinion that the changes in temperature can predicted					
13.	he rise of temperature results in a shortage of food in our locality					

6.2. Farmers' Perception on Rainfall

No.	Statements	1	2	3	4	5
1.	I know that rainfall pattern affects the cropping and grazing calendar (cropping & site of grazing time)					
2.	I think that the amount of rainfall can decrease from time to time					

3.	I know that the amount of rainfall affects agricultural production					
4.	When rainfall variability increases, the incidence of crop pests and diseases as well as animal diseases also increases					
5.	I know that rainfall is highest in kiremt and becomes less during *belg*, *tsedey* and *bega* in that order					
6.	I know that rainfall is highest in July and lowest in January					
7.	I am of the opinion that the number of rainy days has decreased over the last 15 years					
8.	I have observed that the frequency of drought occurrence increases as rainfall amount decreases					
9.	I have observed that land use have changed due to variations in rainfall distribution					
10.	I understand that when rainfall decreases the availability of water for agricultural production and other uses in our locality also decreases					
11.	I am not of the opinion that when the rainfall decreases the quality of grazing land also decreases in our locality					
12.	I know that rainfall variability influences the cropping pattern, livestock size and variety					
13.	I do not have enough knowledge to state that rainfall variability can cause changes in the livelihood strategies					
14.	I am aware that rainfall and agricultural production are directly associated to each other					
15.	I do not have enough knowledge to acknowledge that there is an inverse relationship between rainfall and the magnitude of drought severity					
16.	I think that rainfall variability is predictable					
17.	am aware that rainfall variability contributes to food shortage in our locality					
18.	I am aware that high intensity of rainfall can aggravate soil erosion					

19.	believe that the annual rains do not support the crop and livestock production as was the case in the past in my locality					

Impact of climate variability and change on rural household food security

1. Do you think temperature can negatively affects agricultural production? Yes____ No_____

2. Have you seen any weather hazard in the past? Yes _____ No ___

3. Do you think the climate situation has affected your agriculture? Yes ____ No ____

4. Do you change the cropping pattern due to climate variability? Yes _____ No____

SECTION 8: ADAPTATION AND COPING STRATEGIES TO DEAL WITH CLIMATE VARIABILITY

This section aims at establishing information on the types of strategies farmers employ to adapt and cope with climate variability. To this end, some possible adaptation and coping strategies are listed below. You are expected to rank order the coping and adaptation strategies from the most frequently applied to the least one. Please read each strategy carefully and write the rank in the space provided left of each statement.

Note: Use number 1 for the most frequently applied and 14 for the least.

I. For crop production

____. Using different crop varieties

____.Varying the planting and harvesting dates

____.Increased use of irrigation

____.Increasing the use of water and soil conservation techniques

____.Employing water harvesting technology

____.Use of shade and shelter

____.Shortening the length of growing season

____.Diversifying household economy by engaging in non–farming activities

____.Shift from crop production to livestock husbandry

____.Intensification of the farming system by applying farm technology

____.Receiving remittance outside household members

____.Seasonal migration of household heads

____.Receiving aid from government and NGOs for months of food insecurity

____.No adaptation method used

Other (if any):

a. _____

b. _____

c. _____

d. _____

For effective implementation of strategies mentioned 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

IV. Household food security status measurement

Food consumption score

A brief questionnaire is used to ask respondents about the frequency of their household's consumption of eight different food groups over the previous seven days

Food Group	**Frequency**
Main staples	
Pulses	
Vegetables	
Fruit	
Meat/Fish	
Milk	
Sugar	
Oil	

APPENDIX II: 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 are the major reasons of food insecurity in your Woreda?
3. Which growing season is more important/major one for agricultural production in your area; belg or meher?
4. What are the major types of crops grown and livestock's in the Woreda?

5. 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?

6. 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?

7. 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

8. What methods the farmers use to cope with the existing changes of cropping calendar?

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

10. 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?

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

12. 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?

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

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

6. 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?

7. 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?

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

9. 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?

10. What methods the farmers use to cope with the existing changes of cropping calendar?

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

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

13. 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 v: Monthly Average Annual Rainfall

	Jan	Feb	M	A	M	J	J	A	S	O	N	D
1981	2.5	31.1	187.3	161.2	66.7	40.1	187.1	92	137.4	23	12.5	5
1982	38.1	36.7	31.3	57.3	105.4	46.4	59.3	67.5	44.9	59	14.4	52.5
1983	20.4	14.9	44.9	104.1	128.5	44.6	87.6	141.5	81.1	56	35.6	14.4
1984	1.3	2.5	19.6	30.8	111.8	30.6	50.3	54.2	64.4	14	25.9	13.7
1985	19.9	3.7	56.5	147	85.3	53.6	90.6	52.4	50.6	25	12.4	11
1986	1.6	35.4	53.3	93.5	147.1	107.9	67.8	70.7	57.6	33	8.6	39.6
1987	11	22.6	107.9	100.9	219.9	50.6	37.2	79.2	64.2	84	11.5	11.2
1988	29.1	28.6	34.7	156.7	63	97.1	186.9	152.5	45.3	98	0.8	1.9
1989	22.7	42.4	58	84.4	53.9	119.7	85.6	66.5	88.4	57	19	12.7
1990	17.3	115.7	89.7	43.3	87.6	52.4	75.6	63	72.9	30	16.9	27.2
1991	23.5	76.9	83	43.8	107.8	67.1	80.4	63.8	49.8	20	6.4	17.1
1992	13.2	33	55.1	95.8	75.3	68.2	138	127	85.2	99	48.8	26.6
1993	69.2	57.3	17.9	177.2	166.7	75.2	32.5	57.5	30.6	52	7.6	3
1994	3.5	15.4	58.9	115.9	147.1	110.1	172.1	113.6	40.9	59	49.7	11.2
1995	1.2	41.1	52.9	162	87.7	95	105.5	61.5	90.9	33	31.2	17.2
1996	33.6	11.4	114.9	160.5	137.6	253.7	137.7	197.2	134.2	31	34.2	2.5
1997	8	0.8	13.2	187.6	87.6	85.2	110.2	56.2	34.5	251	217	38.3
1998	76.3	44.1	60.9	96.3	82.3	130.5	110.6	141.2	48.1	177	17.6	3.5
1999	15.9	0.9	60.3	66.8	74.1	67.1	111	86.3	61.7	121	9.7	6.9
2000	2.9	0	11.9	93.6	194	74	123	98.7	77.9	125	62	17.2
2001	18.4	19.6	93.5	84.9	155.4	118.8	128.8	144.8	67.4	101	16.2	11.9
2002	51	11.7	104.5	82.1	100.7	35.7	68.1	109.9	53.1	31	15.3	156
2003	43.9	12.4	46	173	65.1	115.6	140.7	137.5	42.7	29	28.9	82
2004	74.5	26.8	21.2	148.5	50	38.2	75.4	71.7	54.5	44	23	17.2
2005	17.6	9.7	82.2	154.9	210.8	91.2	119.4	79.1	148.1	80	46.7	2
2006	9.3	36.4	94.1	185.8	79.2	62.6	99.5	162.1	48.4	102	50.7	52.3
2007	40.1	35	50.6	92.6	157.2	138.7	111.7	200.3	183.2	19	6.6	0.9
2008	8.7	11.2	6.6	74.2	85.2	61	125.2	114.9	131.5	143	97.7	10.8
2009	14.1	9.3	32.8	46.6	119.9	48.7	53.9	40.4	38.5	76	28.1	46.3
2010	34.7	68.3	153.9	182.7	224.7	79.5	98.2	74.6	52.1	27	10.9	12.2
2011	4.4	12.1	40.1	31.5	193.6	70.2	114.5	131.5	116.3	43	79	3.4

2012	0	2.3	6.6	130.4	59.7	56.3	147.6	116	125.1	13	33.5	17.7
2013	23.5	4.6	73.7	176.4	135.8	76.9	120.8	112.2	81.9	68	44.3	2.3
2014	16.7	28.4	69.8	37.7	101.5	63.8	81.8	100.1	83.3	89	39.7	1.5
2015	1.3	2	44	28	78.8	57.5	53.7	23.9	35.7	25	120	21.9
2016	27.7	20.3	52.6	168.2	102.2	80.8	39	41.8	35.7	47	25.9	11.3
2017	0.4	19.3	27.4	30.2	117.6	23.2	129.1	89.6	112.5	116	27.7	0
2018	0.1	32	57.2	165.4	171.1	131.1	26.8	127.7	28	27	80.8	6

Appendix vii :Monthly Average Max. Temp.(oC

	Jan	Feb	Ma	Ap	Ma	J	Ju	A	Sep	Oct	No	Dec
1981	31.2	30.9	29.7	29.3	28.5	28.3	26.9	27.1	27.1	28.5	29.8	30.2
1982	30.2	30.4	31.1	29.7	29.1	28.6	28.3	28.7	29.2	28.9	28.5	29.1
1983	29.9	30.6	32.1	30.7	27.8	27.2	25.5	25.1	26.1	27.6	28.6	29.8
1984	29.5	31.4	30.1	27.3	25.7	25.2	24.8	24.8	29.3	29.9	30.5	31
1985	30.5	28.3	28.8	26.6	25.4	26.5	27.6	28.8	29.6	29.4	30.2	30.5
1986	30.7	28.2	27.4	26.3	26.5	27.9	28.5	29.2	30.4	29.8	29.3	30.1
1987	29.2	29.2	28.3	27.2	28.3	28.3	28.8	28.2	29.1	29.9	29.6	30
1988	30.9	28.9	28.4	27.6	24.7	26.4	27.2	28	29.2	29.5	28.8	28.6
1989	29.6	28	28.7	27.4	26.2	27.9	28.2	28.6	29.6	27.9	28.1	27.7
1990	28.1	27.7	28.1	28.2	28.1	27.4	26.2	26.4	28.4	28.9	29.7	29.3
1991	29.9	29.8	29.3	29.3	28.4	27.9	25.6	26.7	28.6	29.1	29.6	28.9
1992	29.7	28.6	30.8	30	28.9	27.5	26.7	25.4	27.4	27.4	28.4	28.7
1993	27.3	27.3	30.7	28.7	27.7	27	26.8	27.2	28.1	28.9	30	31.4
1994	31.6	31.9	30	29.1	28	26	25.7	26.1	28.5	29.5	29.4	30
1995	31	30.5	28.8	28.4	28.9	27.9	26.8	26.4	27.7	28.7	30.6	31.8
1996	28.9	30.8	29.7	28.5	26.4	26.9	27	27	27.5	28.8	29.8	30.5
1997	30.9	32.4	33.2	27.7	29.1	28	28.6	29.3	30.3	29.2	28.3	29.7
1998	29.4	30	30.5	30.8	29.3	27.8	26.1	27.3	28.6	27.6	29.6	30.6
1999	30.5	32.1	29.6	31.1	29.5	28.3	25.6	27.6	29.1	27.5	29.7	30.9
2000	33.3	30.1	28.1	27.3	27	26.9	28.2	27.5	29.1	29.7	29.8	30.9
2001	30	29	28.9	28	26.9	26.7	28.5	28.9	30.1	31.8	31.1	32.5
2002	29.2	29.4	29.1	29.9	30.6	29.5	30.4	31.3	32.5	30.7	29.8	32.6
2003	32.1	29.7	29.2	28	27.1	26.3	28.5	30.2	30.1	29.8	30.4	31.8
2004	28	29.4	28.1	28.7	27.1	28.5	28.7	29.6	29.3	29.4	31	29.4

2005	30.4	27.6	28.4	26.6	27.7	28.1	28.9	30.1	31.7	32.3	32	29.2
2006	28	28.9	28.6	27.2	27	29.1	29.2	29.5	29.3	29.5	30.6	31

Appendix vi: Monthly Average Min. Temp. (oC

Year	Jan	Feb	Ma	Ap	Ma	J	Ju	A	Sep	Oct	No	Dec
1981	15.3	14.8	14.1	15.1	15.1	15.1	15.1	15.2	14.5	14.2	14.1	13.7
1982	14.2	14.8	14.3	15.3	15.9	15.6	15.4	15.7	15.2	14.7	14.4	14.6
1983	13.3	14.7	15.4	14.8	14.9	15	12.5	13	13.4	12.6	11.1	11.1
1984	12.6	12.1	14.4	16	15.8	15.1	15.7	16	14.5	13.6	14.9	13.8
1985	14.2	14.4	15.3	15.3	15.6	14.7	15.7	15.6	15.8	14.3	14.5	13.7
1986	14.2	15.9	16.1	16	15.5	11.7	11.2	12.5	9.6	11.4	10.4	12.8
1987	13	13.8	14.4	14.6	14	13.8	13.7	13.6	13.1	12.9	12.9	13.4
1988	13.6	14.1	13.9	14.2	13.4	12.8	13.1	12.7	12.4	11.1	11.6	11.7
1989	10.3	12.9	13.7	13.4	13.1	13	11.9	13	12.9	11.8	13.4	10.2
1990	13.6	12	13.2	11.1	10.1	11.6	11.8	11.9	10.8	10.8	12.2	10.5
1991	10.5	10.2	10.4	10.7	10.6	9.8	9.9	.8	8.8	8.8	9.5	9.5
1992	9.5	10.5	10.6	10.4	9.6	8.8	8.7	8.4	8.4	8.1	14.3	14.3
1993	14.4	14.9	15.5	15.5	15	14.6	14.6	14.2	14	13.7	13.7	13.6
1994	14.5	14.9	15.1	15.5	14.7	14.1	14.2	14.5	13.6	13.6	13	14
1995	14.2	14.7	15.2	15.5	14.9	14.7	14.7	14.6	14.2	13.1	14.5	14.7
1996	14.8	15	15	15.1	14.6	14.7	14.7	14.5	13.4	12.8	13.8	14.4
1997	13.9	16.6	14.8	14.4	13.3	13.4	13.4	13.5	13.9	14.2	15.8	15.7
1998	15.6	15.4	15.8	14.9	15.2	14.7	15	14.8	12.1	12.4	13.8	13.3

1999	14.8	14.4	14.6	14.3	14.4	14.6	14.5	14	12.9	12.7	12.8	12.2
2000	14.3	14.9	14.8	14.35	15.5	15	15.1	14.8	15.2	13.3	13.8	14.2
2001	13.9	14	15.5	15	14.4	14.8	14.5	14.6	14.5	14.5	15.1	14.5
2002	14.1	14.2	14.9	14.6	14.5	14	14	14.3	14.6	15	13.6	13.5
2003	14.4	15	15.4	15.7	14.7	15.5	14.6	14.8	14.3	14.5	14.3	13.1
2004	14.6	15.3	14.5	14.8	15.4	14.8	15.2	15	14.9	15.1	14.7	14.2
2005	14.1	13.9	14.8	14.8	14.8	15.3	15.2	15.2	15.3	14	13.8	13
2006	12.1	13	12.8	13.6	14.3	15.8	17.5	16.9	16.6	16.6	15.5	14.4
2007	14.1	15.2	15.6	17	16.3	15.5	15.8	15.5	15.8	15.2	14.6	13.4
2008	14.6	13.8	15.4	14.9	15.4	15.6	15	14.6	14.5	14.4	14	12.6
2009	12.7	13.4	13	14.6	14.6	14.6	13.6	13.3	13.1	12.9	12	12.6
2010	11.2	12.4	15.1	13.8	14.7	14.7	13.6	13.5	13.4	12.8	12.8	12.1
2011	13	14.2	14.9	14.5	14	14.2	13.2	13.1	14.1	13.2	12	11.5
2012	13.4	13.4	13.2	14.5	14.4	13.1	13.4	13.6	12.8	12.9	12.7	12.7
2013	11.9	13.7	13.2	13.5	13.7	13.2	13.1	12.9	13.6	12.4	12.2	14.4
2014	13.4	13.1	14.5	14.4	13.1	13.4	13.6	12.8	12.9	12.9	12.9	12.7
2015	11.9	13.7	13.2	13.5	13.7	13.2	13.1	12.9	13.6	13.6	12.4	12.2
2016	14.4	14.7	13.8	13.1	13.5	12.6	12.8	13	12.9	12.9	11.5	12.9
2017	14.5	14.7	15	14.3	13.7	14.5	13.5	13.5	14.4	13.5	13.7	13.5
2018	14.2	14.3	13.4	14.1	13.5	13.6	13.6	13.2	13.4	13.7	13	14.6